Heatmor Manufacturing

Model 200 SSP
EPA Certification Testing
Project # 005-HH-6-7

Prepared by Dirigo Laboratories, Inc. September 29, 2011

DIRIGO LABORATORIES INC.

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Affidavit:

All certification testing and associated procedures were conducted at Heatmor Manufacturing, Inc. beginning 8/26/2011 and ending on 8/28/2011. Heatmor Manufacturing, Inc. is located at 105 Industrial Park Ct NE, Warroad, MN 56763. All EPA protocols from Methods 1, 2, 3, 4, 5 and 28 WHH were followed in the testing, sampling, analysis, and calibrations for these tests and all results are based on these methods. Particulate sampling was performed per EPA Method 5G sampling option 3 and ASTM E2515 *Standard Test Method for Determination of Particulate Matter Emissions Collected in a Dilution Tunnel.* Efficiency was calculated using EPA Method 28 WHH and checked using CAN/CSA-B415.1-10 *Performance Testing of Solid-Fuel Burning Heating Appliances*.

Dirigo Laboratories is accredited by the U.S. Environmental Protection Agency for the certification of wood heaters pursuant to subpart AAA of 40 CFR Part 60, New Source Performance Standards For Residential Wood Heaters- Methods 28, 28A, 28 OWHH, 5G, 5H. Certificate Numbers 9 and 9M (mobile). See Appendix H for Certification.

The following people were associated with the testing, analysis and report writing associated with this project.

John Steinert, President — Signature — Date 9/29/11

Gary Nelke CMfgE, Vice-President — Signature — Date 9/29/11

Ryan Smith, Q/A — Signature — Date 9/29/11

Introduction:

Heatmor Manufacturing, Inc. contracted with Dirigo Laboratories, Inc. to perform EPA certification testing on Heatmor Model # 200 SSP pellet fired hydronic heater per the newly revised WHH voluntary wood fired hydronic heater program. Efficiency testing was also performed per CSA B-415.1-10 "Performance Testing of Solid-Fuel Burning Heating Appliances". All test results apply solely to the Heatmor Model # 200 SSP. This test report shall not be reproduced except in full, without the written approval of Dirigo Laboratories, Inc.

Technician Notes:

Technician arrived at client facilities on Monday August 22, 2011.

- Set up and calibration of test equipment occurred on 8/22/11 and 8/23/11.
- Conditioning occurred on 8/28/2011-(over 10 hours at a medium draw).
- Prior to start of each certification run, the dilution tunnel was cleaned with a steel chimney brush.
- Run #1 (Cat. 4) began on 8/29/2011
- Run #2 (Cat. 3) began on 8/29/2011
- Run #3 (Cat. 2) began on 8/30/2011
- Run #4 (Cat. 1) began on 8/31/2011

Wood Heater Identification:

- Appliance Tested: *Model # 200 SSP*
- Serial Number: *26807*
- Manufacturer: *Heatmor Manufacturing, Inc.*
- Address: *105 Industrial Park Ct NE, Warroad, MN 56763*
- Catalyst: *No*
- Heat exchange blower: *N/A*
- Type: *Hydronic Heater*
- Style: *Outdoor Pellet*
- Date Received: *N/A*
- Wood Heater Aging: 8/28/2011
- Testing Period – Start: Monday, *August 29, 2011* Finish: *Wednesday, August 31, 2011*
- Test Location: Heatmor Manufacturing, Inc. *105 Industrial Park Ct NE, Warroad, MN 56763*
- Elevation: *1076 Feet above sea level*
- Test Technician(s): *Gary Nelke*
- Test Observer(s): Dian Mullis, Chris Heppner, and Butch Reed

The Heatmor model 200 SSP is manufactured by Heatmor Manufacturing, Inc., of Warroad, MN. The unit is an automatically fed, outdoor, wood pellet fueled hydronic heater and was tested to EPA Method 28 WHH protocol. All testing was conducted by Gary Nelke of Dirigo Laboratories, Inc.

Statement of Estimated Uncertainty:

The combined estimated uncertainty of measurement is ± 10% for emissions results and ± 4% for efficiency results. The precision of the testing procedure cannot be specified because of differences in fueling protocols between appliances and the appliances themselves.

Test Procedures and Equipment:

All test procedures used followed EPA Methods 1, 2, 3, 4, 5g option 3, 28 WHH, ASTM 2515 and CSA B-415.1-10. See Figures 1, 2, and 12 for equipment used. See Appendix F for detailed calibration data.

Equipment List:

1. Flow Meter – Flow Dynamics Model DX-12AN-W-B 0.6 GPM – 300.0 GPM – Load side.
2. Flow Meter – Omega FTB-1431 15.0 GPM – 180.0 GPM Boiler side
3. Analyzer –Servomex CO_2 Analyzer.
4. Analyzer - Servomex O_2 Analyzer.
5. Analyzer – Horiba 510 CO Analyzer
6. Delmhorst J-2000 Wood Moisture Meter.
7. ScienTech Balance Scale.
8. 10 lb. Calibration Weight.
9. APEX XC-60 Digital Emissions Sampling Box A.
10. APEX XC-60 Digital Emissions Sampling Box B.
11. DGM Standard - APEX
12. Weigh-Tronix 84"x60" 10,000 X 1 lb. floor scale w/digital weight indicator.
13. Apex AK 6000 Ambient Sampling Box.

Data Summary:

See Tables 1, and 2 below for individual run summary and Appendix E for full run information. Hang tag information can be found in Table 3 and Weighted averages can be found in Table 4.

Data Summary Part A

						θ	Wfuel	MCave	Qin	Qout
Category	Run No	Load% Capacity	Target Load	Actual Load	Actual Load	Test Duration	Wood Weight as-fired	Wood Moisture	Heat Input	Heat Output
			Btu/hr	Btu/hr	% of max	hrs	lb	% DB	Btu	Btu
I	4	≤ 15% of max	≤ 24,419	12,798	7.86	4.0	10.6	7.4	80,996	51,190
II	3	16-24% of max	26,047 to 39,070	33,542	20.60	4.0	23.0	7.4	175,745	134,167
III	2	25-50% of max	40,698 to 81,396	70,991	43.61	4.0	42.5	7.4	324,746	283,962
IV	1	Max capacity		162,793	100	4.0	95.5	7.4	729,724	651,171

Table 1

Data Summary Part B

			T2 Min	E_T	E	E	$E_{g/hr}$	$E_{g/kg}$	BR -dry	η_{del}	η_{SLM}
Category	Run No	Load% Capacity	Min Return H_2O Temp	Total PM Emissions	PM Output Based	PM Output Based	PM Rate	PM Factor	Burn Rate	Delivered Efficiency	Stack Loss Efficiency
			°F	g	lbs/MMBtu Output	g/MJ	g/hr	g/kg	Kg/hr	%	%
I	4	≤ 15% of max	158.7	1.30	0.0560	0.0241	0.32	0.29	1.12	63.2	75.4
II	3	16-24% of max	158.7	5.71	0.0938	0.0404	1.43	0.59	2.43	76.3	77.1
III	2	25-50% of max	157.0	8.07	0.0626	0.0269	2.02	0.45	4.49	87.4	70.5
IV	1	Max capacity	156.0	6.59	0.0223	0.0096	1.65	0.16	10.09	89.2	85.4

Table 2

Hang Tag Information:

Manufacturer:	Heatmor		
Model Number:	200 SSP		
8-Hour Output Rating:	$Q_{out\text{-}8hr}$	33,542	Btu/hr
8-Hour Average Efficiency:	$\eta_{avg\text{-}8hr}$	76%	**(Using higher heating value)**
		82%	(Using lower heating value)
Annual Efficiency Rating:	η_{avg}	74%	**(Using higher heating value)**
		80%	(Using lower heating value)
Particle Emissions:	E_{avg}	1.12	Grams/hr (average)
		0.07	Lbs/Million Btu Output

Table 3: Hang Tag

Year Round Use Weighting:

Category	Run No.	Weighting Factor (Fi)	$\eta_{del,i} \times F_i$	$\eta_{del\text{-}LHV,i} \times F_i$	$E_{g/MJ,i} \times F_i$	$E_{g/kg,i} \times F_i$	$E_{lb/MMBtu,i} \times F_i$	$E_{g/hr,i} \times F_i$
I	4	0.437	27.6184	29.79029	0.0105251	0.126866915	0.024465176	0.142015974
II	3	0.238	18.16892	19.59692	0.009605693	0.139858236	0.022328049	0.339702571
III	2	0.275	24.035	25.938	0.007410989	0.123592126	0.017226549	0.554705773
IV	1	0.050	4.462	4.813	0.000480196	0.008172464	0.001116197	0.082421281
Totals:		**1.000**	**74.3**	**80.1**	**0.0280**	**0.40**	**0.07**	**1.12**

Table 4: Weighted Average

Stack Loss Efficiency Discussion:

Stack loss statement:

The HHV overall weighted average was 74.6 % for the B415 (stack loss efficiency); 0.3% higher than the appliance delivered efficiency of 74.3 %. Although, the stack loss efficiency showed slightly less than the delivered efficiency for Runs 1 and 2, the findings show better linear results for the appliance efficiency than the stack loss. The B-415 does not show linear results due to the cycling of the appliance and the B415 spreadsheet inability to account for zero weight loss. Runs 1 and 2 show the calculated heat output for the delivered efficiency is greater than the stack loss efficiency, and for Runs 3 and 4 the stack loss is greater. We believe the inconsistency in the B-415 results is caused from unit cycling, the length of the cycling, if the unit is on or off when the run was started, and from the lack of chemical break down from consistent fuel being fed though out the run verse if a single fuel load was used.

The comparison between runs show that the cycling had an effect on the stack loss calculation because of inconsistency of CO_2 data and stack temperatures between runs. Cycling refers to the unit combustion fan turning on and off. All runs had auger cycling that released fuel for different combustion rates. Run 1 did not cycle on and off, but with a continuous fed (auger cycling) fuel load, verses a single fuel load; the combustion gases had very little chemical loss allowing the total loss to increase, which decreases the overall efficiency. The appliance output does not account for chemical loss and the lack of chemical loss for the B-415 spreadsheet results in a higher efficiency than the stack loss by 4 %.

Effects on B-415 data from cycling & continuously fed fuel:

- Run 1:
  - Did not cycle
  - 100% combustion efficiency though out run.
  - Constant Fuel fed – consistent CO_2 readings and excess air.
  - Minimal chemical loss – difference of 27,525 Btu output between test methods.
- Run 2:
  - During on cycle, one interval reading of high CO_2 concentration.
  - During off cycle, had interval calculated efficiency readings below 50%.
  - Had the lowest stack loss efficiency of all four runs.
  - Had more cycles than the other runs
- Run 3:
  - During on cycle, two interval reading of high CO_2 concentration.
  - During off cycle, did not have calculated efficiency readings below 50%.
- Run 4:
  - Long off cycle, but higher overall CO_2 concentrations (all above 50%) than Run 2.

Stack Temperature effects from cycling:

- Run 1:
  - Had consistent temperature, with low excess air and combustion efficiency of 100% per interval reading.
- Run 2:
  - Stack temperature did not have a chance to cool because of the short on / off cycles. Had an average combustion efficiency of 95.5% with some interval readings as low as 87%.
- Run 3:
  - Stack temperature had more time to cool with longer off cycle with temperatures up to 20 degrees cooler than run 2. Had an average combustion efficiency of 93.0% with interval readings not less than 89%.
- Run 4:
  - Stack temperature were up to 20 degrees cooler than run 2. Had an average combustion efficiency of 91.3% with interval reading down to 85%.

*See Appendix F for supporting data.

Deviation from Standard Forms:

The weight data entered into the provided CSA B-415.1-10 spreadsheet was changed to show total fuel loss. The original spreadsheet is designed to have the test end when the final fuel weight equals zero. Being a pellet fueled appliance, the test does not end when the scale equals zero, therefore the initial weight was changed to the total weight loss and the weight change per interval was changed using the same weight loss as the data during the run.

Process Operations:

The appliance was operated according to procedures as described in the Operations Manual. Aquastat was set to a temperature differential of 20° F. All exterior draft measurements around the unit for all 4 runs were less than 1 ft^3 per minute. See Appendix E for detailed run information.

Test Fuel Analysis:

Test fuel consisted of wood pellets with a detailed analysis below.

Analytical Report

Sample Log No:		**11C2503**			**Sample Recognized As:**	
Sample Reference:		**Arrival Date:**			8/16/2011	
Sample Designation:	Heatmor		**Analyzed Date:**		8/24/2011	
Sample Date / Time:		**Report Date Version:**			8/25/2011 11:17	
Report ID:			11C2503-01			
MOISTURE METHOD		**UNITS**	**AS FREE**		**RECEIVED**	
Moisture Total	ASTM E871		wt. %		6.87	
Ash	ASTM D1102	wt. %	0.41		0.38	
Volatile Matter	ASTM D3175	wt. %	82.84		77.15	
Fixed Carbon by Difference	ASTM D3175	wt. %	16.75		15.60	
Sulfur	ASTM D4239	wt. %	0.022		0.021	
SO_2	Calculated		lb/mmbtu		0.049	
Net Cal. Value at Const. Pressure	ISO 1928	GJ/tonne	19.18		17.69	
Net Cal. Value at Const. Pressure	ISO 1928	J/g	19178		17693	
Gross Cal. Value at Const. Vol.	ASTM E711	J/g	20493		19084	
Gross Cal. Value at Const. Vol.	ASTM E711	Btu/lb	8811		8205	
Carbon	ASTM D5373	wt. %	50.57		47.09	
Hydrogen	ASTM D5373	wt. %	6.04		5.62	
Nitrogen	ASTM D5373	wt. %	<	0.01	<	0.01
Oxygen	ASTM D3176	wt. %	>	42.95	>	40.01

Sampling Methods:

A dual filter dry sampling train system (ASTM 2515-10 / 5G sample option 3) was used in collecting particulate samples. The dilution tunnel is 16 inches in diameter. All particulate sampling conditions per ASTM 2515-10 and method 5G option 3 were followed.

Sampling and Analytical Procedures:

All sampling and analytical procedures used followed EPA Methods 1, 2, 3, 4, 5 and 28, ASTM 2515-10, and CSA B-415.1-10. See Figure 10 for sample port locations.

Analytical Methods Description:

All sample recovery and analysis procedures followed EPA Method 5 procedures. At the end of each test run, filters were removed from their housings, dessicated for 24 hours, and then weighed to a constant weight per Method 5 section 11.0.

Quality Control and Assurance Procedures and Results:

Calibration procedures and results were conducted per ASTM 2515-10, EPA Method 1 through 5 and Method 28WHH. Calibration certificates and results can be found in Appendix F.

Test method quality control procedures (leak checks, volume meter checks, stratification checks, proportionality results) followed the procedures outlined in Method 5.

Appendices:

Appendix A: Sampling and Analytical Procedures

All Sampling and Analytical Procedures were performed by Gary Nelke. All procedures used were directly from ASTM 2515-10, EPA Methods 1, 2, 3, 4, 5 and 28WHH. Efficiency testing was performed to CSA B-415.1-10.

Appendix B: Alternate Procedures

No alternate procedures were used.

Dirigo Laboratories, Inc.

Manufacturer:	Heatmor
Model:	200 SSP
Date:	08/29/11
Run:	1
Control #:	006
Test Duration:	240
Output Category:	VI

Technicians: _____

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Test Results In Accordance with CSA B415.1-10

	HHV Basis	LHV Basis
Overall Efficiency	85.4%	91.2%
Combustion Efficiency	99.5%	99.5%
Heat Transfer Efficiency	86%	91.6%

Output Rate (kJ/h)	164,385	155,937	**(Btu/h)**
Burn Rate (kg/h)	10.09	22.23	**(lb/h)**
Input (kJ/h)	192,527	182,632	**(Btu/h)**

Test Load Weight (dry kg)	40.35	88.94	**dry lb**
MC wet (%)	6.87		
MC dry (%)	7.38		
Particulate (g)	6.59		
CO (g)	97		
Test Duration (h)	4.00		

Emissions	**Particulate**	**CO**
g/MJ Output	0.01	0.15
g/kg Dry Fuel	0.16	2.41
g/h	1.65	24.28
lb/MM Btu Output	0.02	0.34

Air/Fuel Ratio (A/F)	9.05

VERSION: **2.4** **4/15/2010**

Dirigo Laboratories, Inc.

Manufacturer:	Heatmor
Model:	200 SSP
Date:	08/29/11
Run:	2
Control #:	006
Test Duration:	240
Output Category:	III

Technicians: _____

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Test Results in Accordance with CSA B415.1-10

	HHV Basis	LHV Basis
Overall Efficiency	70.5%	75.3%
Combustion Efficiency	96.8%	96.8%
Heat Transfer Efficiency	73%	77.7%

Output Rate (kJ/h)	60,385	57,281	**(Btu/h)**
Burn Rate (kg/h)	4.49	9.90	**(lb/h)**
Input (kJ/h)	85,679	81,276	**(Btu/h)**

Test Load Weight (dry kg)	17.96	39.58	**dry lb**
MC wet (%)	6.87		
MC dry (%)	7.38		
Particulate (g)	8.01		
CO (g)	1,350		
Test Duration (h)	4.00		

Emissions	**Particulate**	**CO**
g/MJ Output	0.03	5.59
g/kg Dry Fuel	0.45	75.18
g/h	2.00	337.51
lb/MM Btu Output	0.08	12.99

Air/Fuel Ratio (A/F)	21.04

VERSION: 2.4 4/15/2010

Dirigo Laboratories, Inc.

Manufacturer:	Heatmor
Model:	200 SSP
Date:	08/31/11
Run:	3
Control #:	006
Test Duration:	240
Output Category:	II

Technicians: _____

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Test Results in Accordance with CSA B415.1-10

	HHV Basis	LHV Basis
Overall Efficiency	77.1%	82.4%
Combustion Efficiency	97.2%	97.2%
Heat Transfer Efficiency	79%	84.7%

Output Rate (kJ/h)	35,767	33,929	**(Btu/h)**
Burn Rate (kg/h)	2.43	5.35	**(lb/h)**
Input (kJ/h)	46,368	43,985	**(Btu/h)**

Test Load Weight (dry kg)	9.72	21.42	**dry lb**
MC wet (%)	6.87		
MC dry (%)	7.38		
Particulate (g)	5.71		
CO (g)	727		
Test Duration (h)	4.00		

Emissions	**Particulate**	**CO**
g/MJ Output	0.04	5.08
g/kg Dry Fuel	0.59	74.85
g/h	1.43	181.85
lb/MM Btu Output	0.09	11.82

Air/Fuel Ratio (A/F)	21.76

VERSION: 2.4 4/15/2010

Dirigo Laboratories, Inc.

Manufacturer:	Heatmor
Model:	200 SSP
Date:	08/31/11
Run:	4
Control #:	006
Test Duration:	240
Output Category:	I

Technicians: _____

Test Results in Accordance with CSA B415.1-10

	HHV Basis	LHV Basis
Overall Efficiency	75.4%	80.5%
Combustion Efficiency	96.5%	96.5%
Heat Transfer Efficiency	78%	83.4%

Output Rate (kJ/h)	16,112	15,284	**(Btu/h)**
Burn Rate (kg/h)	1.12	2.47	**(lb/h)**
Input (kJ/h)	21,369	20,271	**(Btu/h)**

Test Load Weight (dry kg)	4.48	9.87	**dry lb**
MC wet (%)	6.87		
MC dry (%)	7.38		
Particulate (g)	1.3		
CO (g)	405		
Test Duration (h)	4.00		

Emissions	**Particulate**	**CO**
g/MJ Output	0.02	6.28
g/kg Dry Fuel	0.29	90.35
g/h	0.33	101.17
lb/MM Btu Output	0.05	14.59

Air/Fuel Ratio (A/F)	46.27

VERSION: 2.4 4/15/2010