
Heatmor Manufacturing

**Model 400 4S
EPA Certification Testing
Project # 005-HH-6-7**

**Prepared by Dirigo Laboratories, Inc.
September 23, 2011**

DIRIGO
LABORATORIES INC. 

**11785 SW Highway 212 – Suite 305
Clackamas, OR 97015-9050
(503) 650-0088
WWW.DIRIGOLAB.COM**

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

 9/23/11
Signature Date

Gary Nelke CMfgE, Vice-President

 9/23/11
Signature Date

Ryan Smith, Q/A

 9/23/11
Signature Date

Introduction:

Heatmor Manufacturing, Inc. contracted with Dirigo Laboratories, Inc. to perform EPA certification testing on the 400 4S wood 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 # 400 4S. 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 8/24 and 8/25/ 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 8/26/2011
- Run #2 (Cat. 3) began on 8/26/2011
- Run #3 (Cat. 2) began on 8/27/2011
- Run #4 (Cat. 1) began on 8/28/2011

Wood Heater Identification:

- Appliance Tested: *Model # 400 4S*
- Serial Number: *26100*
- 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*
- Date Received: *N/A*
- Wood Heater Aging: *8/23/2011 and 8/24/2011*
- Testing Period – Start: *Friday, August 26, 2011* Finish: *Monday, August 29, 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 400 4S is manufactured by Heatmor Manufacturing, Inc. of Warroad, MN. The unit is a manually fed outdoor wood fired 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 $\pm 10\%$ for emissions results and $\pm 4\%$ 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 CO₂ Analyzer.
4. Analyzer - Servomex O₂ 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.

Heatmor Manufacturing

Model 400 4S

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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

Category	Run No	Load% Capacity	Target Load	Actual Load	Actual Load	θ	W _{fuel}	MC _{ave}	Q _{in}	Q _{out}
						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	≤ 56,461	46,074	12.24	23.8	214.9	22.9	1,503,775	1,098,102
II	3	16-24% of max	60,225 to 90,338	82,492	21.92	14.0	207.2	23.1	1,447,259	1,154,882
III	2	25-50% of max	94,102 to 188,204	182,296	48.43	6.3	212.1	23.8	1,469,831	1,154,542
IV	1	Max capacity		376,409	100	3.0	209.4	23.4	1,459,630	1,129,227

Table 1

Data Summary Part B

Category	Run No	Load% Capacity	T2 Min	E _r	E	E	E _{g/hr}	E _{g/kg}	η_{del}	η_{SLM}
			Min Return H ₂ O Temp	Total PM Emissions	PM Output Based	PM Output Based	PM Rate	PM Factor	Delivered Efficiency	Stack Loss Efficiency
			°F	g	lbs/MMBtu Output	g/MJ	g/hr	g/kg	%	%
I	4	≤ 15% of max	151.9	192.02	0.3855	0.1659	8.06	2.42	73.0	73.8
II	3	16-24% of max	149.0	132.17	0.2523	0.2482	9.44	1.73	79.8	74.0
III	2	25-50% of max	144.6	79.30	0.1514	0.0651	12.52	1.02	78.6	73.7
IV	1	Max capacity	144.5	41.20	0.0804	0.0346	13.73	0.54	77.4	70.7

Table 2

Heatmor Manufacturing

Model 400 4S

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Hang Tag Information:

Manufacturer:	Heatmor		
Model Number:	400 4S		
8-Hour Output Rating:	$Q_{out-8hr}$	160,599	Btu/hr
8-Hour Average Efficiency:	$\eta_{avg-8hr}$	79%	(Using higher heating value)
		85%	(Using lower heating value)
Annual Efficiency Rating:	η_{avg}	76%	(Using higher heating value)
		82%	(Using lower heating value)
Particle Emissions:	E_{avg}	9.90	Grams/hr (average)
		0.27	Lbs/Million Btu Output

Table 3: Hang Tag

Year Round Use Weighting:

Category	Run No.	Weighting Factor (Fi)	$\eta_{del,i} \times Fi$	$\eta_{del-LHV,i} \times Fi$	$E_g/MJ,i \times Fi$	$E_g/kg,i \times Fi$	$E_{lb/MMBtu,i} \times Fi$	$E_g/hr,i \times Fi$
I	4	0.437	31.90974	34.35694	0.072477991	1.057994433	0.168472196	3.520865798
II	3	0.238	18.9924	20.4442	0.059072143	0.412097134	0.060049957	2.246910387
III	2	0.275	21.60125	23.25675	0.017915698	0.281315469	0.041644324	3.443471546
IV	1	0.050	3.868	4.1645	0.001730207	0.026758011	0.004021797	0.686662598
Totals:		1.000	76.4	82.2	0.1512	1.78	0.27	9.90

Table 4: Weighted Average

Stack Loss Efficiency Discussion:

The stack loss efficiency (B415) was lower than the delivered efficiency on runs 1 (category IV), 2 (category III), and 3 (category II). The stack loss difference was 6.8 % for run 1, 4.8 % of run 2, and 5.9 % for run 3. The reason for the stack loss efficiency being lower than the delivered efficiency was that the unit was equipped with a barometric damper that is integral to the unit. The barometric damper is located at the flue collar where the exhaust pipe is attached. The resulting effect of this is a diluted stack gas with lower stack loss efficiency. The barometric damper is used to help get the draft started during on / off cycling. It is assumed that the stack gas was diluted by as much as 50%. The CO and CO₂ were lower and the O₂ was higher than what we would have expected in a non-diluted stack.

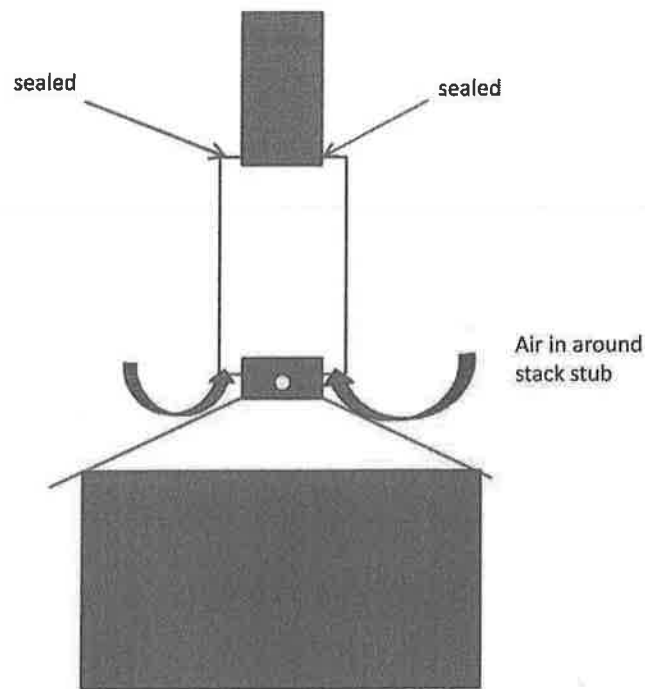


Figure 3: Barometric Damper Diagram

Test Condition Summary:

All testing conditions for runs 1, 2, 3 and 4 fell within allowable specifications of Method - 28. Details of all run conditions can be found in Appendix D.

Description:

Dimensions, air flow, firebox configuration, air supply locations, air introduction locations, and baffle locations of the wood heater are referenced below in Figures 3 through 7. Detailed firebox drawings can be found in Appendix C.

Dirigo Laboratories, Inc.

Manufacturer: Heatmor
Model: 400ss
Date: 08/28/11
Run: 4
Control #: 005
Test Duration: 1430
Output Category: II

Technicians: Jan

Test Results In Accordance with CSA B415.1-10

	HHV Basis	LHV Basis
Overall Efficiency	73.8%	79.5%
Combustion Efficiency	96.6%	96.6%
Heat Transfer Efficiency	76%	82.4%

Output Rate (kJ/h)	48,882	46,370	(Btu/h)
Burn Rate (kg/h)	3.33	7.34	(lb/h)
Input (kJ/h)	66,202	62,800	(Btu/h)

Test Load Weight (dry kg)	79.34	174.86	dry lb
MC wet (%)	18.63		
MC dry (%)	22.90		
Particulate (g)	192.02		
CO (g)	5,358		
Test Duration (h)	23.83		

Emissions	Particulate	CO
g/MJ Output	0.16	4.60
g/kg Dry Fuel	2.42	67.53
g/h	8.06	224.80
lb/MM Btu Output	0.38	10.69

Air/Fuel Ratio (A/F)	29.67
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VERSION:

2.4

4/15/2010