TEST REPORT

REPORT NUMBER: 102092693MID-008a
REPORT DATE: March 31, 2016

EVALUATION CENTER
Intertek Testing Services NA Inc.
8431 Murphy Drive
Middleton, WI 53562

RENDERED TO

Dectra Corporation
3425 33rd Avenue, NE
Saint Anthony, MN 55418

PRODUCT EVALUATED:

Model WHS1000 Solid Fuel Hydronic Furnace

Report of Testing Model WHS1000 Solid Fuel Hydronic Heater for compliance with the applicable requirements of the following criteria: Appendix A1 Modified test method for wood-fired hydronic appliances that utilize full thermal storage of ASTM E2618-13 Measurement of particulate emissions and heating efficiency of outdoor solid fuel-fired hydronic heating appliances and EPA 40 CFR Part 60 "Standards of Performance for New Residential Wood Heaters, New Residential Hydronic Heaters and Forced-Air Furnaces", March 16, 2015..

TABLE OF CONTENTS

APPENDICES

REVISION SUMMARY

DATE	SUMMARY

I. INTRODUCTION

I.A. GENERAL

From March 8, 2016 to March 11, 2016 Intertek Testing Services NA Inc. (Intertek) conducted tests on the WHS1000 Solid Fuel Hydronic Heater to determine emission and efficiency results for Dectra Corporation.

Tests were conducted by Ken Slater at the Intertek Testing Services NA Inc. laboratory located at 8431 Murphy Drive, Middleton, Wisconsin. Tests were evaluated to the Appendix A1 Modified test method for wood-fired hydronic appliances that utilize full thermal storage for ASTM E2618-13 Standard Test Method for Measurement of Particulate Emissions and Heating Efficiency of Outdoor Solid Fuel-Fired Hydronic Heating Appliances.

I.B. TEST UNIT DESCRIPTION

The model WHS1000 is a solid fueled unit with a 8.83 cubic foot firebox constructed of carbon sheet steel, and weighs 2200 lbs. dry. The heat exchanger extends through the water vessel, which holds 8424 lbs. of water.

I.C. RESULTS

The unit as tested produced an average emissions rate of:
0.257 lbs/million Btu of output for the heating season
0.262 lbs/million Btu of output for year round

I.D. PRETEST INFORMATION

The unit was inspected upon arrival at the Dectra Corporation facility and found to be in good condition. The unit was set up per the manufacturer’s instructions. The unit was placed on the test stand and instrumented with thermocouples in the specified locations. The chimney system and laboratory dilution tunnel was cleaned using standard wire brush chimney cleaning equipment.

On March 8, 2016 the unit was ready for testing.

II. SUMMARY OF TEST RESULTS

II.A EPA Results

Table 1A. Data Summary Part A

Category	Load % Capacity	Target Load	Actual Load	Actual Load	Θ Test Duration	W_{fuel} Wood Weight as-fired	MC_{ave} Wood Moisture	Q_{in} Heat Input	Q_{out} Heat Output
		Btu/hr	Btu/hr	% of Max	hrs	lb	% DB	Btu	Btu
I	15% of Max	24,000	24,000	15%	22.9	106.98	22.09	765,110	548,404
II	20% of Max	32,000	32,000	20%	17.7	106.98	22.09	765,110	567,609
III	37.5% of max	60,000	60,000	37.5%	9.9	106.98	22.09	765,110	596,871
IV	Max capacity	160,000	160,000	100%	3.9	106.98	22.09	765,110	619,691

Table 1B. Data Summary Part B

Category	Load % Capacity	E_T Total PM Emissions	E PM Output Based	E PM Output Based	$E_{g/hr}$ PM Rate	$E_{g/kg}$ PM Factor	η_{del} Delivered Efficiency HHV
		g	lb/mmBtu Out	g/MJ	g/hr	g/kg	%
I	15% of Max	67.3	0.272	0.116	2.94	1.67	71.7%
II	16-24% of Max	67.3	0.263	0.112	3.79	1.67	74.2%
III	25-50% of max	67.3	0.250	0.107	6.76	1.67	78.0%
IV	Max capacity	67.3	0.241	0.103	17.37	1.67	81.0%

II.B Summary of other Data

Table 2. Year Round Use Weighting

Category	Weighting Factor	$\eta_{del,i}$ x F_i-HHV	$E_{g/MJ,i}$ x F_i	$E_{g/kg,i}$ x F_i	$E_{lb/mmbtu,i}$ x F_i	$E_{g/hr,i}$ x F_i
I	0.437	0.31	0.051	0.73	0.12	0.08
II	0.238	0.18	0.027	0.40	0.06	0.05
III	0.275	0.21	0.029	0.46	0.07	0.05
IV	0.050	0.04	0.005	0.08	0.01	0.01
Totals	**1.000**	**74%**	**0.11**	**1.67**	**0.262**	**0.19**

II.C Summary of other Data

	Run 2	Run 3	Run 4	Standby	Units
Steel Mass	2200	2200	2200	2200	lbs
Water Mass	8428	8294	8294	8294	lbs
Fuel Load Weight	110.64	104.86	105.45		lbs
Fuel MC (dry basis)	22.58	21.84	21.86		%
Kindling Mass	1.73	1.59	1.68		lbs
Kindling MC (dry basis)	23.7	23.7	23.7		%
Starting system temp.	126.92	121.91	117.75	172.50	F
Ending System Temp.	203.58	196.58	188.73	168.20	F
Average Room Temp.	67.55	64.76	57.20	66.80	
Burn Time	134.00	126	127	480.00	Minutes
Burn Time	2.23	2.10	2.12	8.00	Hours
Standby Test Duration				8	Hours
HHV	8600	8600	8600		BTU/lb
Dry Fuel Weight	41.59	39.63	39.88		Kg
Burn Rate	18.62	18.87	18.84		Kg/hr
Input	788,236	751,237	755,858		BTU
Heat Stored	662,968	635,733	604,332		BTU
Average	662,968	635,733	604,332		
Standby Loss Rate				44.2	BTU/hr-F
Total Emissions	63.2	52.2	86.4		Grams
Total Emissions	0.139	0.115	0.190		lbs
Category I Output Rate	24000	24000	24000	3756	BTU/hr
Category II Output Rate	32000	32000	32000	3756	BTU/hr
Category III Output Rate	60000	60000	60000	3756	BTU/hr
Category IV Output Rate	160000	160000	160000	3756	BTU/hr

				Average	
Output Time Cat I	23.9	22.9	21.8	22.9	Hours
Output Time Cat II	18.5	17.8	16.9	17.7	Hours
Output Time Cat III	10.4	10.0	9.5	9.9	Hours
Output Time Cat IV	4.0	3.9	3.7	3.9	Hours
				Average	
Category I Efficiency	72.7%	73.2%	69.1%	71.7%	
Category II Efficiency	75.3%	75.7%	71.6%	74.2%	
Category III Efficiency	79.2%	79.6%	75.2%	78.0%	
Category IV Efficiency	82.2%	82.7%	78.1%	81.0%	
Category I Emissions	0.243	0.209	0.364	0.27	lbm/mmBTU output
Category II Emissions	0.235	0.202	0.352	0.26	lbm/mmBTU output
Category III Emissions	0.223	0.192	0.335	0.25	lbm/mmBTU output
Category IV Emissions	0.215	0.185	0.323	0.24	lbm/mmBTU output

III. PROCESS DESCRIPTION

III.A. DISCUSSION

RUN #1 (March 8, 2016). The starting temperature in the heat storage vessel was 126.9°F. Burn time was 2.23 hours and ended with a heat storage vessel temperature of 202.5°F.

RUN #2 (March 10, 2016). The starting temperature in the heat storage vessel was 121.9°F. Burn time was 2.10 hours and ended with a heat storage vessel temperature of 195.8°F.

RUN #3 (March 11, 2016). The starting temperature in the heat storage vessel was 120°F. Burn time was 2.85 hours and ended with a heat storage vessel temperature of 170°F.

III.B. UNIT DIMENSIONS

Overall dimensions are 67-in wide, 77-in deep, 65-in high.

III.C. AIR SUPPLY SYSTEM

Combustion air enters from a fresh air intake located on the rear of the unit. The air travels to a collar in the front of the unit where it enters the firebox via primary and secondary combustion air nozzles. The movement of combustion air is aided by a constant 3600 RPM induced-draft combustion air blower. Combustion products flow through a heat exchanger system before exiting through a 6-in flue collar located at the top back of the outer enclosure. Combustion air is terminated by an electronic digital controller. The controller compares the flue and water temperatures until they fall to within 5 °F of each other. The blower is then turned off and combustion air is terminated.

III.D. OPERATION DURING TEST

The boiler is operated until the entire fuel load is consumed and there is no further combustion in the firebox. The end of the test is determined when the water storage temperature is no longer increasing.

III.E TEST FUEL PROPERTIES

The fuel used was Douglas fir. The fuel was split cordwood with dimensions around 6-in thick x 12-in wide x 24-in in length. The fuel was dried to average moisture content between 19% and 25% on a dry basis.

III.F. START-UP OPERATION

The cordwood fuel started with newspaper and a measured kindling load. As the test load was being lit, the sampling system was started simultaneously. The unit was allowed to operate until all combustion in the firebox had ceased.

IV. SAMPLING SYSTEMS

The ASTM E2515-11 sampling procedure was used.

IV.A. SAMPLING LOCATIONS

Particulate samples are collected from the dilution tunnel at a point 16 feet from the tunnel entrance. The tunnel has two elbows ahead of the sampling section. (See Figure 3.) The sampling section is a continuous 14-foot section of 10-inch diameter pipe straight over its entire length. Tunnel velocity pressure is determined by a standard Pitot tube located 96 inches from the beginning of the sampling section. The dry bulb thermocouple is located six inches downstream from the Pitot tube. Tunnel samplers are located 36 inches downstream of the Pitot tube and 36 inches upstream from the end of this section. (See Figure 1.)

IV.A.(1) DILUTION TUNNEL

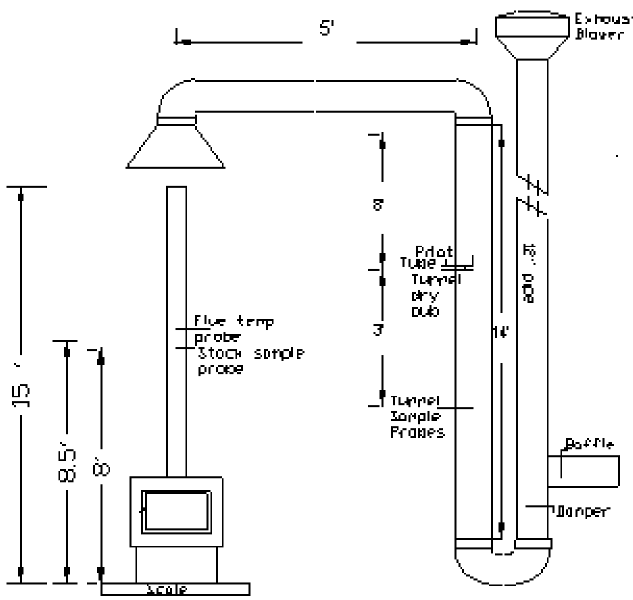

FIGURE 1

IV.B.OPERATIONAL DRAWINGS

IV.B.(2). DILUTION TUNNEL SAMPLE SYSTEMS

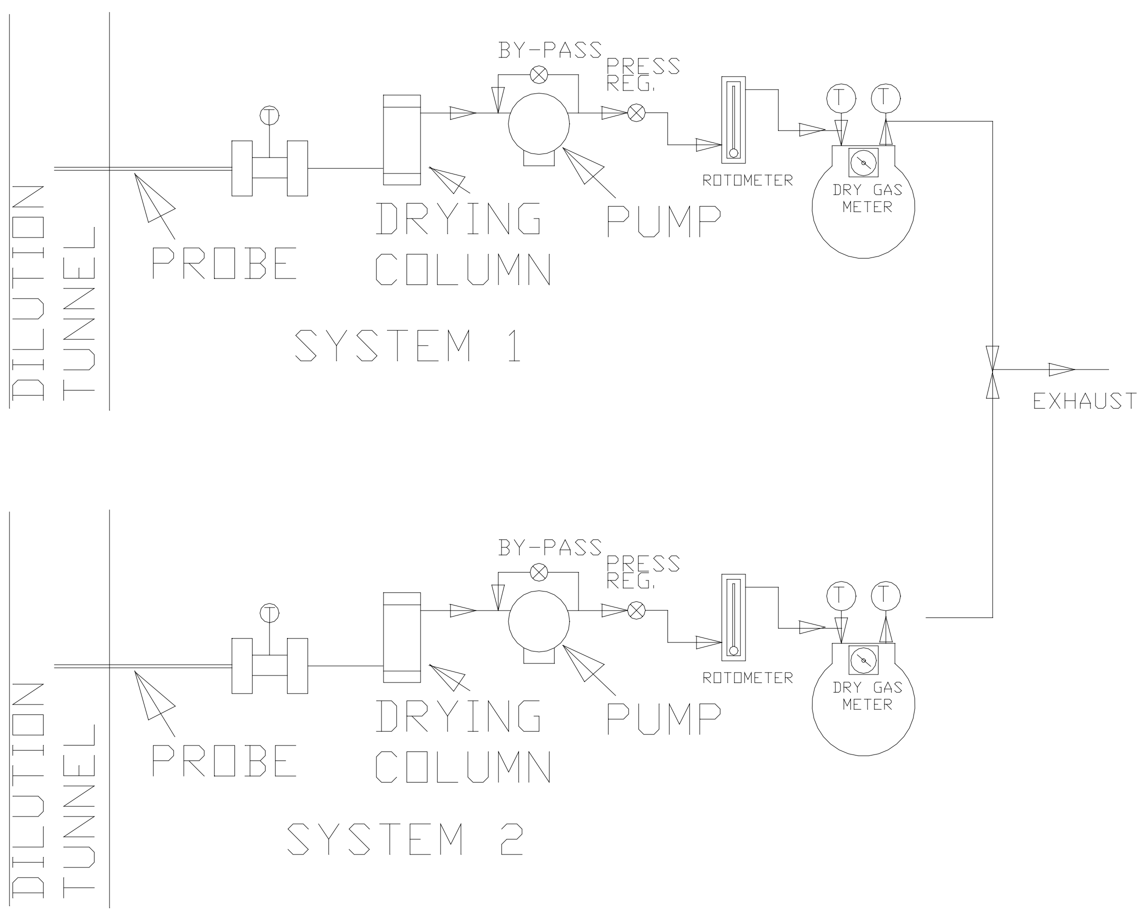

Figure 2

V. SAMPLING METHODS

V.A. PARTICULATE SAMPLING

Particulates were sampled in strict accordance with ASTM E2515-11. This method uses two identical sampling systems with Gelman A/E 61631 binder free, 47-mm diameter filters. The dryers used in the sample systems are filled with “Drierite” before each test run.

VI. QUALITY ASSURANCE

VI.A. INSTRUMENT CALIBRATION

VI.A. (1). DRY GAS METERS

At the conclusion of each test program the dry gas meters are checked against our standard dry gas meter. Three runs are made on each dry gas meter used during the test program. The average calibration factors obtained are then compared with the six-month calibration factor and, if within 5%, the six-month factor is used to calculate standard volumes. Results of this calibration are contained in Appendix D.

An integral part of the post test calibration procedure is a leak check of the pressure side by plugging the system exhaust and pressurizing the system to 10” W.C. The system is judged to be leak free if it retains the pressure for at least 10 minutes.

The standard dry gas meter is calibrated every 6 months using a Spirometer designed by the EPA Emissions Measurement Branch. The process involves sampling the train operation for 1 cubic foot of volume. With readings made to .001 ft^3, the resolution is .1%, giving an accuracy higher than the ±2% required by the standard.

VI.A.(2). STACK SAMPLE ROTOMETER

The stack sample rotometer is checked by running three tests at each flow rate used during the test program. The flow rate is checked by running the rotometer in series with one of the dry gas meters for 10 minutes with the rotometer at a constant setting. The dry gas meter volume measured is then corrected to standard temperature and pressure conditions. The flow rate determined is then used to calculate actual sampled volumes.

VI.B. TEST METHOD PROCEDURES

VI.B.(1). LEAK CHECK PROCEDURES

Before and after each test, each sample train is tested for leaks. Leakage rates are measured and must not exceed 0.02 CFM or 4% of the sampling rate. Leak checks are performed checking the entire sampling train, not just the dry gas meters. Pre-test and post-test leak checks are conducted with a vacuum of 10 inches of mercury. Vacuum is monitored during each test and the highest vacuum reached is then used for the post test vacuum value. If leakage limits are not met, the test run is rejected. During, these tests the vacuum was typically less than 2 inches of mercury. Thus, leakage rates reported are expected to be much higher than actual leakage during the tests.

VI.B.(2). TUNNEL VELOCITY/FLOW MEASUREMENT

The tunnel velocity is calculated from a center point Pitot tube signal multiplied by an adjustment factor. This factor is determined by a traverse of the tunnel as prescribed in EPA Method 1. Final tunnel velocities and flow rates are calculated from EPA Method 2, Equation 6.9 and 6.10. (Tunnel cross sectional area is the average from both lines of traverse.)

Pitot tubes are cleaned before each test and leak checks are conducted after each test.

VI.B.(3). PM SAMPLING PROPORTIONALITY (5G-3)

Proportionality was calculated in accordance with EPA Method 5G-3. The data and results are included in Appendix C.

VII RESULTS AND OBSERVATIONS

This test demonstrates that model WHS1000 is an affected facility under the definition given in the regulation. The emission rate of 0.262 lbs/million Btu of output does meet the EPA requirements for the Step 1 limits for the 2015 regulation.
The model WHS1000 has been found to be in compliance with the applicable performance and construction requirements of the following criteria:
"**Appendix A1 Modified test method for wood-fired hydronic appliances that utilize full thermal storage of ASTM E2618-13 Measurement of particulate emissions and heating efficiency of outdoor solid fuel-fired hydronic heating appliances**" **and EPA 40 CFR Part 60 "Standards of Performance for New Residential Wood Heaters, New Residential Hydronic Heaters and Forced-Air Furnaces", March 16, 2015.**

The model WHS1000 was the model tested, which is configured with a horizontal flue located at the top back of the unit.

INTERTEK TESTING SERVICES NA

Evaluated by: Ken Slater
Ken Slater
Associate Engineer - Hearth

Reviewed by:
Brian Ziegler
Engineering Team Leader - Hearth