TEST REPORT

TEST OF PELLET STOVE FOR EMISSIONS AND EFFICIENCY

PER EPA METHODS 28 AND 5G-3, FEBRUARY 1988

Client: Ravelli

Attention: Rafaël Sanchez

TESTED BY:

Services Polytests
411 St-Jacques
Napierville, QC, J0J 1L0

TEST DATES :
REPORT DATE : september 18, 2013
Project number : P-1199
unit model : Spillo

Tested by: written by :

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Verified by :

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SUMMARY

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1 INTRODUCTION

1.1 GENERAL

Laboratory

- Location: Services Inc., 411 St-Jacques st, Napierville QC, Canada JOJ 1LO
- Elevation: 100 feet above see level

Test program

- Purpose: unit qualification E.P.A. Phase II
- Test dates: june 25th to 26th 2013
- Test methods used:
    - Particulate emissions: methods 28 and 5G-3 as referred into 40 CFR Part 60 Subpart AAA
    - Efficiency: CSA B415.1-10

1.2 TEST UNIT INFORMATION

General

- Manufacturer: Ravelli
- Product type: pellet stove
- Combustion system: blower
- Unit tested: SPILLO

Particularities

- Options: None
- Product line similarities: none

1.3 RESULTS

Emission results obtained

- Weighted average emission rate: 2.67 grams/hour
- Maximum rate cap: 3.8 grams/hour at run 4

Conformity: E.P.A. Phase II

1.4 PRETEST INFORMATION

Unit condition: The unit was received by carrier 2013 March 26th . The 10hrs of aging is made June 24th , 2013.

Set up

- Venting system type: pellet venting conduit 3inch. diameter
- System height from floor: 15 feet
- Particularities: none

Break in period

- Duration: the unit received from the manufacturer and run for at least 10 hours at a category 2 burn rate with adequate documentation of fuel additions and flue and unit temperatures during the day of June 24th 2013.
- Fuel: pellet (Lauzon Cubex)

2 SUMMARY OF TEST RESULTS

2.1 EMISSIONS

Run Number	Test Date	Burn Rate (kg/hr)	Adjusted Emission Rate (g/hr)	Heating Efficiency (% Overall)
1	2013-06-25	0,75	2,20	65,7
2	2013-06-25	1,40	3,10	71,1
3	2013-06-25	1,07	2,00	68,9
4	2013-06-26	1,96	3,80	71,2

2.2 WEIGHTED AVERAGE CALCULATION

Test No.	Burn Rate	(E) Ave. Emission Rate g/hr	(OHE)	Heat Output (BTU/HR)	Prob.	(K) Weighting Factor
1	0,75	2,20	65,7	9330	0,1850	0,4282
3	1,07	2,00	68,9	13812	0,4282	0,5100
2	1,40	3,10	71,1	18646	0,6950	0,4790
4	1,96	3,80	71,2	26123	0,9072	0,3050
					sum	2.67

Weighted Average Emissions Rate: 2.67g/hr
Weighted Average Overall Efficiency: 69.1%

2.3 TEST FACILITY CONDITIONS

Run Number	Room Temperature		Barometric pressure		Relative humidity		Air Velocity	
	Before (F)	After (F)	Before (in.Hg)	After (in.Hg)	Before (%)	After (%)	Before (ft/min)	After (ft/min)
1	77	74	29,796	29,796	75,3	82,7	10	10
2	77	82	29,796	29,796	60	47,6	10	20
3	81	97	29,796	29,796	47,6	52	10	12
4	76	80	29,766	29,766	72	65	12	15

2.4 FUEL QUALITIES

Run Number	Pre-test Load			Test Load					
	Loading Weight Wet Basis (lbs)	Moisture Content Dry Basis (%)	Coal bed Weight (lbs)	Weight Wet Basis (lbs)	Density Wet Basis (lbs/cuft)	Moisture Content Dry Basis (%)	Piece Length (in.)	Number of 2X4's	Number of 4x4's
1	2,15	6,53	na	4,30	na	6,53	na	na	na
2	3,45	6,53	na	6,90	na	6,53	na	na	na
3	3,20	6,53	na	6,40	na	6,53	na	na	na
4	4,90	6,53	na	9,80	na	6,53	na	na	na

2.5 DILUTION TUNNEL FLOW RATE MEASUREMENTS AND SAMPLING DATA (5G-3)

Average dilution tunnel measurements				Sam pie Data			
Run Number	Burn Rate (Min)	Volumetrie Flow Rate (dscf/min)	Total Temperatures (°R)	Volume sampled (DSCF)		Particulate catch (mg)	
				1	2	1	2
1	145	149,89	560,29	25,050	24,525	3,60	3,40
2	126	151,28	572,01	21,891	21,427	4,60	4,40
3	153	144,01	570,52	26,704	26,071	3,50	3,20
4	128	150,97	587,50	22,019	21,606	6,06	5,76

2.6 DILUTION TUNNEL DUAL TRAIN PRECISION

Run Number	Sam pie Ratio		Total Emission (g)		
	Train 1	Train 2	Train 1	Train 2	% Deviation
1	867,65	886,24	3,12	3,01	1,80%
2	870,77	889,62	4,01	3,91	1,15%
3	825,13	845,14	2,89	2,70	3,28%
4	877,62	894,39	5,31	5,15	1,59%

2.7 GENERAL SUMMARY OF RESULTS

Run Number	Burn Rate (kg/hr)	Average Surface Temperature (F)	Change in surface Temperature (F)	Initial Draft (in. H^2O)	static pressure tunnel (in. H^2O)	Primary Air Setting	Run Time (min)
1	0,758	231,82	5,5	Na	0.33	1	145
2	1,400	336,26	22,4	Na	0.32	3	126
3	1,069	293,86	13,9	Na	0.33	2	153
4	1,957	389,45	17,7	Na	0.27	5	128

3 PROCESS DESCRIPTION

3.1 DISCUSSION

At the reception of the unit we do preliminary test run to ensure the unit can reach the limit of the standard. We use those run for the aging of the unit

3.2 UNIT DIMENSIONS

Baffle

- Location: top of combustion chamber
- Restriction: 21 11/16 X 21/16
- Dimensions: 21 11/16 X 1 5/16
- Material: steel

Bricks

- Location : back
- Dimension : 14 3/8 X 21 15/16
- material : vermiculite

Flue gas exhaust

- Location: at the back of the unit on the left at 10 3/4 from the bottom
- Dimensions: 3 1/8 inch
- Material: Cast iron

Gasket

- for all detail refer to appendix 14

Overall unit dimension

- Firebox dimensions : 5 3/8 X 2 7/8 X 2 3/4
- Usable volume :30 3/8 X 28 X 24

Convection fan

- Manufacturer : ECOFIT
- model: AC tangential blower model ECOFIT 2GDS15
- Spec sheet provide in appendix 6

Catalyst

- none

Glass

- Location : door and each sides
- Dimension : door : 16 7/8 X 14 7/16 ; Sides : 4 3/16 X 16 5/8
- Material : Robax

- Thickness : 4mm

Combustion air

centrifugal blower model EBM R2E150 spec sheet provide in appendix 6

power	rpm blower	Inlet air speed (m/s)	inlet air flow (m3/min)
1	1350	2,2	0,2288
2	1450	2,25	0,23409
3	1550	2,3	0,2393
4	1650	2,35	0,24450
5	1750	2,4	0,2497

3.3 OPERATION DURING TEST

Run #1
This run was performed on june 25th , 2013. It lasted 145 minutes and a category 1 burn rate was obtained at 0.75kg/hr, 2.2gr/hr and 65.7% Overall efficiency. We set the unit at is minimum power adjustment (level 1)

Run #2
This run was performed on june 25th , 2013. It lasted 126 minutes and a category 3 burn rate was obtained at 1.40kg/hr,3.1gr/hr and 71.1% Overall efficiency. We set the unit power at level 3

Run #3
This run was performed on june 25th , 2013. It lasted 153 minutes and a category 2 burn rate was obtained at 1.07kg/hr, 2.0gr/hr and 68.9% Overall efficiency. We set the unit power at level 2

Run #4
This run was performed on june 26th , 2013. It lasted 128 minutes and a category 4 burn rate was obtained at 1.96kg/hr, 3.8gr/hr and 71.2% Overall efficiency. We set the unit at is maximum power setting : level 5

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- Details: Refer to the front page of each test run data sheets found in appendix for the detailed test sequence showing air supply settings and adjustments, fuel bed adjustments and operational specifics of the test unit.

Test fuel

- Type of wood: hard wood pellet ((Lauzon Cubex)
- Description: The pellet for each test and preburn period was sent to Canadian bioenergy centre of university of New Brunswick for test fuel calorific analysis. This laboratory is ISO/IEC 17025 recognize by the Standard council of Canada (ASTM D444-92). For the test fuel property refer to test fuel analysis in the appendix 3 Calibration data.
- sourcing: by at harware in Napierville (150 bag at the same time)
- handling and storage : keep all the bag in the same room (at 20C ambient and 50% humidity) all wrap together to ensure the stability of the moisture.

3.4 STAR-UP OPERATION

The complete manufacturer's firing procedure of each burn rate category is fully described in appendix 13.

3.5 SAMPLING LOCATIONS

Particulate samples are collected from the dilution tunnel at a point 15 feet from the tunnel entrance. The tunnel has two elbows and two mixing baffles in the system ahead of the sampling section. The sampling

section is a continuous 10 foot section of 6 inch diameter pipe straight over its entire length. Tunnel velocity pressure is determined by a standard pitot tube located 48 inches from the beginning of the sampling section. Thermocouple is installed on the pitot tube to measure the dry bulb temperature. MC is assumed, as allowed, to be 4%. Tunnel samplers are located 56 inches downstream of the pitot tube and 16 inches upstream from the end of this section.

3.6 DRAWINGS

Various drawings of the stack gas sampling train and of dilution tunnel system are found in Appendix 8.

3.7 EMISSIONS EFFICIENCY TESTING EQUIPMENT LIST

The complete test equipment list together with all corresponding calibration data can be found in Appendix 3.

4 SAMPLING METHODS

4.1 PARTICULATE SAMPLING

Particulates were sampled in strict accordance with EPA Method 5G-3. This method uses two identical sampling systems with Gelman AIE 61631 binder free (or equivalent), 47 mm diameter filters. The dryers used in the sample systems are filled with "Drierite" before each test run.

5 QUALITY ASSURANCE

5.1 INSTRUMENT CALIBRATION

5.1.1 GAS METERS

At the conclusion of each test program the gas meters are verified using the reference dry gas meter. This process involves sampling the train operation for 1 cubic foot of volume. With readings made to 0.01 liter, the resolution is 1 %, giving an accuracy higher than the 2% required by the standard.

5.1.2 SCALES

Before each test program, the different scales used are checked with traceable calibration weights to ensure their accuracy.

5.1.3 GAS ANALYZERS

The continuous analyzers are zeroed and spanned before each test with NBS traceable gases. A mid-scale multi-component calibration gas is then analyzed (values are recorded). At the conclusion of a test, the instruments are checked again with zero, span and calibration gases (values are recorded only). The drift in each meter is then calculated and must not exceed 5% of the scale used for the test.

5.2 TEST METHOD PROCEDURES

5.2.1 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. Pre-test and post-test leak checks are conducted with a vacuum of 5 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 is typically less than 2 inches of mercury. Thus, leakage rates reported are expected to be much higher than actual leakage during the tests.

5.2.2 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.

5.2.3 PM SAMPLING PROPORTIONALITY C5G-3)

Proportionalities were calculated in accordance with EPA Method 5G-3. The data and results are found in appendix.

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