

**Non-Confidential Business Information
(Non-CBI)**

Certification Test Report

Esse Engineering Ltd.

Models: WarmHeart, BakeHeart

Wood-Fired Freestanding Room Heater, Non-Catalytic

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Report Number: 0224WS009E

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*Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E*

AUTHORIZED SIGNATORIES

This report has been reviewed and approved by the following authorized signatories:

Evaluator:



Bruce Davis, Testing Manager
OMNI-Test Laboratories, Inc.

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Section 1

Sampling Procedures and Test Results

INTRODUCTION

Esse Engineering Ltd. retained *OMNI* to perform U.S. Environmental Protection Agency (EPA) certification testing on the WarmHeart Freestanding woodstove. The WarmHeart Freestanding wood stove is a Non-Catalytic-type room heater. The firebox is constructed of mild steel. Usable firebox volume was measured to be 1.09 cubic feet and the stove is vented through 6" flue collar located on the stove top. Stove model BakeHeart shares the same firebox and emissions control system, the oven under the firebox is the only difference. It was determined no additional testing was required to include this design variant.

Testing was performed at Nelke Consulting. The altitude of the laboratory is 500 feet above sea level. The unit was received in good condition and logged in on 12/15/20, then assigned and labeled with *OMNI* ID #2400A. *OMNI* representative Bruce Davis conducted the certification testing and completed all testing by December 16, 2020.

This report is organized in accordance with the EPA-recommended outline and is summarized in the Table of Contents immediately preceding this section. The results in this report are limited to the item submitted.

SAMPLING PROCEDURE

The WarmHeart wood stove was tested in accordance with the U.S. EPA 40 CFR Part 60, Subpart AAA – Standards of Performance for New Residential Wood Heaters using ASTM E2515 and EPA Alt-125, ASTM E3053. Particulate emissions were measured using sampling trains consisting of two Teflon coated 47mm filters (front and back). See Appendix A for details on EPA Alt-125.

The model WarmHeart was tested for thermal efficiency and carbon monoxide (CO) emissions in accordance with CSA B415.1-10 using Maple cordwood. A spread sheet provided by CSA was used to calculate efficiency values.

An ambient filter (Background) was not operated during this series, there were no operations in the area that would have generated additional particulate into the ambient air. Running an ambient filter can only reduce emissions by backing out any particulate not generated by fuel in the appliance, it can never increase emissions. Tests conducted without an ambient filter are worse case.

SUMMARY OF RESULTS

The weighted average emissions of the three test runs included in the results indicate a particulate emission rate of 2.15 grams per hour. The WarmHeart results are within the emission limit of 2.5 g/h for affected facilities tested with cordwood, manufactured on or after May 15, 2020.

The proportionality results for all 3 test runs were acceptable. Quality check results for each test run are presented in Section 2 of this report.

INDIVIDUAL RUN SUMMARIES

- Run 1 -** Test procedures followed to produce a high burn rate with a primary air setting of fully open. Observed burn rate was calculated from a hot to hot cycle at 3.37 kg/hr. Emissions results were calculated using particulate sampling from kindling, start-up fuel, and test fuel load combined (cold to hot). Burn rate, and efficiency were calculated using data from the test fuel load only (hot to hot). Gravimetric analysis of probe assemblies did not produce negative weights, train precision meets specified limits. No sampling anomalies occurred, this test run was determined to be valid and appropriate for inclusion in the weighted average.
- Run 2 -** Test procedures were followed to produce a low burn rate with a primary air setting of full closed. Observed burn rate was calculated at 0.73 kg/hr. Emissions and efficiency results were calculated using a hot to hot burn cycle, a coal bed generated by the high burn procedure was used. Gravimetric analysis of probe assemblies did not produce negative weights, train precision meets specified limits. No sampling anomalies occurred, this test run was determined to be valid and appropriate for inclusion in the weighted average.
- Run 3 -** Test procedures followed to produce a high burn rate with a primary air setting of fully open. Observed burn rate was calculated at 2.77 kg/hr. Burn rate was calculated using data from the kindling, start-up, and fuel load (cold to hot). No sampling occurred, this test run was not included in the weighted average.
- Run 4 -** Test procedures were followed to produce a medium high burn rate with a primary air setting of 6" from the left stove leg to the right edge of the air control. Observed burn rate was calculated at 0.70 kg/hr. Burn rate was 0.03 kg/h slower than the low burn operated at an air setting of full closed due to the way the logs fell during the combustion process, coal bed adjustment with intent to increase combustion occurred at 4 hours 50 minutes into the test due to 0 weight loss in 10 minutes. Emissions and efficiency results were calculated using a hot to hot burn cycle, a coal bed generated by a high burn conducted in test three was used. Gravimetric analysis of probe assemblies did not produce negative weights, train precision meets specified limits. No sampling anomalies occurred, this test run was determined to be valid and appropriate for inclusion in the weighted average.

Table 1 – Particulate Emissions

Run	Burn Rate Calculated from a Hot to Hot burn cycle (kg/h dry)	ASTM E2515 Emissions (g/h)	ASTM E3053 Weighting Factor (%)	ASTM E3053 Weighted Emissions (g/h)
1	3.37	14.44	20	0.888
2	0.73	1.85	40	0.740
4	0.70	1.30	40	0.520
The sum of weighted particulate emission of 3 test runs: $0.888 + 0.740 + 0.520 =$ 2.15 grams per hour.				

1. Based on a cold start including kindling and start-up fuel.

Table 2 – Particulate Emissions (First Hour)

Run	ASTM E2515 Emissions – First Hour (g/h)
1	3.21
2	5.80
4	3.89

Table 3 – B415.1 Efficiency and CO Emissions

Run	Heat Output (BTU/h)	HHV Efficiency (%)	LHV Efficiency (%)	CO Emissions (g/MJ Output)	CO Emissions (g/kg Dry Fuel)	CO Emissions (g/min)
1	48,685	74.4	79.5	5.58	79.50	1.526
2	10,486	75.9	81.2	7.41	112.36	1.365
4	10,001	75.4	80.7	5.51	82.98	0.968
Weighted average HHV efficiency of three test runs: $14.88 + 30.36 + 30.16 =$ 75.4% .						
Average CO Emissions of three tests: $(1.526 + 1.365 + 0.968) / 3 =$ 1.286 g/min						

Table 4 – Test Facility Conditions

Run	Room Temperature (°F)		Barometric Pressure (Hg)		Air Velocity (ft/min)	
	Before	After	Before	After	Before	After
1	64	66	29.42	29.45	<50	<50
2	68	66	29.45	29.52	<50	<50
3	67	68	29.22	29.20	<50	<50
4	68	66	29.19	28.96	<50	<50

**Table 5 – Kindling and Start-up Fuel Description Summary
 Maple Cordwood**

Run	Kindling Weight Wet Basis (lbs)	Start-up Fuel Weight Wet Basis (lbs)	Residual Start-up fuel weight (lbs)
1	2.00	3.00	1.3
3	2.10	3.20	1.3

Table 6 – Fuel Measurement and Cordwood Description Summary – TEST
All tests conducted using Maple Cordwood

Run	Test Fuel Wet Basis (lbs)	Firebox Volume (ft³)	Fuel Loading Density Wet Basis (lbs/ft³)	Test Fuel Dry Basis (lbs)	Test Fuel Consumed During Test Dry Basis (lbs)	Nominal Piece Length (in)
1	10.5	1.09	9.6	8.56 + 4.21	10.5	4@11.5
2	12.6	1.09	11.6	10.3	10.3	5@11.5
3	10.8	1.09	9.9	8.65 + 4.53	10.8	4@11.5
4	12.6	1.09	11.6	10.2	10.2	5@11.5

Table 7 – Dilution Tunnel Gas Measurements and Sampling Data Summary

Run	Length of Test (min)	Average Dilution Tunnel Gas Measurements		
		Velocity (ft/sec)	Flow Rate (dscf/min)	Temperature (°F)
1	99	19.61	213.3	91
2	385	20.17	225.6	77
4	395	19.91	219.5	77

Table 8 – Test Configurations

Run	Startup Procedures	Combustion Air
1	<p><u>Fuel Loading:</u> Kindling and start-up fuel loaded together; a torch was used for 60 seconds to establish a top-down fire. At 37 minutes placed fuel load into the firebox. Loading required less than 1 minute to complete.</p> <p><u>Door:</u> For kindling and start-up fuel, loading door was closed by 150 seconds. Test fuel load: fuel loading door was closed 2 minutes and 30 seconds after loading.</p> <p><u>Primary Air:</u> Air control fully open for the entire test.</p> <p><u>Secondary:</u> No user control for secondary air.</p> <p><u>Fan:</u> N/A</p> <p><u>Bypass:</u> N/A</p>	Fully open for entire test.
2	<p><u>Fuel Loading:</u> Test fuel loaded onto coal bed generated by test number 1 by 45 seconds.</p> <p><u>Door:</u> Closed by 3 minutes.</p> <p><u>Primary Air:</u> Fully open, then set to full closed by 12 minutes.</p> <p><u>Secondary:</u> No user control for secondary air.</p> <p><u>Fan:</u> N/A</p> <p><u>Bypass:</u> N/A</p>	Fully open for first 12 minutes, then set to full closed.
3	<p><u>Fuel Loading:</u> Kindling and start-up fuel loaded together; a torch was used for 60 seconds to establish a top-down fire. At 40 minutes placed fuel load into the firebox. Loading required less than 1 minute to complete.</p> <p><u>Door:</u> For kindling and start-up fuel, loading door was closed by 150 seconds. Test fuel load: fuel loading door was closed 2 minutes and 30 seconds after loading.</p> <p><u>Primary Air:</u> Air control fully open for the entire test.</p> <p><u>Secondary:</u> No user control for secondary air.</p> <p><u>Fan:</u> N/A</p> <p><u>Bypass:</u> N/A</p>	Fully open for entire test.
4	<p><u>Fuel Loading:</u> Test fuel loaded onto coal bed generated by test number 3 by 40 seconds.</p> <p><u>Door:</u> Closed by 2 minutes 30 seconds.</p> <p><u>Primary Air:</u> Fully open, then set to 6" from left leg by 15:30 minutes.</p> <p><u>Secondary:</u> No user control for secondary air.</p> <p><u>Fan:</u> N/A.</p> <p><u>Bypass:</u> N/A</p>	Fully open for first 15.5 minutes, then set to 6" from left leg.

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Section 2

Photographs/Appliance Description/Drawings

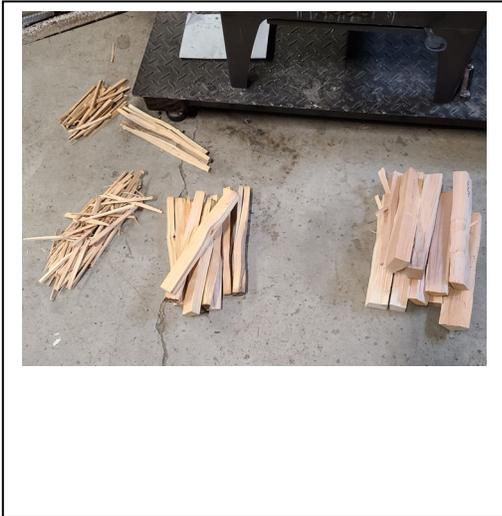
Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Esse Engineering Ltd.
WarmHeart
Test Dates: August 4, 2020 – August 5, 2020



Esse Engineering Ltd.
WarmHeart

Run 1 – Kindling and start-up fuel



Run 1 – Kindling and start-up fuel



Run 1 – Ignition of kindling



Run 1 – Fuel load



Esse Engineering Ltd.
WarmHeart

Run 1 – Test Fuel Load In Stove



Run 1 – Remaining Coal Bed



Run 2 – Test Fuel Load



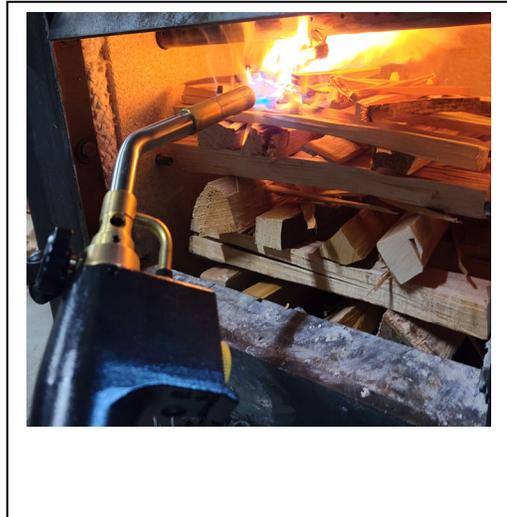
Run 2 – Test Fuel Loaded into Stove



Run 3 – Kindling and start-up fuel



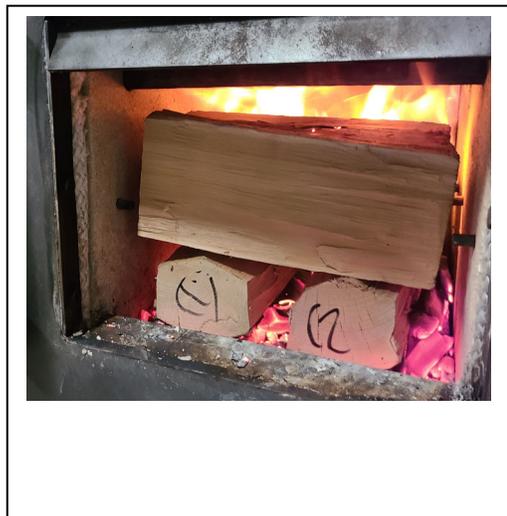
Run 3 – Ignition of kindling



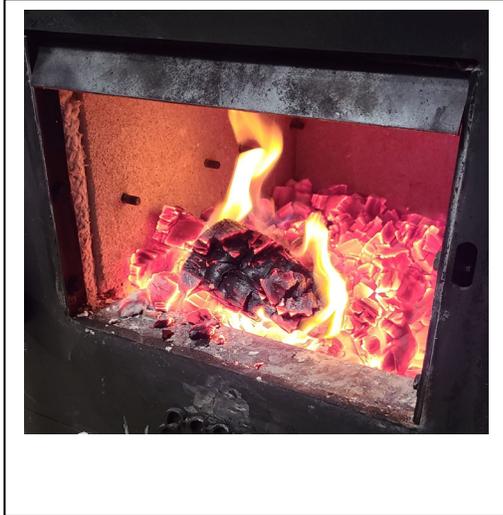
Run 3 – Test Fuel Load



Run 3 – Test Fuel Loaded into Stove



Run 3 - Remaining Coal After Test



Run 4 – Test Fuel Load



Run 4 – Test Fuel Loaded into Stove



Run 4 – Air control setting



Run 4 – Coal bed prior to stir



Run 4 – Coal bed after stir



Run 4 - Remaining Coal After Test



WOOD HEATER DESCRIPTION

Appliance Manufacturer: Esse Engineering Ltd.

Wood Stove Model: WarmHeart, BakeHeart

Type: Freestanding Non-Catalytic Wood Fired Room Heater

WOOD HEATER INFORMATION

Materials of Construction: The unit is constructed primarily of cast iron and mild steel. The firebox is lined with fire compressed vermiculite panels that measures 12.0" x 13.9" at the rear. The feed door has a 12.8 x 9.4 glass panel and 13mm diameter glass fiber seal.

Air Introduction System: Air is introduced into three different areas of the fire chamber and is controlled by one sliding control rod. Secondary air is introduced into the rear of the fire box through the bottom, it is then channeled up into the secondary air tubes located under the baffle. Air wash air is introduced through an opening in the bottom of the fire box. It is then channeled up to a manifold across the top of the door, air is directed down across the glass and into the fire chamber. A lower primary air orifice is mounted on the firebox floor near the loading door. Air is routed through the bottom of the firebox and into the lower orifice manifold, it is then directed horizontally into the coal bed near the front of the combustion chamber.

Combustion Control Mechanisms: Combustion air control mechanism is a sliding rod with flat plates attached that cover and uncover air inlets when the rod is moved from left to right.

Combustor: N/A

Internal Baffles: A fire brick baffle is mounted above the secondary air tubes, a ½" thick ceramic wool blanket rests on top for additional firebox insulation.

Other Features: The BakeHeart model has an oven mounted below the firebox, oven is heated by heat transfer through the firebox bottom, flue gas passageway is not directed around the oven. Additional testing was not required to include this model design.

Flue Outlet: The 6" diameter flue outlet is located at the rear of the top of the appliance.

WOOD HEATER OPERATING INSTRUCTIONS

Specific Written Instructions: See Section 4 of this report. All markings and instruction materials were reviewed for content prior to printing.

Section 3

Test Data by Run

Conditioning Data - ASTM E3053/ ASTM E2515

Manufacturer: Esse
 Model: WarmHeart
 Tracking No.: 2400A
 Project No.: 0224WS0009E
 Test Date: Sept, Oct. 2020
 Technician: Ben Nelke
 Operation Category: Medium

Fuel moisture between 19 - 25% db, operated at a medium burn rate.

Elapsed Time (hr)	Scale(lb)	Flue (F)
0	0.0	221.6
1	5.2	301.0
2	1.7	203.0
3	1.2	159.0
4	0.7	147.0
5	0.2	147.0
6	7.2	392.0
7	2.0	297.0
8	1.2	227.0
9	0.7	194.0
10	0.2	177.0
11	7.5	429.0
12	2.1	327.0
13	0.9	253.0
14	0.4	220.0
15	0.1	201.0
16	5.5	452.0
17	1.4	276.0
18	0.7	232.0
19	0.3	201.0
20	9.8	386.0
21	2.5	373.0
22	1.2	236.0
23	0.8	212.0
24	0.3	194.0
25	9.1	366.0

Elapsed Time (hr)	Scale(lb)	Flue(F)
26	2.8	354.0
27	1.5	226.0
28	0.8	196.0
29	0.3	180.0
30	0.3	302.4
31	4.8	350.0
32	1.8	243.0
33	1.3	200.0
34	0.9	183.0
35	0.5	170.0
36	0.2	160.0
37	5.5	405.0
38	1.8	251.0
39	1.1	206.0
40	0.5	186.0
41	0.0	173.0
42	5.8	399.0
43	1.9	271.0
44	1.5	209.0
45	1.1	189.0
46	0.6	178.0
47	0.3	164.0
48	0.1	153.0
49	5.9	378.0
50	2.0	238.0

Technician Signature: _____

ESSE Warmheart High Burn Procedure

Kindling:

Kindling weight in total should be 1.5lbs (± 0.5 bs) 10 pieces in total. Ten pieces at 10.5" of equal size. Making sure the weight doesn't exceed what's allowed per the standard.

Start-up Fuel:

The start-up fuel consists of 10 pieces at 10.5" of equal size. A total weight of 2.6lbs (± 0.5 lbs).

Test Fuel:

The test fuel consists of four pieces with a nominal length of 11.5". Follow the fuel sheet guideline for specific weights of the core and remainder loads.

Test fuel:



Start-up Procedure:

The start-up fuel is comprised of Six layers as follows.

Bottom: Two start-up and two kindling pieces North/South

2nd: Two start-up pieces and two kindling pieces East/West

3rd: Two start-up and Two kindling pieces North/South

4th: Two start-up and two kindling pieces East/West

5th: Two start-up and two kindling pieces North/South

Top: 0.6lbs – 0.5lbs pile of small kindling pieces in the middle as shown in the picture below, (4-5 Layers).

Kindling and Start-up:



Use a torch for 30 seconds to one minute to ignite the fuel, focusing the torch on the top middle portion of the load. Leave the door wide open for one and a half to three minutes. The amount of time for the door is to be based on how involved the fuel is.

The test load should be loaded at the bottom end of the allowable coal bed within 0.2lbs.

When loading, two of the four pieces are to be loaded on the bottom in a North/South direction. These pieces should measure 12.5". The remaining two pieces are to be placed East/West and measure 10.5". Making sure the top has plenty of clearance and under to secondary tubes. The door should be open two to five minutes. The fuel should be very involved before shutting the door.

End the test at the high end of the allowable remaining weight.

ESSE Warmheart Medium and Low Procedure

Test Fuel:

Follow the guidelines of the cordwood standard (E3053-17) for correct moisture and weight ratios for the core and sub loads. There are five pieces in total. The nominal length is 11.5”.



Coal Bed:

The coal bed will always result in running a high burn. There may be large pieces of fuel left after the high burn, as soon as the high burn has been complete, move the larger raw pieces toward the middle of the firebox stacked up for best combustion. Load the test fuel at the very low end of the coal bed within 0.2lbs. This allows more room to place the fuel.

Fuel Loading & Settings:

Level the coal bed before you start sampling. If there happens to be any raw pieces left over, place them in the very rear of the stove. There should be minimal gaps between all fuel pieces. Two pieces at 12.5” in a North/South direction on the bottom and the remaining three pieces at 10.5” on top going East/West on the top. Make sure there are gaps between the fuel and secondary tubes. The door is to be wide open for two to four minutes. Keep the primary control open for 8-15 minutes until fifteen percent of the fuel load is burnt. If you see the combustion getting noticeably dirtier, set the control at the desired setting.

The setting for the low is all the way closed.

The setting for the medium burn is 6” from the left leg to the end of the control (right side). See picture below.

Medium Setting:



Moving Fuel Load:

It may be necessary to move the fuel load at some point during the medium and low burns. Keep an eye on weight drop and stack draft to determine when to move the fuel if needed.

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Run 1

High Burn 1-minute data

Emissions Results (Cold to Hot Cycle)

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 1
 Manufacturer: ESSE
 Model: Vermont
 Tracking No.: 240A
 Project No.: 2240/S009E
 Test Date: 12/26/20
 Beginning Clock Time: 11:04
 Meter Box Y Factor: 0.995 (1) 0.991 (2)
 Barometric Pressure: Begin Middle End Average
 29.42 29.45 29.44 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 371.372
 Dilution Tunnel MW(wet): 229.00 lb/bt-mole
 Dilution Tunnel MW(wet): 28.78 lb/bt-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Static: -0.234 "H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: 19.61 ft/sec
 Initial Tunnel Flow: 223.9 scfm
 Average Tunnel Flow: 213.3 scfm
 Post-Test Leak Check (1): 0.000 cfm @ 12 in. Hg
 Post-Test Leak Check (2): 0.000 cfm @ 10 in. Hg
 Average Test Piece Fuel Moisture: 19.36 Dry Basis %

Technician Signature: *[Signature]*

Velocity Traverse Data									
	PI.1	PI.2	PI.3	PI.4	PI.5	PI.6	PI.7	PI.8	Center
Initial dP	0.078	0.092	0.088	0.086	0.074	0.094	0.094	0.088	0.098
Temp:	65	65	65	65	65	65	65	65	65
V _{aver}	19.78 ft/sec			V _{aver}			20.87 ft/sec		
F _p	0.947								

Elapsed Time (min)	Particulate Sampling Data										Fuel Weight (lb)				Temperature Data (°F)										Stack Gas Data						
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH1 (in)	Meter 1 Temp (°F)	Meter 1 Vacuum (inHg)	Orifice dH2 (in)	Meter 2 Temp (°F)	Meter 2 Vacuum (inHg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (inHg)	CO ₂ (%)	CO (%)
0	0.000	0.000	0.15	0.17	2.26	62	-0.75	2.86	62	-0.8	67	0.100			6.0		63	61	64	63	63	63		62	85	54		64	0.013	1.62	0.02
1	0.150	0.172	0.15	0.17	2.26	62	-1.89	1.75	62	0.2	79	0.100	89	97	4.9	-0.1	66	61	63	63	63	63		118	83	52		63	-0.023	1.01	0.04
2	0.312	0.339	0.16	0.17	2.20	63	-1.76	1.72	62	-0.1	88	0.090	102	100	4.8	-0.1	77	61	63	63	63	65		185	82	52		64	-0.030	1.42	0.07
3	0.473	0.509	0.16	0.17	2.30	63	-1.73	1.81	62	-0.1	79	0.090	100	101	4.7	-0.1	89	61	64	64	64	68		223	82	51		64	-0.028	1.73	0.06
4	0.636	0.680	0.16	0.17	2.25	63	-2.03	1.80	62	-0.1	73	0.100	96	96	4.7	0	100	60	64	64	64	70		201	82	51		64	-0.026	5.3	0.58
5	0.799	0.857	0.16	0.17	2.25	63	-1.66	1.79	62	-0.2	72	0.100	96	96	4.6	-0.1	109	60	64	65	64	72		194	82	51		67	-0.028	5.75	0.52
6	0.961	1.023	0.16	0.17	2.26	63	-2	1.78	62	0.1	72	0.090	100	101	4.5	-0.1	117	60	65	66	65	75		196	81	51		66	-0.029	7.45	0.42
7	1.122	1.193	0.16	0.17	2.27	63	-1.98	1.78	62	0.1	71	0.100	95	95	4.4	-0.08	123	60	66	67	66	76		196	81	50		66	-0.028	7.08	0.27
8	1.285	1.362	0.16	0.17	2.24	63	-1.71	1.78	62	0.1	72	0.100	96	94	4.4	-0.02	129	60	68	69	67	79		199	81	50		65	-0.033	6.59	0.32
9	1.445	1.531	0.16	0.17	2.28	63	-1.77	1.77	62	-0.2	72	0.100	94	94	4.4	-0.1	138	60	69	71	69	81		210	81	50		65	-0.036	7.45	0.35
10	1.607	1.701	0.16	0.17	2.22	63	-1.54	1.75	62	0.1	73	0.100	95	95	4.2	-0.1	148	60	71	74	71	85		225	80	50		65	-0.040	8.29	0.31
11	1.767	1.869	0.16	0.17	2.23	63	-1.53	1.75	62	-0.2	74	0.100	94	94	4.1	-0.1	161	60	73	76	73	89		243	80	49		65	-0.044	9.1	0.36
12	1.929	2.039	0.16	0.17	2.30	63	-1.61	1.77	62	0.1	76	0.100	96	95	4.0	-0.1	180	60	75	82	76	95		273	80	49		65	-0.050	9.77	0.52
13	2.091	2.209	0.16	0.17	2.26	63	-1.68	1.77	62	0.1	78	0.100	96	95	3.9	-0.1	200	60	77	87	79	101		299	80	49		65	-0.055	11	0.47
14	2.253	2.378	0.16	0.17	2.27	63	-1.65	1.77	62	0	80	0.100	96	95	3.7	-0.2	229	61	80	92	82	109		330	80	49		65	-0.058	11.47	0.3
15	2.415	2.548	0.16	0.17	2.26	64	-1.99	1.75	62	0.1	81	0.090	101	101	3.6	-0.1	257	61	83	97	85	117		351	80	49		65	-0.061	12.11	0.3
16	2.576	2.717	0.16	0.17	2.25	64	-1.59	1.75	63	-0.2	82	0.100	95	95	3.5	-0.1	285	61	86	103	89	124		362	80	49		65	-0.060	12.17	0.45
17	2.737	2.888	0.16	0.17	2.25	64	-1.99	1.75	63	-0.2	83	0.090	101	100	3.3	-0.2	302	61	90	110	93	131		364	80	48		65	-0.060	11.99	0.33
18	2.899	3.055	0.16	0.17	2.27	64	-1.96	1.80	63	-0.2	83	0.100	96	95	3.2	-0.1	317	62	93	117	98	137		362	80	48		65	-0.060	11.51	0.24
19	3.060	3.228	0.16	0.17	2.28	64	-1.72	1.80	63	-0.1	83	0.090	101	102	3.1	-0.1	331	62	96	124	102	143		363	80	48		65	-0.060	11.2	0.32
20	3.223	3.397	0.16	0.17	2.25	64	-1.76	1.80	63	-0.2	84	0.100	97	96	3.0	-0.1	343	63	102	132	107	149		362	80	48		65	-0.060	11.01	0.41
21	3.384	3.567	0.16	0.17	2.28	64	-2.03	1.79	63	-0.3	83	0.090	101	101	2.9	-0.1	354	63	107	140	112	155		361	80	48		65	-0.060	10.98	0.49
22	3.545	3.738	0.16	0.17	2.27	64	-2	1.78	63	0.1	83	0.100	95	96	2.8	-0.1	362	64	111	147	118	160		367	80	48		65	-0.059	10.97	0.28
23	3.708	3.909	0.16	0.17	2.25	64	-1.67	1.78	63	0	83	0.090	102	102	2.7	-0.1	368	65	116	155	124	166		354	80	48		65	-0.059	10.74	0.22
24	3.868	4.079	0.16	0.17	2.25	64	-2.02	1.77	63	-0.2	84	0.090	100	101	2.6	-0.1	377	65	121	163	130	171		356	80	48		65	-0.060	10.44	0.21
25	4.031	4.250	0.16	0.17	2.25	64	-1.63	1.79	63	-0.2	83	0.090	102	102	2.5	-0.1	384	66	126	170	136	176		353	80	48		65	-0.057	10.6	0.22
26	4.191	4.420	0.16	0.17	2.25	65	-1.62	1.79	63	0.1	83	0.090	100	101	2.4	-0.1	388	67	131	177	142	181		350	80	48		65	-0.058	10.68	0.14
27	4.352	4.590	0.16	0.17	2.25	65	-1.79	1.79	63	-0.3	83	0.090	100	101	2.3	-0.1	394	68	136	185	148	186		349	80	48		65	-0.058	10.3	0.08
28	4.516	4.763	0.16	0.17	2.22	65	-1.85	1.78	63	0	84	0.100	97	96	2.2	-0.1	400	69	141	192	155	191		350	80	48		65	-0.059	10.24	0.15
29	4.675	4.930	0.16	0.17	2.24	65	-1.76	1.78	63	0.1	83	0.100	95	96	2.1	-0.1	404	70	146	199	162	196		351	80	48		65	-0.058	10.68	0.2
30	4.837	5.100	0.16	0.17	2.23	65	-1.79	1.76	64	-0.2	84	0.090	101	101	2.0	-0.1	411	72	151	207	168	202		352	80	48		65	-0.058	11.11	0.22
31	4.997	5.269	0.16	0.17	2.23	65	-1.84	1.76	64	-0.3	83	0.090	100	100	1.9	-0.1	416	73	156	214	175	207		348	80	48		65	-0.057	11.27	0.47
32	5.159	5.441	0.16	0.17	2.29	65	-1.72	1.80	64	-0.3	83	0.100	96	97	1.8	-0.1	419	74	160	222	182	211		340	80	48		65	-0.056	11.46	0.56
33	5.322	5.613	0.16	0.17	2.26	65	-2.07	1.80	64	-0.2	83	0.090	102	102	1.7	-0.1	418	76	166	230	189	216		334	80	48		65	-0.055	11	0.66
34	5.483	5.784	0.16	0.17	2.27	65	-2.13	1.80	64	-0.2	82	0.100	95	96	1.6	-0.1	419	77	171	238	196	220		330	79	48		65	-0.054	10.7	0.63
35	5.646	5.956	0.16	0.17	2.26	65	-2.09	1.80	64	-0.3	82	0.090	102	102	1.5	-0.1	420	79	177	246	203	225		328	79	48		65	-0.055	10.61	0.58

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 1
 Manufacturer: ESSSE
 Model: WarmHeart
 Tracking No.: 2400A
 Project No.: 22240/S009E
 Test Date: 12/26/20
 Beginning Clock Time: 11:04
 Meter Box Y Factor: 0.995 (1) 0.991 (2) (Amb)
 Barometric Pressure: Begin Middle End Average
 29.42 29.45 29.44 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 271.372
 Dilution Tunnel MW(wet): 229.00
 Dilution Tunnel MW(wet): 28.78 lb/bt-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Sulfate: 0.234 H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: 19.81 ft/sec
 Initial Tunnel Flow: 223.9 scfm
 Average Tunnel Flow: 213.3 scfm
 Post-Test Leak Check (1): 0.000 cfm @ 12 in. Hg
 Post-Test Leak Check (2): 0.000 cfm @ 10 in. Hg
 Average Test Piece Fuel Moisture: 19.36 Dry Basis %

Technician Signature: *[Signature]*

Velocity Traverse Data										
	Pt.1	Pt.2	Pt.3	Pt.4	Pt.5	Pt.6	Pt.7	Pt.8	Center	
Initial dP	0.078	0.092	0.088	0.086	0.074	0.094	0.088	0.098	H ₂ O	
Temp:	65	65	65	65	65	65	65	65	65	
V _{aver}	19.78 ft/sec								V _{center}	20.87 ft/sec
F _p									0.947	

Elapsed Time (min)	Particulate Sampling Data										Fuel Weight (lb)				Temperature Data (°F)										Stack Gas Data					
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (dm)	Sample Rate 2 (dm)	Orifice dH1 (H ₂ O)	Meter 1 Temp (°F)	Meter 1 Vacuum (Hg)	Orifice dH1 (H ₂ O)	Meter 2 Temp (°F)	Meter 2 Vacuum (Hg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Drift (H ₂ O)	CO ₂ (%)
36	5.808	6.127	0.16	0.17	2.26	65	-1.71	1.80	64	-0.3	81	0.100	96	96	1.4	-0.1	418	81	183	254	210	229	324	80	48	48	65	-0.064	10.66	0.43
37	5.970	6.297	0.16	0.17	2.25	66	-1.73	1.79	64	-0.1	81	0.090	101	101	1.3	-0.1	420	83	189	262	218	234	320	83	48	48	65	-0.063	10.62	0.3
38	6.131	6.467	0.16	0.17	2.23	66	-1.75	1.75	64	0	127	0.090	104	105	10.2	8.9	413	85	196	271	226	238	347	86	48	48	64	-0.067	10.37	0.31
39	6.291	6.636	0.16	0.17	2.27	66	-1.91	1.81	64	-0.2	109	0.090	106	107	9.9	-0.3	408	88	203	282	237	244	432	87	48	48	64	-0.076	9.42	0.21
40	6.453	6.806	0.16	0.17	2.21	66	-2.43	1.73	64	-0.2	111	0.090	103	103	9.7	-0.2	426	90	209	288	245	252	447	88	49	49	64	-0.072	8.92	0.25
41	6.611	6.973	0.16	0.17	2.16	66	-2.31	1.69	64	-0.3	103	0.090	100	101	8.5	-0.2	455	92	217	293	253	262	440	88	49	49	64	-0.076	5.81	0.57
42	6.773	7.141	0.16	0.17	2.25	68	-2.92	1.77	64	-0.5	99	0.090	102	101	9.2	-0.26	488	94	223	297	259	272	452	87	49	49	64	-0.077	7.98	1.12
43	6.934	7.311	0.16	0.17	2.24	68	-3.07	1.75	64	-0.4	98	0.090	102	102	9.1	-0.14	516	97	230	300	263	291	458	87	49	49	64	-0.077	11.96	0.76
44	7.095	7.479	0.16	0.17	2.23	66	-2.97	1.76	65	-0.7	96	0.090	101	101	8.9	-0.2	537	96	236	303	267	296	465	86	49	49	64	-0.077	13.96	0.7
45	7.258	7.648	0.16	0.17	2.28	66	-3.3	1.74	65	-0.8	96	0.090	103	101	8.7	-0.2	555	102	240	307	270	295	468	86	49	49	64	-0.078	14.24	0.69
46	7.418	7.815	0.16	0.17	2.25	66	-3.74	1.78	65	-0.7	96	0.090	101	100	8.6	-0.1	570	104	244	310	273	300	469	86	49	49	64	-0.077	14.26	0.69
47	7.579	7.984	0.16	0.17	2.28	67	-4.01	1.76	65	-0.6	96	0.090	101	101	8.4	-0.2	583	106	250	314	276	306	467	86	50	49	64	-0.077	14.04	0.6
48	7.740	8.152	0.16	0.17	2.21	67	-4.12	1.74	65	-0.7	96	0.090	101	101	8.2	-0.2	595	108	253	318	279	311	467	86	50	49	64	-0.077	14.07	0.6
49	7.900	8.324	0.16	0.17	2.22	67	-4.32	1.82	65	-1	96	0.090	101	103	8.1	-0.1	604	110	257	323	281	315	466	85	50	49	64	-0.078	13.9	0.53
50	8.061	8.495	0.16	0.17	2.20	67	-4.4	1.80	65	-0.8	96	0.090	101	102	7.9	-0.2	612	112	262	328	283	319	467	85	50	49	64	-0.076	13.9	0.56
51	8.221	8.666	0.16	0.17	2.20	67	-4.92	1.78	65	-0.9	96	0.090	101	102	7.7	-0.2	619	114	264	332	285	323	468	84	50	49	64	-0.076	13.97	0.61
52	8.382	8.835	0.16	0.17	2.17	67	-5.22	1.74	65	-1	96	0.090	101	101	7.6	-0.1	628	116	267	337	287	327	469	84	50	49	64	-0.077	14.04	0.66
53	8.543	9.006	0.16	0.17	2.20	67	-6.14	1.83	65	-1.2	97	0.090	101	102	7.4	-0.2	635	118	270	342	290	331	471	83	50	49	64	-0.077	14.17	0.68
54	8.704	9.177	0.16	0.17	2.32	67	-7.48	1.77	65	-1.1	97	0.090	101	102	7.2	-0.2	641	120	273	347	292	335	474	83	50	49	64	-0.076	14.34	0.68
55	8.864	9.348	0.16	0.17	2.38	67	-8.45	1.77	65	-1.5	97	0.090	101	101	7.1	-0.1	648	122	276	353	296	339	474	83	50	49	64	-0.077	14.52	0.71
56	9.025	9.514	0.16	0.17	2.28	67	-10.02	1.78	65	-1.8	97	0.090	101	101	6.9	-0.2	654	123	279	358	297	342	476	83	51	49	64	-0.078	14.6	0.76
57	9.187	9.694	0.16	0.17	2.23	67	-11.76	1.75	65	-1.9	98	0.090	102	102	6.8	-0.14	662	125	281	362	301	346	477	83	51	49	64	-0.077	14.64	0.81
58	9.344	9.851	0.16	0.17	2.05	67	-12.19	1.77	65	-2.6	97	0.090	99	100	6.6	-0.2	667	126	284	368	303	350	477	82	51	49	65	-0.079	14.68	0.85
59	9.502	10.014	0.16	0.17	2.11	67	-1.34	1.50	65	-3.2	99	0.090	100	98	6.4	-0.16	672	128	288	373	307	354	480	81	52	49	65	-0.079	14.78	0.86
60	9.659	10.177	0.16	0.16	2.24	67	-1.84	1.72	65	-5	98	0.090	99	98	6.2	-0.2	681	129	289	378	310	357	482	81	51	49	64	-0.079	14.91	0.89
61	9.821	10.344	0.16	0.17	2.25	68	-1.79	1.65	65	-5.8	98	0.090	102	100	6.1	-0.1	687	131	292	382	314	361	482	81	51	49	64	-0.080	15.06	0.93
62	9.983	10.513	0.16	0.17	2.26	68	-1.81	1.77	65	-6.9	99	0.090	102	101	5.9	-0.2	694	132	296	387	318	365	483	81	51	49	65	-0.079	15.13	0.94
63	10.145	10.682	0.16	0.17	2.26	68	-1.77	1.76	66	-7.3	99	0.090	102	101	5.7	-0.2	699	134	300	393	322	370	484	81	52	49	65	-0.079	15.15	0.96
64	10.307	10.850	0.16	0.17	2.24	68	-2.04	1.76	66	-7.9	99	0.090	102	101	5.6	-0.1	702	136	302	397	325	372	485	81	52	49	65	-0.078	15.2	0.96
65	10.468	11.018	0.16	0.17	2.25	68	-1.7	1.72	66	-7.9	99	0.090	101	101	5.4	-0.2	710	137	305	402	330	377	485	81	52	49	64	-0.079	15.25	0.93
66	10.631	11.186	0.16	0.17	2.27	68	-1.75	1.75	66	-8.3	98	0.090	103	101	5.2	-0.2	713	138	306	406	334	380	482	82	52	49	64	-0.080	15.23	0.92
67	10.793	11.354	0.16	0.17	2.28	68	-1.87	1.72	66	-8.1	99	0.090	102	101	5.1	-0.1	715	140	311	411	338	383	481	82	52	49	65	-0.079	15.16	0.88
68	10.957	11.521	0.16	0.17	2.29	68	-1.85	1.76	66	-8.5	98	0.090	103	100	4.9	-0.2	718	141	315	415	342	386	479	82	52	49	65	-0.079	15.1	0.87
69	11.119	11.689	0.16	0.17	2.26	68	-1.83	1.75	66	-8.7	98	0.090	102	101	4.8	-0.1	720	143	318	419	346	389	478	82	52	49	64	-0.079	15.03	0.87
70	11.281	11.857	0.16	0.17	2.27	68	-2.18	1.80	66	-8.9	99	0.090	102	101	4.6	-0.2	724	143	321	423	350	392	476	81	53	49	64	-0.079	14.99	0.84
71	11.445	12.028	0.16	0.17	2.24	68	-1.78	1.78	66	-9	97	0.090	103	102	4.5	-0.1	726	146	324	427	354	395	477	81	53	49	64	-0.078	14.96	0.9

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 1
 Manufacturer: ESSE
 Model: Warmheart
 Tracking No.: 2400A
 Project No.: 22240/S009E
 Test Date: 12/26/20
 Beginning Clock Time: 11:04
 Meter Box Y Factor: 0.995 (1) 0.991 (2) (Amb)
 Barometric Pressure: Begin Middle End Average
 29.42 29.45 29.44 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 271.372
 Dilution Tunnel MW(wet): 225.00
 Dilution Tunnel MW(wet): 28.78 lb/bt-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Static: -0.234 "H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: 19.81 ft/sec
 Initial Tunnel Flow: 223.9 scfm
 Average Tunnel Flow: 213.3 scfm
 Post-Test Leak Check (1): 0.000 cfm @ 12 in. Hg
 Post-Test Leak Check (2): 0.000 cfm @ 10 in. Hg
 Average Test Piece Fuel Moisture: 19.36 Dry Basis %

Technician Signature: *B. K...*

Velocity Traverse Data										
	PI.1	PI.2	PI.3	PI.4	PI.5	PI.6	PI.7	PI.8	Center	
Initial dP	0.078	0.092	0.088	0.086	0.074	0.094	0.088	0.098		
Temp:	65	65	65	65	65	65	65	65	65	
V _{meter}	19.78 ft/sec								V _{vacant}	20.87 ft/sec
F _p									0.947	

Elapsed Time (min)	Particulate Sampling Data												Fuel Weight (lb)		Temperature Data (°F)										Stack Gas Data						
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH1 (H ₂ O)	Meter 1 Temp (°F)	Meter 1 Vacuum (Hg)	Orifice dH2 (H ₂ O)	Meter 2 Temp (°F)	Meter 2 Vacuum (Hg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (H ₂ O)	CO ₂ (%)	CO (%)
72	11.606	12.197	0.16	0.17	2.25	68	-1.81	1.76	66	-9.1	98	0.000	101	101	4.3	-0.2	727	147	328	431	358	398		477	81	53		64	-0.078	15.04	0.04
73	11.768	12.366	0.16	0.17	2.26	69	-2.23	1.74	66	-9.1	97	0.000	102	101	4.1	-0.2	732	149	331	435	362	402		475	81	53		65	-0.078	15.15	0.06
74	11.930	12.534	0.16	0.17	2.24	69	-1.88	1.73	66	-9.2	97	0.000	102	100	4.0	-0.1	737	150	333	439	366	405		474	81	53		65	-0.077	15.21	0.09
75	12.091	12.703	0.16	0.17	2.24	69	-2.05	1.76	66	-9.4	97	0.000	101	101	3.8	-0.2	741	151	337	443	371	409		478	81	53		64	-0.079	15.21	0.05
76	12.253	12.873	0.16	0.17	2.25	69	-2.07	1.75	66	-9.5	98	0.000	102	102	3.7	-0.12	748	153	339	446	374	412		481	81	53		64	-0.079	15.29	0.06
77	12.414	13.042	0.16	0.17	2.23	69	-1.81	1.74	66	-9.3	98	0.000	101	101	3.5	-0.18	751	154	342	450	378	415		479	82	53		65	-0.078	15.45	0.01
78	12.576	13.210	0.16	0.17	2.23	69	-1.97	1.73	66	-9.5	97	0.000	101	100	3.4	-0.1	756	155	345	453	382	418		477	82	54		65	-0.078	15.46	0.77
79	12.738	13.378	0.16	0.17	2.22	69	-2.25	1.73	66	-9.5	97	0.000	101	100	3.2	-0.2	757	158	349	456	386	421		475	81	54		65	-0.077	15.32	0.81
80	12.898	13.548	0.16	0.17	2.27	69	-1.96	1.77	66	-9.7	97	0.000	102	102	3.0	-0.16	762	160	351	459	389	424		470	81	54		65	-0.077	15.2	0.82
81	13.061	13.719	0.16	0.17	2.27	69	-2.09	1.77	66	-9.7	97	0.000	102	102	2.9	-0.14	769	161	354	463	394	428		466	81	54		65	-0.077	15.05	0.81
82	13.223	13.888	0.16	0.17	2.24	69	-2.2	1.76	66	-9.8	97	0.000	102	101	2.8	-0.1	768	163	358	466	398	429		464	81	54		65	-0.075	14.92	0.82
83	13.385	14.058	0.16	0.17	2.25	69	-1.97	1.76	66	-9.9	96	0.000	102	100	2.6	-0.2	760	165	363	469	403	432		460	81	54		65	-0.075	14.84	0.87
84	13.547	14.225	0.16	0.17	2.25	69	-2.03	1.75	66	-9.8	96	0.000	102	101	2.5	-0.1	762	167	366	472	407	435		456	81	54		65	-0.073	14.86	0.93
85	13.708	14.394	0.16	0.17	2.24	69	-2.03	1.75	66	-9.9	95	0.000	101	101	2.4	-0.1	758	168	368	475	412	436		449	81	54		65	-0.073	14.76	0.8
86	13.870	14.562	0.16	0.17	2.24	69	-2.34	1.75	66	-9.8	95	0.000	101	100	2.3	-0.1	767	170	370	478	415	438		445	81	54		65	-0.073	14.48	0.6
87	14.034	14.732	0.16	0.17	2.33	69	-2.16	1.79	66	-10	95	0.000	103	101	2.2	-0.1	762	172	373	481	420	440		441	81	54		65	-0.072	14.24	0.53
88	14.196	14.903	0.16	0.17	2.25	69	-2.36	1.78	67	-10	95	0.000	101	102	2.0	-0.2	750	174	375	484	425	442		437	81	55		65	-0.072	14.14	0.52
89	14.358	15.071	0.16	0.17	2.26	69	-2.11	1.79	67	-10	94	0.000	101	102	1.9	-0.1	751	176	378	487	429	444		431	81	55		65	-0.070	14.1	0.46
90	14.520	15.245	0.16	0.17	2.24	70	-2.04	1.79	67	-10.1	94	0.000	101	102	1.8	-0.1	746	178	381	490	434	446		426	81	55		66	-0.071	13.95	0.31
91	14.682	15.416	0.16	0.17	2.24	70	-2.05	1.80	67	-9.9	93	0.000	101	102	1.7	-0.1	740	180	382	492	438	447		420	81	55		66	-0.069	13.81	0.25
92	14.844	15.587	0.16	0.17	2.24	70	-1.98	1.80	67	-10	93	0.000	101	102	1.6	-0.1	738	182	386	495	443	448		415	81	55		66	-0.068	13.71	0.27
93	15.006	15.758	0.16	0.17	2.24	70	-2.25	1.80	67	-9.9	93	0.000	101	102	1.5	-0.1	736	184	389	498	447	451		410	81	55		66	-0.068	13.58	0.27
94	15.167	15.929	0.16	0.17	2.26	70	-2.33	1.80	67	-10	93	0.000	100	102	1.4	-0.1	730	186	389	500	452	451		405	81	55		66	-0.067	13.48	0.22
95	15.329	16.101	0.16	0.17	2.21	70	-2.01	1.81	67	-10	91	0.000	101	102	1.3	-0.1	727	189	394	503	455	454		401	81	55		66	-0.066	13.37	0.15
96	15.490	16.273	0.16	0.17	2.24	70	-2.36	1.81	67	-10.1	91	0.000	100	102	1.3	0	723	190	396	505	460	455		398	81	55		66	-0.067	13.22	0.09
97	15.653	16.446	0.16	0.17	2.24	70	-2.37	1.83	67	-10	91	0.000	101	103	1.2	-0.1	719	192	398	508	463	456		394	81	55		66	-0.064	13.08	0.06
98	15.814	16.618	0.16	0.17	2.24	70	-2.04	1.82	67	-9.9	91	0.000	100	102	1.1	-0.1	715	195	399	511	467	457		389	81	55		66	-0.064	12.99	0.03
99	15.975	16.791	0.16	0.17	2.24	70	-2.12	1.83	67	-9.9	90	0.000	100	103	1.0	-0.1	711	197	402	512	470	458		386	81	55		66	-0.064	12.85	0.01
Avg Tot	15.975	16.791	0.16	0.17	2.24	68		1.78	65		91	0.002	100	100								395.6					51	#DIV/0!	#DIV/0!	65	-0.065

OMNI-Test Laboratories, Inc.

Wood Heater Test Results - ASTM E3053 / ASTM E2515

Manufacturer: ESSE
 Model: WarmHeart
 Project No.: 0224WS009E
 Tracking No.: 2400A
 Run: 1
 Test Date: 12/15/20

Burn Rate	2.89 kg/hr dry
Average Tunnel Temperature	91 degrees Fahrenheit
Average Gas Velocity in Dilution Tunnel - vs	19.61 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	12799.4 dscf/hour
Average Delta p	0.092 inches H2O
Total Time of Test	99 minutes

	AMBIENT	SAMPLE TRAIN 1	SAMPLE TRAIN 2	FIRST HOUR FILTER (TRAIN 1)
Total Sample Volume - Vm	0.000 cubic feet	15.975 cubic feet	16.791 cubic feet	9.659 cubic feet
Average Gas Meter Temperature	65 degrees Fahrenheit	66 degrees Fahrenheit	65 degrees Fahrenheit	65 degrees Fahrenheit
Total Sample Volume (Standard Conditions) - Vmstd	0.000 dscf	15.764 dscf	16.543 dscf	9.560 dscf
Total Particulates - m _n	0 mg	5.7 mg	5.5 mg	2.4 mg
Particulate Concentration (dry-standard) - C _p /C _s	0.000000 grams/dscf	0.00036 grams/dscf	0.00033 grams/dscf	0.00025 grams/dscf
Total Particulate Emissions - E _T	0.00 grams	7.64 grams	7.02 grams	3.21 grams
Particulate Emission Rate	0.00 grams/hour	4.63 grams/hour	4.26 grams/hour	3.21 grams/hour
Emissions Factor		1.60 g/kg	1.47 g/kg	-7.05 g/kg
Difference from Average Total Particulate Emissions		0.31 grams	0.31 grams	

Dual Train Comparison Results Are Acceptable

FINAL AVERAGE RESULTS	
Complete Test Run	
Total Particulate Emissions - E _T	7.33 grams
Particulate Emission Rate	4.44 grams/hour
Emissions Factor	1.54 grams/kg
First Hour Emissions	
Total Particulate Emissions - E _T	3.21 grams
Particulate Emission Rate	3.21 grams/hour
Emissions Factor	-7.05 grams/kg
7.5% of Average Total Particulate Emissions	0.55 grams

QUALITY CHECKS	
Filter Temps < 90 °F	OK
Filter Face Velocity (47 mm)	OK
Dryer Exit Temp < 80F	OK
Leakage Rate	OK
Ambient Temp (55-90°F)	OK
Negative Probe Weight Eval.	OK
Pro-Rate Variation	OK
Train A - Train B G/KG ≤ 0.5	0.13
Total PM Precision (%)	4.20

Technician Signature: 

Control No. P-SSAR-0003

High Burn Run 1 Emissions

Wood Heater Efficiency Results - CSA B415.1

Manufacturer: ESSE
Model: WarmHeart
Date: 12/15/20
Run: 1
Control #: 0224WS009E
Test Duration: 99
Output Category: II

Technician Signature: 

Test Results in Accordance with CSA B415.1-09

	HHV Basis	LHV Basis
Overall Efficiency	71.3%	76.2%
Combustion Efficiency	94.6%	94.6%
Heat Transfer Efficiency	75%	80.6%

Output Rate (kJ/h)	16,397	15,554	(Btu/h)
Burn Rate (kg/h)	1.15	2.54	(lb/h)
Input (kJ/h)	23,007	21,825	(Btu/h)

Test Load Weight (dry kg)	1.90	4.19	dry lb
MC wet (%)	16.21983914		
MC dry (%)	19.36		
Particulate (g)	4.44		
CO (g)	151		
Test Duration (h)	1.65		

Emissions	Particulate	CO
g/MJ Output	0.16	5.58
g/kg Dry Fuel	2.34	79.50
g/h	2.69	91.57
lb/MM Btu Output	0.38	12.98

Air/Fuel Ratio (A/F)	8.68
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VERSION:

2.2

12/14/2009

Adjunct to ASTM E XXXX Wood Heater Cordwood Test Method - May 10, 2017 Version
 Cordwood Fuel Load Calculators - 10 lb/ft³ Nominal Load Density
 Core 45-65% of Total Load Weight, Remainder 35-55% of Total Load Weight
 Values to be input manually

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For All Usable Firebox Volumes - High Fire Test Only				
Nominal Required Load Density (wet basis)	10	lb/ft ³		
Usable Firebox Volume	1.09	ft ³		
Total Nom. Load Wt. Target	10.90	lb		
Total Load Wt. Allowable Range	10.40	to 11.40	lb	
Core Target Wt. Allowable Range	4.90	to 7.10	lb	
Remainder Load Wt. Allowable Range	3.80	to 6.00	lb	
				Mid-Point
Core Load Pc. Wt. Allowable Range	1.60	to 2.70	lb	2.15
Remainder Load Pc. Wt. Allowable Range	1.10	to 6.00	lb	3.55
	Pc. #			
Core Load Piece Wt. Actual	1	2.60	lb	In Range
	2	2.30	lb	In Range
	3	1.80	lb	In Range
Core Load Total. Wt. Actual		6.70	lb	In Range
	Pc. #			
Remainder Load Piece Wt.	1	3.80	lb	In Range
(1 to 3 Pcs.)	2		lb	NA
	3		lb	NA
Remainder Load Tot. Wt. Act		3.80	lb	In Range
Total Load Wt. Actual		10.50	lb	In Range
Core % of Total Wt.		64%		In Range 45-65%
Remainder % of Total Wt.		36%		In Range 35-55%
Actual Load % of Nominal Target		96%		In Range 95-105%
Actual Fuel Load Density		9.6	lb/ft ³	
<u>Kindling and Start-up Fuel</u>				
Maximum Kindling Wt. (20% of Tot. Load Wt.)		2.10	lb	
Actual Kindling Wt.		2.00	lb	In Range 19.0%
Maximum Start-up Fuel Wt. (30% of Tot. Load Wt.)		3.15	lb	
Actual Start-up Fuel Wt.		3.00	lb	In Range 28.6%
Allowable Residual Start-up Fuel Wt. Range	1.1	to 2.1	lb	Mid-Point
Actual Residual Start-up Fuel Wt.		1.3	lb	In Range 1.6
Total Wt. All Fuel Added (wet basis)		15.50	lb	
<u>High Fire Test Run End Point Range</u>				
	Low		High	Mid-Point
Based on Fuel Load Wt. (w/tares)	0.9	to 1.2	lb	1.1
Actual Fuel Load Ending Wt.		1.0	lb	In Range

Fuel Piece Moisture Reading (%-dry basis)					Pc. Wt. Dry Basis	
1	2	3	Ave.			
23.1	23.7	21.4	22.7	In Range	2.12	0.96
20.8	21.2	22.9	21.6	In Range	1.89	0.86
24.6	23.2	24.2	24.0	In Range	1.45	0.66
24.8	20.6	22.5	22.6	In Range	3.10	1.41
			NA	NA	NA	NA
			NA	NA	NA	NA
Total Load Ave. MC (%-dry basis)			22.7	In Range		
Total Load Ave. MC % (wet basis)			18.5			
Total Test Load Weight (dry basis)					8.56	3.88
<u>Kindling Moisture (%-dry basis)</u>						
12	11.8	11.4	11.7	In Range	1.79	0.81
<u>Start-up Fuel Moisture Readings (%-dry basis)</u>						
27	20.8	23.4	23.7	In Range	2.42	1.10
Total Wt. All Fuel Added (dry basis)					12.77	5.79
Total Wt. All Fuel Burned (dry basis)					10.5	4.8

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 1
 Model: WarmHeart Tracking Number: 2400A Date: 12/15/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: 637, 410, 371, 372

Wood Heater Supplemental Data

Start Time: 11:04 Booth #: NA
 Stop Time: 12:43

Stack Gas Leak Check: Initial: good Final: see Run 2 end
Sample Train Leak Check: A: 0.0 @ 12 "Hg
 B: 0.0 @ 10 "Hg

Calibrations: Span Gas CO₂: 17.06 CO: 4.29

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	<u>1054</u>	<u>1054</u>	<u>See end of Run 2</u>	
CO ₂	<u>0.00</u>	<u>17.06</u>		
CO	<u>0.00</u>	<u>4.29</u>		

Air Velocity (ft/min): Initial: 250 Final: 250
 Scale Audit (lbs): Initial: 10.0 Final: 10.0
 Pitot Tube Leak Test: Initial: good Final: good
 Stack Diameter (in): 6"
 Induced Draft: 0.0
 % Smoke Capture: 100/77
 Flue Pipe Cleaned Prior to First Test in Series:
 Date: 12/10/20 Initials: BC

	Initial	Middle	Ending
P _b (in/Hg)	<u>29.42</u>		<u>29.45</u>
RH (%)			
Ambient (°F)	<u>64</u>		<u>66</u>

Tunnel Traverse		
Microtector Reading	dP (in H ₂ O)	T(°F)
	<u>.074</u>	<u>65</u>
	<u>.092</u>	<u>65</u>
	<u>.088</u>	<u>65</u>
	<u>.086</u>	<u>65</u>
	<u>.074</u>	<u>65</u>
	<u>.094</u>	<u>65</u>
	<u>.094</u>	<u>65</u>
	<u>.088</u>	<u>65</u>
Center:		
	<u>.078</u>	<u>65</u>

Background Filter Volume: NA

Tunnel Static Pressure (in H ₂ O):	
Beginning of Test	End of Test
<u>-.234</u>	<u>-.234</u>

Technician Signature: B D = Date: 12/15/20

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 1
 Model: WarmHeart Tracking Number: 2400A Date: 12/15/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: _____

Wood Heater Run Notes

Air Control Settings

Primary:

Fully open

Secondary: Fixed

Tertiary/Pilot: N/A

Fan: N/A

Preburn Notes

Time	Notes
Ø	Torch used for 60 sec. to light top down burn. Door fully open until 2:30 then fully closed. Comb Air fully open.
37	Tared 1.3 lbs, loaded test fuel

Test Notes

Sketch test fuel configuration:

See photo

Start up procedures & Timeline:

Bypass: N/A
 Fuel loaded by: 40 seconds
 Door closed at: 2:30 min.
 Primary air: Fully open entire test

Notes: N/A

Time	Notes
60	changed back filter in train A.

Technician Signature: *B Davis*

Date: 12/15/20

Run 1

High Burn 1-minute data

Efficiency and Heat Output Results **Kindling and start-up fuel removed from calculations**

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: **1**

Manufacturer: ESSE
 Model: WarmHeart
 Tracking No.: 2400B
 Project No.: 0224WS009E
 Test Date: 15-Dec-20
 Beginning Clock Time: 11:04
 Total Sampling Time: 61 min
 Recording Interval: 1 min
 Background Sample Volume: _____ cubic feet
 Meter Box Y Factor: 0.995 (1) 0.991 (2) _____ (Amb)
 Barometric Pressure: Begin Middle End Average
29.42 29.45 29.44 "Hg
 OMNI Equipment Numbers: _____

PM Control Modules: 371, 372
 Dilution Tunnel MW(dry): 29.00 lb/lb-mole
 Dilution Tunnel MW(wet): 28.78 lb/lb-mole
 Dilution Tunnel H2O: 2.00 percent
 Dilution Tunnel Static: -0.234 "H2O
 Tunnel Area: 0.19635 ft2
 Pitot Tube Cp: 0.99
 Avg. Tunnel Velocity: #DIV/0! ft/sec
 Initial Tunnel Flow: 223.9 scfm
 Average Tunnel Flow: #DIV/0! scfm
 Post-Test Leak Check (1): _____ cfm @ _____ in. Hg
 Post-Test Leak Check (2): _____ cfm @ _____ in. Hg
 Average Test Piece Fuel Moisture: 22.70 Dry Basis %

Technician Signature: 

Velocity Traverse Data										
	Pt.1	Pt.2	Pt.3	Pt.4	Pt.5	Pt.6	Pt.7	Pt.8	Center	
Initial dP	0.078	0.092	0.088	0.086	0.074	0.094	0.094	0.088	0.098	
Temp:	65	65	65	65	65	65	65	65	65	
V _{strav}	19.76			ft/sec			V _{scent} 20.87			F _p 0.947

Elapsed Time (min)	Particulate Sampling Data														Fuel Weight (lb)		Temperature Data (°F)											Stack Gas Data			
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH 1 ("H ₂ O)	Meter 1 Temp (°F)	Meter 1 Vacuum ("Hg)	Orifice dH 2 ("H ₂ O)	Meter 2 Temp (°F)	Meter 2 Vacuum ("Hg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft ("H ₂ O)	CO ₂ (%)	CO (%)
0															9.5		413	85	196	271	226	238	347	86	48			64	-0.057	10.37	0.31
1															8.9		408	88	203	282	237	244	432	87	48			64	-0.076	9.42	0.21
2															8.7		426	90	209	288	245	252	447	88	49			64	-0.072	6.92	0.25
3															8.5		455	92	217	293	253	262	440	88	49			64	-0.076	5.61	0.57
4															8.2		488	94	223	297	259	272	452	87	49			64	-0.077	7.99	1.12
5															8.1		516	97	230	300	263	281	458	87	49			64	-0.077	11.96	0.76
6															7.9		537	99	235	303	267	288	465	86	49			64	-0.077	13.96	0.7
7															7.7		555	102	240	307	270	295	468	86	49			64	-0.078	14.24	0.69
8															7.6		570	104	244	310	273	300	469	86	49			64	-0.077	14.26	0.69
9															7.4		583	106	250	314	276	306	467	86	50			64	-0.077	14.24	0.69
10															7.2		595	108	253	318	279	311	467	86	50			64	-0.077	14.07	0.6
11															7.1		604	110	257	323	281	315	466	85	50			64	-0.078	13.9	0.53
12															6.9		612	112	262	328	283	319	467	85	50			64	-0.076	13.9	0.56
13															6.7		619	114	264	332	285	323	468	84	50			64	-0.076	13.97	0.61
14															6.6		628	116	267	337	287	327	469	84	50			64	-0.077	14.04	0.66
15															6.4		635	118	270	342	290	331	471	83	50			64	-0.077	14.17	0.68
16															6.2		641	120	273	347	292	335	474	83	50			64	-0.078	14.34	0.68
17															6.1		648	122	276	353	295	339	474	83	50			64	-0.077	14.52	0.71
18															5.9		654	123	279	358	297	342	476	83	51			64	-0.078	14.6	0.76
19															5.8		662	125	281	362	301	346	477	83	51			64	-0.077	14.64	0.81
20															5.6		667	126	284	368	303	350	477	82	51			65	-0.079	14.68	0.85
21															5.4		672	128	288	373	307	354	480	81	52			65	-0.079	14.78	0.86
22															5.2		681	129	289	378	310	357	482	81	51			64	-0.079	14.91	0.89
23															5.1		687	131	292	382	314	361	482	81	51			64	-0.080	15.06	0.93
24															4.9		694	132	296	387	318	365	483	81	51			65	-0.079	15.13	0.94
25															4.7		699	134	300	393	322	370	484	81	52			65	-0.079	15.15	0.96
26															4.6		702	136	302	397	325	372	485	81	52			65	-0.079	15.2	0.96
27															4.4		710	137	305	402	330	377	485	81	52			64	-0.079	15.25	0.93
28															4.2		713	138	308	406	334	380	482	82	52			64	-0.080	15.23	0.92
29															4.1		715	140	311	411	338	383	481	82	52			65	-0.079	15.16	0.88
30															3.9		718	141	315	415	342	386	479	82	52			65	-0.079	15.1	0.87
31															3.8		720	143	318	419	346	389	478	82	52			64	-0.079	15.03	0.87
32															3.6		724	143	321	423	350	392	476	81	53			64	-0.079	14.99	0.84
33															3.5		726	146	324	427	354	395	477	81	53			64	-0.078	14.96	0.9
34															3.3		727	147	328	431	358	398	477	81	53			64	-0.078	15.04	0.94
35															3.1		732	149	331	435	362	402	475	81	53			65	-0.078	15.15	0.98

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: **1**

Manufacturer: ESSE
 Model: WarmHeart
 Tracking No.: 2400B
 Project No.: 0224WS009E
 Test Date: 15-Dec-20
 Beginning Clock Time: 11:04
 Total Sampling Time: 61 min
 Recording Interval: 1 min
 Background Sample Volume: _____ cubic feet
 Meter Box Y Factor: 0.995 (1) 0.991 (2) _____ (Amb)
 Barometric Pressure: Begin Middle End Average
29.42 29.45 29.44 "Hg
 OMNI Equipment Numbers: _____

PM Control Modules: 371, 372
 Dilution Tunnel MW(dry): 29.00 lb/lb-mole
 Dilution Tunnel MW(wet): 28.78 lb/lb-mole
 Dilution Tunnel H2O: 2.00 percent
 Dilution Tunnel Static: -0.234 "H2O
 Tunnel Area: 0.19635 ft2
 Pitot Tube Cp: 0.99
 Avg. Tunnel Velocity: #DIV/0! ft/sec
 Initial Tunnel Flow: 223.9 scfm
 Average Tunnel Flow: #DIV/0! scfm
 Post-Test Leak Check (1): _____ cfm @ _____ in. Hg
 Post-Test Leak Check (2): _____ cfm @ _____ in. Hg
 Average Test Piece Fuel Moisture: 22.70 Dry Basis %

Technician Signature: 

Velocity Traverse Data															
	Pt.1	Pt.2	Pt.3	Pt.4	Pt.5	Pt.6	Pt.7	Pt.8	Center						
Initial dP	0.078	0.092	0.088	0.086	0.074	0.094	0.094	0.088	0.098						
Temp:	65	65	65	65	65	65	65	65	65						
V _{strav}		19.76		ft/sec		V _{scent}		20.87		ft/sec		F _p		0.947	

Elapsed Time (min)	Particulate Sampling Data														Fuel Weight (lb)		Temperature Data (°F)											Stack Gas Data					
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH 1 ("H ₂ O)	Meter 1 Temp (°F)	Meter 1 Vacuum ("Hg)	Orifice dH 2 ("H ₂ O)	Meter 2 Temp (°F)	Meter 2 Vacuum ("Hg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft ("H ₂ O)	CO ₂ (%)	CO (%)		
36															3.0		737	150	333	439	366	405		474	81	53			65	-0.077	15.21	0.99	
37															2.8		741	151	337	443	371	409		478	81	53			64	-0.079	15.21	0.95	
38															2.7		748	153	339	446	374	412		481	81	53			64	-0.079	15.29	0.86	
39															2.5		751	154	342	450	378	415		479	82	53			65	-0.078	15.45	0.81	
40															2.4		756	156	345	453	382	418		477	82	54			65	-0.078	15.46	0.77	
41															2.2		757	158	349	456	386	421		475	81	54			65	-0.077	15.32	0.81	
42															2.0		762	160	351	459	389	424		470	81	54			65	-0.077	15.2	0.82	
43															1.9		759	161	354	463	394	426		466	81	54			65	-0.077	15.05	0.81	
44															1.8		758	163	358	466	398	429		464	81	54			65	-0.075	14.92	0.82	
45															1.6		760	165	363	469	403	432		460	81	54			65	-0.075	14.84	0.87	
46															1.5		762	167	366	472	407	435		456	81	54			65	-0.073	14.86	0.93	
47															1.4		758	168	368	475	412	436		449	81	54			65	-0.073	14.76	0.8	
48															1.3		757	170	370	478	415	438		445	81	54			65	-0.073	14.48	0.6	
49															1.2		752	172	373	481	420	440		441	81	54			65	-0.072	14.24	0.53	
50															1.0		750	174	375	484	425	442		437	81	55			65	-0.072	14.14	0.52	
51															0.9		751	176	378	487	429	444		431	81	55			65	-0.070	14.1	0.46	
52															0.8		746	179	381	490	434	446		426	81	55			66	-0.071	13.95	0.31	
53															0.7		740	180	382	492	439	447		420	81	55			66	-0.069	13.81	0.25	
54															0.6		736	182	386	495	443	448		415	81	55			66	-0.068	13.71	0.27	
55															0.5		736	184	389	498	447	451		410	81	55			66	-0.068	13.58	0.27	
56															0.4		730	186	389	500	452	451		405	81	55			66	-0.067	13.48	0.22	
57															0.3		727	189	394	503	455	454		401	81	55			66	-0.066	13.37	0.15	
58															0.3		723	190	396	505	460	455		398	81	55			66	-0.067	13.22	0.09	
59															0.2		719	192	398	508	463	456		394	81	55			66	-0.064	13.08	0.06	
60															0.1		715	195	399	511	467	457		389	81	55			66	-0.064	12.99	0.03	
61															0.0		711	197	402	512	470	458		386	81	55			66	-0.064	12.85	0.01	
Avg/Tot	0.000	0.000	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!																			

Wood Heater Test Results - ASTM E3053 / ASTM E2515

Manufacturer: ESSE
 Model: WarmHeart
 Project No.: 0224WS009E
 Tracking No.: 2400B
 Run: 1
 Test Date: 12/15/20

Burn Rate	3.37 kg/hr dry
Total Time of Test	61 minutes

	AMBIENT	SAMPLE TRAIN 1	SAMPLE TRAIN 2	FIRST HOUR FILTER (TRAIN 1)
	#DIV/0!			

	FINAL AVERAGE RESULTS

B. J. Di

	QUALITY CHECKS
Ambient Temp (55-90°F)	OK

Technician Signature: _____

Wood Heater Efficiency Results - CSA B415.1

Manufacturer: ESSE
Model: WarmHeart
Date: 12/15/20
Run: 1
Control #: 0224WS009E
Test Duration: 61
Output Category: IV

Technician Signature: 

Test Results in Accordance with CSA B415.1-09

	HHV Basis	LHV Basis
Overall Efficiency	74.4%	79.5%
Combustion Efficiency	96.1%	96.1%
Heat Transfer Efficiency	77%	82.8%

Output Rate (kJ/h)	51,323	48,685	(Btu/h)
Burn Rate (kg/h)	3.46	7.62	(lb/h)
Input (kJ/h)	69,013	65,466	(Btu/h)

Test Load Weight (dry kg)	3.51	7.74	dry lb
MC wet (%)	18.5004075		
MC dry (%)	22.70		
Particulate (g)	#DIV/0!		
CO (g)	196		
Test Duration (h)	1.02		

Emissions	Particulate	CO
g/MJ Output	#DIV/0!	3.77
g/kg Dry Fuel	#DIV/0!	55.93
g/h	#DIV/0!	193.25
lb/MM Btu Output	#DIV/0!	8.75

Air/Fuel Ratio (A/F)	7.62
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VERSION:

2.2

12/14/2009

Adjunct to ASTM E XXXX Wood Heater Cordwood Test Method - May 10, 2017 Version
 Cordwood Fuel Load Calculators - 10 lb/ft³ Nominal Load Density
 Core 45-65% of Total Load Weight, Remainder 35-55% of Total Load Weight
 Values to be input manually

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For All Usable Firebox Volumes - High Fire Test Only				
Nominal Required Load Density (wet basis)	10	lb/ft ³		
Usable Firebox Volume	1.09	ft ³		
Total Nom. Load Wt. Target	10.90	lb		
Total Load Wt. Allowable Range	10.40	to 11.40	lb	
Core Target Wt. Allowable Range	4.90	to 7.10	lb	
Remainder Load Wt. Allowable Range	3.80	to 6.00	lb	
				Mid-Point
Core Load Pc. Wt. Allowable Range	1.60	to 2.70	lb	2.15
Remainder Load Pc. Wt. Allowable Range	1.10	to 6.00	lb	3.55
	Pc. #			
Core Load Piece Wt. Actual	1	2.60	lb	In Range
	2	2.30	lb	In Range
	3	1.80	lb	In Range
Core Load Total. Wt. Actual		6.70	lb	In Range
	Pc. #			
Remainder Load Piece Wt.	1	3.80	lb	In Range
(1 to 3 Pcs.)	2		lb	NA
	3		lb	NA
Remainder Load Tot. Wt. Act		3.80	lb	In Range
Total Load Wt. Actual		10.50	lb	In Range
Core % of Total Wt.		64%		In Range 45-65%
Remainder % of Total Wt.		36%		In Range 35-55%
Actual Load % of Nominal Target		96%		In Range 95-105%
Actual Fuel Load Density		9.6	lb/ft ³	
Kindling and Start-up Fuel				
Maximum Kindling Wt. (20% of Tot. Load Wt.)		2.10	lb	
Actual Kindling Wt.		2.00	lb	In Range 19.0%
Maximum Start-up Fuel Wt. (30% of Tot. Load Wt.)		3.15	lb	
Actual Start-up Fuel Wt.		3.00	lb	In Range 28.6%
Allowable Residual Start-up Fuel Wt. Range	1.1	to 2.1	lb	Mid-Point
Actual Residual Start-up Fuel Wt.		1.3	lb	In Range 1.6
Total Wt. All Fuel Added (wet basis)		15.50	lb	
High Fire Test Run End Point Range				
	Low		High	Mid-Point
Based on Fuel Load Wt. (w/tares)	0.9	to 1.2	lb	1.1
Actual Fuel Load Ending Wt.		1.0	lb	In Range

Fuel Piece Moisture Reading (%-dry basis)					Pc. Wt. Dry Basis	
1	2	3	Ave.			
23.1	23.7	21.4	22.7	In Range	2.12	0.96
20.8	21.2	22.9	21.6	In Range	1.89	0.86
24.6	23.2	24.2	24.0	In Range	1.45	0.66
24.8	20.6	22.5	22.6	In Range	3.10	1.41
			NA	NA	NA	NA
			NA	NA	NA	NA
Total Load Ave. MC (%-dry basis)			22.7	In Range		
Total Load Ave. MC % (wet basis)			18.5			
Total Test Load Weight (dry basis)					8.56	3.88
Kindling Moisture (%-dry basis)						
12	11.8	11.4	11.7	In Range	1.79	0.81
Start-up Fuel Moisture Readings (%-dry basis)						
27	20.8	23.4	23.7	In Range	2.42	1.10
Total Wt. All Fuel Added (dry basis)					12.77	5.79
Total Wt. All Fuel Burned (dry basis)					10.5	4.8

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 1
 Model: WarmHeart Tracking Number: 2400A Date: 12/15/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: 637, 410, 371, 372

Wood Heater Supplemental Data

Start Time: 11:04 Booth #: NA
 Stop Time: 12:43

Stack Gas Leak Check: Initial: good Final: see Run 2 end
Sample Train Leak Check: A: 0.0 @ 12 "Hg
 B: 0.0 @ 10 "Hg

Calibrations: Span Gas CO₂: 17.06 CO: 4.29

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	<u>1054</u>	<u>1054</u>	<u>See end of Run 2</u>	
CO ₂	<u>0.00</u>	<u>17.06</u>		
CO	<u>0.00</u>	<u>4.29</u>		

Air Velocity (ft/min): Initial: 250 Final: 250
 Scale Audit (lbs): Initial: 10.0 Final: 10.0
 Pitot Tube Leak Test: Initial: good Final: good
 Stack Diameter (in): 6"
 Induced Draft: 0.0
 % Smoke Capture: 100/77
 Flue Pipe Cleaned Prior to First Test in Series:
 Date: 12/10/20 Initials: BC

Tunnel Traverse		
Microtector Reading	dP (in H ₂ O)	T(°F)
	<u>.074</u>	<u>65</u>
	<u>.092</u>	<u>65</u>
	<u>.088</u>	<u>65</u>
	<u>.086</u>	<u>65</u>
	<u>.074</u>	<u>65</u>
	<u>.094</u>	<u>65</u>
	<u>.094</u>	<u>65</u>
	<u>.088</u>	<u>65</u>
Center:		
	<u>.078</u>	<u>65</u>

	Initial	Middle	Ending
P _b (in/Hg)	<u>29.42</u>		<u>29.45</u>
RH (%)			
Ambient (°F)	<u>64</u>		<u>66</u>

Background Filter Volume: NA

Tunnel Static Pressure (in H ₂ O):	
Beginning of Test	End of Test
<u>-.234</u>	<u>-.234</u>

Technician Signature: B D = Date: 12/15/20

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 1
 Model: WarmHeart Tracking Number: 2400A Date: 12/15/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: _____

Wood Heater Run Notes

Air Control Settings

Primary:

Fully open

Secondary: Fixed

Tertiary/Pilot: N/A

Fan: N/A

Preburn Notes

Time	Notes
Ø	Torch used for 60 sec. to light top down burn. Door fully open until 2:30 then fully closed. Comb Air fully open.
37	Tared 1.3 lbs, loaded test fuel

Test Notes

Sketch test fuel configuration:

See photo

Start up procedures & Timeline:

Bypass: N/A
 Fuel loaded by: 40 seconds
 Door closed at: 2:30 min.
 Primary air: Fully open entire test

Notes: N/A

Time	Notes
60	changed back filter in train A.

Technician Signature: *B Davis*

Date: 12/15/20

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Run 2

Low Burn

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 2
 Manufacturer: ESSSE
 Model: Vermont
 Tracking No.: 2400A
 Project No.: 2220/S008E
 Test Date: 12/26/20
 Beginning Clock Time: 13:04
 Meter Box Y Factor: 0.995 (1) 0.991 (2) (Amb)
 Barometric Pressure: Begin Middle End Average
 29.45 29.52 29.49 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 371.372
 Dilution Tunnel MW(wet): 23.90 lb/bt-mole
 Dilution Tunnel MW(wet): 28.78 lb/bt-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Static: -0.232 "H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: 20.17 ft/sec
 Initial Tunnel Flow: 222.3 scfm
 Average Tunnel Flow: 225.8 scfm
 Post-Test Leak Check (1): 0.000 cfm @ 10 in. Hg
 Post-Test Leak Check (2): 0.000 cfm @ 8 in. Hg
 Average Test Piece Fuel Moisture: 22.20 Dry Basis %

Technician Signature: *[Signature]*

Velocity Traverse Data									
	Pt.1	Pt.2	Pt.3	Pt.4	Pt.5	Pt.6	Pt.7	Pt.8	Center
Initial dP	0.076	0.094	0.092	0.086	0.074	0.094	0.092	0.086	0.096
Temp:	73	73	73	73	74	74	74	74	74
V _{aver}	19.88 ft/sec			V _{aver}			20.82 ft/sec		
F _p	0.955								

Elapsed Time (min)	Particulate Sampling Data										Fuel Weight (lb)				Temperature Data (°F)										Stack Gas Data							
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH1 (in)	Meter 1 Temp (°F)	Meter 1 Vacuum (inHg)	Orifice dH2 (in)	Meter 2 Temp (°F)	Meter 2 Vacuum (inHg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (H ₂ O)	CO ₂ (%)	CO (%)	
0	0.000	0.000			2.44	70	-1.37	1.02	68	-0.3	84	0.080			12.6		507	231	407	510	480	427		274	88	57	89	47	68	-0.044	3.9	0.25
5	0.798	0.843	0.16	0.17	2.30	71	-2.01	1.79	68	0	84	0.080	110	111	11.8	-0.74	407	233	398	494	466	418		361	83	54	83	49	68	-0.069	12.87	1.42
10	1.615	1.698	0.16	0.17	2.26	71	-1.76	1.77	68	-0.2	95	0.080	113	113	11.0	-0.86	607	230	375	475	435	424		423	83	55	83	49	69	-0.072	14.97	0.88
15	2.428	2.549	0.16	0.17	2.27	71	-1.9	1.77	68	-0.3	89	0.080	111	112	10.4	-0.6	629	227	355	464	412	417		353	83	55	83	50	69	-0.060	11.91	1.13
20	3.242	3.399	0.16	0.17	2.28	72	-1.86	1.76	69	0	87	0.080	105	105	9.9	-0.5	593	224	340	453	402	402		305	82	55	82	50	69	-0.055	10.44	1.1
25	4.060	4.243	0.16	0.17	2.29	72	-2.11	1.76	69	0	85	0.080	105	105	9.4	-0.5	570	219	328	441	386	391		294	82	55	82	50	69	-0.055	11.48	0.97
30	4.880	5.098	0.16	0.17	2.30	72	-2.11	1.76	69	-0.2	86	0.080	106	105	8.8	-0.5	574	214	323	431	382	387		298	81	55	81	51	69	-0.054	12.41	0.95
35	5.701	5.948	0.16	0.17	2.31	72	-1.7	1.77	69	0.1	85	0.100	100	99	8.3	-0.58	586	208	316	423	390	385		302	81	56	82	51	70	-0.057	12.95	0.96
40	6.523	6.797	0.16	0.17	2.31	73	-1.75	1.75	70	-0.2	85	0.100	100	99	7.9	-0.44	598	203	313	419	390	385		306	81	56	81	52	69	-0.057	13.19	1.28
45	7.346	7.645	0.16	0.17	2.29	73	-1.81	1.76	70	-0.3	86	0.100	100	99	7.3	-0.62	609	198	310	418	391	385		310	81	57	81	53	68	-0.058	13.64	1.84
50	8.167	8.492	0.16	0.17	2.30	73	-2.12	1.75	70	-0.2	86	0.100	100	99	6.7	-0.56	611	193	310	421	394	386		313	81	57	81	53	68	-0.056	13.77	1.87
55	8.988	9.339	0.16	0.17	2.31	73	-1.85	1.75	70	0	87	0.100	100	99	6.1	-0.6	614	189	309	425	397	387		309	81	58	81	54	70	-0.056	13.6	2.51
60	9.810	10.184	0.16	0.17	2.28	73	-1.81	1.79	70	0	86	0.100	100	99	5.6	-0.5	608	186	313	430	402	388		303	81	58	81	54	70	-0.055	12.99	2.31
65	10.636	11.040	0.17	0.17	2.30	74	-2.11	1.78	70	-0.3	87	0.100	100	100	5.0	-0.6	608	184	315	437	408	390		300	82	58	81	55	71	-0.054	12.75	2.36
70	11.458	11.893	0.16	0.17	2.31	74	-2.05	1.76	71	-0.3	87	0.100	100	99	4.4	-0.6	609	181	318	442	415	393		297	82	58	82	55	71	-0.054	12.65	2.18
75	12.279	12.740	0.16	0.17	2.29	74	-1.76	1.79	71	-0.2	88	0.100	100	99	4.0	-0.4	613	181	322	448	421	397		296	81	59	81	56	72	-0.053	12.46	2.01
80	13.100	13.588	0.16	0.17	2.30	74	-2.14	1.79	71	-0.5	87	0.100	100	98	3.6	-0.4	610	179	326	453	426	399		296	82	59	82	56	72	-0.050	12.38	1.96
85	13.923	14.436	0.16	0.17	2.30	74	-1.77	1.78	71	-0.3	85	0.100	100	99	3.3	-0.3	605	180	329	457	431	400		279	81	59	82	57	71	-0.048	12.07	1.44
90	14.747	15.286	0.16	0.17	2.32	75	-2.13	1.75	72	-0.6	84	0.100	100	99	3.0	-0.3	592	180	331	459	435	399		282	82	59	82	57	71	-0.046	10.99	0.4
95	15.573	16.138	0.17	0.17	2.33	75	-1.71	1.76	72	-0.3	84	0.080	106	104	2.8	-0.2	576	181	335	459	437	398		282	81	60	81	57	71	-0.042	10.8	0.27
100	16.402	16.987	0.17	0.17	2.35	75	-1.99	1.76	72	-0.3	83	0.100	100	99	2.6	-0.2	567	181	339	458	439	395		244	81	60	81	58	71	-0.041	10.47	0.34
105	17.233	17.837	0.17	0.17	2.35	75	-1.7	1.77	72	-0.6	81	0.100	100	98	2.4	-0.2	542	181	341	457	440	392		236	81	60	81	58	70	-0.039	9.92	0.4
110	18.066	18.692	0.17	0.17	2.36	75	-2.06	1.79	72	-0.5	80	0.080	106	104	2.2	-0.2	518	182	340	456	440	387		222	81	60	81	58	69	-0.036	8.83	0.19
115	18.899	19.550	0.17	0.17	2.35	75	-1.71	1.78	72	-0.4	79	0.100	100	99	2.1	-0.1	496	183	341	456	440	383		214	80	60	81	58	68	-0.035	9.12	0.18
120	19.733	20.407	0.17	0.17	2.36	75	-2.07	1.79	72	-0.4	78	0.100	101	99	2.0	-0.1	477	185	341	454	439	379		205	80	60	80	58	69	-0.031	7.75	0.16
125	20.564	21.266	0.17	0.17	2.28	75	-1.63	1.79	72	-0.3	78	0.100	100	99	2.0	0	464	186	340	452	436	374		194	80	60	80	59	69	-0.028	7.08	0.24
130	21.386	22.123	0.16	0.17	2.28	75	-1.6	1.78	72	-0.5	78	0.100	99	99	1.9	-0.1	436	186	339	449	432	368		186	80	59	80	59	70	-0.027	6.96	0.33
135	22.207	22.981	0.16	0.17	2.29	75	-1.8	1.79	72	-0.3	78	0.100	99	99	1.8	-0.1	421	187	337	445	426	363		181	80	59	80	59	71	-0.025	7.12	0.39
140	23.028	23.840	0.16	0.17	2.29	75	-1.58	1.79	72	-0.7	78	0.100	99	99	1.7	-0.1	405	188	335	439	421	358		176	80	59	80	59	71	-0.023	7.35	0.43
145	23.850	24.700	0.16	0.17	2.29	75	-1.58	1.79	72	-0.6	78	0.100	99	99	1.7	0	393	188	331	435	415	352		173	80	59	80	59	71	-0.022	7.25	0.48
150	24.672	25.558	0.16	0.17	2.29	75	-1.57	1.79	72	-0.4	77	0.100	99	99	1.6	-0.08	381	188	328	430	409	347		170	80	59	80	59	70	-0.022	7.12	0.47
155	25.493	26.419	0.16	0.17	2.27	75	-1.73	1.79	72	-0.4	77	0.100	99	99	1.6	-0.02	371	188	326	426	403	343		168	80	59	80	59	70	-0.020	7.15	0.52
160	26.315	27.280	0.16	0.17	2.29	75	-1.82	1.80	72	-0.3	77	0.100	99	99	1.5	-0.1	362	188	324	422	398	339		165	80	59	80	59	70	-0.020	7.02	0.46
165	27.137	28.141	0.16	0.17	2.29	75	-1.85	1.80	72	-0.6	76	0.100	99	99	1.5	0	355	188	322	418	394	335		163	80	59	80	59	70	-0.020	7.09	0.48
170	27.959	29.002	0.16	0.17	2.28	75	-1.74	1.80	72	-0.7	76	0.100	99	99	1.4	-0.1	346	188	321	415	389	332		161	80	59	80	59	69	-0.019	7.18	0.46
175	28.782	29.864	0.16	0.17	2.28	75	-1.82	1.79	72	-0.6	75	0.100	99	99	1.4	0	341	187	318	413	386	329		160	79	59	80	59	69	-0.019	7.15	0.43

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 2
 Manufacturer: ESSE
 Model: Warmheart
 Tracking No.: 240A
 Project No.: 2240/S008
 Test Date: 12/26/20
 Beginning Clock Time: 13:04
 Meter Box Y Factor: 0.995 (1) 0.991 (2) (Amb)
 Barometric Pressure: Begin Middle End Average
 29.45 29.52 29.49 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 371, 372
 Dilution Tunnel MW(wt%): 22.90
 Dilution Tunnel MW(wet): 28.78 lb/lb-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Sulfate: 0.2302 H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: 20.17 ft/sec
 Initial Tunnel Flow: 222.3 scfm
 Average Tunnel Flow: 225.8 scfm
 Post-Test Leak Check (1): 0.000 cfm @ 10 in. Hg
 Post-Test Leak Check (2): 0.000 cfm @ 8 in. Hg
 Average Test Piece Fuel Moisture: 22.20 Dry Basis %

Technician Signature: *[Signature]*

Velocity Traverse Data										
	Pl. 1	Pl. 2	Pl. 3	Pl. 4	Pl. 5	Pl. 6	Pl. 7	Pl. 8	Center	
Initial dP	0.076	0.094	0.092	0.086	0.074	0.094	0.092	0.086	0.096	
Temp:	73	73	73	73	74	74	74	74	74	
V _{aver}	19.88 ft/sec			V _{aver}			20.82 ft/sec			F _p 0.955

Elapsed Time (min)	Particulate Sampling Data										Fuel Weight (lb)				Temperature Data (°F)										Stack Gas Data						
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (dm)	Sample Rate 2 (dm)	Orifice dH1 (H ₂ O)	Meter 1 Temp (°F)	Meter 1 Vacuum (Hg)	Orifice dH2 (H ₂ O)	Meter 2 Temp (°F)	Meter 2 Vacuum (Hg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (H ₂ O)	CO ₂ (%)	CO (%)
180	29.603	30.726	0.16	0.17	2.27	75	-1.69	1.80	72	-0.6	75	0.100	99	99	1.3	-0.1	307	186	317	412	383	327	158	79	59	79	59	69	-0.019	7.26	0.41
185	30.425	31.567	0.16	0.17	2.29	75	-1.86	1.79	72	-0.5	75	0.100	99	99	1.3	0	333	186	316	411	379	325	158	81	59	83	59	69	-0.018	7.15	0.47
190	31.248	32.449	0.16	0.17	2.29	75	-1.67	1.80	72	-0.6	74	0.100	99	99	1.3	0	327	185	314	409	376	322	157	82	59	82	59	68	-0.018	6.54	0.54
195	32.069	33.311	0.16	0.17	2.29	75	-1.67	1.80	72	-0.4	74	0.100	99	99	1.2	-0.1	324	185	314	406	373	320	156	80	60	80	59	68	-0.019	6.48	0.52
200	32.892	34.174	0.16	0.17	2.29	75	-1.66	1.80	72	-0.3	74	0.100	99	99	1.2	0	320	184	314	401	371	318	155	80	60	80	59	68	-0.018	6.42	0.5
205	33.714	35.038	0.16	0.17	2.27	75	-1.92	1.81	72	-0.5	74	0.100	99	99	1.1	-0.1	316	184	314	395	368	315	154	80	60	80	59	68	-0.018	5.39	0.49
210	34.538	35.897	0.16	0.17	2.29	75	-1.79	1.81	72	-0.6	73	0.100	98	99	1.1	0	312	183	312	390	366	313	153	82	60	83	59	68	-0.017	6.31	0.47
215	35.367	36.759	0.16	0.17	2.29	75	-1.98	1.81	72	-0.4	73	0.100	98	99	1.0	-0.1	308	182	310	385	364	310	152	82	60	81	59	68	-0.018	6.34	0.48
220	36.179	37.622	0.16	0.17	2.29	74	-1.84	1.81	72	-0.5	73	0.100	98	99	1.0	0	305	181	309	380	361	307	152	80	60	79	59	67	-0.018	6.33	0.47
225	37.002	38.486	0.16	0.17	2.28	74	-1.9	1.81	71	-0.4	72	0.100	99	99	1.0	0	302	181	307	377	359	306	151	80	60	81	59	68	-0.017	5.98	0.45
230	37.823	39.348	0.16	0.17	2.30	74	-1.92	1.80	71	-0.4	72	0.100	99	99	1.0	0	300	179	305	373	357	303	150	82	60	82	59	68	-0.017	5.96	0.45
235	38.644	40.212	0.16	0.17	2.30	74	-1.89	1.81	71	-0.4	72	0.100	99	99	0.9	-0.06	297	178	303	370	356	301	149	82	60	80	59	67	-0.017	5.98	0.44
240	39.466	41.075	0.16	0.17	2.28	74	-1.56	1.81	71	-0.6	72	0.100	99	99	0.9	-0.04	294	177	302	367	354	299	148	81	60	79	59	67	-0.017	5.99	0.46
245	40.286	41.938	0.16	0.17	2.29	74	-1.67	1.80	71	-0.6	71	0.100	98	99	0.8	-0.1	292	176	300	364	352	297	147	80	60	84	59	67	-0.017	6.11	0.5
250	41.109	42.800	0.16	0.17	2.31	73	-1.82	1.80	70	-0.6	71	0.100	99	99	0.8	0	290	175	299	360	350	295	146	80	60	82	59	66	-0.016	6.13	0.53
255	41.930	43.662	0.16	0.17	2.29	73	-1.58	1.80	70	-0.5	71	0.100	99	99	0.8	0	285	175	300	358	348	293	146	80	60	80	59	67	-0.017	6.16	0.52
260	42.752	44.524	0.16	0.17	2.29	73	-1.92	1.80	70	-0.6	71	0.100	99	99	0.8	0	288	174	301	356	347	293	145	81	60	79	59	66	-0.016	6.21	0.54
265	43.572	45.386	0.16	0.17	2.29	73	-1.87	1.80	70	-0.4	70	0.100	98	99	0.7	-0.1	284	174	301	354	345	292	145	81	60	83	59	66	-0.016	5.68	0.48
270	44.393	46.246	0.16	0.17	2.30	73	-2	1.81	70	-0.6	71	0.100	98	99	0.7	0	281	173	299	353	343	290	144	80	60	82	59	67	-0.016	5.57	0.48
275	45.213	47.108	0.16	0.17	2.29	73	-2	1.81	70	-0.6	71	0.100	98	99	0.6	-0.1	280	173	297	353	342	289	144	81	60	81	59	67	-0.016	5.32	0.41
280	46.034	47.969	0.16	0.17	2.30	73	-1.83	1.81	69	-0.6	71	0.100	99	99	0.6	0	277	173	293	352	340	287	142	81	60	81	59	66	-0.016	5.31	0.43
285	46.855	48.831	0.16	0.17	2.27	73	-1.66	1.81	69	-0.4	72	0.100	99	99	0.6	0	274	172	290	350	337	285	141	80	60	80	59	67	-0.015	5.19	0.43
290	47.675	49.693	0.16	0.17	2.29	72	-1.88	1.82	69	-0.3	71	0.100	99	99	0.5	-0.1	271	171	287	347	335	282	140	81	60	80	58	68	-0.015	5.17	0.42
295	48.495	50.555	0.16	0.17	2.29	72	-1.7	1.82	69	-0.6	72	0.100	99	99	0.5	0	268	171	285	343	333	280	139	81	60	80	58	68	-0.014	4.84	0.38
300	49.316	51.417	0.16	0.17	2.29	72	-1.77	1.81	69	-0.3	71	0.100	99	99	0.5	0	265	170	282	340	330	277	138	80	60	80	58	68	-0.014	4.86	0.38
305	50.137	52.279	0.16	0.17	2.30	72	-1.61	1.81	69	-0.5	72	0.100	99	99	0.4	-0.1	262	169	280	336	327	275	137	81	60	80	58	67	-0.014	4.86	0.39
310	50.957	53.141	0.16	0.17	2.29	72	-1.7	1.81	69	-0.6	72	0.100	99	99	0.4	0	259	168	279	332	324	272	136	81	60	82	58	68	-0.013	4.82	0.39
315	51.779	54.003	0.16	0.17	2.29	73	-1.67	1.81	69	-0.4	72	0.100	99	99	0.4	0	256	167	276	329	321	270	135	81	60	81	58	68	-0.013	4.81	0.4
320	52.599	54.865	0.16	0.17	2.30	72	-1.76	1.80	69	-0.6	72	0.100	99	99	0.4	0	255	166	275	328	318	268	135	80	60	81	59	68	-0.013	4.79	0.41
325	53.419	55.727	0.16	0.17	2.28	73	-1.61	1.81	69	-0.6	72	0.100	98	99	0.3	-0.1	252	165	274	323	316	268	135	81	60	80	59	67	-0.013	4.78	0.41
330	54.239	56.589	0.16	0.17	2.29	72	-1.69	1.81	69	-0.6	71	0.100	98	99	0.3	0	249	164	273	320	314	264	133	81	60	80	59	68	-0.013	4.77	0.42
335	55.060	57.452	0.16	0.17	2.27	72	-1.98	1.80	69	-0.4	70	0.100	99	99	0.3	0	248	163	272	317	312	262	133	80	60	82	60	67	-0.013	4.77	0.42
340	55.880	58.314	0.16	0.17	2.29	72	-1.67	1.80	69	-0.5	70	0.100	99	99	0.3	0	246	163	271	315	311	261	133	81	60	82	60	68	-0.013	4.91	0.46
345	56.701	59.177	0.16	0.17	2.31	72	-2.01	1.81	69	-0.3	70	0.100	99	99	0.2	-0.1	245	162	271	313	310	260	132	81	60	81	60	67	-0.012	5.01	0.46
350	57.523	60.041	0.16	0.17	2.27	72	-2.01	1.81	69	-0.6	70	0.100	99	100	0.2	0	244	161	270	311	308	259	132	80	60	80	60	67	-0.012	5.21	0.49
355	58.343	60.904	0.16	0.17	2.30	72	-1.69	1.82	69	-0.6	70	0.100	99	99	0.2	0	242	160	272	309	307	258	132	81	60	80	60	66	-0.012	5.18	0.46

OMNI-Test Laboratories, Inc.

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 2
 Manufacturer: ESSE
 Model: WarmHeart
 Tracking No.: 240A
 Project No.: 2240/S009E
 Test Date: 12/22/20
 Beginning Clock Time: 13:04
 Meter Box Y Factor: 0.995 (1) 0.991 (2) (Amb)
 Barometric Pressure: Begin Middle End Average
 29.45 29.52 29.49 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 271, 372
 Dilution Tunnel MW(dry): 229.00 lb/b-mole
 Dilution Tunnel MW(wet): 28.78 lb/b-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Static: -0.2302 "H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: 20.17 ft/sec
 Initial Tunnel Flow: 222.3 scfm
 Average Tunnel Flow: 225.8 scfm
 Post-Test Leak Check (1): 0.000 cfm @ 10 in. Hg
 Post-Test Leak Check (2): 0.000 cfm @ 8 in. Hg
 Average Test Piece Fuel Moisture: 22.20 Dry Basis %

Technician Signature: *[Signature]*

Velocity Traverse Data									
	PI.1	PI.2	PI.3	PI.4	PI.5	PI.6	PI.7	PI.8	Center
Initial dP	0.076	0.094	0.092	0.086	0.074	0.094	0.092	0.086	0.096
Temp:	73	73	73	73	74	74	74	74	74
V _{center}	19.88 ft/sec				20.82 ft/sec				F _p 0.955

Elapsed Time (min)	Particulate Sampling Data													Temperature Data (°F)										Stack Gas Data							
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH 1 (H ₂ O)	Meter 1 Temp (°F)	Meter 1 Vacuum (Hg)	Orifice dH 2 (H ₂ O)	Meter 2 Temp (°F)	Meter 2 Vacuum (Hg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Slove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (H ₂ O)	CO ₂ (%)	CO (%)
360	59.164	61.766	0.16	0.17	2.29	72	-1.66	1.82	69	-0.3	70	0.100	99	99	0.2	0	242	160	275	306	305	258	133	81	60	79	60	66	-0.012	5.17	0.45
365	59.985	62.630	0.16	0.17	2.29	72	-1.82	1.81	69	-0.4	69	0.100	99	99	0.2	0	242	160	278	307	304	258	132	80	60	85	60	67	-0.012	5.17	0.44
370	60.806	63.492	0.16	0.17	2.30	72	-1.91	1.81	69	-0.5	69	0.100	99	99	0.1	-0.1	242	159	279	307	302	258	133	81	60	83	60	66	-0.013	5.06	0.44
375	61.626	64.354	0.16	0.17	2.29	72	-1.65	1.81	69	-0.3	69	0.100	99	99	0.1	0	242	159	280	306	301	258	133	80	60	82	60	66	-0.012	4.97	0.42
380	62.446	65.217	0.16	0.17	2.30	72	-2	1.80	69	-0.3	69	0.100	99	99	0.1	0	241	159	281	306	300	257	133	80	60	81	60	66	-0.013	4.81	0.4
385	63.266	66.079	0.16	0.17	2.28	72	-1.81	1.81	69	-0.4	69	0.100	98	99	0.0	-0.1	240	158	280	304	299	256	133	81	60	80	60	66	-0.013	4.75	0.4
Avg/Std	63.266	66.079	0.16	0.17	2.30	73		1.78	70		77	0.098	100	100								170.8		80	81	57	68	-0.028			

OMNI-Test Laboratories, Inc.

Wood Heater Test Results - ASTM E3053 / ASTM E2515

Manufacturer: ESSE
 Model: WarmHeart
 Project No.: 0224WS009E
 Tracking No.: 2400A
 Run: 2
 Test Date: 12/15/20

Burn Rate	0.73 kg/hr dry
Average Tunnel Temperature	77 degrees Fahrenheit
Average Gas Velocity in Dilution Tunnel - vs	20.17 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	13535.7 dscf/hour
Average Delta p	0.098 inches H2O
Total Time of Test	385 minutes

	AMBIENT	SAMPLE TRAIN 1	SAMPLE TRAIN 2	FIRST HOUR FILTER (TRAIN 1)
Total Sample Volume - Vm	0.000 cubic feet	63.266 cubic feet	66.079 cubic feet	9.810 cubic feet
Average Gas Meter Temperature	68 degrees Fahrenheit	73 degrees Fahrenheit	70 degrees Fahrenheit	74 degrees Fahrenheit
Total Sample Volume (Standard Conditions) - Vmstd	0.000 dscf	61.732 dscf	64.503 dscf	9.566 dscf
Total Particulates - m _n	0 mg	8.1 mg	9.2 mg	4.1 mg
Particulate Concentration (dry-standard) - C _p /C _s	0.000000 grams/dscf	0.00013 grams/dscf	0.00014 grams/dscf	0.00043 grams/dscf
Total Particulate Emissions - E _T	0.00 grams	11.40 grams	12.39 grams	5.80 grams
Particulate Emission Rate	0.00 grams/hour	1.78 grams/hour	1.93 grams/hour	5.80 grams/hour
Emissions Factor		2.44 g/kg	2.65 g/kg	2.23 g/kg
Difference from Average Total Particulate Emissions		0.50 grams	0.50 grams	

Dual Train Comparison Results Are Acceptable

	FINAL AVERAGE RESULTS
Complete Test Run	
Total Particulate Emissions - E _T	11.89 grams
Particulate Emission Rate	1.85 grams/hour
Emissions Factor	2.55 grams/kg
First Hour Emissions	
Total Particulate Emissions - E _T	5.80 grams
Particulate Emission Rate	5.80 grams/hour
Emissions Factor	2.23 grams/kg
7.5% of Average Total Particulate Emissions	0.89 grams

QUALITY CHECKS	
Filter Temps < 90 °F	OK
Filter Face Velocity (47 mm)	OK
Dryer Exit Temp < 80F	OK
Leakage Rate	OK
Ambient Temp (55-90°F)	OK
Negative Probe Weight Eval.	OK
Pro-Rate Variation	OK
Train A - Train B G/KG ≤ 0.5	0.21
Total PM Precision (%)	4.17

Technician Signature: 

Control No. P-SSAR-0003

Low Burn Run 2

Wood Heater Efficiency Results - CSA B415.1

Manufacturer: ESSE
Model: WarmHeart
Date: 12/15/20
Run: 2
Control #: 0224WS009E
Test Duration: 385
Output Category: I

Technician Signature: 

Test Results in Accordance with CSA B415.1-09

	HHV Basis	LHV Basis
Overall Efficiency	75.9%	81.2%
Combustion Efficiency	92.1%	92.1%
Heat Transfer Efficiency	82%	88.2%

Output Rate (kJ/h)	11,054	10,486	(Btu/h)
Burn Rate (kg/h)	0.73	1.61	(lb/h)
Input (kJ/h)	14,562	13,814	(Btu/h)

Test Load Weight (dry kg)	4.68	10.31	dry lb
MC wet (%)	18.16693944		
MC dry (%)	22.20		
Particulate (g)	1.85		
CO (g)	526		
Test Duration (h)	6.42		

Emissions	Particulate	CO
g/MJ Output	0.03	7.41
g/kg Dry Fuel	0.40	112.36
g/h	0.29	81.92
lb/MM Btu Output	0.06	17.22

Air/Fuel Ratio (A/F)	12.53
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VERSION:

2.2

12/14/2009

Values to be input manually

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For Usable Firebox Volumes up to 3.0 ft ³ - Low and Medium Fire				
Nominal Required Load Density (wet basis)	12	lb/ft ³		
Usable Firebox Volume	1.09	ft ³		
Total Nom. Load Wt. Target	13.08	lb		
Total Load Wt. Allowable Range	12.43	to 13.73	lb	
Core Target Wt. Allowable Range	5.886	to 8.50	lb	
Remainder Load Wt. Allowable Range	4.58	to 7.19	lb	
				Mid-Point
Core Load Fuel Pc. Wt. Allowable Range	1.96	to 3.27	lb	2.62
Remainder Load Pc. Wt. Allowable Range	1.31	to 3.92	lb	2.62
	Pc. #			
Core Load Piece Wt. Actual	1	2.70	lb	In Range
	2	2.60	lb	In Range
	3	2.60	lb	In Range
Core Load Total. Wt. Actual		7.90	lb	In Range
	Pc. #			
Remainder Load Piece Wt.	1	1.80	lb	In Range
(2 or 3 Pcs.)	2	2.90	lb	In Range
	3		lb	NA
Remainder Load Piece Weight Ratio - Small/Large		62%		In Range ≤ 67%
Remainder Load Tot. Wt. Act		4.70	lb	In Range
Total Load Wt. Actual		12.60	lb	In Range
Core % of Total Wt.		63%		In Range 45-65%
Remainder % of Total Wt.		37%		In Range 35-55%
Actual Load % of Nominal Target		96%		In Range 95-105%
Actual Fuel Load Density		11.6	lb/ft ³	
Allowable Charcoal Bed Wt. Range (lb)	1.3	to 2.5		Mid-Point
Actual Charcoal Bed Wt.		1.4	lb	In Range 1.9
Actual Fuel Load Ending Wt.		0.0	lb	Valid Test ≥ 90%
Total Wt. of Fuel Burned During Test Run lb.		12.6	lb	

Fuel Piece Moisture Reading (%-dry basis)							
	1	2	3	Ave.		Pc. Wt. Dry Basis	
	20.6	23.8	23.9	22.8	In Range	2.20	1.00
	22.3	24.2	23.1	23.2	In Range	2.11	0.96
	21.4	22.3	18.6	20.8	In Range	2.15	0.98
	26.3	19.7	22.9	23.0	In Range	1.46	0.66
	24.2	18.1	23	21.8	In Range	2.38	1.08
				NA	NA	NA	NA
Total Load Ave. MC % (dry basis)				22.2	In Range		
Total Load Ave. MC % (wet basis)				18.2			
Total Test Load Weight (dry basis)						10.31	4.68
Total Fuel Weight Burned During Test Run (dry basis)						10.3	4.68

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 2
 Model: WarmHeart Tracking Number: 2400A Date: 12/15/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: _____

Wood Heater Supplemental Data

Start Time: 1304 Booth #: N/A

Stop Time: 1929

Stack Gas Leak Check:

Initial: 1^{sec Rn} Final: good

Sample Train Leak Check:

A: 0.0 @ 10 "Hg
 B: 0.0 @ 8 "Hg

Calibrations: Span Gas CO₂: 17.08 CO: 4.02

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	<u>1932</u>		<u>1932</u>	<u>1932</u>
CO ₂			<u>0.09</u>	<u>16.95</u>
CO			<u>0.00</u>	<u>4.02</u>

Air Velocity (ft/min): Initial: 250 Final: 250

Scale Audit (lbs): Initial: 10.0 Final: 10.0

Pitot Tube Leak Test: Initial: good Final: good

Stack Diameter (in): 6"

Induced Draft: 0.0

% Smoke Capture: 100%

Flue Pipe Cleaned Prior to First Test in Series:

Date: 12/10/20 Initials: RL

	Initial	Middle	Ending
P _b (in/Hg)	<u>29.45</u>		<u>29.52</u>
RH (%)			
Ambient (°F)	<u>68</u>		<u>66</u>

Tunnel Traverse		
Microtector Reading	dP (in H ₂ O)	T(°F)
	<u>.076</u>	<u>73</u>
	<u>.094</u>	<u>73</u>
	<u>.092</u>	<u>73</u>
	<u>.086</u>	<u>73</u>
	<u>.074</u>	<u>74</u>
	<u>.094</u>	<u>74</u>
	<u>.092</u>	<u>74</u>
	<u>.086</u>	<u>74</u>
Center:		
	<u>.096</u>	<u>73</u>

Background Filter Volume: N/A

Tunnel Static Pressure (in H ₂ O):	
Beginning of Test	End of Test
<u>-240</u>	<u>-240</u>

Technician Signature: B Davis

Date: 12/15/20

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 2
 Model: WarmHeart Tracking Number: 2400A Date: 12/15/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: _____

Wood Heater Run Notes

Air Control Settings

Primary:

Fully closed

Secondary: Fixed

Tertiary/Pilot: N/A

Fan: N/A

Preburn Notes

Time	Notes
	N/A

Test Notes

Sketch test fuel configuration:

See photo

Start up procedures & Timeline:

Bypass: N/A

Fuel loaded by: 45 seconds

Door closed at: 3:00 min

Primary air: Fully open v-h/ 12 min 10.7 15%
16s

Notes: N/A

Time	Notes
60	Changed front filter in frame A.

Technician Signature: [Signature]

Date: 12/15/20

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Run 3

High Burn 1-minute data

Non-Sampling

OMNI-Test Laboratories, Inc.

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 3
 Manufacturer: ESSE
 Model: WarmHeart
 Tracking No.: 240A
 Project No.: 2240/S009E
 Test Date: 12/22/20
 Beginning Clock Time: 10:50
 Meter Box Y Factor: 0.995 (1) 0.991 (2) (Amb)
 Barometric Pressure: Begin Middle End Average
 29.22 29.2 29.21 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 271, 372
 Dilution Tunnel MW(dry): 22.00 lb/lb-mole
 Dilution Tunnel MW(wet): 28.78 lb/lb-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Static: H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: #DIV/0! ft/sec
 Initial Tunnel Flow: #DIV/0! scfm
 Average Tunnel Flow: #DIV/0! scfm
 Post-Test Leak Check (1): #DIV/0! cm @ in. Hg
 Post-Test Leak Check (2): #DIV/0! cm @ in. Hg
 Average Test Piece Fuel Moisture: 19.07 Dry Basis %

Technician Signature: *[Signature]*

Velocity Traverse Data									
	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Pt. 7	Pt. 8	Center
Initial dP									
Temp:									

V_{meter} _____ ft/sec V_{vacant} _____ ft/sec F_p _____

Elapsed Time (min)	Particulate Sampling Data										Fuel Weight (lb)										Temperature Data (°F)										Stack Gas Data		
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH 1 (in)	Meter 1 Temp (°F)	Meter 1 Vacuum (inHg)	Orifice dH 2 (in)	Meter 2 Temp (°F)	Meter 2 Vacuum (inHg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (inH ₂ O)	CO ₂ (%)	CO (%)		
0															5.3		66	64	67	66	66	66		68						67	-0.013		
1															5.2		68	64	67	66	66	66		113						67	-0.015		
2															5.1		78	64	67	66	66	66		195						67	-0.036		
3															5.0		96	64	67	66	66	66		259						67	-0.042		
4															4.9		122	63	67	67	66	66		262						67	-0.043		
5															4.8		139	63	67	67	67	67		262						67	-0.043		
6															4.7		156	63	68	68	67	67		268						67	-0.044		
7															4.6		174	63	69	69	68	68		285						67	-0.050		
8															4.5		198	63	70	71	69	69		311						67	-0.055		
9															4.3		217	63	72	73	71	69		324						67	-0.054		
10															4.2		236	63	75	77	74	105		332						67	-0.054		
11															4.1		262	63	78	81	76	110		339						67	-0.058		
12															3.9		274	63	81	87	80	117		358						67	-0.062		
13															3.8		298	63	84	92	83	124		374						67	-0.062		
14															3.7		314	63	89	98	87	130		371						67	-0.059		
15															3.6		328	63	93	105	91	136		364						67	-0.059		
16															3.5		335	63	98	112	98	141		357						67	-0.056		
17															3.3		340	64	103	119	101	145		352						67	-0.057		
18															3.3		347	64	108	127	108	150		354						67	-0.058		
19															3.1		358	64	112	135	112	156		360						67	-0.058		
20															3.0		365	65	117	143	118	162		354						67	-0.056		
21															2.9		370	65	121	151	124	166		351						67	-0.055		
22															2.9		377	66	126	160	130	172		353						67	-0.057		
23															2.7		383	67	130	168	137	177		356						67	-0.058		
24															2.7		392	68	135	177	144	183		357						67	-0.058		
25															2.6		399	68	139	185	150	188		361						67	-0.060		
26															2.5		411	69	143	193	157	195		367						67	-0.060		
27															2.4		421	70	147	200	164	200		370						67	-0.060		
28															2.2		438	72	151	207	171	205		367						67	-0.060		
29															2.2		433	73	155	214	178	211		365						67	-0.059		
30															2.1		438	74	159	221	186	216		359						67	-0.058		
31															2.0		439	75	164	229	193	220		355						67	-0.057		
32															1.8		443	77	169	236	201	225		353						67	-0.057		
33															1.8		444	78	174	242	208	229		347						67	-0.056		
34															1.8		444	80	179	249	215	233		339						67	-0.055		
35															1.7		440	81	185	256	223	237		334						67	-0.054		

OMNI-Test Laboratories, Inc.

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 3
 Manufacturer: ESSE
 Model: WarmHeart
 Tracking No.: 240A
 Project No.: 2220/S009E
 Test Date: 12/22/20
 Beginning Clock Time: 10:50
 Meter Box Y Factor: 0.995 (1) 0.991 (2) (Amb)
 Total Sampling Time: 198 min
 Recording Interval: 1 min
 Background Sample Volume: cubic feet
 Barometric Pressure: Begin Middle End Average
 29.22 29.2 29.21 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 271, 372
 Dilution Tunnel MW(dry): 22.90 lb/lb-mole
 Dilution Tunnel MW(wet): 28.78 lb/lb-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Static: H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: #DIV/0! ft/sec
 Initial Tunnel Flow: #DIV/0! scfm
 Average Tunnel Flow: #DIV/0! scfm
 Post-Test Leak Check (1): #DIV/0! cfm @ in. Hg
 Post-Test Leak Check (2): #DIV/0! cfm @ in. Hg
 Average Test Piece Fuel Moisture: 19.07 Dry Basis %

Technician Signature: *B. K. R.*

Velocity Traverse Data									
	PI.1	PI.2	PI.3	PI.4	PI.5	PI.6	PI.7	PI.8	Center
Initial dP									
Temp:									
	V _{center} ft/sec			V _{vacant} ft/sec			F _p		

Elapsed Time (min)	Particulate Sampling Data										Fuel Weight (lb)										Temperature Data (°F)										Stack Gas Data		
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice d1 (in)	Meter 1 Temp (°F)	Meter 1 Vacuum (in Hg)	Orifice d2 (in)	Meter 2 Temp (°F)	Meter 2 Vacuum (in Hg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (in H ₂ O)	CO ₂ (%)	CO (%)		
36															1.6		442	83	190	263	230	242		330						67	-0.063		
37															1.5		442	85	196	269	237	246		326						67	-0.063		
38															1.4		440	87	201	275	244	249		324						67	-0.063		
39															1.4		441	88	206	281	252	254		322						67	-0.063		
40															10.8		437	91	212	287	259	257		357						66	-0.052		
41															10.5		430	94	217	294	266	260		418						66	-0.066		
42															10.2		426	96	222	300	273	263		359						67	-0.071		
43															10.0		454	97	228	304	280	273		413						67	-0.071		
44															9.8		485	99	233	309	285	282		431						67	-0.074		
45															9.8		511	101	238	312	290	290		450						67	-0.074		
46															9.4		538	103	242	315	294	298		459						66	-0.075		
47															9.3		568	105	246	317	297	307		472						67	-0.076		
48															9.0		588	107	250	320	300	313		480						67	-0.076		
49															8.9		609	109	253	323	301	319		486						67	-0.078		
50															8.7		628	111	257	327	303	325		494						67	-0.077		
51															8.5		642	113	260	330	304	330		492						67	-0.078		
52															8.3		654	115	263	333	306	334		492						67	-0.077		
53															8.2		664	117	266	337	307	338		495						67	-0.078		
54															8.0		674	119	269	341	308	342		496						67	-0.078		
55															7.8		682	120	272	346	309	346		497						67	-0.077		
56															7.6		689	122	275	350	311	349		498						67	-0.078		
57															7.4		698	124	279	354	312	353		498						67	-0.079		
58															7.3		705	125	281	359	314	357		497						67	-0.078		
59															7.1		710	127	284	363	316	360		499						67	-0.078		
60															6.9		715	128	287	368	318	363		499						67	-0.078		
61															6.7		719	130	291	373	320	367		500						67	-0.079		
62															6.5		720	131	293	377	322	369		499						67	-0.078		
63															6.4		723	132	296	382	325	372		497						68	-0.078		
64															6.2		728	134	299	387	327	375		496						66	-0.077		
65															6.0		732	135	302	392	330	378		493						67	-0.077		
66															5.8		734	137	304	396	333	381		490						67	-0.078		
67															5.7		737	138	308	401	338	384		488						67	-0.078		
68															5.5		738	139	311	405	339	386		484						67	-0.077		
69															5.3		737	141	313	410	342	389		479						67	-0.075		
70															5.2		740	142	317	414	346	392		474						67	-0.075		
71															5.0		737	143	321	418	349	394		472						67	-0.076		

OMNI-Test Laboratories, Inc.

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 3
 Manufacturer: ESSE
 Model: WarmHeart
 Tracking No.: 240A
 Project No.: 22240/3009E
 Test Date: 12/22/20
 Beginning Clock Time: 10:50
 Meter Box Y Factor: 0.995 (1) 0.991 (2) (Amb)
 Barometric Pressure: Begin Middle End Average
 29.22 29.2 29.21 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 271.372
 Dilution Tunnel MW(dry): 22.00
 Dilution Tunnel MW(wet): 28.78 lb/lb-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Static: H₂O
 Tunnel Area: 0.19635 R2
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: #DIV/0! ft/sec
 Initial Tunnel Flow: #DIV/0! scfm
 Average Tunnel Flow: #DIV/0! scfm
 Post-Test Leak Check (1): #DIV/0! cm @ #DIV/0! in. Hg
 Post-Test Leak Check (2): #DIV/0! cm @ #DIV/0! in. Hg
 Average Test Piece Fuel Moisture: 19.07 Dry Basis %

Technician Signature: *[Signature]*

Velocity Traverse Data									
	PI.1	PI.2	PI.3	PI.4	PI.5	PI.6	PI.7	PI.8	Center
Initial dP									
Temp:									

V_{meter} _____ ft/sec V_{vacant} _____ ft/sec F_p _____

Elapsed Time (min)	Particulate Sampling Data										Fuel Weight (lb)										Temperature Data (°F)										Stack Gas Data			
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH 1 (H ₂ O)	Meter 1 Temp (°F)	Meter 1 Vacuum (Hg)	Orifice dH 2 (H ₂ O)	Meter 2 Temp (°F)	Meter 2 Vacuum (Hg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Slove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (H ₂ O)	CO ₂ (%)	CO (%)			
72															4.8		742	145	322	422	352	397		476						67	-0.076			
73															4.7		748	146	326	426	355	400		480						67	-0.077			
74															4.5		752	147	329	430	359	403		483						68	-0.077			
75															4.3		762	148	331	434	362	407		486						67	-0.077			
76															4.2		768	150	333	438	366	411		486						67	-0.077			
77															4.0		769	151	337	441	370	414		484						67	-0.077			
78															3.9		769	153	339	445	375	418		480						68	-0.075			
79															3.8		770	154	342	448	380	419		476						68	-0.074			
80															3.6		770	155	343	452	385	421		473						68	-0.075			
81															3.5		772	157	347	455	391	424		471						67	-0.076			
82															3.3		771	159	349	458	396	427		469						67	-0.075			
83															3.2		771	160	353	462	401	429		466						68	-0.073			
84															3.1		768	162	354	465	406	431		462						67	-0.073			
85															2.9		767	164	357	468	411	433		458						68	-0.072			
86															2.8		769	165	360	472	416	436		451						68	-0.071			
87															2.7		765	167	364	476	421	439		447						68	-0.072			
88															2.6		761	169	367	479	426	440		442						68	-0.069			
89															2.4		758	171	371	482	431	443		438						67	-0.069			
90															2.4		759	173	374	486	435	445		435						68	-0.070			
91															2.3		756	175	376	489	440	447		432						68	-0.069			
92															2.1		748	176	379	492	443	448		429						69	-0.067			
93															2.0		749	178	381	495	447	450		423						68	-0.066			
94															2.0		744	180	382	498	451	451		417						67	-0.066			
95															1.9		738	181	385	500	454	452		411						68	-0.068			
96															1.8		733	184	387	503	457	453		406						68	-0.066			
97															1.7		730	185	389	506	461	454		402						68	-0.066			
98															1.6		724	187	391	509	464	455		396						67	-0.064			
99															1.6		716	189	394	511	467	455		392						68	-0.064			
100															1.5		712	191	397	513	470	457		387						68	-0.064			
101															1.4		709	193	399	515	473	458		384						67	-0.063			
102															1.4		704	195	403	517	476	459		380						68	-0.063			
103															1.3		702	197	404	518	479	460		376						68	-0.061			
104															1.3		698	200	405	520	482	461		372						68	-0.061			
105															1.2		695	202	408	522	484	462		369						68	-0.060			
106															1.1		687	205	409	523	487	462		364						68	-0.060			
Avg Tot	0.000	0.000	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!								386.4						#DIV/0!	#DIV/0!	#DIV/0!	67	-0.065		

Control No. P-SSAR-0003

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High Burn Run 3 Non-Sampling

OMNI-Test Laboratories, Inc.

Wood Heater Test Results - ASTM E3053 / ASTM E2515

Manufacturer: ESSE
Model: WarmHeart
Project No.: 0224WS009E
Tracking No.: 2400A
Run: 3
Test Date: 12/16/20

Burn Rate	2.77 kg/hr dry
Total Time of Test	106 minutes

	AMBIENT	SAMPLE TRAIN 1	SAMPLE TRAIN 2	FIRST HOUR FILTER (TRAIN 1)

FINAL AVERAGE RESULTS	

QUALITY CHECKS	
Ambient Temp (55-90°F)	OK

Technician Signature: 

Control No. P-SSAR-0003

High Burn Run 3 Non-Sampling

Adjunct to ASTM E XXXX Wood Heater Cordwood Test Method - May 10, 2017 Version
 Cordwood Fuel Load Calculators - 10 lb/ft³ Nominal Load Density
 Core 45-65% of Total Load Weight, Remainder 35-55% of Total Load Weight
 Values to be input manually

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For All Usable Firebox Volumes - High Fire Test Only				
Nominal Required Load Density (wet basis)	10	lb/ft ³		
Usable Firebox Volume	1.09	ft ³		
Total Nom. Load Wt. Target	10.90	lb		
Total Load Wt. Allowable Range	10.40	to 11.40	lb	
Core Target Wt. Allowable Range	4.90	to 7.10	lb	
Remainder Load Wt. Allowable Range	3.80	to 6.00	lb	
				Mid-Point
Core Load Pc. Wt. Allowable Range	1.60	to 2.70	lb	2.15
Remainder Load Pc. Wt. Allowable Range	1.10	to 6.00	lb	3.55
	Pc. #			
Core Load Piece Wt. Actual	1	2.60	lb	In Range
	2	2.30	lb	In Range
	3	1.90	lb	In Range
Core Load Total. Wt. Actual		6.80	lb	In Range
	Pc. #			
Remainder Load Piece Wt.	1	4.00	lb	In Range
(1 to 3 Pcs.)	2		lb	NA
	3		lb	NA
Remainder Load Tot. Wt. Act		4.00	lb	In Range
Total Load Wt. Actual		10.80	lb	In Range
Core % of Total Wt.		63%		In Range 45-65%
Remainder % of Total Wt.		37%		In Range 35-55%
Actual Load % of Nominal Target		99%		In Range 95-105%
Actual Fuel Load Density		9.9	lb/ft ³	
Kindling and Start-up Fuel				
Maximum Kindling Wt. (20% of Tot. Load Wt.)		2.16	lb	
Actual Kindling Wt.		2.10	lb	In Range 19.4%
Maximum Start-up Fuel Wt. (30% of Tot. Load Wt.)		3.24	lb	
Actual Start-up Fuel Wt.		3.20	lb	In Range 29.6%
Allowable Residual Start-up Fuel Wt. Range	1.1	to 2.2	lb	Mid-Point
Actual Residual Start-up Fuel Wt.		1.3	lb	In Range 1.6
Total Wt. All Fuel Added (wet basis)		16.10	lb	
High Fire Test Run End Point Range				
	Low		High	Mid-Point
Based on Fuel Load Wt. (w/tares)	1.0	to 1.2	lb	1.1
Actual Fuel Load Ending Wt.		1.1	lb	In Range

Fuel Piece Moisture Reading (%-dry basis)						
1	2	3	Ave.		Pc. Wt. Dry Basis	
24	22.1	20.2	22.1	In Range	2.13 lb	0.97 kg
24.7	23.5	19.3	22.5	In Range	1.88 lb	0.85 kg
23.2	27.4	28	26.2	In Range	1.51 lb	0.68 kg
28	27.1	27.2	27.4	In Range	3.14 lb	1.42 kg
			NA	NA	NA lb	NA kg
			NA	NA	NA lb	NA kg
Total Load Ave. MC (%-dry basis)			24.8	In Range		
Total Load Ave. MC % (wet basis)			19.9			
Total Test Load Weight (dry basis)					8.65 lb	3.92 kg
Kindling Moisture (%-dry basis)						
11	11.4	11.1	11.2	In Range	1.89 lb	0.86 kg
Start-up Fuel Moisture Readings (%-dry basis)						
20.2	23	20.5	21.2	In Range	2.64 lb	1.20 kg
Total Wt. All Fuel Added (dry basis)					13.18 lb	5.98 kg
Total Wt. All Fuel Burned (dry basis)					10.8 lb	4.9 kg

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 3
 Model: WarmHeart Tracking Number: 240A Date: 12/16/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: _____

Wood Heater Supplemental Data

Start Time: 10:50 Booth #: N/A

Stop Time: 12:38

Stack Gas Leak Check:

Initial: N/A Final: _____

Sample Train Leak Check:

A: N/A @ _____ "Hg
 B: _____ @ _____ "Hg

Calibrations: Span Gas CO₂: _____ CO: _____

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	<u>N/A</u>			
CO ₂				
CO				

Air Velocity (ft/min): Initial: 250 Final: 250

Scale Audit (lbs): Initial: 10.0 Final: 10.0

Pitot Tube Leak Test: Initial: good Final: good

Stack Diameter (in): 6"

Induced Draft: 0.0

% Smoke Capture: 100%

Flue Pipe Cleaned Prior to First Test in Series:

Date: 12/10/20 Initials: BD

	Initial	Middle	Ending
P _b (in/Hg)	<u>29.22</u>		<u>29.20</u>
RH (%)			
Ambient (°F)	<u>67</u>		<u>68</u>

Tunnel Traverse		
Microtector Reading	dP (in H ₂ O)	T(°F)
<u>N/A</u>		
Center:		

Background Filter Volume: N/A

Tunnel Static Pressure (in H ₂ O):	
Beginning of Test	End of Test
<u>N/A</u>	

Technician Signature: B Davis

Date: 12/16/20

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 3
 Model: WarmHeart Tracking Number: 2400A Date: 12/16/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: _____

Wood Heater Run Notes

Air Control Settings

Primary:

Fully open

Secondary: fixed

Tertiary/Pilot: N/A

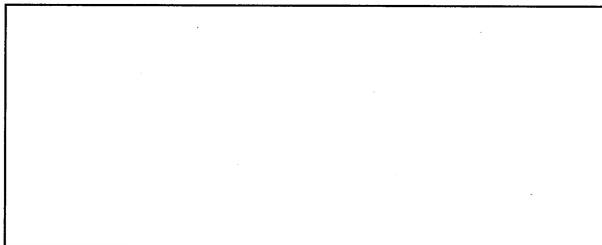
Fan: N/A

Preburn Notes

Time	Notes
Ø	Torch used for 60 seconds to light top down burn. Door ^{fully open} closed until 2:30 minutes then closed. Comb Air fully open entire test. Tared 1.3 lbs and Added Fuel load

Test Notes

Sketch test fuel configuration:



Start up procedures & Timeline:

Bypass: N/A

Fuel loaded by: 30 seconds

Door closed at: 2:30

Primary air: Fully open entire test

Notes: N/A

Time	Notes
	Non-sampling High

Technician Signature: B Davis

Date: 12/16/20

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Run 4

Low Burn

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 4
 Manufacturer: ESSE
 Model: Warmheart
 Tracking No.: 240A
 Project No.: 22240/S030E
 Test Date: 12/26/20
 Beginning Clock Time: 13:06
 Meter Box Y Factor: 0.995 (1) 0.991 (2) (Amb)
 Barometric Pressure: Begin Middle End Average
 29.19 28.96 29.08 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 371 372
 Dilution Tunnel MW(wet): 22.90
 Dilution Tunnel MW(wet): 28.78 lb-ft-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Static: -0.244 "H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: 19.91 ft/sec
 Initial Tunnel Flow: 229.7 scfm
 Average Tunnel Flow: 219.5 scfm
 Post-Test Leak Check (1): 0.000 cfm @ 8 in. Hg
 Post-Test Leak Check (2): 0.000 cfm @ 10 in. Hg
 Average Test Piece Fuel Moisture: 24.10 Dry Basis %

Technician Signature: *[Signature]*

Velocity Traverse Data									
	Pt.1	Pt.2	Pt.3	Pt.4	Pt.5	Pt.6	Pt.7	Pt.8	Center
Initial dP	0.078	0.093	0.094	0.086	0.072	0.090	0.092	0.084	0.094
Temp:	70	70	70	70	70	70	70	70	71
V _{meter}	19.82 ft/sec			V _{vacant}			20.64 ft/sec		
F _p	0.960								

Elapsed Time (min)	Particulate Sampling Data												Fuel Weight (lb)				Temperature Data (°F)										Stack Gas Data					
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH1 (H ₂ O)	Meter 1 Temp (°F)	Meter 1 Vacuum (H ₂ O)	Orifice dH2 (H ₂ O)	Meter 2 Temp (°F)	Meter 2 Vacuum (H ₂ O)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (H ₂ O)	CO ₂ (%)	CO (%)	
0	0.000	0.000	0.16	0.17	2.72	70	-1.94	1.62	68	-0.1	86	0.090			12.6		455	238	384	474	461	402		265	81	62	81	60	68	-0.039	2.53	0.24
5	0.784	0.833	0.16	0.17	2.23	71	-1.62	1.77	68	-0.2	87	0.090	99	99	12.4	-0.2	428	236	377	462	448	390		284	81	60	80	60	68	-0.057	8.81	0.72
10	1.598	1.685	0.16	0.17	2.25	71	-2.02	1.77	68	0.1	92	0.090	103	102	11.6	-0.6	554	231	356	437	419	399		404	81	61	81	61	68	-0.069	12.87	0.8
15	2.417	2.538	0.16	0.17	2.32	71	-1.68	1.77	68	0.1	92	0.090	103	102	11.1	-0.7	598	225	337	415	394	394		404	82	62	80	62	69	-0.065	11.71	0.68
20	3.244	3.394	0.17	0.17	2.30	71	-1.63	1.76	69	0.1	86	0.090	104	102	10.6	-0.5	570	219	323	404	381	379		313	81	62	80	63	68	-0.053	7.87	1.17
25	4.070	4.248	0.17	0.17	2.31	71	-2	1.76	69	0	84	0.090	104	102	10.2	-0.4	531	214	314	395	374	368		288	81	63	80	64	69	-0.052	8.79	1.03
30	4.895	5.105	0.17	0.17	2.29	72	-1.59	1.78	69	-0.3	84	0.090	103	102	9.7	0.5	538	208	304	389	370	362		301	81	64	80	65	68	-0.053	11.17	0.79
35	5.718	5.963	0.16	0.17	2.28	72	-1.64	1.77	69	-0.2	84	0.090	103	102	9.3	-0.42	553	201	298	384	367	361		311	81	65	80	66	68	-0.057	11.82	0.43
40	6.541	6.820	0.16	0.17	2.29	72	-2	1.77	69	0	84	0.090	103	102	8.8	-0.48	574	196	296	380	368	363		314	80	66	80	67	67	-0.055	11.81	0.5
45	7.364	7.677	0.16	0.17	2.27	72	-1.63	1.76	69	-0.2	84	0.090	103	102	8.3	-0.5	577	191	293	379	371	362		311	81	67	82	68	68	-0.055	11.71	0.36
50	8.186	8.534	0.16	0.17	2.28	72	-1.59	1.77	69	-0.1	85	0.090	103	102	7.8	-0.5	590	186	292	380	375	365		315	80	67	80	68	68	-0.056	11.97	0.83
55	9.009	9.391	0.16	0.17	2.28	72	-2.02	1.76	69	-0.1	84	0.090	103	102	7.3	-0.5	598	181	291	382	380	366		317	81	68	80	69	68	-0.056	12.12	0.91
60	9.831	10.247	0.16	0.17	2.28	72	-2	1.76	69	-0.2	85	0.090	103	102	6.9	-0.4	605	179	292	387	384	369		315	80	68	79	69	68	-0.055	11.73	0.9
65	10.628	11.104	0.16	0.17	2.28	72	-1.67	1.76	69	0	84	0.100	95	97	6.4	-0.5	609	177	294	394	388	372		314	80	69	84	70	68	-0.055	12.04	0.89
70	11.450	11.998	0.16	0.17	2.25	72	-1.58	1.75	69	-0.2	86	0.090	103	102	5.9	-0.5	621	175	297	400	391	377		324	81	69	83	70	69	-0.056	13.04	1.39
75	12.271	12.812	0.16	0.17	2.26	72	-1.6	1.75	69	0.1	85	0.100	98	96	5.4	-0.5	634	172	301	405	395	381		328	81	69	82	70	68	-0.057	12.21	1.82
80	13.092	13.666	0.16	0.17	2.24	73	-1.74	1.75	69	-0.3	86	0.090	103	102	4.9	-0.5	641	172	305	412	400	388		324	82	70	81	71	68	-0.055	12.09	1.79
85	13.912	14.518	0.16	0.17	2.26	73	-1.54	1.74	69	0	86	0.100	97	96	4.5	-0.4	652	172	311	421	405	388		315	81	70	80	71	68	-0.055	11.4	1.09
90	14.733	15.372	0.16	0.17	2.25	73	-1.97	1.76	69	-0.2	85	0.090	103	102	4.1	-0.4	629	171	315	428	410	391		311	82	70	82	71	68	-0.053	8.75	0.82
95	15.552	16.227	0.16	0.17	2.29	73	-1.76	1.75	69	0	85	0.090	102	102	3.7	-0.4	628	172	320	435	416	394		308	81	70	82	71	67	-0.052	7.46	0.58
100	16.373	17.081	0.16	0.17	2.26	73	-1.96	1.76	69	-0.1	83	0.090	102	101	3.4	-0.3	624	172	324	444	421	397		299	81	70	81	71	67	-0.061	6.76	0.36
105	17.194	17.934	0.16	0.17	2.25	73	-1.92	1.74	69	-0.2	83	0.090	102	101	3.1	-0.3	606	174	328	451	425	397		289	81	70	80	71	68	-0.049	6.2	0.28
110	18.014	18.801	0.16	0.17	2.25	73	-1.89	1.79	69	-0.3	82	0.100	97	98	2.9	-0.2	591	175	332	457	429	397		277	81	71	80	72	67	-0.045	5.74	0.13
115	18.834	19.665	0.16	0.17	2.25	73	-1.65	1.79	69	-0.1	81	0.090	102	102	2.7	-0.2	568	177	336	462	436	396		261	80	71	82	72	67	-0.043	5.32	0.12
120	19.655	20.529	0.16	0.17	2.25	73	-1.67	1.79	69	-0.3	81	0.090	102	102	2.5	-0.2	540	179	336	466	440	392		244	80	71	83	71	66	-0.038	4.73	0
125	20.475	21.396	0.16	0.17	2.25	73	-1.99	1.79	69	-0.3	79	0.090	102	102	2.4	-0.06	514	182	338	468	441	389		229	80	71	81	71	67	-0.035	4.53	0.01
130	21.295	22.261	0.16	0.17	2.27	73	-1.8	1.79	69	0	78	0.090	102	102	2.3	-0.14	491	184	339	469	439	384		219	80	70	80	71	68	-0.033	4.51	0.01
135	22.116	23.127	0.16	0.17	2.25	73	-1.67	1.79	69	-0.3	78	0.100	97	97	2.3	0	475	196	342	472	436	382		211	80	70	79	71	67	-0.032	4.47	0.02
140	22.936	23.992	0.16	0.17	2.26	73	-1.8	1.80	69	-0.1	76	0.090	102	102	2.2	-0.1	459	198	346	475	433	380		205	79	70	85	71	68	-0.029	4.54	0.03
145	23.757	24.857	0.16	0.17	2.25	73	-1.64	1.80	69	-0.2	77	0.090	102	102	2.2	-0.04	445	191	348	475	430	378		200	79	70	83	71	68	-0.028	4.43	0.07
150	24.578	25.722	0.16	0.17	2.25	73	-1.87	1.80	69	-0.1	77	0.090	102	102	2.1	-0.06	431	193	350	473	428	375		196	82	70	81	70	68	-0.028	4.44	0.12
155	25.398	26.569	0.16	0.17	2.25	73	-1.98	1.79	69	0	77	0.090	102	102	2.0	-0.1	421	195	348	469	426	372		192	82	70	80	70	68	-0.025	4.44	0.15
160	26.218	27.458	0.16	0.17	2.25	73	-1.71	1.80	69	0	76	0.100	96	97	1.9	-0.06	409	197	347	466	421	368		188	81	69	81	70	68	-0.025	4.35	0.16
165	27.040	28.322	0.16	0.17	2.26	73	-1.87	1.80	69	-0.3	76	0.090	102	102	1.9	-0.04	400	199	346	462	418	365		185	81	69	84	70	68	-0.023	3.91	0.25
170	27.860	29.188	0.16	0.17	2.25	73	-1.99	1.80	69	-0.1	76	0.090	102	102	1.9	0	390	199	345	458	413	361		182	80	69	82	70	68	-0.023	3.91	0.29
175	28.682	30.054	0.16	0.17	2.25	73	-1.72	1.79	69	0	76	0.100	97	97	1.8	-0.1	382	201	342	454	409	358		180	80	69	81	69	68	-0.022	4.09	0.32

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 4
 Manufacturer: ESSE
 Model: Warmheart
 Tracking No.: 240A
 Project No.: 2220/S008
 Test Date: 12/22/20
 Beginning Clock Time: 13:06
 Meter Box Y Factor: 0.995 (1) 0.991 (2)
 Total Sampling Time: 395 min
 Recording Interval: 5 min
 Background Sample Volume: cubic feet
 Barometric Pressure: Begin Middle End Average
 29.19 28.96 29.08 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 371, 372
 Dilution Tunnel MW(wt): 22.90 lb/bt-mole
 Dilution Tunnel MW(wet): 28.78 lb/bt-mole
 Dilution Tunnel H₂O: 2.00 percent
 Dilution Tunnel Sulfur: 0.244 %
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: 19.91 ft/sec
 Initial Tunnel Flow: 229.7 scfm
 Average Tunnel Flow: 219.5 scfm
 Post-Test Leak Check (1): 0.000 cfm @ 8 in. Hg
 Post-Test Leak Check (2): 0.000 cfm @ 10 in. Hg
 Average Test Piece Fuel Moisture: 24.10 Dry Basis %

Technician Signature: *[Signature]*

Velocity Traverse Data									
	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Pt. 7	Pt. 8	Center
Initial dP	0.078	0.093	0.094	0.086	0.072	0.090	0.092	0.084	0.094
Temp:	70	70	70	70	70	70	70	70	71
V _{aver}	19.82 ft/sec			V _{aver}			20.64 ft/sec		
F _p	0.960			F _p			0.960		

Elapsed Time (min)	Particulate Sampling Data												Fuel Weight (lb)				Temperature Data (°F)										Stack Gas Data				
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH1 (in)	Meter 1 Temp (°F)	Meter 1 Vacuum (inHg)	Orifice dH2 (in)	Meter 2 Temp (°F)	Meter 2 Vacuum (inHg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Stove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (H ₂ O)	CO ₂ (%)	CO (%)
180	29.602	30.921	0.16	0.17	2.25	73	-1.69	1.80	69	-0.2	76	0.100	96	97	1.7	-0.1	373	201	340	450	404	354	178	83	69	85	69	68	-0.021	4.15	0.29
185	30.323	31.787	0.16	0.17	2.25	73	-1.82	1.80	70	-0.2	76	0.090	102	102	1.6	-0.1	368	203	338	446	400	351	176	82	69	83	69	68	-0.021	4.17	0.26
190	31.144	32.653	0.16	0.17	2.25	73	-1.6	1.79	70	-0.3	75	0.090	102	102	1.6	0	363	203	336	442	397	348	174	81	69	81	69	68	-0.021	4.1	0.22
195	31.965	33.521	0.16	0.17	2.26	73	-1.63	1.79	70	0	74	0.090	102	102	1.5	-0.1	368	203	335	439	394	346	172	80	69	80	69	68	-0.020	4.06	0.22
200	32.787	34.388	0.16	0.17	2.22	73	-1.62	1.79	70	0	74	0.100	97	97	1.5	0	353	202	333	435	391	343	170	85	69	85	69	68	-0.020	3.92	0.24
205	33.607	35.254	0.16	0.17	2.26	73	-1.79	1.80	70	-0.2	74	0.090	101	102	1.4	-0.1	347	202	331	433	388	340	170	83	69	83	69	68	-0.021	3.51	0.28
210	34.428	36.121	0.16	0.17	2.25	73	-1.73	1.80	70	-0.2	74	0.090	102	102	1.4	0	340	201	328	431	385	337	169	82	69	81	69	67	-0.020	3.37	0.24
215	35.249	36.988	0.16	0.17	2.25	73	-1.67	1.80	70	-0.2	74	0.100	96	97	1.5	-0.1	336	201	325	428	382	334	167	81	68	80	69	68	-0.019	3.26	0.22
220	36.072	37.856	0.16	0.17	2.24	73	-1.58	1.81	69	-0.3	73	0.090	102	102	1.2	-0.06	331	200	320	423	379	331	165	80	68	79	68	67	-0.020	3.27	0.23
225	36.892	38.722	0.16	0.17	2.24	72	-1.86	1.80	69	-0.2	74	0.090	102	102	1.2	-0.04	325	198	317	418	374	326	163	86	68	85	68	68	-0.018	3.12	0.23
230	37.713	39.588	0.16	0.17	2.26	73	-1.67	1.80	69	-0.3	74	0.090	102	102	1.2	0	321	197	313	413	370	323	162	84	68	83	68	68	-0.018	3.12	0.27
235	38.533	40.455	0.16	0.17	2.25	73	-1.62	1.79	69	-0.2	74	0.090	101	102	1.2	0	316	195	309	408	366	319	160	82	68	81	68	68	-0.018	3.05	0.25
240	39.354	41.322	0.16	0.17	2.26	73	-1.78	1.80	69	0	74	0.090	102	102	1.2	0	312	194	306	402	361	315	158	81	68	80	68	68	-0.017	2.91	0.26
245	40.175	42.189	0.16	0.17	2.22	73	-1.58	1.80	69	-0.3	74	0.100	96	97	1.1	-0.1	305	192	303	396	357	311	157	85	68	86	68	68	-0.017	2.86	0.25
250	40.995	43.056	0.16	0.17	2.25	73	-1.94	1.80	69	-0.3	75	0.100	96	97	1.0	-0.1	301	191	299	389	353	307	155	86	68	85	68	69	-0.016	2.87	0.25
255	41.816	43.922	0.16	0.17	2.22	73	-1.98	1.79	70	-0.3	73	0.100	96	97	1.0	0	297	189	296	383	349	303	155	83	68	83	68	68	-0.016	2.9	0.25
260	42.636	44.789	0.16	0.17	2.25	73	-1.98	1.80	70	-0.1	74	0.100	96	97	0.9	-0.1	293	188	293	378	345	299	153	82	68	81	68	68	-0.016	2.83	0.23
265	43.457	45.656	0.16	0.17	2.25	73	-1.65	1.81	70	-0.3	74	0.100	96	97	0.9	0	289	185	290	373	341	298	152	81	68	86	68	69	-0.015	2.81	0.21
270	44.278	46.523	0.16	0.17	2.25	73	-1.99	1.79	70	0	73	0.090	102	102	0.8	-0.1	285	184	287	368	338	295	151	80	68	88	68	68	-0.015	2.85	0.22
275	45.100	47.390	0.16	0.17	2.26	73	-1.97	1.79	70	-0.3	73	0.100	96	97	0.8	0	281	183	286	363	335	290	149	79	68	86	68	68	-0.014	2.91	0.22
280	45.921	48.256	0.16	0.17	2.25	73	-1.82	1.80	70	0	72	0.100	96	96	0.8	0	279	181	284	358	333	287	148	86	68	83	68	68	-0.015	2.93	0.23
285	46.742	49.124	0.16	0.17	2.23	73	-1.97	1.80	70	0	73	0.100	96	97	0.8	0	275	181	284	355	330	285	147	84	68	82	68	68	-0.014	2.92	0.23
290	47.562	49.991	0.16	0.17	2.25	73	-1.89	1.80	70	-0.2	72	0.100	96	97	0.8	0	274	180	283	351	328	283	147	83	68	80	68	68	-0.014	2.94	0.24
295	48.383	50.858	0.16	0.17	2.26	73	-1.99	1.80	70	-0.2	73	0.090	102	102	0.8	0	272	179	282	349	327	282	147	81	68	80	67	68	-0.014	2.95	0.24
300	49.202	51.724	0.16	0.17	2.24	73	-1.58	1.80	70	0	73	0.090	101	102	0.7	-0.1	270	178	283	347	327	281	150	86	68	85	67	68	-0.014	2.96	0.32
305	50.022	52.590	0.16	0.17	2.25	73	-1.67	1.80	70	-0.3	73	0.090	101	102	0.7	0	270	177	283	349	328	281	149	85	68	83	67	68	-0.014	3.28	0.31
310	50.843	53.457	0.16	0.17	2.23	73	-1.58	1.80	70	-0.2	73	0.090	102	102	0.6	-0.1	270	177	280	352	329	282	148	83	68	81	67	68	-0.014	3.3	0.33
315	51.663	54.325	0.16	0.17	2.26	73	-1.79	1.79	70	-0.2	73	0.090	101	102	0.6	0	271	177	280	355	330	283	148	82	67	80	67	68	-0.014	3.31	0.32
320	52.484	55.191	0.16	0.17	2.23	73	-1.57	1.80	70	0	73	0.100	96	96	0.5	-0.1	269	175	278	357	331	282	148	84	67	83	67	68	-0.014	3.2	0.26
325	53.304	56.057	0.16	0.17	2.25	72	-1.97	1.80	70	0	73	0.100	96	96	0.4	-0.1	267	175	278	357	331	282	147	84	67	83	67	68	-0.014	3.08	0.27
330	54.125	56.923	0.16	0.17	2.23	72	-1.57	1.79	70	-0.1	72	0.090	102	102	0.4	0	267	174	276	357	331	281	147	82	67	81	67	67	-0.014	2.98	0.23
335	54.945	57.791	0.16	0.17	2.26	72	-1.91	1.79	70	-0.2	73	0.090	102	102	0.4	0	266	173	275	355	330	280	146	81	67	80	67	67	-0.014	2.84	0.23
340	55.767	58.657	0.16	0.17	2.25	72	-1.98	1.80	70	0	72	0.100	97	96	0.4	0	265	172	273	353	328	279	146	80	67	79	67	67	-0.014	2.84	0.23
345	56.588	59.522	0.16	0.17	2.25	72	-1.6	1.80	70	-0.1	72	0.100	96	96	0.3	-0.1	265	171	272	352	327	277	145	83	67	86	67	67	-0.014	2.79	0.25
350	57.408	60.388	0.16	0.17	2.26	72	-1.89	1.79	70	-0.3	72	0.090	102	102	0.3	0	264	169	272	350	325	276	145	82	67	83	67	67	-0.014	2.83	0.23
355	58.228	61.254	0.16	0.17	2.24	72	-1.84	1.80	70	-0.3	71	0.090	101	102	0.3	0	262	170	272	348	323	275	145	81	67	81	67	67	-0.014	2.79	0.23

Wood Heater Test Data - ASTM E3053 / ASTM E2515

Run: 4
 Manufacturer: ESSE
 Model: WarmHeart
 Tracking No: 240A
 Project No: 22240/S009E
 Test Date: 12/22/20
 Beginning Clock Time: 13:06
 Meter Box Y Factor: 0.995 (1) 0.991 (2)
 Barometric Pressure: Begin Middle End Average
 29.19 28.96 29.08 "Hg
 OMNI Equipment Numbers:

PM Control Modules: 271, 372
 Dilution Tunnel MW(dry): 229.00
 Dilution Tunnel MW(wet): 28.78 lb/lb-mole
 Dilution Tunnel H₂O: 0.244 H₂O
 Tunnel Area: 0.19635 ft²
 Pilot Tube Cp: 0.99
 Avg. Tunnel Velocity: 19.91 ft/sec
 Initial Tunnel Flow: 229.7 scfm
 Average Tunnel Flow: 219.5 scfm
 Post-Test Leak Check (1): 0.000 cfm @ 8 in. Hg
 Post-Test Leak Check (2): 0.000 cfm @ 10 in. Hg
 Average Test Piece Fuel Moisture: 24.10 Dry Basis %

Technician Signature: 

Velocity Traverse Data									
	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Pt. 7	Pt. 8	Center
Initial dP	0.078	0.093	0.094	0.086	0.072	0.090	0.092	0.084	0.094
Temp:	70	70	70	70	70	70	70	70	71
V _{center}	19.82 ft/sec				V _{center} 20.64 ft/sec				F _p 0.960

Elapsed Time (min)	Particulate Sampling Data														Temperature Data (°F)										Stack Gas Data						
	Gas Meter 1 (ft ³)	Gas Meter 2 (ft ³)	Sample Rate 1 (cfm)	Sample Rate 2 (cfm)	Orifice dH 1 (H ₂ O)	Meter 1 Temp (°F)	Meter 1 Vacuum (°Hg)	Orifice dH 2 (H ₂ O)	Meter 2 Temp (°F)	Meter 2 Vacuum (°Hg)	Dilution Tunnel (°F)	Dilution Tunnel Center dP	Pro. Rate 1	Pro. Rate 2	Scale Reading	Weight Change	Firebox Top	Firebox Bottom	Firebox Back	Firebox Left	Firebox Right	Avg. Slove Surface	Stack	Filter 1	Dryer Exit 1	Filter 2	Dryer Exit 2	Ambient	Draft (H ₂ O)	CO ₂ (%)	CO (%)
360	59.049	62.121	0.16	0.17	2.25	72	-1.63	1.81	69	-0.1	71	0.100	96	97	0.2	-0.1	260	169	271	345	322	273	144	80	67	80	67	66	-0.014	2.53	0.21
365	59.869	62.986	0.16	0.17	2.25	72	-1.66	1.80	69	-0.3	71	0.100	96	96	0.2	0	259	168	269	341	320	271	144	84	67	86	67	66	-0.014	2.47	0.2
370	60.689	63.851	0.16	0.17	2.25	72	-1.63	1.80	69	-0.3	71	0.100	96	96	0.1	-0.1	257	167	268	337	318	269	143	86	67	83	67	66	-0.013	2.45	0.19
375	61.508	64.717	0.16	0.17	2.24	72	-1.6	1.79	69	0	70	0.090	101	102	0.1	0	255	166	268	333	316	268	141	84	67	81	67	66	-0.013	2.4	0.18
380	62.329	65.584	0.16	0.17	2.27	72	-1.99	1.80	69	-0.1	70	0.100	96	97	0.1	0	254	166	265	329	313	265	141	82	67	80	67	65	-0.014	2.38	0.17
385	63.148	66.449	0.16	0.17	2.26	72	-1.84	1.80	69	0	70	0.090	101	101	0.1	0	250	165	263	325	311	263	140	81	67	83	67	65	-0.013	2.34	0.16
390	63.969	67.315	0.16	0.17	2.26	72	-1.96	1.80	69	0	70	0.100	96	96	0.1	0	248	164	262	322	308	261	139	80	67	83	67	66	-0.013	2.3	0.16
395	64.790	68.180	0.16	0.17	2.25	72	-1.67	1.80	69	-0.3	70	0.090	101	101	0.0	-0.1	247	163	260	318	305	259	138	82	67	81	67	66	-0.012	2.29	0.16
AvgTot	64.790	68.180	0.16	0.17	2.26	73	-1.79	1.80	69	-0.3	70	0.093	100	100								143.8			68	82	68	68	-0.029		

OMNI-Test Laboratories, Inc.

Wood Heater Test Results - ASTM E3053 / ASTM E2515

Manufacturer: ESSE
 Model: WarmHeart
 Project No.: 0224WS009E
 Tracking No.: 2400A
 Run: 4
 Test Date: 12/16/20

Burn Rate	0.70 kg/hr dry
Average Tunnel Temperature	77 degrees Fahrenheit
Average Gas Velocity in Dilution Tunnel - vs	19.91 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	13167.2 dscf/hour
Average Delta p	0.093 inches H2O
Total Time of Test	395 minutes

	AMBIENT	SAMPLE TRAIN 1	SAMPLE TRAIN 2	FIRST HOUR FILTER (TRAIN 1)
Total Sample Volume - Vm	0.000 cubic feet	64.790 cubic feet	68.180 cubic feet	9.831 cubic feet
Average Gas Meter Temperature	68 degrees Fahrenheit	73 degrees Fahrenheit	69 degrees Fahrenheit	73 degrees Fahrenheit
Total Sample Volume (Standard Conditions) - Vmstd	0.000 dscf	62.445 dscf	65.766 dscf	9.474 dscf
Total Particulates - m _n	0 mg	5.9 mg	6.8 mg	2.8 mg
Particulate Concentration (dry-standard) - C _p /C _s	0.000000 grams/dscf	0.00009 grams/dscf	0.00010 grams/dscf	0.00030 grams/dscf
Total Particulate Emissions - E _T	0.00 grams	8.19 grams	8.96 grams	3.89 grams
Particulate Emission Rate	0.00 grams/hour	1.24 grams/hour	1.36 grams/hour	3.89 grams/hour
Emissions Factor		1.77 g/kg	1.94 g/kg	1.87 g/kg
Difference from Average Total Particulate Emissions		0.39 grams	0.39 grams	

Dual Train Comparison Results Are Acceptable

FINAL AVERAGE RESULTS	
Complete Test Run	
Total Particulate Emissions - E _T	8.58 grams
Particulate Emission Rate	1.30 grams/hour
Emissions Factor	1.85 grams/kg
First Hour Emissions	
Total Particulate Emissions - E _T	3.89 grams
Particulate Emission Rate	3.89 grams/hour
Emissions Factor	1.87 grams/kg
7.5% of Average Total Particulate Emissions	0.64 grams

QUALITY CHECKS	
Filter Temps < 90 °F	OK
Filter Face Velocity (47 mm)	OK
Dryer Exit Temp < 80F	OK
Leakage Rate	OK
Ambient Temp (55-90°F)	OK
Negative Probe Weight Eval.	OK
Pro-Rate Variation	OK
Train A - Train B G/KG ≤ 0.5	0.17
Total PM Precision (%)	4.50

Technician Signature:  _____

Control No. P-SSAR-0003

Medium Burn Run 4

Wood Heater Efficiency Results - CSA B415.1

Manufacturer: ESSE
Model: WarmHeart
Date: 12/16/20
Run: 4
Control #: 0224WS009E
Test Duration: 395
Output Category: I

Technician Signature: 

Test Results in Accordance with CSA B415.1-09

	HHV Basis	LHV Basis
Overall Efficiency	75.4%	80.7%
Combustion Efficiency	94.5%	94.5%
Heat Transfer Efficiency	80%	85.4%

Output Rate (kJ/h)	10,543	10,001	(Btu/h)
Burn Rate (kg/h)	0.70	1.54	(lb/h)
Input (kJ/h)	13,976	13,258	(Btu/h)

Test Load Weight (dry kg)	4.61	10.15	dry lb
MC wet (%)	19.41982272		
MC dry (%)	24.10		
Particulate (g)	8.58		
CO (g)	382		
Test Duration (h)	6.58		

Emissions	Particulate	CO
g/MJ Output	0.12	5.51
g/kg Dry Fuel	1.86	82.98
g/h	1.30	58.07
lb/MM Btu Output	0.29	12.80

Air/Fuel Ratio (A/F)	17.46
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VERSION:

2.2

12/14/2009

Values to be input manually

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For Usable Firebox Volumes up to 3.0 ft ³ - Low and Medium Fire				
Nominal Required Load Density (wet basis)	12	lb/ft ³		
Usable Firebox Volume	1.09	ft ³		
Total Nom. Load Wt. Target	13.08	lb		
Total Load Wt. Allowable Range	12.43	to 13.73	lb	
Core Target Wt. Allowable Range	5.886	to 8.50	lb	
Remainder Load Wt. Allowable Range	4.58	to 7.19	lb	
				Mid-Point
Core Load Fuel Pc. Wt. Allowable Range	1.96	to 3.27	lb	2.62
Remainder Load Pc. Wt. Allowable Range	1.31	to 3.92	lb	2.62
	Pc. #			
Core Load Piece Wt. Actual	1	2.80	lb	In Range
	2	2.90	lb	In Range
	3	2.20	lb	In Range
Core Load Total. Wt. Actual		7.90	lb	In Range
	Pc. #			
Remainder Load Piece Wt.	1	3.30	lb	In Range
(2 or 3 Pcs.)	2	1.40	lb	In Range
	3		lb	NA
Remainder Load Piece Weight Ratio - Small/Large		42%		In Range ≤ 67%
Remainder Load Tot. Wt. Act		4.70	lb	In Range
Total Load Wt. Actual		12.60	lb	In Range
Core % of Total Wt.		63%		In Range 45-65%
Remainder % of Total Wt.		37%		In Range 35-55%
Actual Load % of Nominal Target		96%		In Range 95-105%
Actual Fuel Load Density		11.6	lb/ft ³	
Allowable Charcoal Bed Wt. Range (lb)	1.3	to 2.5		Mid-Point
Actual Charcoal Bed Wt.		1.4	lb	In Range 1.9
Actual Fuel Load Ending Wt.		0.0	lb	Valid Test ≥ 90%
Total Wt. of Fuel Burned During Test Run lb.		12.6	lb	

Fuel Piece Moisture Reading (%-dry basis)									
1	2	3	Ave.		Pc. Wt. Dry Basis				
28	28	23.8	26.6	In Range	2.21	lb	1.00	kg	
27.4	27.2	25.1	26.6	In Range	2.29	lb	1.04	kg	
22.8	21	18	20.6	In Range	1.82	lb	0.83	kg	
24.7	25.1	23.2	24.3	In Range	2.65	lb	1.20	kg	
19.4	19.2	20.1	19.6	In Range	1.17	lb	0.53	kg	
			NA	NA	NA	lb	NA	kg	
Total Load Ave. MC % (dry basis)				24.1	In Range				
Total Load Ave. MC % (wet basis)				19.4					
Total Test Load Weight (dry basis)						10.15	lb	4.61	kg
Total Fuel Weight Burned During Test Run (dry basis)						10.2	lb	4.61	kg

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 4
 Model: WarmHeart Tracking Number: 240A Date: 12/16/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: _____

Wood Heater Supplemental Data

Start Time: 1308 Booth #: N/A

Stop Time: 1943

Stack Gas Leak Check:

Initial: good Final: good

Sample Train Leak Check:

A: 0.0 @ 8"Hg
 B: 0.0 @ 10"Hg

Calibrations: Span Gas CO₂: 17.06 CO: 4.29

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	<u>1225</u>	<u>1225</u>	<u>1957</u>	<u>1957</u>
CO ₂	<u>0.00</u>	<u>17.06</u>	<u>0.07</u>	<u>16.97</u>
CO	<u>0.00</u>	<u>4.29</u>	<u>0.00</u>	<u>4.27</u>

Air Velocity (ft/min): Initial: 450 Final: 452

Scale Audit (lbs): Initial: 10.0 Final: 10.0

Pitot Tube Leak Test: Initial: good Final: good

Stack Diameter (in): 6"

Induced Draft: 0.0

% Smoke Capture: 100%

Flue Pipe Cleaned Prior to First Test in Series:

Date: 12/16/20 Initials: rc

	Initial	Middle	Ending
P _b (in/Hg)	<u>29.19</u>		<u>28.96</u>
RH (%)			
Ambient (°F)	<u>68</u>		<u>66</u>

Tunnel Traverse		
Microtector Reading	dP (in H ₂ O)	T(°F)
	<u>.078</u>	<u>70</u>
	<u>.093</u>	<u>70</u>
	<u>.094</u>	<u>70</u>
	<u>.086</u>	<u>70</u>
	<u>.072</u>	<u>70</u>
	<u>.090</u>	<u>70</u>
	<u>.092</u>	<u>70</u>
	<u>.084</u>	<u>70</u>
Center:		
	<u>.094</u>	<u>71</u>

Background Filter Volume: N/A

Tunnel Static Pressure (in H ₂ O):	
Beginning of Test	End of Test
<u>-.244</u>	<u>-.244</u>

Technician Signature: [Signature]

Date: 12/16/20

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 4
 Model: WarmHeart Tracking Number: 240A Date: 12/16/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: _____

Wood Heater Run Notes

Air Control Settings

Primary: _____ Secondary: Fixed
 Tertiary/Pilot: N/A
 Fan: N/A

6" from outside of left leg to right edge of air control.

Preburn Notes

Time	Notes

Test Notes

Sketch test fuel configuration:

See photo

Start up procedures & Timeline:

Bypass: N/A
 Fuel loaded by: 40 seconds
 Door closed at: 2:30 min
 Primary air: Fully open until 15:30 then set to test setting
 Notes: N/A

Time	Notes
60	Changed front filter in h.a. n.a.
4hr 50min	Shoved coals due to no weight loss in 20 min

Technician Signature: [Signature]

Date: 12/16/20

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Section 4

Quality Assurance/Quality Control

QUALITY ASSURANCE/QUALITY CONTROL

OMNI follows the guidelines of ISO/IEC 17025, “General Requirements for the Competence of Testing and Calibration Laboratories,” and the quality assurance/quality control (QA/QC) procedures found in OMNI’s Quality Assurance Manual.

OMNI’s scope of accreditation includes, but is not limited to, the following:

- ANSI (American National Standards Institute) for certification of product to safety standards.
- To perform product safety testing by the International Accreditation Service, Inc. (formerly ICBO ES) under accreditation as a testing laboratory designated TL-130.
- To perform product safety testing as a “Certification Organization” by the Standards Council of Canada (SCC).
- Serving as a testing laboratory for the certification of wood heaters by the U.S. Environmental Protection Agency.

This report is issued within the scope of OMNI’s accreditation. Accreditation certificates are available upon request.

The manufacturing facilities and quality control system for the production of the WarmHeart and BakeHeart at Esse Engineering Ltd. were evaluated to determine if sufficient to maintain conformance with OMNI’s requirements for product certification. OMNI has concluded that the manufacturing facilities, processes, and quality control system are adequate to produce the appliance congruous with the standards and model codes to which it was evaluated.

This report shall not be reproduced, except in full, without the written approval of OMNI-Test Laboratories, Inc.

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Sample Analysis
Analysis Worksheets
Tared Filter, Probe, and O-Ring Data

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 1
 Model: WarmHeart Tracking Number: 2400A Date: 12/15/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: 637, 283A, 592

ASTM E2515 Lab Sheet

Assembled By:

B Davis

Date/Time in Dessicator:

12/17/20 15:25

Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
Date/Time: <u>12/21/20</u>	Date/Time: <u>12/22/20</u>	Date/Time: <u>01/04/21</u>	Date/Time: <u>01/06/2021</u>	Date/Time:
R/H %: <u>18.6</u>	R/H %: <u>19.3</u>	R/H %: <u>13.6</u>	R/H %: <u>10.1</u>	R/H %:
Temp: <u>66.4</u>	Temp: <u>65.8</u>	Temp: <u>63.5</u>	Temp: <u>66.0</u>	Temp:
200 mg Audit: <u>200.0</u>	200 mg Audit: <u>199.9</u>	200 mg Audit: <u>200.1</u>	200 mg Audit: <u>200.2</u>	200 mg Audit:
2 g Audit: <u>200.3</u>	2 g Audit: <u>200.3</u>	2 g Audit: <u>200.3</u>	2 g Audit:	2 g Audit:
100 g Audit: <u>99997.8</u>	100 g Audit: <u>99997.8</u>	100 g Audit: <u>99998.5</u>	100 g Audit:	100 g Audit:
Initials: <u>DL</u>	Initials: <u>TT</u>	Initials: <u>TT</u>	Initials: <u>TT</u>	Initials:

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A (First Hour)	Front Filter	T293S	96.5	99.1	98.9			
	Rear Filter							
	Probe							
	O-Ring Set							
A (Remainder)	Front Filter	T288AP	192.1	194.5	194.2	194.0		
	Rear Filter							
	Probe	12	114285.0	114286.3		114286.2		
	O-Ring Set	S061	3515.5	3515.8	3515.7			
B	Front Filter	T288BP	193.4	197.6	197.1	197.5	197.5	
	Rear Filter							
	Probe	17	114562.9	114563.7		114563.9		
	O-Ring Set	S062	3324.2	3324.8	3324.6			
BG	Filter	N/A						

Technician Signature: B Davis

Date: 1/6/21

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 2
 Model: WarmHeart Tracking Number: 2401A Date: 12/15/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: 637, 831, 592

ASTM E2515 Lab Sheet

Assembled By: B.D.

Date/Time in Dessicator: 12/17/20 1525

Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
Date/Time: <u>12/20/20 1035</u>	Date/Time: <u>12/22/20 8:55</u>	Date/Time: <u>01/09/21 8:20</u>	Date/Time:	Date/Time:
R/H %:	R/H %:	R/H %:	R/H %:	R/H %:
Temp:	Temp: <u>19.3</u>	Temp: <u>13.6</u>	Temp:	Temp:
200 mg Audit:	200 mg Audit: <u>65.8</u>	200 mg Audit: <u>63.5</u>	200 mg Audit:	200 mg Audit:
2 g Audit:	2 g Audit: <u>199.9</u>	2 g Audit: <u>200.1</u>	2 g Audit:	2 g Audit:
100 g Audit:	100 g Audit: <u>2000.3</u>	100 g Audit: <u>2000.3</u>	100 g Audit:	100 g Audit:
Initials:	Initials: <u>TT</u>	Initials: <u>TT</u>	Initials:	Initials:

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A (First Hour)	Front Filter	<u>T294S</u>	<u>90.3</u>	<u>94.4</u>	<u>94.4</u>			
	Rear Filter							
	Probe							
	O-Ring Set							
A (Remainder)	Front Filter	<u>T289BP</u>	<u>189.9</u>	<u>192.8</u> <u>197.602</u>	<u>192.9</u> <u>197.2</u>			
	Rear Filter							
	Probe	<u>24</u>	<u>114127.8</u>	<u>114128.4</u>		<u>114128.4</u>		
	O-Ring Set	<u>S063</u>	<u>3374.1</u>	<u>3374.7</u>	<u>3374.5</u>			
B	Front Filter	<u>T289BP</u>	<u>190.1</u>	<u>197.6</u>	<u>197.2</u>	<u>197.4</u>		
	Rear Filter							
	Probe	<u>31</u>	<u>114364.0</u>	<u>114365.1</u>		<u>114365.2</u>		
	O-Ring Set	<u>S064</u>	<u>3349.0</u>	<u>3349.5</u>	<u>3349.7</u>			
BG	Filter	<u>N/A</u>						

Technician Signature: B.D.

Date: 1/4/21

Wood Heater Run Sheets

Client: ESSE Project Number: 0224WS009E Run Number: 4
 Model: WarmHeart Tracking Number: 2400A Date: 12/16/20
 Test Crew: B Davis
 OMNI Equipment ID numbers: 637, 281A, 592

ASTM E2515 Lab Sheet

Assembled By: *DD*

Date/Time in Dessicator: 12/17/20 1525

Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
Date/Time: <u>12/16/20 12:35</u>	Date/Time: <u>12/22/20 8:50</u>	Date/Time: <u>01/04/2021 8:30</u>	Date/Time:	Date/Time:
R/H %: <u>18.6</u>	R/H %: <u>19.3</u>	R/H %: <u>13.6</u>	R/H %:	R/H %:
Temp: <u>66.4</u>	Temp: <u>65.8</u>	Temp: <u>63.5</u>	Temp:	Temp:
200 mg Audit: <u>200.0</u>	200 mg Audit: <u>199.9</u>	200 mg Audit: <u>200.1</u>	200 mg Audit:	200 mg Audit:
2 g Audit: <u>2000.3</u>	2 g Audit: <u>2000.3</u>	2 g Audit: <u>2000.3</u>	2 g Audit:	2 g Audit:
100 g Audit: <u>99997.4</u>	100 g Audit: <u>99997.8</u>	100 g Audit: <u>99998.5</u>	100 g Audit:	100 g Audit:
Initials: <u>DD</u>	Initials: <u>TT</u>	Initials: <u>TT</u>	Initials:	Initials:

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A (First Hour)	Front Filter	7295S	88.7	91.8	91.3	91.5		
	Rear Filter							
	Probe							
	O-Ring Set							
A (Remainder)	Front Filter	7290AP	186.7	188.7	188.3	188.5		
	Rear Filter							
	Probe	25	114300.5	114301.6		114301.4		
	O-Ring Set	5065	3413.4	3413.9	3413.8			
B	Front Filter	7290 AP	182.2	187.3	186.8	187.0		
	Rear Filter							
	Probe	29	114276.5	114277.9	114272.8			
	O-Ring Set	5066	3584.3	3585.1	3585.0			
BG	Filter	N/A						

Technician Signature: *DD*

Date: 1/4/21

Tare Sheet: (check one)

Probes _____

47mm Filters

100mm Filters _____

O-Ring Pair _____

Prepared By: Tony Tony

Balance ID #: 00637

Thermohyrometer ID #: 00592

Audit Weight ID #/Mass: 00283A 1.200 mg

Placed in Dessicator:	Date: <u>09/24/20</u>	Date: <u>09/29/20</u>	Date: _____	Date: _____	Date Used	Project Number	Run No.
Date: <u>09/23/20</u>	Time: <u>15:30</u>	Time: <u>8:00</u>	Time: _____	Time: _____			
Time: <u>15:20</u>	RH %: <u>18.5</u>	RH %: <u>23.3</u>	RH %: _____	RH %: _____			
ID #	T (°F): <u>75.5</u>	T (°F): <u>75.0</u>	T (°F): _____	T (°F): _____			
	Audit: <u>200.1</u>	Audit: <u>200.0</u>	Audit: _____	Audit: _____			
T 293 S	96.5	96.5	/		12-15-20	0224WS009 E	1
T 294 S	90.3	90.3	/		↓		2
T 295 S	88.8	88.7	/		12-16-20		4
T 296 S	88.7	88.6	/				
T 297 S	89.3	89.2	/				
T 298 S	88.3	88.3	/				
T 299 S	96.8	96.8	/				
T 300 S	96.5	96.4	/				
T 301 S	96.3	96.2	/				
T 302 S	97.6	97.4	/				
T 303 S	96.4	96.6	/				
T 304 S	90.7	90.5	/				
T 305 S	93.9	93.9	/				
T 306 S	94.0	93.8	/				
T 307 S	95.0	94.9	/				
T 308 S	93.8	93.7	/				
T 309 S	94.9	94.8	/				
T 310 S	95.4	95.5	/				
T 311 S	94.7	94.9	/				
T 312 S	95.1	95.1	/				
Initials: <u>TT</u>	Initials: <u>TT</u>	Initials: _____	Initials: _____				

Final Technician Signature: Tony Tony
 Control No. P-SFDP-0002.xls, Effective date: 2/1/2017

Date: 09/29/2020
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Evaluator signature: [Signature]

Tare Sheet: (check one)

Probes _____

47mm Filters

100mm Filters _____

O-Ring Pair _____

Prepared By: Tomy Tong

Balance ID #: 00637

Thermohyrometer ID #: 00592

Audit Weight ID #/Mass: 00283A 1200mg

Placed in Dessicator: Date: <u>07/20/2020</u> Time: <u>16:30</u>	Date: <u>10/21/2020</u> Time: <u>16:30</u> RH %: <u>10.8</u> T (°F): <u>81.1</u> Audit: <u>200.1</u>	Date: <u>7/22/2020</u> Time: <u>14:00</u> RH %: <u>15.9</u> T (°F): <u>79.7</u> Audit: <u>200.1</u>	Date: _____ Time: _____ RH %: _____ T (°F): _____ Audit: _____	Date: _____ Time: _____ RH %: _____ T (°F): _____ Audit: _____	Date Used	Project Number	Run No.
	ID #						
T283AP	195.4	195.4 ✓					
T283BP	186.9	186.9 ✓					
T284AP	181.0	181.1 ✓					
T284BP	191.3	191.2 ✓					
T285AP	191.6	191.6 ✓					
T285BP	190.8	190.9 ✓					
T286AP	194.1	194.1 ✓					
T286BP	195.1	195.2 ✓					
T287AP	194.8	194.9 ✓					
T287BP	191.0	191.1 ✓					
T288AP	192.2	192.1 ✓			12-15-20	0224WS009E	1
T288BP	193.8	193.4 ✓			↓		↓
T289AP	190.1	189.9 ✓			↓		↓
T289BP	190.0	190.1 ✓			↓		↓
T290AP	186.8	186.7 ✓			12-16-20		4
T290BP	182.3	182.2 ✓			↓		↓
T291AP	182.1	182.2 ✓					
T291BP	178.5	178.3 ✓					
T292AP	179.3	179.4 ✓					
T292BP	179.3	179.4 ✓					
Initials: <u>TT</u>	Initials: <u>TT</u>	Initials: _____	Initials: _____	Initials: _____			

Final Technician Signature: Tomy Tong
Control No. P-SFDP-0002.xls, Effective date: 2/1/2017

Date: 7/22/2020
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Evaluator signature: BD

Calibrations

ASTM E2515, ASTM E3053

ID #	Lab Name/Purpose	Log Name	Attachment Type
132	10 lb Weight	Weight Standard, 10 lb.	Calibration Certificate
195050662	Platform Scale	AWTX – ZM301-AD1	Calibration Certificate
650	Digital Barometer	Traceable Barometer	Calibration Certificate
283A	Audit Weights	Troemner 21pc Mass Set	Calibration Certificate
371	Sample Box / Dry Gas Meter	Apex Automated Emissions Sampling Box	Calibration Log
372	Sample Box / Dry Gas Meter	Apex Automated Emissions Sampling Box	Calibration Log
410	Microtector	Dwyer Microtector	Calibration Certificate
559	Vaneometer	Dwyer Vaneometer	Equipment Record
592	Thermohydrometer	Omega Digital Thermohydrometer	Calibration Log
594	Combustion Gas Analyzer	CAI Gas Analyzer	See Run Sheet
637	Milligram Balance	Analytical Balance - Mettler - Toledo	Calibration Certificate

SCALE WEIGHT CALIBRATION DATA SHEET

Weight to be calibrated: 10 pounds

ID Number: OMNI-00132

Standard Calibration Weight: 10 pounds

ID Number: OMNI-00255

Scale Used: MTW-150K

ID Number: OMNI-00353

Date: 2/23/2018

By: B. Davis

Standard Weight (A) (Lb.)	Weight Verified (B) (Lb.)	Difference (A - B)	% Error
10.0	10.0	0.0	0

*Acceptable tolerance is 1%.

This calibration is traceable to NIST using calibrated standard weights.

Technician signature:  Date: 2/23/18

Certificate of Calibration

Certificate Number: **725761**



JJ Calibrations, Inc.

7724 SE Aspen Summit Drive
Portland, OR 97266-9217
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

PO: **200299**
Order Date: **05/28/2020**
Authorized By: **N/A**



0723.01
Calibration

Property #: **OMNI-00650**
User: **N/A**
Department: **N/A**
Make: **Control Company**
Model: **6530**
Serial #: **181062211**
Description: **Thermohygrometer / Barometer**
Procedure: **403406**
Accuracy: **±3%RH, ±.4°C(0.8°F), ±4mbar(0.12inHg)**

Calibrated on: **06/01/2020**
*Recommended Due: **06/01/2021**
Environment: **23 °C 41 % RH**
* As Received: **Within Tolerance**
* As Returned: **Within Tolerance**
Action Taken: **Calibrated**
Technician: **146**

Remarks: * Many factors may cause the unit to drift out of calibration before the recommended due date. Any reported error is the absolute value between the reference and the unit. Uncertainties include the effects of the unit.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
644A	Thunder Scientific	1200	Two Pressure Humidity Generator	10/14/2020	710583

Parameter

Measurement Data

Measurement Description	Range	Unit	Reference	Min	Max	Error	UUT	Uncertainty
Before/After Humidity								Accredited = ✓
		%	25.0	22	28	1	26 %	8.1E-01 ✓
		%	50.0	47	53	3	47 %	8.1E-01 ✓
		%	75.0	72	78	3	72 %	8.1E-01 ✓
Temperature								
		°F	68.00	67.2	68.8	0.2	68.2 °F	1.2E-01 ✓
		°F	86.00	85.2	86.8	0.2	85.8 °F	1.2E-01 ✓
		°F	104.00	103.2	104.8	0.3	104.3 °F	1.2E-01 ✓

This instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual and is traceable to either the SI or to National Institute of Standards and Technology (NIST). The quality system and this certificate are in compliance with ANSI/NCCL Z540-1-1994, ISO/IEC 17025-2017, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. Unless stated in the comments, certificates reflect the "Simple Acceptance Rule" as specified by JCGM 106:2012. Unless otherwise stated, a test accuracy ratio (TAR) of 4:1, if achievable, is maintained. The results reported herein apply only to the calibration of the item described above. This report may not be reproduced, except in full, without written approval of JJ Calibrations.

Reviewer

3 Issued 06/04/2020 Rev # 15

Inspector

Certificate of Calibration



JJ Calibrations, Inc.

7007 SE Lake Rd
Portland, OR 97267-2105
Phone 503.786.3005
FAX 503.786.2994

Certificate Number: **685888**

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

PO: **180188**
Order Date: **10/09/2018**
Authorized By: **N/A**



Calibrated on: **10/26/2018**
*Recommended Due: **10/26/2023**
Environment: **20 °C 57 % RH**
* As Received: **Within Tolerance**
* As Returned: **Within Tolerance**
Action Taken: **Calibrated**
Technician: **139**

Property #: **OMNI-00283A**
User: **N/A**
Department: **N/A**
Make: **Troemner Inc**
Model: **1mg-100g (Class F)**
Serial #: **47883**
Description: **Mass Set, 21pc**
Procedure: **DCN 500901**
Accuracy: **Class F**

Remarks: * Many factors may cause the unit to drift out of calibration before the recommended due date. Any reported error is the absolute value between the reference and the unit. Uncertainties include the effects of the unit.

This set meets Class F specifications.
Received and returned eight (8) masses in a black case secured by a rubber band.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
723A	Rice Lake	1mg-200g (Class 0)	Mass Set,	03/23/2019	668240
800A	Sartorius	MSA225W100DI	Analytical Balance	12/11/2018	663857

Measurement Data

Parameter	Measurement Description	Range Unit	Reference	Min	Max	*Error	UUT	Uncertainty
Before/After								Accredited = ✓
Mass								
Dot	200 mg		200.00030	199.4603	200.5403	0.0500	200.0503 mg	6.2E-01 ✓
	1 g		1.00000880	0.9991088	1.0009088	0.0000000	1.0000088 g	1E-03 ✓
	2 g		2.00001470	1.9989147	2.0011147	0.0003250	2.0003397 g	1.3E-03 ✓
	5 g		5.00000840	4.9985084	5.0015084	0.0000400	4.9999684 g	1.7E-03 ✓
	10 g		10.0000100	9.998010	10.002010	0.000245	9.999765 g	2.3E-03 ✓
Dot	20 g		20.0000140	19.996014	20.004014	0.000990	20.001004 g	4.6E-03 ✓
	50 g		49.9999660	49.989966	50.009966	0.000595	49.999371 g	1.1E-02 ✓
	100 g		100.000000	99.98000	100.02000	0.00194	99.99806 g	2.3E-02 ✓

JJ Calibrations, Inc. certifies that this instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual with the stated procedure using standards that are traceable to the National Institute of Standards and Technology (NIST), or other National Measurement Institutes (NMI's), or by using natural physical constants, intrinsic standards or ratio calibration techniques. The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2005, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. Unless otherwise stated, a test accuracy ratio (TAR) of 4:1, if achievable, is maintained. The results reported herein apply only to the calibration of the item described above. This report may not be reproduced, except in full, without prior written consent of JJ Calibrations, Inc.
JJ Calibrations, Inc. quality system has been assessed and accredited to ISO/IEC 17025:2005.


Reviewer

3 Issued 10/29/2018 Rev # 15


Inspector

Thermal Metering System Calibration

Y Factor

Manufacturer: Apex
 Model: XC-60-EP
 Serial Number: 702003
 OMNI Tracking No.: OMNI-00371
 Calibrated Orifice: Yes

Average Gas Meter y Factor
0.995

Orifice Meter dH@
N/A

Calibration Date: 11/25/20
 Calibrated by: Tony Tong
 Calibration Frequency: Six Month
 Next Calibration Due: 5/25/2021
 Instrument Range: 1.000 cfm
 Standard Temp.: 68 oF
 Standard Press.: 29.92 "Hg
 Barometric Press., Pb: 30.22 "Hg
 Signature/Date: Tony Tong / 11/25/2020


Previous Calibration Comparison

Date	<u>6/15/2020</u>	Acceptable Deviation (5%)	Deviation
y Factor	<u>0.994</u>	0.0497	0.001
Acceptance	Acceptable		

Current Calibration

Acceptable y Deviation	0.020
Maximum y Deviation	0.007
Acceptable dH@ Deviation	N/A
Maximum dH@ Deviation	N/A
Acceptance	Acceptable

Reference Standard *

Standard	Model	Standard Test Meter
Calibrator	S/N	<u>OMNI-00001</u>
	Calib. Date	<u>25-Nov-19</u>
	Calib. Value	<u>0.9981</u> y factor (ref)

Calibration Parameters	Run 1	Run 2	Run 3
Reference Meter Pressure ("H2O), Pr	0.00	0.00	0.00
DGM Pressure ("H2O), Pd	2.20	0.92	3.20
Initial Reference Meter	470.757	476.852	484.075
Final Reference Meter	475.9	481.838	489.442
Initial DGM	0	0	0
Final DGM	5.133	5.042	5.326
Temp. Ref. Meter (°F), Tr	64.6	63.3	63.0
Temperature DGM (°F), Td	65.0	65.0	65.0
Time (min)	32.0	50.0	26.5
Net Volume Ref. Meter, Vr	5.143	4.986	5.367
Net Volume DGM, Vd	5.133	5.042	5.326
Gas Meter y Factor =	0.996	0.988	1.002
Gas Meter y Factor Deviation (from avg.)	0.000	0.007	0.007
Orifice dH@	N/A	N/A	N/A
Orifice dH@ Deviation (from avg.)	N/A	N/A	N/A

where:

1. Deviation = |Average value for all runs - current run value|
- ** 2. $y = [Vr \times (y \text{ factor (ref)}) \times (Pb + (Pr / 13.6)) \times (Td + 460)] / [Vd \times (Pb + (Pd / 13.6)) \times (Tr + 460)]$
- ** 3. $dH@ = 0.0317 \times Pd / (Pb (Td + 460)) \times [(Tr + 460) \times \text{time}] / Vr^2$

* Reference calibration is traceable to NIST through NIST Test # 40674, Kimble ASTM E1272, or NIST traceable laboratory

** Equations come from EPA Method 5

The uncertainty of measurement is $\pm 0.14 \text{ ft}^3/\text{min}$. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA SHEET

Instrument to be calibrated: Pressure Transducer

Maximum Range: 0 – 2" H₂O

ID Number: OMNI-00371

Calibration Instrument: Digital Manometer

ID Number: OMNI-00633

Date: 11/30/2020

By: Tony Tong

This form is to be used only in conjunction with Standard Procedure C-SPC.

Range of Calibration Point ("WC)	Digital Manometer Input ("WC)	Pressure Gauge Response ("WC)	Difference Input – Response	% Error of Full Span*
0-20% Max. Range 0.0 – 0.4	0.088	0.103	0.015	0.75
20-40% Max. Range 0.4 – 0.8	0.476	0.490	0.014	0.70
40-60% Max. Range 0.8 – 1.2	0.971	0.984	0.013	0.65
60-80% Max. Range 1.2 – 1.6	1.427	1.435	0.008	0.40
80-100% Max. Range 1.6 – 2.0	1.700	1.705	0.005	0.25

*Acceptable tolerance is 4%.

The uncertainty of measurement is ± 0.4 " WC. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

Technician signature: Tony Tong

Date: 11/30/2020

Reviewed by: B. [Signature]

Date: 11/30/2020

Temperature Calibration EPA Method 28R, ASTM 2515								
BOOTH:	TEMPERATURE MONITOR TYPE:				EQUIPMENT NUMBER:			
Field Test Kit	National Instruments Logger				00371, 00372			
REFERENCE METER EQUIPMENT NUMBER: 00373				Calibration Due Date:				
CALIBRATION PERFORMED BY:			DATE:		AMBIENT TEMPERATURE:		BAROMETRIC PRESSURE:	
Tony Tong			11/30/2020		70 °F		30.45	
Input Temperature (F)	Ambient	Meter A					Tunnel	FB Interior
			Meter B	Filter A	Filter B			
0	-2	-1	-1	-1	-1	-1	-1	
100	99	99	99	99	99	99	99	
300	299	299	299	299	299	299	299	
500	499	499	499	499	499	499	499	
700	699	699	699	699	699	699	699	
1000	999	999	999	999	999	999	999	
1500	1499	1499	1499	1499	1499	1499	1499	
2000	1999	1999	1999	1999	1999	1999	1999	

Input (F)	FB Top	FB Bottom	FB Back	FB Left	FB Right	Imp A	Imp B	Cat	Stack
0	-1	-1	-1	-1	-1	-1	-1	-1	-1
100	99	99	99	99	99	99	99	99	99
300	299	299	299	299	299	299	299	299	299
500	499	499	499	499	499	499	499	499	499
700	699	699	699	699	699	699	699	699	699
1000	999	999	999	999	999	999	999	999	999
1500	1499	1499	1499	1499	1499	1499	1499	1499	1499
2000	1999	1999	1999	1999	1999	1999	1999	1999	1999

Technician signature: Tony Tong Date: 01/21/2020

Reviewed By: B. [Signature] Date: 01/21/20

Thermal Metering System Calibration Y Factor

Manufacturer: Apex
 Model: XC-60-EP
 Serial Number: 702004
 OMNI Tracking No.: OMNI-00372
 Calibrated Orifice: Yes

Previous Calibration Comparison

Date	6/16/2020	Acceptable Deviation (5%)	Deviation
y Factor	0.998	0.0499	0.007
Acceptance	Acceptable		

Current Calibration

Acceptable y Deviation	0.020
Maximum y Deviation	0.001
Acceptable dH@ Deviation	N/A
Maximum dH@ Deviation	N/A
Acceptance	Acceptable

Average Gas Meter y Factor 0.991

Orifice Meter dH@ N/A
--

Calibration Date: 11/25/20
 Calibrated by: Tony Tong
 Calibration Frequency: Six Month
 Next Calibration Due: 5/25/2021
 Instrument Range: 1.000 cfm
 Standard Temp.: 68 oF
 Standard Press.: 29.92 "Hg
 Barometric Press., Pb: 30.24 "Hg
 Signature/Date: Tony Tong / 11/25/2020

Reference Standard *		
Standard	Model	Standard Test Meter
Calibrator	S/N	<u>OMNI-00001</u>
	Calib. Date	<u>25-Nov-19</u>
	Calib. Value	<u>0.9981</u> y factor (ref)

Calibration Parameters	Run 1	Run 2	Run 3
Reference Meter Pressure ("H2O), Pr	0.00	0.00	0.00
DGM Pressure ("H2O), Pd	1.70	2.58	0.70
Initial Reference Meter	490.143	495.912	503.601
Final Reference Meter	495.2	500.943	508.881
Initial DGM	0	0	0
Final DGM	5.092	5.041	5.34
Temp. Ref. Meter (°F), Tr	64.0	69.0	64.7
Temperature DGM (°F), Td	66.0	70.0	67.0
Time (min)	31.0	24.8	53.0
Net Volume Ref. Meter, Vr	5.057	5.031	5.280
Net Volume DGM, Vd	5.092	5.041	5.34
Gas Meter y Factor =	0.991	0.992	0.990
Gas Meter y Factor Deviation (from avg.)	0.000	0.001	0.001
Orifice dH@	N/A	N/A	N/A
Orifice dH@ Deviation (from avg.)	N/A	N/A	N/A

where:

1. Deviation = |Average value for all runs - current run value|
- ** 2. $y = [Vr \times (y \text{ factor (ref)}) \times (Pb + (Pr / 13.6)) \times (Td + 460)] / [Vd \times (Pb + (Pd / 13.6)) \times (Tr + 460)]$
- ** 3. $dH@ = 0.0317 \times Pd / (Pb (Td + 460)) \times [(Tr + 460) \times \text{time}] / Vr^2$

* Reference calibration is traceable to NIST through NIST Test # 40674, Kimble ASTM E1272, or NIST traceable laboratory

** Equations come from EPA Method 5

The uncertainty of measurement is $\pm 0.14 \text{ ft}^3/\text{min}$. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA SHEET

Instrument to be calibrated: Pressure Transducer

Maximum Range: 0 – 2" H₂O

ID Number: OMNI-00372

Calibration Instrument: Digital Manometer

ID Number: OMNI-00633

Date: 11/30/2020

By: Tony Tong

This form is to be used only in conjunction with Standard Procedure C-SPC.

Range of Calibration Point ("WC)	Digital Manometer Input ("WC)	Pressure Gauge Response ("WC)	Difference Input – Response	% Error of Full Span *
0-20% Max. Range 0.0 – 0.4	0.062	0.072	0.010	0.50
20-40% Max. Range 0.4 – 0.8	0.625	0.629	0.004	0.20
40-60% Max. Range 0.8 – 1.2	1.088	1.092	0.004	0.20
60-80% Max. Range 1.2 – 1.6	1.424	1.428	0.004	0.20
80-100% Max. Range 1.6 – 2.0	1.723	1.734	0.011	0.55

*Acceptable tolerance is 4%.

The uncertainty of measurement is ± 0.4 " WC. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

Technician signature: Tony Tong

Date: 11/30/2020

Reviewed by: B. K. J.

Date: 11/30/2020

Temperature Calibration EPA Method 28R, ASTM 2515								
BOOTH:	TEMPERATURE MONITOR TYPE:					EQUIPMENT NUMBER:		
Field Test Kit	National Instruments Logger					00371, 00372		
REFERENCE METER EQUIPMENT NUMBER: 00373				Calibration Due Date:				
CALIBRATION PERFORMED BY:			DATE:		AMBIENT TEMPERATURE:		BAROMETRIC PRESSURE:	
Tony Tong			11/30/2020		70 °F		30.45	
Input Temperature (F)	Ambient	Meter A					Tunnel	FB Interior
			Meter B	Filter A	Filter B			
0	-2	-1	-1	-1	-1	-1	-1	
100	99	99	99	99	99	99	99	
300	299	299	299	299	299	299	299	
500	499	499	499	499	499	499	499	
700	699	699	699	699	699	699	699	
1000	999	999	999	999	999	999	999	
1500	1499	1499	1499	1499	1499	1499	1499	
2000	1999	1999	1999	1999	1999	1999	1999	

Input (F)	FB Top	FB Bottom	FB Back	FB Left	FB Right	Imp A	Imp B	Cat	Stack
0	-1	-1	-1	-1	-1	-1	-1	-1	-1
100	99	99	99	99	99	99	99	99	99
300	299	299	299	299	299	299	299	299	299
500	499	499	499	499	499	499	499	499	499
700	699	699	699	699	699	699	699	699	699
1000	999	999	999	999	999	999	999	999	999
1500	1499	1499	1499	1499	1499	1499	1499	1499	1499
2000	1999	1999	1999	1999	1999	1999	1999	1999	1999

Technician signature: Tony Tong Date: 01/21/2020

Reviewed By: B. P. D. Date: 01/21/2020

Certificate of Calibration

Certificate Number: **712014**



JJ Calibrations, Inc.

7724 SE Aspen Summit Drive
Portland, OR 97266-9217
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230



PO: **190268**
Order Date: **10/29/2019**
Authorized By: **N/A**
Calibrated on: **11/07/2019**
*Recommended Due: **11/07/2020**
Environment: **19 °C 38 % RH**
* As Received: **Limited**
* As Returned: **Limited**
Action Taken: **Calibrated**
Technician: **53**

Property #: **OMNI-00410**
User: **N/A**
Department: **N/A**
Make: **Dwyer**
Model: **1430**
Serial #: **OMNI-00410**
Description: **Microtector**
Procedure: **500364**
Accuracy: **±0.00025" WC**

Remarks: * Many factors may cause the unit to drift out of calibration before the recommended due date. Any reported error is the absolute value between the reference and the unit. Uncertainties include the effects of the unit.

Previous limitation continued: **Calibrated micrometer head only.**

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
541A	Select	E8FED2	Gage Block Set, 8pc	12/30/2019	689507

Parameter

Measurement Data

Measurement Description	Range	Unit	Reference	Min	Max	±Error	UUT	Uncertainty
Before/After Length								Accredited = ✓
	Inch		0.1300	0.129	0.131	0.000	0.130 Inch	8.1E-03 ✓
	Inch		0.3850	0.384	0.386	0.000	0.385 Inch	8.1E-03 ✓
	Inch		0.6150	0.614	0.616	0.000	0.615 Inch	8.1E-03 ✓
	Inch		0.8700	0.869	0.871	0.000	0.870 Inch	8.1E-03 ✓
	Inch		1.0000	0.999	1.001	0.000	1.000 Inch	8.1E-03 ✓

This instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual and is traceable to either the SI or to National Institute of Standards and Technology (NIST). The quality system and this certificate are in compliance with ANSI/NC SL Z540-1-1994, ISO/IEC 17025-2017, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. Unless stated in the comments, certificates reflect the "Simple Acceptance Rule" as specified by JCGM 106:2012. Unless otherwise stated, a test accuracy ration (TAR) of 4:1, if achievable, is maintained. The results reported herein apply only to the calibration of the item described above. This report may not be reproduced, except in full, without written approval of JJ Calibrations.


Reviewer

3 Issued 11/08/2019 Rev # 15


Inspector

Certificate of Calibration

Certificate Number: **742797**



JJ Calibrations, Inc.

7724 SE Aspen Summit Drive
Portland, OR 97266-9217
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

PO: **210345**
Order Date: **02/18/2021**
Authorized By: **N/A**



Property #: **OMNI-00410**
User: **N/A**
Department: **N/A**
Make: **Dwyer**
Model: **1430**
Serial #: **OMNI-00410**
Description: **Microtector**
Procedure: **500908**
Accuracy: **±0.00025" WC**

Calibrated on: **03/02/2021**
*Recommended Due: **03/02/2022**
Environment: **19 °C 39 % RH**
* As Received: **Limited**
* As Returned: **Limited**
Action Taken: **Calibrated**
Technician: **111**

Remarks: * Many factors may cause the unit to drift out of calibration before the recommended due date. Any reported error is the absolute value between the reference and the unit. Uncertainties include the effects of the unit.

Previous limitation of Micrometer Head calibrated only continued. Unit was received and returned in a case.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
541A	Select	E8FED2	Gage Block Set, 8pc	12/09/2021	738140

Measurement Data

Parameter	Measurement Description	Range Unit	Reference	Min	Max	*Error	UUT	Uncertainty
Before/After								Accredited = \bar{U}
Length		Inch	0.1300	0.129	0.131	0.000	0.130 Inch	5.7E-04 \bar{U}
		Inch	0.3850	0.384	0.386	0.000	0.385 Inch	5.7E-04 \bar{U}
		Inch	0.6150	0.614	0.616	0.000	0.615 Inch	5.7E-04 \bar{U}
		Inch	0.8700	0.869	0.871	0.000	0.870 Inch	5.7E-04 \bar{U}
		Inch	1.0000	0.999	1.001	0.000	1.000 Inch	5.7E-04 \bar{U}

This instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual and is traceable to either the SI or to National Institute of Standards and Technology (NIST). The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2017, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. Unless stated in the comments, certificates reflect the "Simple Acceptance Rule" as specified by JCGM 106:2012. Unless otherwise stated, a test accuracy ratio (TAR) of 4:1, if achievable, is maintained. The results reported herein apply only to the calibration of the item described above. This report may not be

Reviewer

3 Issued 03/09/2021 Rev # 15

Inspector

VWR Temperature Hygrometer Calibration Procedure and Data Sheet

Frequency: Every Two Years

Step 1: Locate NIST traceable standard.

Step 2: Place unit to be calibrated, tracking No. OMNI-00592, inside OMNI desiccate box on the same shelf with the NIST traceable standard.

Step 3: After a period of not less than four hours record the temperature and humidity of both units in the spaces provide below.

Step 4: If the unit to be calibrated matches the NIST standard within $\pm 4\%$, it is acceptable. If not, the unit needs to be sent to a repair company or replaced.

Verification Data:

Date: 1/29/19
1/29/19 Technician: B. Davis

Time in desiccate: 0840 Recording time: 1415

NIST Standard Temperature: 70.2 °F NIST Standard Humidity: 14.6

Test Unit Temperature Reading: 69.9 °F Test Unit Humidity Reading: 12.1

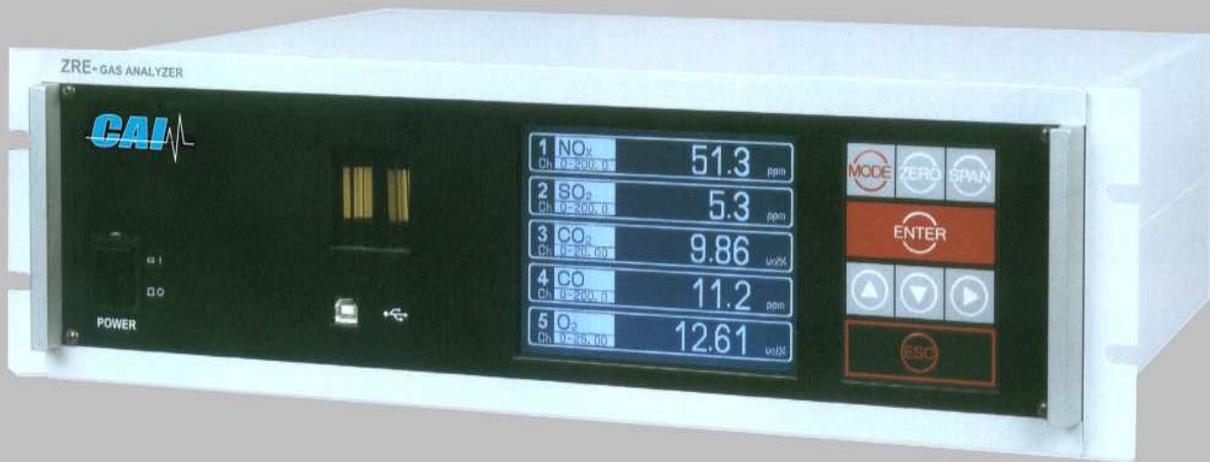
Test unit OMNI-00592 is or was not within acceptable limits.

Technician Signature: [Signature]

Comments: A difference of 2.5% was found, with a full scale of 90%
on the instrument this gives a 2.77% deviation.

ZRE

NDIR/O₂



USER'S

MANUAL



1312 West Grove Avenue
Orange, CA 92865-4134
Phone: 714-974-5560 Fax: 714-921-2531
www.gasanalyzers.com

Certificate of Calibration

Certificate Number: **728321**



JJ Calibrations, Inc.

7724 SE Aspen Summit Drive
Portland, OR 97266-9217
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

OnSite

PO: **200302**

Order Date: **07/09/2020**

Authorized By: **N/A**



Calibrated on: **07/09/2020**

*Recommended Due: **01/09/2021**

Environment: **20 °C 42 % RH**

* As Received: **Within Tolerance**

* As Returned: **Within Tolerance**

Action Taken: **Calibrated**

Technician: **111**

Property #: **OMNI-00637**
User: **N/A**
Department: **N/A**
Make: **Mettler Toledo**
Model: **MS104TS/00**
Serial #: **B729400181**
Description: **Analytical Scale, 120g**
Procedure: **DCN 500887**
Accuracy: **±0.0005g**

Remarks: * Many factors may cause the unit to drift out of calibration before the recommended due date. Any reported error is the absolute value between the reference and the unit. Uncertainties include the effects of the unit.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
503A	Rice Lake	1mg-200g (Class 0)	Mass Set,	08/08/2020	702709

Measurement Data

Parameter	Measurement Description	Range	Unit	Reference	Min	Max	*Error	UUT	Uncertainty
Before/After Force									Accredited = U
			g	10.00000	9.9995	10.0005	0.0001	9.9999 g	9.7E-05 U
			g	30.00000	29.9995	30.0005	0.0000	30.0000 g	1.3E-04 U
			g	60.00000	59.9995	60.0005	0.0000	60.0000 g	2E-04 U
			g	90.00000	89.9995	90.0005	0.0002	90.0002 g	2.4E-04 U
			g	120.00000	119.9995	120.0005	0.0001	120.0001 g	3E-04 U

This instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual and is traceable to either the SI or to National Institute of Standards and Technology (NIST). The quality system and this certificate are in compliance with ANSI/NC SL Z540-1-1994, ISO/IEC 17025-2017, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. Unless stated in the comments, certificates reflect the "Simple Acceptance Rule" as specified by JCGM 106:2012. Unless otherwise stated, a test accuracy ratio (TAR) of 4:1, if achievable, is maintained. The results reported herein apply only to the calibration of the item described above. This report may not be

Reviewer

3 Issued 07/15/2020 Rev # 15

Inspector

Example Calculations

Equations and Sample Calculations – ASTM E3053 & E2515

Manufacturer: ESSE
Model: WarmHeart
Run: 2
Category: Low

Equations used to calculate the parameters listed below are described in this appendix. Sample calculations are provided for each equation. The raw data and printout results from a sample run are also provided for comparison to the sample calculations.

BR – Dry burn rate, kg/hr

V_s – Average gas velocity in the dilution tunnel, ft/sec

Q_{sd} – Average gas flow rate in dilution tunnel, dscf/hr

$V_{m(std)}$ – Volume of gas sampled, corrected to dry standard conditions, dscf

m_n – Total particulate matter collected, mg

C_s - Concentration of particulate matter in tunnel gas, dry basis, corrected to standard conditions, g/dscf

E_T – Total particulate emissions, g

PR - Proportional rate variation

PM_R – Particulate emissions for test run, g/hr

PM_F – Particulate emission factor for test run, g/dry kg of fuel burned

BR – dry burn rate, kg/hr

ASTM E2780 equation (5)

$$BR = \frac{60 M_{FTAdb}}{\theta}$$

Where,

θ = Total length of test run, min

Sample Calculation:

$$M_{Bdb} = 4.68 \quad \text{kg}$$

$$\theta = 385 \quad \text{min}$$

$$BR = \frac{60 \times 4.68}{385}$$

$$BR = \mathbf{0.73} \quad \text{kg/hr}$$

V_s – Average gas velocity in the dilution tunnel, ft/sec

ASTM E2515 equations (9)

$$V_s = F_p \times k_p \times C_p \times (\sqrt{\Delta P})_{avg} \times \sqrt{\frac{T_{s(avg)}}{P_s \times M_s}}$$

Where:

- F_p = Adjustment factor for center of tunnel pitot tube placement, $F_p = \frac{V_{strav}}{V_{scent}}$, ASTM E2515 Equation (1)
- V_{scent} = Dilution tunnel velocity calculated after the multi-point pitot traverse at the center, ft/sec
- V_{strav} = Dilution tunnel velocity calculated after the multi-point pitot traverse, ft/sec
- k_p = Pitot tube constant, 85.49
- C_p = Pitot tube coefficient: 0.99, unitless
- ΔP* = Velocity pressure in the dilution tunnel, in H₂O
- T_s = Absolute average gas temperature in the dilution tunnel, °R; (°R = °F + 460)
- P_s = Absolute average gas static pressure in dilution tunnel, = P_{bar} + P_g, in Hg
- P_{bar} = Barometric pressure at test site, in. Hg
- P_g = Static pressure of tunnel, in. H₂O; (in Hg = in H₂O/13.6)
- M_s = **The dilution tunnel wet molecular weight; M_s = 28.78 assuming a dry weight of 29 lb/lb-mole

Sample calculation:

$$F_p = \frac{19.88}{20.82} = 0.955$$

$$V_s = 0.955 \times 85.49 \times 0.99 \times 0.314 \times \left(\frac{76.8 + 460}{29.49 + \frac{-0.24}{13.6}} \right)^{1/2} \times 28.78$$

$$V_s = \mathbf{20.17 \text{ ft/s}}$$

*The ASTM test standard mistakenly has the square root of the average delta p instead of the average of the square root of delta p. The current EPA Method 2 is also incorrect. This was verified by Mike Toney at EPA.

**The ASTM test standard mistakenly identifies M_s as the dry molecular weight. It should be the wet molecular weight as indicated in EPA Method 2.

Q_{sd} – Average gas flow rate in dilution tunnel, dscf/hr

ASTM E2515 equation (3)

$$Q_{sd} = 3600 \times (1 - B_{ws}) \times v_s \times A \times \frac{T_{std}}{T_{s(avg)}} \times \frac{P_s}{P_{std}}$$

Where:

- 3600 = Conversion from seconds to hours (ASTM method uses 60 to convert in minutes)
- B_{ws} = Water vapor in gas stream, proportion by volume; assume 2%
- A = Cross sectional area of dilution tunnel, ft²
- T_{std} = Standard absolute temperature, 528 °R
- P_s = Absolute average gas static pressure in dilution tunnel, = P_{bar} + P_g, in Hg
- T_{s(avg)} = Absolute average gas temperature in the dilution tunnel, °R; (°R = °F + 460)
- P_{std} = Standard absolute pressure, 29.92 in Hg

Sample calculation:

$$Q_{sd} = 3600 \times (1 - 0.02) \times 20.17 \times 0.196 \times \frac{528}{76.8 + 460} \times \frac{29.5 + \frac{-0.24}{13.6}}{29.92}$$

Q_{sd} = **13535.7** dscf/hr

$V_{m(std)}$ – Volume of Gas Sampled Corrected to Dry Standard Conditions, dscf
 ASTM E2515 equation (6)

$$V_{m(std)} = K_1 V_m Y \frac{P_{bar} + \left(\frac{\Delta H}{13.6}\right)}{T_m}$$

Where:

- K_1 = 17.64 °R/in. Hg
- V_m = Volume of gas sample measured at the dry gas meter, dcf
- Y = Dry gas meter calibration factor, dimensionless
- P_{bar} = Barometric pressure at the testing site, in. Hg
- ΔH = Average pressure differential across the orifice meter, in. H₂O
- T_m = Absolute average dry gas meter temperature, °R

Sample Calculation:

Using equation for Train 1:

$$V_{m(std)} = 17.64 \times 63.266 \times 0.995 \times \frac{\left(29.49 + \frac{2.30}{13.6} \right)}{\left(73.4 + 460 \right)}$$

$$V_{m(std)} = \mathbf{61.732} \text{ dscf}$$

Using equation for Train 2:

$$V_{m(std)} = 17.64 \times 66.079 \times 0.991 \times \frac{\left(29.49 + \frac{1.78}{13.6} \right)}{\left(70.4 + 460 \right)}$$

$$V_{m(std)} = \mathbf{64.503} \text{ dscf}$$

Using equation for ambient train:

$$V_{m(std)} = 17.64 \times 0.00 \times 0 \times \frac{\left(29.49 + \frac{0.00}{13.6} \right)}{\left(68.4 + 460 \right)}$$

$$V_{m(std)} = \mathbf{0} \text{ dscf}$$

m_n – Total Particulate Matter Collected, mg

ASTM E2515 Equation (12)

$$m_n = m_p + m_f + m_g$$

Where:

m_p = mass of particulate matter from probe, mg

m_f = mass of particulate matter from filters, mg

m_g = mass of particulate matter from filter seals, mg

Sample Calculation:

Using equation for Train 1 (first hour):

$$m_n = 0.0 + 4.1 + 0.0$$

$$m_n = 4.1 \text{ mg}$$

Using equation for Train 1 (post-first hour):

$$m_n = 0.6 + 3.0 + 0.4$$

$$m_n = 4.0 \text{ mg}$$

Train 1 aggregate:

$$m_n = 4.1 + 4.0$$

$$m_n = \mathbf{8.1} \text{ mg}$$

Using equation for Train 2:

$$m_n = 1.2 + 7.3 + 0.7$$

$$m_n = \mathbf{9.2} \text{ mg}$$

C_s - Concentration of particulate matter in tunnel gas, dry basis, corrected to standard conditions, g/dsc
ASTM E2515 equation (13)

$$C_s = K_2 \times \frac{m_n}{V_{m(\text{std})}}$$

Where:

K₂ = Constant, 0.001 g/mg

m_n = Total mass of particulate matter collected in the sampling train, mg

V_{m(std)} = Volume of gas sampled corrected to dry standard conditions, dscf

Sample calculation:

For Train 1:

$$C_s = 0.001 \times \frac{8.1}{61.73}$$

$$C_s = \mathbf{0.00013} \text{ g/dscf}$$

For Train 2

$$C_s = 0.001 \times \frac{9.2}{64.50}$$

$$C_s = \mathbf{0.00014} \text{ g/dscf}$$

For Ambient Train

$$C_r = 0.001 \times \frac{0.0}{0}$$

$$C_r = \mathbf{0} \text{ g/dscf}$$

E_T – Total Particulate Emissions, g

ASTM E2515 equation (15)

$$E_T = (C_s - C_r) \times Q_{std} \times \theta$$

Where:

- C_s = Concentration of particulate matter in tunnel gas, g/dscf
- C_r = Concentration particulate matter room air, g/dscf
- Q_{std} = Average dilution tunnel gas flow rate, dscf/hr
- θ = Total time of test run, minutes

Sample calculation:

For Train 1

$$E_T = (\underline{0.000131} - 0) \times \underline{13535.7} \times \underline{385} / 60$$
$$E_T = \underline{11.40} \text{ g}$$

For Train 2

$$E_T = (\underline{0.000143} - 0) \times \underline{13535.7} \times \underline{385} / 60$$
$$E_T = \underline{12.39} \text{ g}$$

Average

$$E = \underline{11.89} \text{ g}$$

Total emission values shall not differ by more than 7.5% from the total average emissions

$$7.5\% \text{ of the average} = \underline{0.89}$$

$$\text{Train 1 difference} = \underline{0.50}$$

$$\text{Train 2 difference} = \underline{0.50}$$

PR - Proportional Rate Variation

ASTM E2515 equation (16)

$$PR = \left[\frac{\theta \times V_{mi} \times V_s \times T_m \times T_{si}}{\theta_i \times V_m \times V_{si} \times T_{mi} \times T_s} \right] \times 100$$

Where:

- θ = Total sampling time, min
- θ_i = Length of recording interval, min
- V_{mi} = Volume of gas sample measured by the dry gas meter during the "ith" time interval, dcf
- V_m = Volume of gas sample as measured by dry gas meter, dcf
- V_{si} = Average gas velocity in the dilution tunnel during the "ith" time interval, ft/sec
- V_s = Average gas velocity in the dilution tunnel, ft/sec
- T_{mi} = Absolute average dry gas meter temperature during the "ith" time interval, °R
- T_m = Absolute average dry gas meter temperature, °R
- T_{si} = Absolute average gas temperature in the dilution tunnel during the "ith" time interval, °R
- T_s = Absolute average gas temperature in the dilution tunnel, °R

Sample calculation (for the first 1 minute interval of Train 1):

$$PR = \left(\frac{385 \times 0.798 \times 20.17 \times (94.0 + 460) \times (73.4 + 460)}{5 \times 63.27 \times 18.48 \times (76.8 + 460) \times (71.0 + 460)} \right) \times 100$$

$$PR = \underline{110} \%$$

PM_R – Particulate emissions for test run, g/hr

ASTM E2780 equation (6)

$$PM_R = 60 (E_T/\theta)$$

Where,

E_T = Total particulate emissions, grams

θ = Total length of full integrated test run, min

Sample Calculation:

$$E_T (\text{Dual train average}) = 11.89 \text{ g}$$

$$\theta = 385 \text{ min}$$

$$PM_R = 60 \times (11.89 / 385)$$

$$PM_R = 1.85 \text{ g/hr}$$

PM_F – Particulate emission factor for test run, g/dry kg of fuel burned
ASTM E2780 equation (7)

$$PM_F = E_T / M_{FTAdb}$$

Sample Calculation:

$$E_T (\text{Dual train average}) = 11.89 \text{ g}$$

$$M_{Bdb} = 4.68 \text{ kg}$$

$$PM_F = 11.89 / 4.68$$

$$PM_F = \mathbf{2.54} \text{ g/kg}$$

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

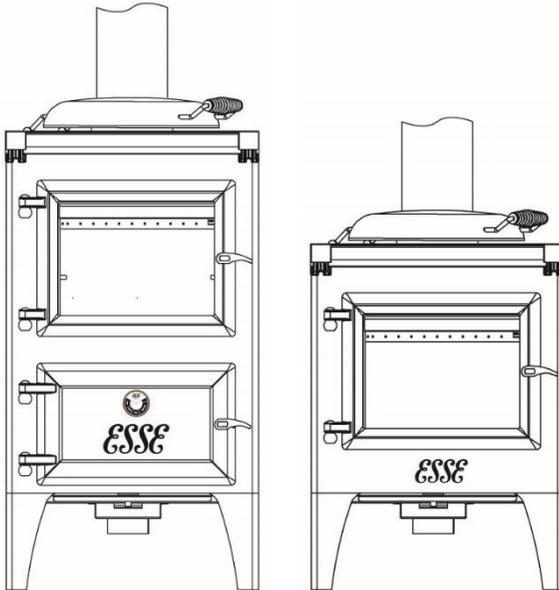
Section 5

Labeling & Owner's Manual

ESSE

Bakeheart and Warmheart

Wood Fired Cook Stove
Owner's Manual



**MADE IN
BRITAIN** 



OMNI-Test
Laboratories, Inc.
0224WS009S
0224WS009E

GENERAL SAFETY

All ESSE cook stoves are designed and manufactured to be simple and efficient to use, and we've taken great care to ensure that they meet the applicable safety requirements, when appropriately installed and used. Before use, ensure you are familiar with the following:

	PLEASE READ THIS ENTIRE MANUAL BEFORE YOU INSTALL AND USE YOUR NEW ROOM HEATER. FAILURE TO FOLLOW INSTRUCTIONS MAY RESULT IN PROPERTY DAMAGE, BODILY INJURY, OR EVEN DEATH.
	THIS COOK STOVE HAS A MANUFACTURER-SET MINIMUM LOW BURN RATE THAT MUST NOT BE ALTERED. IT IS AGAINST FEDERAL REGULATIONS TO ALTER THIS SETTING OR OTHERWISE OPERATE THIS WOOD HEATER IN A MANNER INCONSISTENT WITH THE OPERATING INSTRUCTIONS IN THIS MANUAL.
	DO NOT INSTALL THIS APPLIANCE WITHIN A MOBILE HOME.
	DO NOT CONNECT THE UNIT TO A CHIMNEY FLUE SERVING ANOTHER APPLIANCE.
	DO NOT CONNECT TO OR USE IN CONJUNCTION WITH ANY AIR DISTRIBUTION DUCTWORK UNLESS SPECIFICALLY APPROVED FOR SUCH INSTALLATIONS.
	CONTACT LOCAL BUILDING OR FIRE OFFICIALS ABOUT RESTRICTIONS AND INSTALLATION INSPECTION REQUIREMENTS IN YOUR AREA AND THE NEED TO OBTAIN A PERMIT.
	WHEN THIS ROOM HEATER IS NOT PROPERLY INSTALLED, A HOUSE FIRE MAY RESULT. TO REDUCE THE RISK OF FIRE, FOLLOW THE INSTALLATION INSTRUCTIONS. CONTACT LOCAL BUILDING OR FIRE OFFICIALS ABOUT RESTRICTIONS AND INSTALLATION INSPECTION REQUIREMENTS IN YOUR AREA.
	THIS ROOM HEATER MUST BE CONNECTED TO: <ul style="list-style-type: none"> • A CHIMNEY COMPLYING WITH THE REQUIREMENTS FOR TYPE HT CHIMNEYS IN THE STANDARD FOR CHIMNEYS, FACTORY-BUILT, RESIDENTIAL TYPE AND BUILDING HEATING APPLIANCE, UL 103, OR... • A CODE-APPROVED MASONRY CHIMNEY WITH A FLUE LINER.
	THIS HEATER HAS BEEN CERTIFIED UNDER THE 2020 U.S. ENVIRONMENTAL PROTECTION AGENCY'S CORD WOOD EMISSIONS LIMITS FOR WOOD HEATERS.
	DO NOT USE A GRATE OR OTHER DEVICE TO ELEVATE THE FIRE OFF THE FIREBOX FLOOR. BURN THE FIRE DIRECTLY ONTO THE BRICKS.
	NEVER USE GASOLINE, GASOLINE-TYPE LANTERN FUEL, KEROSENE, CHARCOAL LIGHTER FLUID, OR SIMILAR LIQUIDS OR CHEMICALS TO START OR 'FRESHEN UP' A FIRE IN THIS HEATER. KEEP ALL SUCH LIQUIDS WELL AWAY FROM THE HEATER WHILE IT IS IN USE.
	HOT WHILE IN OPERATION. KEEP CHILDREN, CLOTHING AND FURNITURE AWAY. CONTACT MAY CAUSE SKIN BURNS.
	SAVE THESE INSTRUCTIONS FOR FUTURE USE.

This manual describes the installation and operation of the ESSE Bakeheart / Warmheart wood heater and cook stove. Under specific test conditions this heater has been shown to deliver heat at rates ranging from 10,001 – 46,685 Btu/hr. This appliance has been tested to ASTM 2515 and ASTM 3053 for Emissions, and UL 1482-2015 and ULC S627-00 for Safety.

Model name: ESSE Warmheart / ESSE Bakeheart

Manufacturer: ESSE Engineering Ltd., Long Ing, Barnoldswick, Lancashire, BB18 6BJ, UK

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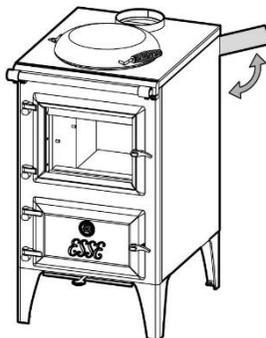
1. WELCOME TO YOUR ESSE

Welcome to the ESSE family. We've poured all of our knowledge, expertise and passion for designing and manufacturing market leading stoves, dating back to 1854, into producing your ESSE cook stove. All ESSE cook stoves are manufactured at our UK factory in Lancashire, UK, and we're confident that if appropriately installed, maintained and cared for, your ESSE cook stove will provide you with many years of room heating, cooking, comfort and joy.

Before you fire up your ESSE cook stove for the first time, ensure that your installer has installed the stove in line with the 'Installation' section of this manual, and that the flue and chimney has been swept. The cook stove is not suitable for use in a shared flue.

As you would expect, when in use, all parts of the stove become hot, so always use the supplied operating tool or glove when interacting with your ESSE cook stove. The cook stove is suitable for intermittent operation. Do not use an aerosol spray close to the stove when alight.

These instructions provide all the necessary information to both install, then operate your ESSE cook stove. The key information relating to your stove, including the serial number, can be found on the data plate, located at the rear of the cook stove. Please quote the model and serial number, in any future communication with your retailer or the manufacturer.



Data plate location

2. OPERATING INSTRUCTIONS

BEFORE USING YOUR COOK STOVE

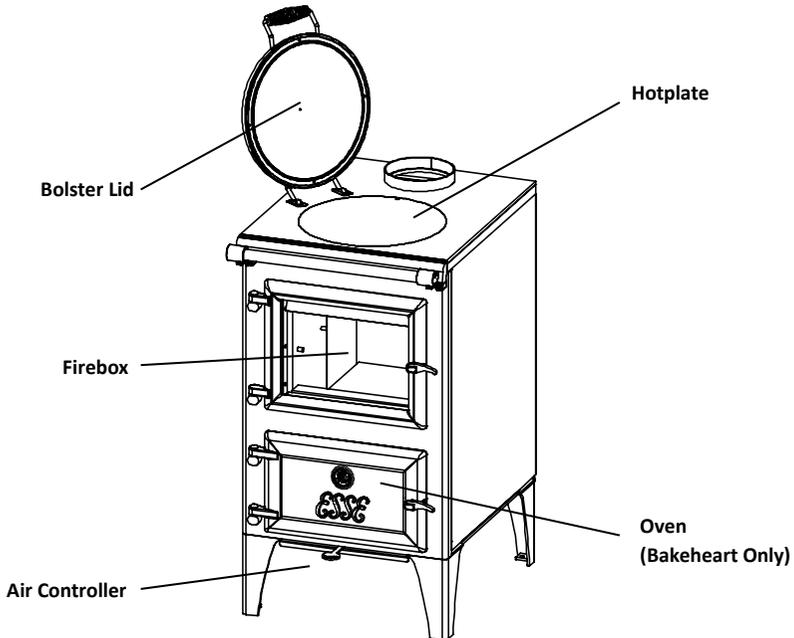
Ensure that all protective packaging has been removed. The hotplate has been oiled at the factory to prevent rusting and therefore will require wiping with a damp cloth and drying with a paper towel, before use.

This appliance is suitable for burning wood only. An extractor should not be fitted within the same room as the appliance.



Do not place tea towels or similar items on the handrail.

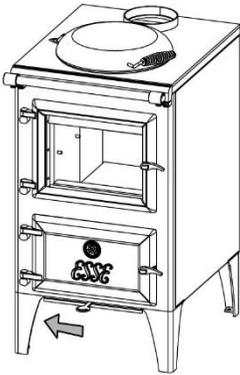
GETTING TO KNOW YOUR COOK STOVE



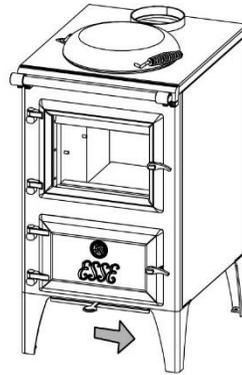
Air Controller

This is used to control the fire intensity, by managing the amount of air supplied to the fire. When moved to the right, there is more air and a fiercer burn rate, whilst moved to the left, there is less air, and softer burn rate.

2. OPERATING INSTRUCTIONS



Move left, to reduce intensity



Move right, to increase intensity

The firebox is accessed through the large glass fronted fire door, which is opened by rotating the catch 90° counter-clockwise. On the Bakeheart model, the oven is behind the bottom door, which is also opened by rotating the catch 90° counter-clockwise. Please note, when in use, both of these catches will become hot, so always use the supplied operating tool or glove to open and close them. The operating tool or glove should also be used to adjust the Air Controller.

If the cook stove is being used primarily to heat the room, we recommend leaving the bolster lids open, allowing heat from the hotplate to radiate into the room.

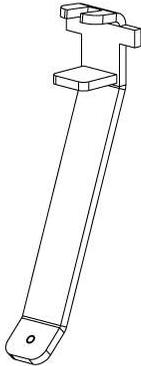
2. OPERATING INSTRUCTIONS

SUPPLIED TOOLS AND PARTS

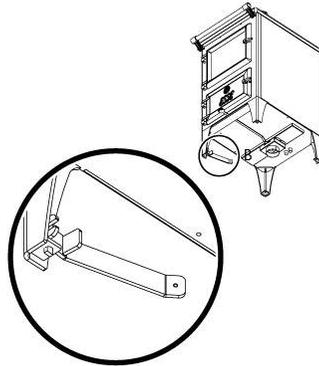
Your ESSE cook stove comes supplied with...

		BH	WH
Heatshield	• To install on the rear wall	✓	✓
Glove	• For interacting with the controls	✓	✓
Operating Tool	• Hotplate removal & opening doors	✓	✓
Wire Brush	• For cleaning ovens & hotplate	✓	✓
Firebox Shelf	• For cooking direct onto embers	✓	✓
Oven Shelf	• For cooking within the oven	✓	✓
Fireshield	• To direct heat away, whilst cooking	✓	X

Please keep all of these items in a safe place.



Operating Tool (I-WH-100-004US)



Operating Tool storage



This appliance is not appropriate for use as an incinerator, and unsuitable fuels should not be used. Failure to follow this requirement will invalidate your warranty.

2. OPERATING INSTRUCTIONS

CO AND SMOKE ALARM

Your installer should have ensured that you have a carbon monoxide (CO) and smoke alarm fitted, in the same room as your ESSE cook stove. You should make sure that you are familiar with the operation of these essential pieces of equipment.

VENTILATION

All stoves require a consistent supply of 'combustion air', to allow for the combustion of the fire. Your installer should have ensured that there is appropriate air source to your ESSE cook stove. For more information, see the 'Ventilation' section within the Installation part of this manual.

FUEL

Your ESSE stove has been designed to burn wood logs, of appropriate quality and moisture content.

Approved fuels

- ✓ Wood logs

Unapproved fuels

- X Wet wood
- X Overly dry wood
- X Treated timber
- X Smokeless mineral fuel
- X Petroleum based fuels
- X Bituminous house coal
- X Printed paper and cardboard



This appliance is not appropriate for use as an incinerator, and unsuitable fuels should not be used. Failure to follow this requirement will invalidate your warranty.

THE HEATSHIELD

Your cook stove comes supplied with a heatshield. This heatshield must be installed if the vertical substrate behind the cook stove is of combustible

2. OPERATING INSTRUCTIONS

material. See the 'INSTALLING THE HEATSHIELD' section in the 'Installation instructions' section of this document for more information.

WOOD LOGS

Burning wood logs within your ESSE cook stove provides sustainable, efficient and 'clean' heating to your room. The moisture content of your wood is very important, as this affects both how 'cleanly' your stove will burn, and also how long the fuel will burn for. Referred to as 'green wood', recently felled wood will almost certainly have a moisture content that is too high to burn efficiently and cleanly. Similarly, overly dry wood will burn quickly, with higher emissions, making your stove less economical to run.

We recommend using wood logs with a moisture content of 15 – 20%. This is best achieved by either storing green wood yourself for a period of 12 – 18 months, and checking regularly with a moisture detector, or purchasing it from a reputable fire wood specialist, who is able to control the moisture content of their wood logs.

Your wood should be stacked safely, so as to not allow absorption of moisture from rain, condensation or flooding. If stacked outdoors, ensure your wood is not stacked directly onto the ground.

Do not store wood in the space between your cook stove and adjacent surfaces, which provides the required distance to combustibles, or in areas which may become hot over time, causing a fire risk, eg, under the cook stove.

AIR SUPPLY

ESSE cook stoves are designed to achieve the most efficient heat outputs, with the 'cleanest burn'. To achieve this, significant research and development investment has been given to how to provide appropriate levels of 'combustion air' to the correct parts of the fire, at the correct time of the burn cycle.

Combustion air is drawn into your ESSE stove from four locations, one of which is controllable. It is important to understand the function of each, and where appropriate, how they are controlled.

2. OPERATING INSTRUCTIONS

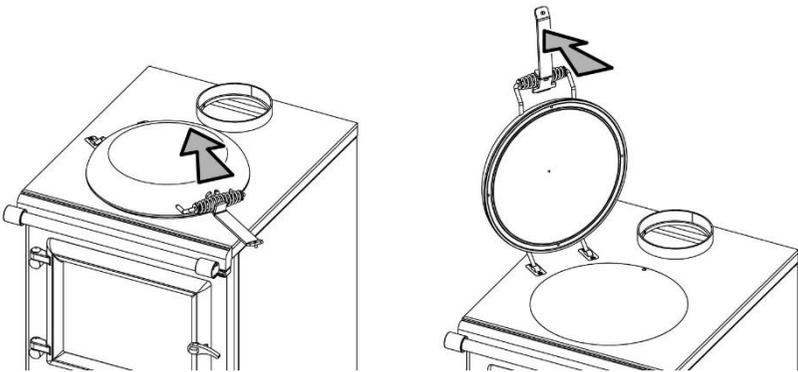
Controllable Combustion Air Controllable Combustion Air enters your ESSE cook stove from the circular air inlet at the base of the appliance, and is adjusted by the air controller. When moved to the right, there is more air and a fiercer burn rate, whilst moved to the left, there is less air, and softer burn rate.

Tertiary Air Tertiary Air enters your ESSE cook stove through two small air inlets the base of the appliance, entering the firebox through a series of holes in two pipes located at the top of the firebox. The amount of Tertiary Air is not adjustable, but carefully positioned to help achieve improved efficiency and a clean burn.

Pilot Air Pilot Air enters your ESSE cook stove through a small hole at the front of the base of the appliance. The Pilot Air helps keep the cook stove burning cleanly, even towards the end of a log's useful life.

LIFTING THE BOLSTER LID

The bolster lid should be lifted using the supplied Operating Tool.



1. Position the Operating Tool under the Bolster Lid handle.

2. Carefully pull the Bolster Lid upwards, until it holds in an open position.

LIGHTING YOUR ESSE COOK STOVE

2. OPERATING INSTRUCTIONS

When your ESSE cook stove is first lit, it may smoke, give off an odour, or make ‘ticking noises’. This is quite normal, as the materials used within its manufacture are heated up for the first time. These symptoms will stop within a short period, but ensure that the room is well ventilated during this ‘settling in’ process.

The pallet that your ESSE cook stove was supplied on has been produced from timber that is appropriate for use as kindling, so can be broken up and chopped, for this purpose.

Initially only light a small fire, for a period of 1 – 2 hours, to dry out any moisture found within the flue and chimney.



Whilst lighting the fire, do not leave your ESSE cook stove unattended, until the fire is established, the door is fully closed, and you have adjusted the Air Controller to the appropriate level.



Before lighting your ESSE cook stove, ensure that the Air Controller is fully open (Pushed to the right).

Lay two small wood logs along the length of the firebox base, and place a firelighter / tightly rolled up newspaper on top of them. On top, use wood kindling to create a small lattice structure.

Safely light the firelighter / newspaper and close the door, but leaving it slightly ajar. Once the flames have established on the wood logs, (typically within 3 – 5 minutes), place a small wood log on top and fully close the door. Slowly reduce the air volume, by moving the Air Controller to the left. Continue to use the Air

2. OPERATING INSTRUCTIONS

Controller to control the fire, until the flames are slowly 'dancing' on top of the wood logs.

It is very important that your ESSE cook stove is not overfired, as this may cause long term damage to the appliance, and invalidate your warranty.



The door should only be opened during the initial lighting / refuelling of your ESSE cook stove. If left open during normal operation, you may experience excessive smoke emitting into your room.



When the fire is lit within the cook stove, all controls and handles become hot - The operating tool or glove provided should be used when interacting with the appliance.



Take care not to strike the glass in the fire door, or slam the door shut, which may result in damage.

REFUELLING

Refuelling should be undertaken whilst the flames on the current fuel are still established, or you may experience excessive smoking. If the current fire has died out, reignite the fire with additional kindling, before adding additional fuel. When positioning fuel into the firebed, ensure that the fuel is not touching the back or side walls, or the glass window, as this will result in a less clean burn.

To enjoy optimum wood burning, leave an ashbed of ½" – 1" of ash within the base of the firebox. First rake the current fuel, to create a bed of hot embers, on which to place the new fuel. Then place the new wood logs onto the hot embers.



Do not 'overload' the fire with excessive amounts of fuel, as this will result in over-firing, and may cause permanent damage to your ESSE cook stove.

EMPTYING THE FIREBOX OF EXCESS ASH



Your ESSE cook stove will be hot during and after use. Always use the supplied Operating Tool and / or Stove Glove to riddle the appliance.

2. OPERATING INSTRUCTIONS



Never attempt to remove excess ash whilst the cook stove or ash is still hot.

Once the level of ash has built up greater than $\frac{1}{2}$ " – 1", excess ash should be removed from the base of the firebox using a metal shovel and disposed of safely.

Ash should be placed in a metal container with a tight fitting lid. The closed container of ashes should be placed on a non-combustible floor or on the ground, well away from all combustible materials, pending final disposal.

COOKING ON YOUR COOK STOVE

The ESSE Bakeheart both heats local spaces, whilst also being perfect for cooking on the hotplate, in the oven or even directly to the hot embers.

The ESSE Warmheart is primarily a local space heater, but also incorporates a handy hotplate, for cooking or keeping hot beverages, soups or stews warm.

The Oven (Bakeheart only)

When in use, the oven is heated through heat transfer from the fire, providing all round heat for perfect cooking. As a result, pans and casserole dishes can be placed on the bottom surface of the oven, without frying food, ensuring that all of the near 32lt of capacity is useable space.

The oven is deeper than it is wide, to reduce heat loss when the door is opened for inspection of the food, helping to maintain a cooking temperature. The oven door should be kept closed when in use.

Always use the supplied Glove or Operating Tool to open the oven door, as the handle gets hot when in use. To open the oven door, turn the handle 90° counter-clockwise, and carefully swing open.

A temperature gauge is located within the oven door, which can be used to give a guide to the temperature within the oven. Remember that when the door has been opened, the temperature shown

2. OPERATING INSTRUCTIONS

on the dial will drop, and take time to correct when the door is subsequently closed. Please note, the temperature gauge should only be used as a guide to the oven temperature.

Your ESSE Bakeheart comes supplied with a wire shelf, which can be placed on the steel runner pins in the oven. The wire shelf has a retaining device, to reduce the risk of them pulling free of the cooker accidentally. To remove the shelf, pull forward as far as they come, then lift the front of the shelf up at an angle, and slowly pull free from the shelf runners.

The Hotplate

The design and position of the hotplate is carefully considered to give graduated areas of heat. The centre of the hotplate is positioned directly above the firebox, so will be the hottest area, and is perfect for boiling, whilst the outer areas are ideal for simmering.

To maintain hotplate cooking temperatures, the Bolster Lid should be closed when the hotplate is not in use.

The Firebox (Bakeheart only)

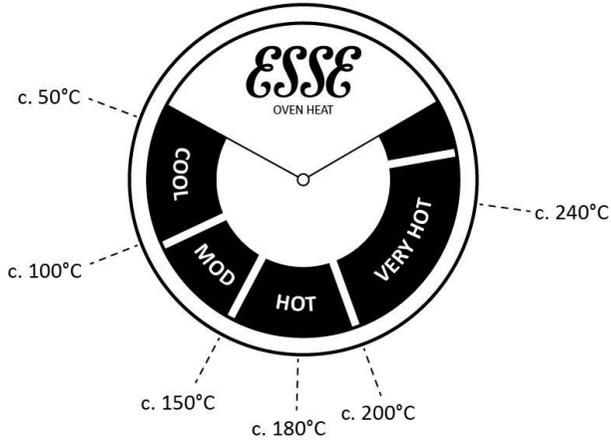
To fully enjoy the unique flavours of wood fired cooking, your ESSE Bakeheart allows for cooking directly over wood embers, providing classic chargrill lines on the supplied wire shelf.

The Firebox Cooking Shelf can be positioned into the firebox after lighting. Once the fire has died down to glowing embers, using the supplied Glove, carefully slide the Firebox Cooking Shelf into position along the steel pin runners, located on the side bricks.



The fire door should always be closed, whilst cooking in the firebox.

2. OPERATING INSTRUCTIONS



The Oven Gauge, with temperature guide

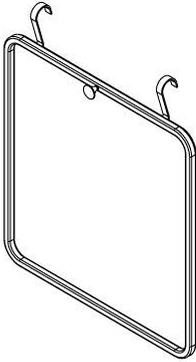
Remember that the oven gauge (Bakeheart only) is a useful tool for giving an indication of the oven temperature, but due to how the oven is heated, should not be relied upon to give an exact temperature reading.

When the hotplate is not in use, the bolster lids should be left down, to help retain heat and keep the hotplates warm.

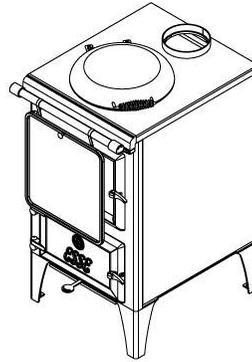
Once up to temperature, relatively small amounts of fuel are required to keep the cooking areas hot. With this in mind, resist the temptation to add excessive amounts of fuel to the firebox, which can cause long-term damage to your ESSE cook stove, whilst also making the appliance uncomfortably hot to stand in front of, during cooking. If this does become a problem, the supplied Fireshield (Bakeheart only) can be placed in front of the glass oven door, to help deflect heat away from the user.

To install the Fireshield, simply hang it onto the hand rail in front of the glass firedoor.

2. OPERATING INSTRUCTIONS



Fireshield (Bakeheart only)



Fireshield in use (Bakeheart only)

REDUCED BURNING

Once a fire has established, close down the air control, and ensure that the door is firmly closed. Experimentation with the setting of air controls may be required, depending upon the flue draft and fuel type. A build-up of soot on the inside face of the glass window is more likely when operating the cook stove in this way.

FLUE DRAFT

An appropriate flue draft is essential for the stove to work safely and efficiently. During installation, your installer should have taken a flue draft reading, to ensure that it is within the recommended range of 12 – 25 Pascals. If your cook stove is burning wood logs quickly, or adjusting the Air Controller is having little effect on controlling the fire, consult with your installer to confirm the flue draft remains appropriate.

CLEANING & MAINTENANCE



This wood heater needs periodic inspection and repair for proper operation. Consult the owner's manual for further information. It is against federal regulations to operate this wood heater in a manner inconsistent with the operating instructions in the owner's manual.

2. OPERATING INSTRUCTIONS

Your ESSE cook stove should be inspected frequently, and any required maintenance undertaken. We recommend that your ESSE cook stove is serviced once a year by a qualified service professional.

As the cook stove top is used for cooking, associated wear and tear will occur. Spills should be wiped up immediately with a damp cloth. Chemical oven cleaners should not be used on the hob surface.

The supplied wire brush can be used to remove stubborn stains from the hotplate, or inside the ovens.

Creosote – Formation and Need for Removal When wood is burned slowly, it produces tar and other organic vapors, which combine with expelled moisture to form creosote. The creosote vapors condense in the relatively cool chimney flue of a slow-burning fire. As a result, creosote residue accumulates on the flue lining. When ignited this creosote makes an extremely hot fire. The chimney connector and chimney should be inspected at least once every two months during the heating season to determine if a creosote build-up has occurred. If creosote has accumulated it should be removed to reduce the risk of a chimney fire.



Be aware that using the wire brush on the painted surfaces, (including the top that surrounds the hotplate), will cause damage to the paint finish.

The inside of the ovens can be given a coating of flax oil, which will help protect them against rusting, particularly when they oven is not in use for prolonged periods.



Repairs or modifications should only be undertaken by ESSE authorised professionals. Only genuine ESSE replacement parts should be used, or your warranty may become invalid.

General cleaning The exterior cast iron and sheet steel parts should be cleaned with a soft brush or lint-free cloth. Should areas

2. OPERATING INSTRUCTIONS

of the appliance need re-painting, high temperature aerosol paints are available from your retailer.

Glass window

Do not clean the glass whilst it is hot. If the glass window needs cleaning, use a damp cloth. If stubborn stains remains, use a dedicated glass cleaning solution. Do not use abrasive cleaners or pads, as these can scratch the surface, which may cause the glass to fail prematurely. Before relighting the appliance ensure that the glass has fully dried.

Rope seals

Ensuring a firm seal between the body of the appliance and the closed door is essential for the efficient and clean burning of your ESSE cook stove. The rope seals on the inside face of the door should be inspected regularly, and replaced as necessary.

Chrome parts

Chrome parts can be cleaned using a dedicated chrome cleaner. Do not use aggressive chemical cleaners, as these can dull the finish. Do not use aggressive scouring pads or brushes, as this can scratch the surface.

Exterior painted surfaces

The exterior of the cook stove is painted in a specialist high temperature wet paint, designed for this application. However, through the life of the cook stove, it may be necessary to touch up areas of paintwork. High temperature cook stove paints are available from your retailer.

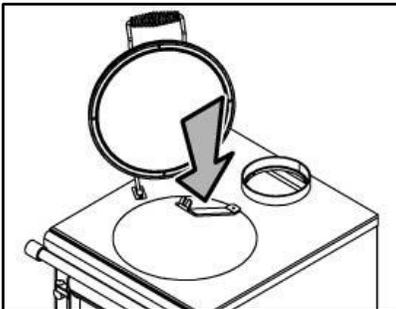
Ensure that the cook stove is completely cool before undertaking any maintenance work. First remove any areas of flaky paint by gently rubbing with a wire brush. Then remove any areas of grease or oil, which will prevent the new layer of paint from adhering to the metal surface. Ensure other areas of the cook stove, and neighbouring items are masked off before applying the high temperature paint. If using an aerosol, ensure there is appropriate ventilation, and use appropriate personal protective equipment. Follow the manufacturer's instructions for application and use.

2. OPERATING INSTRUCTIONS

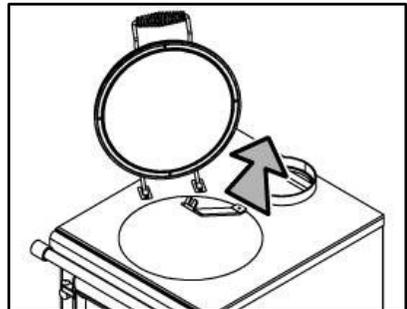
Internal flue ways

The flue ways inside the cook stove should be cleaned as part of the annual service, and at the same time as the flue and chimney are swept.

To do so, remove the hotplate by first inserting the end of the Operating Tool into the hole at the side of the steel disk. Then simply lever the hotplate up and clear of the appliance.



Hotplate removal



REPLACING THE FIRE BRICKS

During the life of your cook stove, the vermiculite firebricks will need replacing. The part numbers are shown in the 'Consumable Parts' section of this document. The bottom and rear bricks can be replaced through the front opening, whilst the side bricks and steel baffle require removal of the side panel.



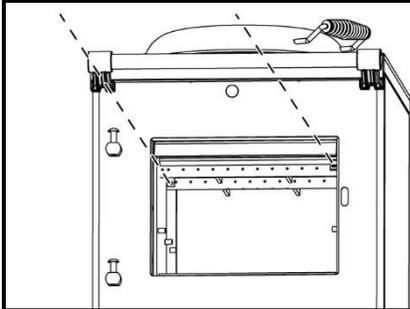
Always wear gloves when undertaking any maintenance on your cook stove.

To replace the bottom and rear firebricks...

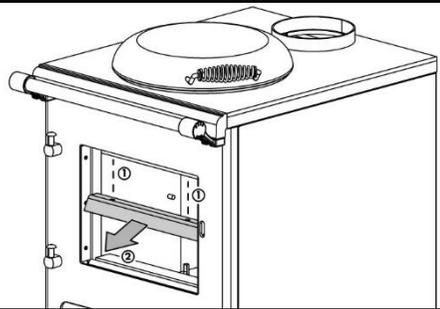
1. Lever up the base brick from the rear, using a flat head screwdriver.
2. Lever forward the rear brick from the top, using a flat head screwdriver.

To replace the side firebricks and steel baffle...

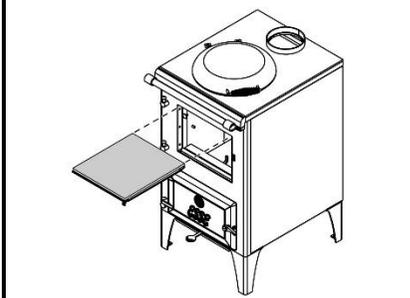
2. OPERATING INSTRUCTIONS



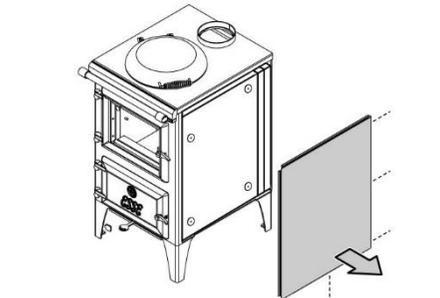
1. Remove the two screws holding the steel baffle in place.



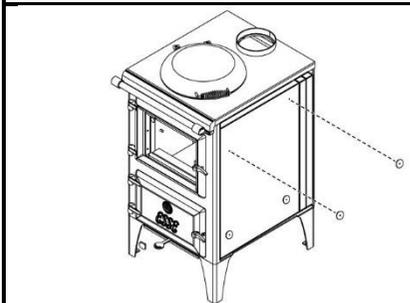
2. Remove the steel airwash by unscrewing the two screws holding it in place, and pulling clear through the front of the cook stove.



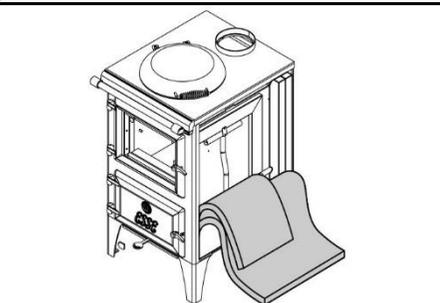
3. Remove the steel baffle and baffle insulation, through the front of the cook stove.



4. Remove the side panel, by unscrewing the three screws at the rear of the cook stove, and the screw at the bottom of the panel.

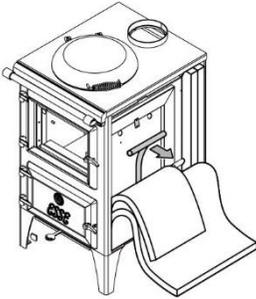


5. Remove the top two disks holding the insulation in place, (do not remove the bottom two disks).

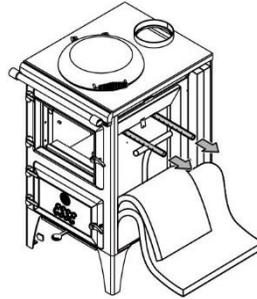


6. Peel down the two layers of insulation, to reveal the air pipes.

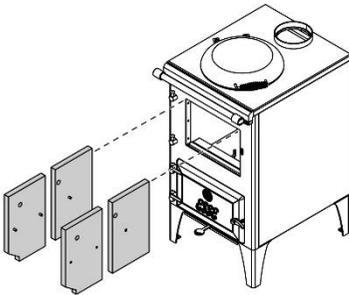
2. OPERATING INSTRUCTIONS



7. Slacken the fixing bolt holding the horizontal air pipe bracket in place, and swing it clear.



8. Pull the two air pipes clear from the firebox.



9. Remove the four side fire bricks through the front of the cook stove, insert the replacement bricks, then reverse steps 1 – 8.

REPLACING THE FIRE GLASS

During the life of your cook stove, the fire door glass may need replacing. Do not use the appliance if there is any sign of damage to the glass. Care should be taken when replacing the fire door glass. Only use 4mm ceramic glass, appropriate for use in wood fired stoves. The replacement glass should be $12^{53/64}$ " x $9^{29/64}$ " (326 x 240mm). If the original glass is damaged, take extra care, using appropriate hand and eye protection, and dispose of the broken glass appropriately.

To replace the glass...

2. OPERATING INSTRUCTIONS

1. Open the fire door.
2. Slacken off the two bottom glass retaining clips.
3. Remove the top two glass retaining clips.
4. Remove the used glass panel and ladder tape (15mm x 3mm thin rope) which sits around the glass panel.
5. Run a new length of ladder tape around the new panel of glass.
6. Insert the glass and ladder tape into position on the bottom two glass retaining clips.
7. Swing the glass up into position, and loosely fix into place with the two top retaining clips.
8. Tuck the rope behind the four retaining clips, and tighten all four up, ensuring the glass is firmly held in place.

CHIMNEY SWEEPING

To ensure continued safe and efficient use of your ESSE cook stove, we recommend that your chimney is swept by a professional at least once a year, typically before the stove season. Where the appliance is used throughout the year, we recommend more regular sweeping.

SAFE SHUTDOWN

In the unlikely event of a chimney fire, a fault occurring with the appliance, or extreme weather affecting the burn of the appliance, move the Air Controller to the left, closing down the combustion air supply to the minimum volume. This will minimise the intensity of the flames in the appliance, which will then slowly die out. In the case of a fire in the chimney or flue, immediately call the Fire Department for assistance.

SEASONAL USE

If your ESSE cook stove is to not be used for a period of time, first clean the appliance as described within the 'Cleaning & Maintenance' section of this manual. Empty the firebox of all ash, before closing the door. Position the Air Controller to a central position – This will allow a flow of air, preventing a build-up of moisture inside your ESSE cook stove, which can lead to rusting. Before re-

2. OPERATING INSTRUCTIONS

lighting the appliance, remove the top baffle bricks, to remove any debris, and check for blockages within the flue.

WARRANTY

Your ESSE cook stove has been built to the highest standard using premium materials, and comes with a two year manufacturer's warranty. Register your ESSE cook stove, by either completing or returning the supplied Warranty Registration Card, or by registering online at www.esse.com/warranty-registration, and receive a warranty upgrade to five years. The warranty must be registered within 1 month of installation to qualify for the 5 year warranty.

The conditions of your warranty are...

- ✘ Does not cover incorrect use or application, as advised within this manual.
- ✘ Must be installed appropriately, by a certified installer.
- ✘ Does not cover consumable parts, including glass window, rope door seals and vermiculite fire bricks.
- ✘ Does not cover general wear and tear or cosmetic damage unrelated to the function of the appliance.

In the first instance, please contact your North American ESSE dealer, for warranty or service matters.

2. OPERATING INSTRUCTIONS

TROUBLESHOOTING

Problem	Cause	Solution
Window glass blackening	• Wet wood logs	• Use wood logs with 15-20% moisture content
	• Fuel touching glass window	• Use a poker to move fuel back within the fire box
	• Too little combustion air	• Increase the setting of the air controller
Fumes emit into room	• Blocked flue	• Check and remove any blockage
	• Downdraft in flue	• Consult with your installer, to add flue cowl or other solution
Fire will not light	• Too little combustion air	• Increase the setting of the air controller
	• Wet wood logs	• Use wood logs with 15-20% moisture content
	• Flue draft is too low	• Consult with your installer, to rectify
Fire burns too quickly	• Too much combustion air	• Reduce the setting of the air controller
	• Overly dry wood logs	• Use wood logs with 15-20% moisture content
	• Flue draft is too high	• Consult with your installer, to rectify

3. INSTALLATION INSTRUCTIONS

PLANNING THE INSTALLATION

It is the installer's responsibility to ensure that when installing the appliance, that all applicable Health and Safety requirements are met.

The installation instructions within this manual provide a guide for safe and appropriate installation, but it is the responsibility of the installer to ensure that the requirements of applicable standards, relating to the installation of solid fuel appliances. The appliance is heavy and care must be taken during handling. Although the appliance does not contain asbestos products, it is possible that asbestos may be disturbed in existing installations and every precaution must be taken.

When considering the installation design, ensure appropriate access is provided for cleaning of the appliance, flue pipe and chimney flue. This appliance is suitable for intermittent operation, but is not suitable for use in a shared flue system. The appliance should not be used in the same room as an extractor fan, as this can cause the stove to emit fumes into the room.

VENTILATION

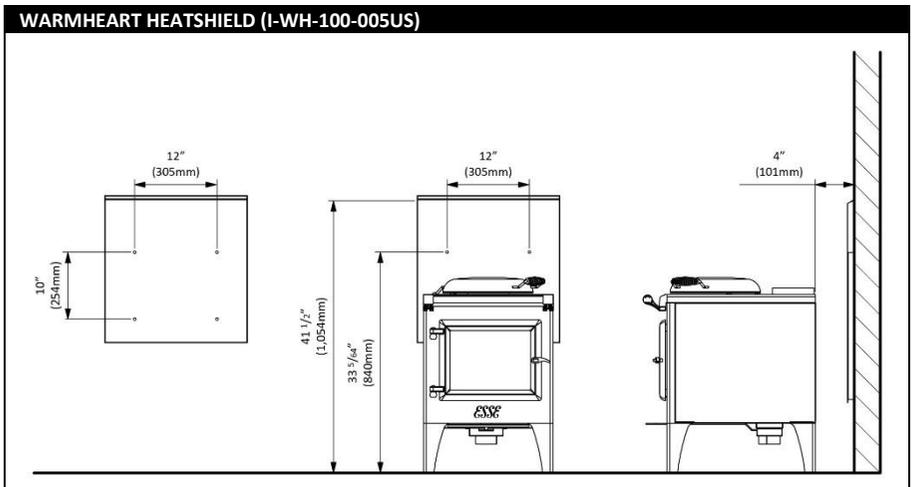
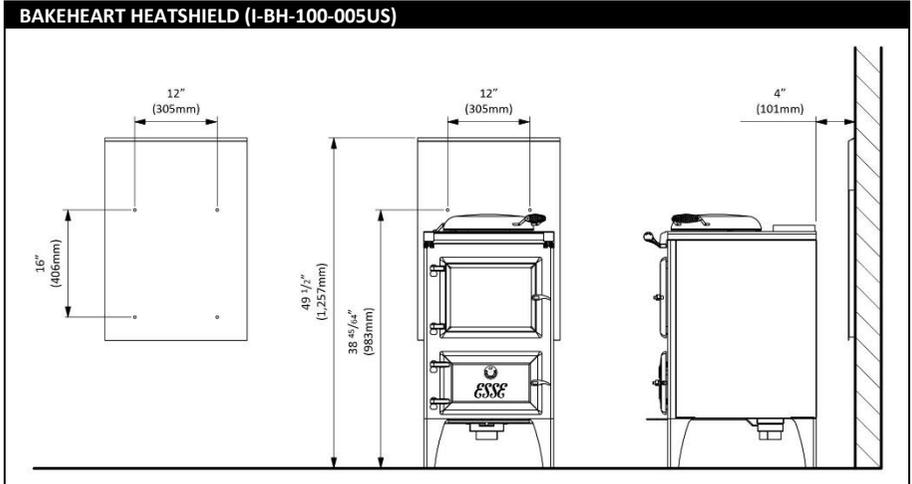
All stoves require a consistent supply of 'combustion air', to allow for combustion of the fire. As a general rule, permanent external air vents are not required for stoves with a nominal output of 5kW or less. However, houses with a low air permeability, such as newer builds, may require a permanent external air vent. Typically, should a stove be installed in a room with an air permeability of lower than $5.0\text{m}^3/(\text{h.m}^2)$, a permanent external air vent is required, irrespective of the nominal output of the stove.

External air vents must be positioned so they are not liable to be blocked.

3. INSTALLATION INSTRUCTIONS

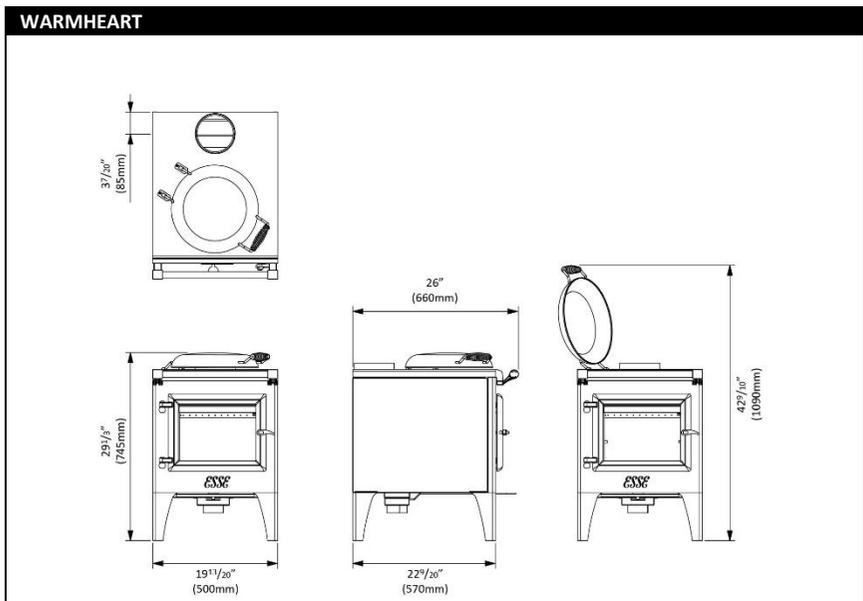
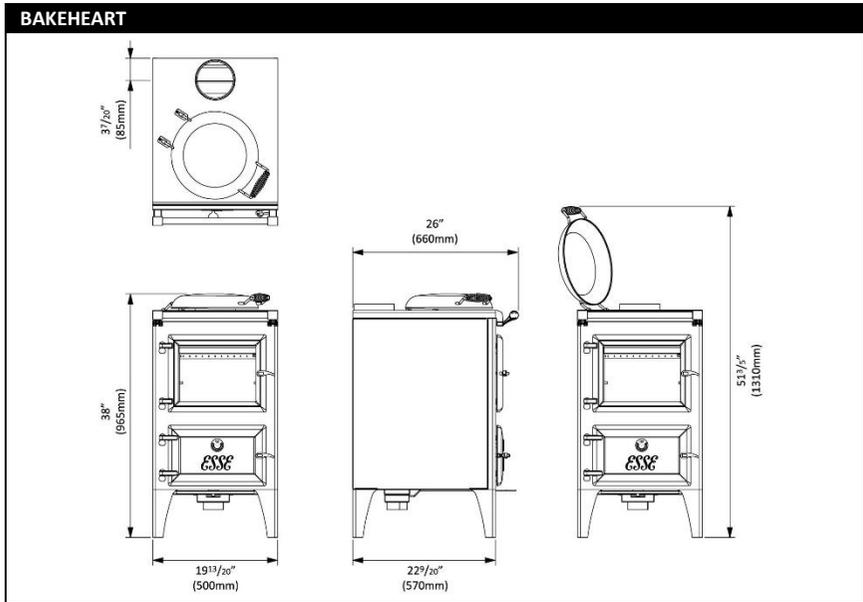
INSTALLING THE HEATSHIELD

Unit is supplied with a heat shield that is to be mounted to the wall.



3. INSTALLATION INSTRUCTIONS

PRODUCT SPECIFICATION



ESSE cook stoves are hand crafted, so small variations in size can occur.

3. INSTALLATION INSTRUCTIONS

Key Product Specifications		
	Bakeheart	Warmheart
Emissions	2.15 grams per hour	2.15 grams per hour
Efficiency	75.4%	75.4%
BTU Range	10,001 – 46,685	10,001 – 46,685
Weight (lbs)*	425	340
Minimum Flue Draft	12 Pa	12 Pa
Flue Diameter	6"	6"

CO AND SMOKE ALARM

Building regulations require that whenever a new or replacement fixed solid fuel or wood / biomass appliance is installed in a dwelling, a carbon monoxide (CO) and smoke alarm must be fitted in the same room as the appliance. The installation of an alarm must not be considered a substitute for either installing the appliance correctly, or ensuring regular servicing and maintenance of the appliance and chimney system.

UNPACKING THE APPLIANCE

The cook stove comes bolted and strapped to a pallet, for simple and secure transportation. To unpack, first remove the strapping and packaging. Then remove the two bolts holding the stove to the pallet. Whilst heat-treated, the pallet has been produced from timber that is appropriate for use as kindling, so can be broken up and chopped, for this purpose. Finally, dispose of the remaining packaging responsibly.

CHIMNEY & FLUE

The stove must be installed and connected to the chimney and flue pipe in line with the current requirements of Building Regulations. Where a prefabricated metal chimney is to be used, it must meet the requirements for Type HT chimneys in the Standard for Chimneys Factory-Built, Residential Type and Building Heating Appliance, UL 103, or High Temperature (650°C) Standard ULC S-629 for Canada. The cook stove is designed to be used with a 6" (150mm) flue connection.

3. INSTALLATION INSTRUCTIONS

As a basic guideline...

- ✓ The minimum chimney internal cross section area must be 6" (150mm) diameter, or 6"x6" (150mm x 150mm).
- ✓ The chimney must have a minimum height of 13' (4m) measured from the top of the stove to the top of the chimney.
The chimney must extend at least 3' (915mm) above the highest
- ✓ point where it passes through a roof, and at least 2' (610mm) higher than any area of a building within 10' (3m).
- ✓ A twin walled flue can be used, but the first 13" (330mm) must be single wall, to allow the bolster lid to open.
- ✓ The chimney must have been swept before installation, and free from cracks, severe bends, voids and obstructions.
- ✓ Ensure where a flue pipe connects to a chimney, the flue passes past the point where the chimney narrows.
- ✓ A flue inspection hatch should be installed, to allow for a flue draft reading to be taken.
- ✓ Ensure an appropriate flue draft, as detailed within the Flue Draft section of this manual.
- ✓ Take into consideration future access for maintenance and sweeping.
- ✓ The flue must be capped / have a cowl, to prevent any ingress of rain.
A single wall starter length with a single to twin wall adapter will be
- ✓ needed to use twin wall insulated flue. The stove will need to be moved away from the wall to accommodate use of twin wall flue.

Masonry Chimney

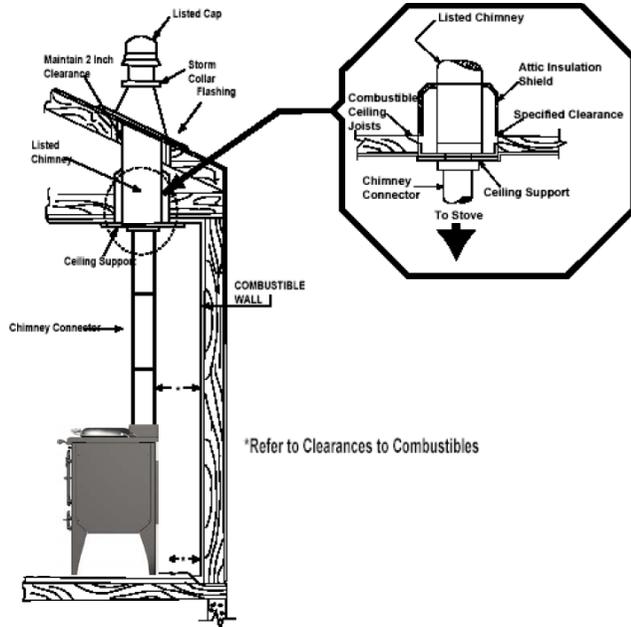
Ensure that a masonry chimney meets the minimum standards of the National Fire Protection Association (NFPA) by having it inspected by a professional. Make sure there are no cracks, loose mortar or other signs of deterioration and blockage. Have the chimney cleaned before the appliance is installed and operated. When connecting the appliance through a combustible wall to a masonry chimney, special methods are needed.

Factory Built Chimney

When a metal prefabricated chimney is used, the manufacturer's installation instructions must be followed. You must also purchase (from the same manufacturer) and install the ceiling support package or wall pass-through and

3. INSTALLATION INSTRUCTIONS

“T” section package, firestops (where needed), insulation shield, roof flashing, chimney cap, etc. maintain proper clearances to the structure as recommended by the manufacturer. The chimney must be the required height above the roof or other obstructions for safety and proper draft operation.

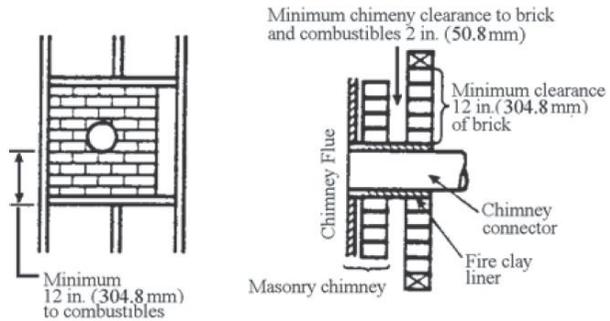


Connection through a combustible wall

Method A

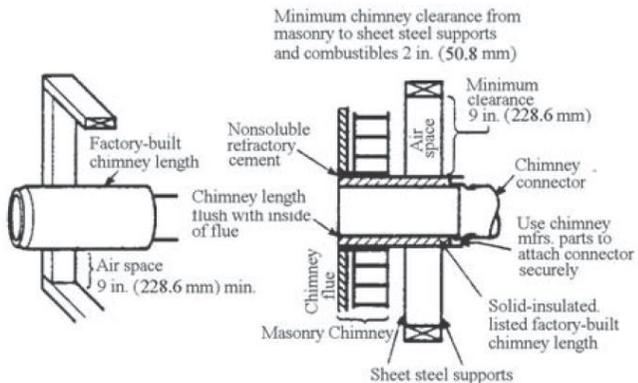
Using a minimum thickness 3.5" (90mm) brick and a 5/8" (16mm) minimum wall thickness clay liner, construct a wall pass-through. The clay liner must conform to ASTM C315 (Standard Specification for Clay Fire Linings) or equivalent. Keep a minimum of 12" (305mm) of brick masonry between the clay liner and wall combustibles. The clay liner shall run from the brick masonry outer surface to the inner surface of the chimney flue liner but not past the inner surface. Firmly grout or cement the clay liner in place to the chimney flue liner.

3. INSTALLATION INSTRUCTIONS



Method B

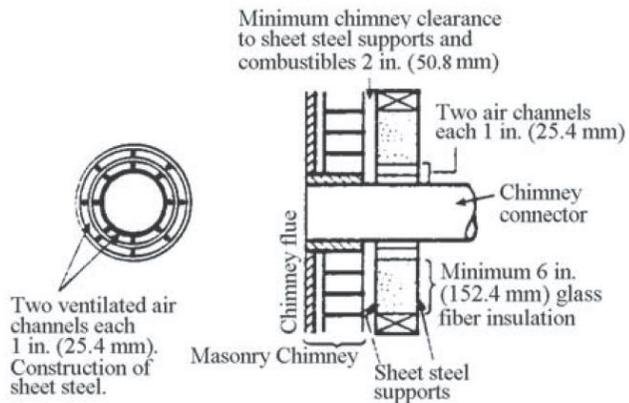
Using 6" (152mm) inside diameter, listed factory-built Solid-Pak chimney section with insulation of 1" (25mm) or more, build a wall pass-through with a minimum 9" (229mm) air space between the outer wall of the chimney length and wall combustibles. Use sheet metal supports fastened securely to wall surfaces on all sides to maintain the 9" (229mm) air space. When fastening supports to chimney length, do not penetrate the chimney liner (the inside wall of the Solid-Pak Chimney). The inner end of the Solid-Pak chimney section shall be flush with the inside of the masonry chimney flue, and sealed with a non-water soluble refractory cement. Use this cement to also seal to the brick masonry penetration.



3. INSTALLATION INSTRUCTIONS

Method C

Starting with a minimum 24 gauge 0.024" (0.6mm) 6" (152mm) metal chimney connector, and a minimum 24 gauge ventilated wall thimble which has two air channels of 1" (25mm) each, construct a wall pass-through. There shall be a minimum 6" (152mm) separation area containing fiberglass insulation from the outer surface of the wall thimble to wall combustibles. Support the wall thimble, and cover its opening with a 24 gauge minimum sheet metal support maintaining the 6" (152mm) space. There should also be a support sized to fit and hold the metal chimney connector. See that the supports are fastened securely to wall surfaces on all sides. Make sure fasteners used to secure the metal chimney connector do not penetrate the chimney flue liner.

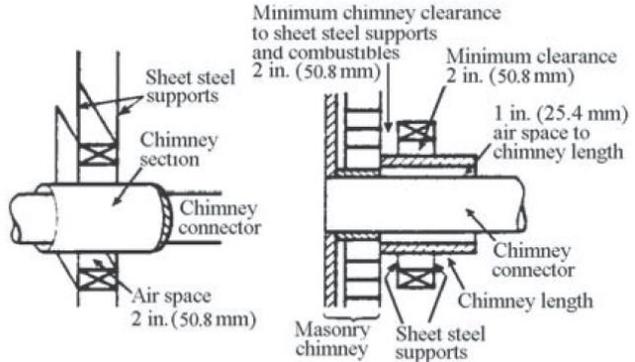


Method D

Start with a Solid-Pak listed factory built chimney section at least 12" (305mm) long, with insulation of 1" (25mm) or more, and an inside diameter of 8" (203mm) - 2" (50mm) larger than the 6" (152mm) chimney connector. Use this as a pass-through for a minimum 24 gauge single wall steel chimney connector. Keep the Solid-Pak section concentric with and spaced 1" (25mm) off the chimney connector by way of sheet metal support plates at both ends of the chimney section. Cover openings with and support the chimney section on both sides with 24 gauge minimum

3. INSTALLATION INSTRUCTIONS

sheet metal supports. Ensure that the supports are fastened securely to wall surfaces on all sides.

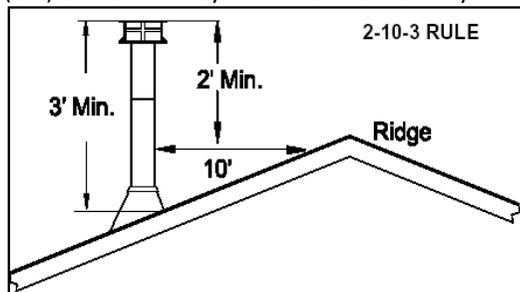


Note:

- Connectors to a masonry chimney, excepting method B, shall extend in one continuous section through the wall pass-through system and the chimney wall, up to but not past the inner flue liner face.
- A chimney connector shall not pass through an attic or roof space, closet or similar concealed space, floor, or ceiling.

CHIMNEY HEIGHT

A masonry chimney or a listed factory-built chimney must be the required height above the roof and any other nearby obstructions. The chimney must be at least 3' (90cm) higher than the highest point where it passes through the roof and at least 2' (60cm) higher than the highest part of the roof or structure that is within 10' (3m) of the chimney measured horizontally.

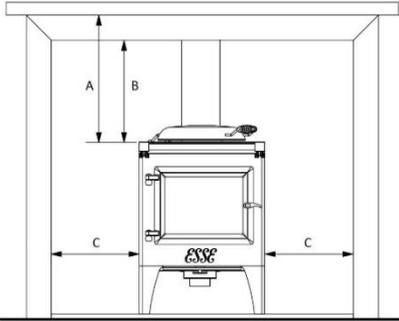


3. INSTALLATION INSTRUCTIONS

POSITIONING WITHIN A MASONRY FIREPLACE

The cook stove can be positioned within a masonry fireplace, but care must be given where a combustible mantelpiece or beam is incorporated.

Remember to incorporate enough room for the bolster lid to be fully opened.



Where a mantelpiece or beam of combustible material, (such as wood), is used in the fireplace, it should be a minimum of 36" (920mm) from the appliance*. In some situations it may be necessary to shield the beam or mantelpiece to protect it. Shielding must be of non-combustible material spaced off the beam by at least ½" (12mm) on non-combustible spacers.

*This is an unlisted clearance distance, as per NFPA 211

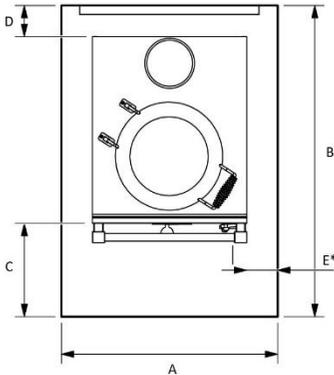
Distances to non-combustible materials

	A	B	C
Minimum Distance	25" (635mm)	20" (508mm)	15" (381mm)

3. INSTALLATION INSTRUCTIONS

FLOOR PROTECTION

The cook stove must be placed upon a hearth or floor protector made from non-combustible material(s). The size of the hearth or floor protector must be in line with national requirements, in extending at least the minimum distance to the front, rear and sides of the appliance, and have a total size as indicated.

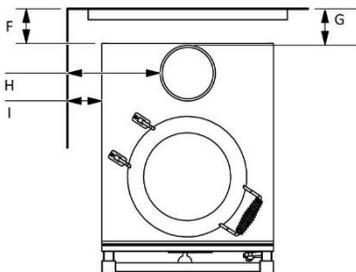


	USA	Canada
A	30" (762mm)	38" (965mm)
B	34" (864mm)	48.5" (1,232mm)
C	16" (406mm)	18" (460mm)
D	0" (0mm)	8" (203mm)
E	6" (152mm)	8" (203mm)

E* - From edge of firebox opening to outside edge of floor protection.

WALL CLEARANCES (CLEARANCE DISTANCES)

The cook stove must be placed an appropriate distance from combustible materials, to both the rear and sides. The Heatshield must be installed in conjunction with these wall clearance distances.



F	4" (101mm)
G	4.5" (114mm)
H	13.5" (343mm)
I	7" (178mm)

3. INSTALLATION INSTRUCTIONS

Check a single wall flue pipe is permitted with State and local officials, regarding the building code restrictions within your area. Clearance distances may only be reduced by means approved by the regulatory authority.

FLUE DRAFT

An appropriate flue draft is essential, for the stove to work safely and efficiently. When installed, and prior to commissioning, a flue draft reading should be taken, to ensure the draft is appropriate. A flue inspection hatch should be installed within the flue, to allow for a flue draft reading to be taken.

When both the cook stove and chimney are warm, a reading in a range between 1.25mm wg (12 Pa) and 2.5mm wg (25 Pa) should be expected. Any readings significantly outside this range are likely to cause problems, so further investigation should be undertaken so as to either reduce or increase the flue draft reading, as appropriate.

COMMISSIONING

Once the installation has been completed, check the flue and chimney connection is fully sealed, and complete a test lighting of the cook stove. Instruct the owner on how to use the appliance, and complete the Commissioning Checklist section of this manual. Finally, ensure that you leave this manual with the owner, for their reference.

3. INSTALLATION INSTRUCTIONS

Please complete, for the owners records and to support any future warranty claims.

Retailer information:

Name: _____

Address: _____

Telephone number: _____

Installation information: (Essential information - must be completed)

Date of installation: _____

ESSE model: _____

Serial number: _____

Installing engineer information:

Name: _____

Address: _____

Telephone number: _____

Commissioning checks: (To be completed & signed for)

Flue draft reading taken and recorded: _____ (Insert reading here)

Flue & chimney setup appropriate: Yes No

Flue & chimney swept & inspected: Yes No

Smoke test completed on appliance: Yes No

Clearance to combustibles checked: Yes No

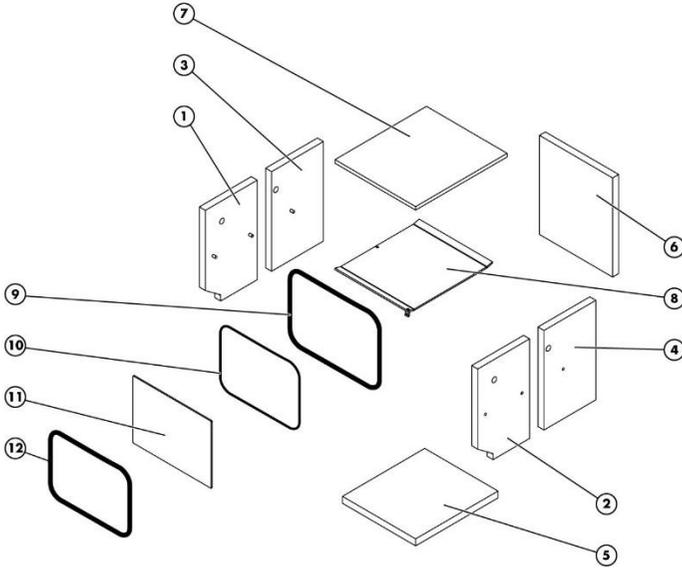
CO and fire alarms fitted: Yes No

Operation of appliance explained to owner: Yes No

Instruction manual handed over to owner: Yes No

Signature: _____ Print name: _____

4. CONSUMABLE PARTS



Item	Part No.	Description	Item	Part No.	Description
1	I-WH-100-006US	Front LHS Brick	7	I-WH-100-118US	Insulating Board
2	I-WH-100-009US	Front RHS Brick	8	I-WH-100-101US	Baffle
3	I-WH-100-007US	Rear LHS Brick	9	ROPE/CUT.GRY 13MM	Door Rope
4	I-WH-100-008US	Rear RHS Brick	10	ROPE/CUT.GRY 4MM	Glass Rope 2
5	I-WH-100-108US	Bottom Brick	11	500-IH-117	Ceramic Glass
6	I-WH-100-109US	Rear Brick	12	ROPE/CUT.GRY 3x15MM	Glass Rope 1

The Bolster Lid Rope Seals will also need replacing during the life of the cook stove.

The above consumable parts can be ordered through your retailer. If your retailer is unable to supply the consumable parts, or you would like to discuss the availability of spare parts, please contact ESSE directly



ESSE Engineering Ltd.,
Long Ing, Barnoldswick, Lancashire, BB18 6BJ, UK

Tel. 01282 813 235
Fax. 01282 816 876
Website www.esse.com

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Appendix A

Alt-125 E3053 Letter



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

FEB 28 2018

Mr. Justin White

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Dear Mr. White,

I am writing in response to your letter dated January 12, 2018, regarding wood heaters manufactured by Hearthstone QHPP, Inc. (Hearthstone). This response, dated February 28, 2018, supercedes our previous response (dated February 26, 2018) to correct an inaccuracy regarding required changes to ASTM E3053-17.

You are requesting to use an alternative test method, using cord wood, as referenced in section 60.532(c) of 40 CFR part 60, Subpart AAA, Standards of Performance for New Residential Wood Heaters (Subpart AAA) to meet the 2020 cord wood alternative compliance option. The 2020 cord wood alternative compliance option states that each affected wood heater manufactured or sold at retail for use in the United States on or after May 15, 2020, must not discharge into the atmosphere any gases that contain particulate matter in excess of 2.5 g/hr. Compliance must be determined by a cord wood test method approved by the Administrator along with the procedures in 40 CFR 60.534. You have requested approval to use the procedures and specifications found in ASTM Method E3053-17, a cord wood test method titled, "Standard Test Method for Determining Particulate Matter Emissions from Wood Heaters using Cordwood Test Fuel," in conjunction with ASTM E2515-11 and Canadian Standards Administration (CSA) Method CSA-B415.1-10, which are specified in 40 CFR 60.534.

We understand that Hearthstone is also requesting that the alternative method proposed above be approved to apply broadly to all wood heaters manufactured by Hearthstone meeting the requirements of Subpart AAA, from the approval date of this request until such time that Subpart AAA is revised or replaced to require a different cord wood certification method, providing all requirements of section 60.533 of Subpart AAA are met.

With the caveats set forth below, we approve your alternative test method request for certifying wood heaters using ASTM E3053-17 in conjunction with section 60.534 of Subpart AAA to meet the 2020 cord wood compliance option until such time that Subpart AAA is revised or replaced to require a different cord wood certification method. We also approve application of this alternative method to all wood heaters manufactured by Hearthstone meeting the requirements of Subpart AAA.

As required in Subpart AAA, section 60.354(d), you or your approved test laboratory must also measure the first hour of particulate matter emissions for each test run using a separate filter in one of the two parallel sampling trains. These results must be reported separately and also included in the total particulate matter emissions per run. Also, as required by Subpart AAA, section 60.534(e), you must have your approved laboratory measure the efficiency, heat output, and carbon monoxide emissions of the tested wood heater using CSA-B415.1-10. For measurement of particulate matter emission concentrations, ASTM 2515-11 must be used.

The following change to ASTM E3053-17 must be followed:

1. Coal bed conditions prior to loading test fuel. The coal bed shall be a level plane without valleys or ridges for all test runs in the high, low, and medium burn rate categories.

The following changes to ASTM E2515-11 must be followed:

1. The filter temperature must be maintained between 80 and 90 degrees F during testing.
2. Filters must be weighed in pairs to reduce weighing error propagation; see ASTM 2515-11, Section 10.2.1 Analytical Procedure.
3. Sample filters must be Pall TX-40 or equivalent Teflon-coated glass fiber, and of 47 mm, 90 mm, 100 mm, or 110 mm in diameter.
4. Only one point is allowed outside the +/- 10 percent proportionality range per test run.

A copy of this letter must be included in each certification test report where this alternative test method is utilized.

It is reasonable that this alternative test method approval be broadly applicable to all wood heaters subject to the requirements of 40 CFR part 60, Subpart AAA. For this reason, we will post this letter as ALT-125 on our website at <http://www3.epa.gov/ttn/emc/approalt.html> for use by other interested parties. As noted earlier in this letter, this alternative method approval is valid until such time that Subpart AAA is revised or replaced to require a different cord wood certification method, and at such time, this alternative will be reconsidered and possibly withdrawn.

If you have additional questions regarding this approval, please contact Michael Toney of my staff at 919-541-5247 or toney.mike@epa.gov.

Sincerely,



Steffan M. Johnson, Group Leader
Measurement Technology Group

cc: Amanda Aldridge, EPA/OAQPS/OID
Adam Baumgart-Getz, EPA/OAQPS/OID
Rafael Sanchez, EPA/OECA
Michael Toney, EPA/OAQPS/AQAD

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Appendix B

Firebox Volume

ESSE

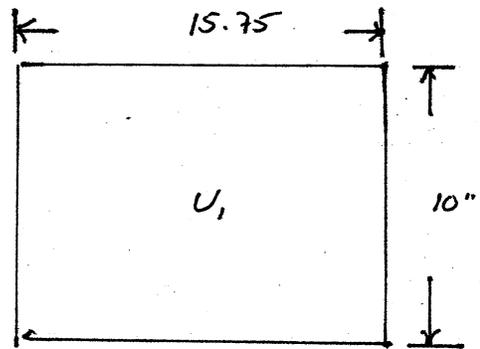
Warm Heart

0224WS 009E

12/15/20
B DAVIS

<u>H</u>	<u>W</u>	<u>D</u>
10"	12"	15.75

$$V_1 = 10 \times 12 \times 15.75 = \frac{1.094}{\text{ft}^3}$$



width = 12.0"

Esse Engineering Ltd.
Model: WarmHeart, BakeHeart
Project Number: 0224WS009E

Appendix C

Revision History Table

