TEST REPORT

TEST OF A WOOD BURNING STOVE
FOR
EMISSIONS AND EFFICIENCY
PER
EPA METHODS 28 AND 5G-3, FEBRUARY 1988

MODEL: FF-032

Client: ICC- Industrial Chimney Company Inc.
400 John F. Kennedy
St-Jerome, Quebec, J7Y 4B7

Attention: Mr. André Bibaud

TESTED BY:
Intertek Testing Services NA Ltd.
1829, 32nd Avenue
Lachine, Québec
H8T 3J1

TEST DATES: From October 15, 2014 to November 13, 2014
REPORT DATE: November 28, 2014
Project number: G101498204

Report Number: G101498204 Issued date: November 28, 2014
Client: ICC- Industrial Chimney Company inc.

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1.0 INTRODUCTION

1.1 GENERAL

From October 15, 2014 to November 13, 2014, Intertek, Lachine, Québec, conducted tests on the FF-032 catalytic fireplace from ICC, to determine compliance with U.S. EPA emissions regulations.

Tests were conducted by Claude Pelland, The undersigned. The tests were conducted at the client facility in St.Jerome located at 400 John F. Kennedy, St-Jerome, Quebec, J7Y 4B7. The laboratory elevation is 360 feet above sea level. Tests were conducted to EPA Method 28 and 5G-3 criteria, February 1988. The unit was tested with fan on and a fan off confirmation test was performed in order to confirm compliance with Para 8.12.5 of EPA Method 28.

1.2. TEST UNIT DESCRIPTION

The FF-032 (development name) is a catalytic unit that uses 7" diameter Excel insulated chimney manufactured by the Industrial Chimney Company (ICC).

The catalytic combustor is installed at the top of the firebox near the front. It is visible for inspection by the homeowner and is accessible for maintenance and/or replacement. The bypass is operated by the handle which protrudes from the front of the unit above the door.

Two possible bypass systems have been developed and are included in the unit drawings. The first one is opened and closed with a forward/backward movement of the bypass handle, through sliding the bypass cover backward over the bypass opening or pulling it forward and out of the way. The second uses a rotation movement of the bypass handle to lift up and down the bypass cover.

The unit utilizes primary and secondary air for combustion. The primary air intake is located at the bottom on the right side of the unit with its control handle located below the glass door(s) towards the right. The primary air control handle allows the homeowner to decide the basic burn rate: from minimum to maximum. Beyond the homeowner selection of the basic burn rate, the primary air control uses a bi-metallic spring that automatically reduces the amount of primary air as a bi-metallic spring gets warmer while the fire is burning. As the fire dies down, control of the primary air is given back to the homeowner. The secondary air intake is located on both sides of the firebox, close to the bottom of the unit and is distributed through a secondary air tube located just below the catalytic combustor. The secondary air is not user controlled.

The firebox is made of regular low carbon steel. The combustion chamber is almost all lined with refractory cement bricks.

The unit is a zero clearance built-in model, and is not free standing. The firebox is thus enclosed in a double insulated casing. Fins and shields are all around the firebox to enhance the heat transfer efficiency. The facing has openings for the lower and the upper louvers to allow the convection heat to circulate around the firebox and into the room. The louvers offered will be of different styles: regular, decorative and blade style but each style provides the same air circulation around the firebox. The louver openings can also be blocked in which case the bottom louver is replaced by an 8" round ambient air entry and the upper louver is replaced by two 8" round gravity vents.

The vent grills offered for the gravity vent and the ambient air entry will also be offered in different styles: regular, recessed and contemporary.

The same unit will be offered with either: 1) a set of double arched cast iron doors, 2) a single arched cast iron door or 3) a single arched door made of thick steel. In all versions, the firebox, the combustion air, the air control and the casing is the same. The only difference is the door frame(s) at the front of the unit. All doors use ceramic glass.

These units will be marketed as part of the RSF line of combustion controlled built-in stoves. The double arched cast iron doors unit will be marketed under "Opel2C", the single arched cast iron door will be marketed under "Opel3C" and the single metal door will be marketed under "Opel4C".

Optional fans will be available: internal fan or an inline fan depending if the louvers are blocked or not. The unit used to conduct all tests had a single cast iron door. Both louver openings were covered with regular louvers, no gravity vent installed, the optional internal fan was installed and the sliding bypass system was used.

The following are the overall tolerances for the manufactured parts and general assembly of the unit:

- Linear dimensions: ±1/8" of the nominal dimension
- Diameters of holes: ± 2% of the nominal diameter
- Radius of holes: ±1% of the nominal radius
- Position of bends: ±1/8" of the nominal position of the bend
- Position of part in assembly: ±1/8" of the nominal position

1.3. RESULTS

The unit as tested, produced a weighted average emissions rate of 2.48 grams/hour and did not exceed any of the emission rate caps specified in the EPA regulations. The unit thus meets EPA certification requirements for 1990.

1.4. PRETEST INFORMATION

The test unit was prepared at client's facility in St.Jerome , Quebec for October 15th, 2014 from the client. The unit was inspected upon program start and found to be in good condition. It had been set up, following the manufacturer's instructions.

Following assembly, the unit was placed on the test stand and the instrumented thermocouples were hooked up to our logging system. Prior to emission testing, a fifty (50) hours break-in period was performed during which the unit was set to operate at high to medium burn rate. During the break-in period, the unit was found to operate satisfactorily.

Following inspection of the unit, the chimney system and laboratory dilution tunnel were cleaned using standard wire brush chimney cleaning equipment.

On October 15th, 2014, the unit was set-up for testing.

1.5. REPORT ORGANIZATION

This report includes summaries of all data necessary to determine compliance with the regulations.

2.0 SUMMARY OF TEST RESULTS

2.1 EMISSIONS

Run Number	Test Date	Burn Rate (kg/hr)	Adjusted Emission Rate (g/hr)	Heating Efficiency (% Overall)	Optional Fan
1	10/15/2014	0.975	3.092	N/A	On
2	10/16/2014	0.883	2.825	N/A	Off
3	10/17/2014	2.251	4.610	N/A	On
4	10/20/2014	1.090	3.294	N/A	Off
5	10/21/2014	1.053	3.188	N/A	On
6	10/22/2014	1.552	1.648	N/A	On
7	11/11/2014	2.186	3.558	N/A	On
8	11/13/2014	1.042	2.384	N/A	On

2.2. WEIGHTED AVERAGE CALCULATION

Run Number	Burn Rate (kg/hr)	Adjusted Emission Rate (g/hr)	OHE (% Overall)	Output (BTU/hr)	Prob	(K) Weighting Factor
1	0.975	3.092	0	13436.28	0.354	0.40268
8	1.042	2.384	0	14359.5936	0.40268	0.42584
6	1.552	1.648	0	21387.8016	0.77984	0.5322
7	2.186	3.558	0	30124.8288	0.93488	0.22016
					Sum:	1.58088

Weighted Average Emissions Rate: 2.48 g/hr

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	87	85	29.58	29.52	58	60	0	0
2	84	0	29.40	29.26	56	56	0	0
3	92	90	29.14	29.14	52	48	0	0
4	81	82	29.58	29.61	37	36	0	0
5	83	81	29.64	29.70	36	30	0	0
6	78	83	29.91	29.85	26	28	0	0
7	83	82	29.58	29.51	26	27	0	0
8	77	78	30.02	29.96	23	24	0	0

2.4. FUEL QUALITIES

Run Number	Pre-Test Load			Test Load					
	Loading Weight Wet Basis (lb)	Moisture Content Dry Basis (%)	Coal Bed Weight (lb)	Weight Wet Basis (lb)	Average Density Wet Basis (lb/ft^3)	Moisture Content Dry Basis (%)	Piece Length (in.)	Number of 2 x 4's	Number of 4 x 4's
1	18.35	22.15	4.55	18.43	35.91	22.54	16.0	4	2
2	18.92	22.25	4.45	18.37	36.87	22.82	16.0	4	2
3	18.62	21.45	3.85	18.16	37.02	21.99	16.0	4	2
4	18.03	21.66	4.45	18.69	37.10	22.77	16.0	4	2
5	18.01	22.04	4.40	18.56	37.13	23.03	16.0	4	2
6	18.02	22.01	4.10	18.25	36.47	23.05	16.0	4	2
7	17.72	21.45	4.10	17.65	35.90	22.07	16.0	4	2
8	18.15	22.16	4.40	18.62	37.17	18.62	16.0	4	2

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

Run Number	Average dilution tunnel Measurements			Sample Data			
	Burn Time (min.)	Volumetric Flow Rate (dscf/min)	Total Temperatures (°R)	Volume Sampled (dscf)		Particulate Catch (mg)	
				1	2	1	2
1	420	140.19	558.91	67.60	67.84	14.6	15.9
2	461	140.46	555.13	74.22	74.62	14.6	15.4
3	180	123.83	592.98	28.23	28.02	11.0	12.2
4	380	142.63	556.33	59.98	60.17	13.8	14.9
5	390	143.42	552.86	61.49	61.53	13.2	14.9
6	260	144.77	565.79	41.40	42.46	3.6	5.0
7	180	128.40	591.95	28.17	28.51	8.0	8.5
8	410	135.24	550.20	65.61	66.24	10.8	11.7

2.6 DILUTION TUNNEL DUAL TRAIN PRECISION

Run Number	Sample Ratio		Total Emission		
	Train 1	Train 2	Train 1 (g)	Train 2 (g)	Deviation %
1	870.97	867.95	12.72	13.80	1.7%
2	872.42	867.76	12.74	13.36	1.0%
3	789.53	795.51	8.68	9.71	2.3%
4	903.60	900.81	12.47	13.42	1.5%
5	909.54	909.01	12.01	13.54	2.5%
6	909.21	886.56	3.27	4.43	6.3%
7	820.58	810.57	6.56	6.89	1.0%
8	845.11	837.04	9.13	9.79	1.5%

2.7 GENERAL SUMMARY OF RESULTS

Run Number	Burn Rate (kg/hr)	Average Catalyst Temperature (°F)	Average Surface Temperature (°F)	Change in Surface Temperature (°F)	Initial Draft (in. H_2O)	Primary Air Setting	Run Time (min.)
1	0.975	1081.39	346.96	-95.92	0.0525	Completely closed	420
2	0.883	994.95	354.47	-87.61	0.0475	Completely closed	461
3	2.251	1067.81	442.89	-46.33	0.0625	Fully opened	180
4	1.090	987.95	400.77	-74.68	0.0500	Completely closed	380
5	1.053	1008.98	360.59	-55.53	0.0475	Completely closed	390
6	1.552	1063.74	403.58	-28.65	0.0575	2/3 open	260
7	2.186	1141.71	461.46	-22.16	0.0575	Fully opened	180
8	1.042	1000.45	347.99	-96.14	0.0525	Completely closed	410

3.0 PROCESS DESCRIPTION

3.1 DISCUSSION

During the entire test program, the unit performed well and no hazardous behavior has been noticed.

Run number 3 performed on the 17th of October was rejected based on the non-compliance of the average flow rate of the dilution tunnel. Room temperature has also reached 95 degrees with a max. allowable of 90.

Runs 1, 5 and 8 were performed in cat II and based on the 2/3 rule, run 1 and 8 wereretained for the calculation of the weighted average emission rate. Data for runs not retained is reproduced in appendix to this report.

At the beginning of the program, it was planned that all required burn rates to get a fan on unit and all those required for a fan off unit were to be conducted. As the test program evolved, it was elected to run the usual fan on program and to do a fan off confirmation run.

3.2 UNIT DIMENSIONS

Unit dimensions are reproduced in appendix E to this report.

Please report to it for all details on unit construction.

3.3 AIR SUPPLY SYSTEM

Air supplies and air channels are explained in appendix E-2 called “Appendix E-2 Combustion air”

Please refer to it for all details.

3.4 OPERATION DURING TEST

Run #1

The run 1 was performed on October 15, 2014.
After one load of warm up period with 15.1 lb to burn, ashes were removed to do a "0 scale". 1.6 lb of ashes was put back in the firebox as well as 18.35 lbs of Pre-burn load. The door was shut after 6min, bypass closed at 20min. and the air control to minimum setting at 42 min. After this final setting, the Pre-burn lasted 1h11min.

The EPA run started at the upper range (25%) with 18.43 lbs of the test fuel load. The run lasted 420 minutes. It was performed with the FAN ON condition. The average of the wood heater surface temperatures (5 T/C) from start to end (delta T) was 96°F.
The burn rate achieved is a Category 2 at 0.97 kg/h, with the primary air control adjusted to the minimum setting. This run didn't achieve the category 1, but was able to reach a burn rate below 1kg/hr. See "Note" at the end of this section.

Refer to the last page of test run data #1 in Appendix A for the detailed test sequence.

Run #2

The run 2 was performed on October 16, 2014.
After one load of warm up period with 15.83 lb to burn, ashes were removed to do a "0 scale". 2.4 lb of ashes was put back in the firebox as well as 18.92 lbs of Pre-burn load. The door was shut after 10min, bypass closed at 20min. and the air control to minimum setting at 45 min. After this final setting, the Pre-burn lasted 1h42min.

The EPA run started at the upper range (25%) with 18.37 lbs of the test fuel load.
The run lasted 461 minutes. The run was performed with the FAN OFF condition. The average of the wood heater surface temperatures (5 T/C) from start to end (delta T) was 88°F.
The burn rate achieved is a Category 2 at 0.88 kg/h, with the primary air control adjusted to the minimum setting. This run didn't achieve the category 1, but was able to reach a burn rate below 1kg/hr. See "Note" at the end of this section.

Refer to the last page of test run data #2 in Appendix A for the detailed test sequence.

Run #3

The run 3 was performed on October 17, 2014.
After one load of warm up period with 16.08 lb to burn, ashes were removed to do a "0 scale". 2.2 lb of ashes was put back in the firebox as well as 18.62 lbs of Pre-burn load. The door was shut after 10min, bypass closed at 24min. and the air control stayed to the maximum setting. After this final setting, the Pre-burn lasted 1h19min.

The EPA run started at 0.2lb above the lower range (20%) with 18.16 lbs of the test fuel load.
The run lasted 180 minutes. The run was performed with the FAN ON condition. The average of the wood heater surface temperatures (5 T/C) from start to end (delta T) was 46°F.

The burn rate achieved is a Category 4 at 2.26 kg/h, with the primary air control adjusted to the maximum setting.

This run was not compliant with EPA's requirements. The tunnel flow rate average was calculated at 123.9 CFM, exceeding the allowable velocity of 140 CFM±10%. Room facility temperature was measured to be up to 95°F, with the allowable maximum temperature is 90°F. This run will not be taken into consideration during weighted average calculation.

Refer to the last page of test run data #3 in Appendix A for the detailed test sequence.

Run #4

The run 4 was performed on October 20, 2014.
After one load of warm up period with 15.79 lb to burn, ashes were removed to do a "0 scale". 2.05 lb of ashes was put back in the firebox as well as 18.03 lbs of Pre-burn load. The door was shut after 7min, bypass closed at 20min. and the air control to minimum setting at 35 min. After this final setting, the Pre-burn lasted 1h27min.

The EPA run started at the upper range (25%) with 18.69 lbs of the test fuel load.
The run lasted 460.5 minutes. The run was performed with the FAN OFF condition. The average of the wood heater surface temperatures (5 T/C) from start to end (delta T) was 88°F.
The burn rate achieved is a Category 2 at 0.88 kg/h, with the primary air control adjusted to the minimum setting. This run didn't achieve the category 1, but was able to reach a burn rate below 1kg/hr. See "Note" at the end of this section.

Refer to the last page of test run data #4 in Appendix A for the detailed test sequence.

Run #5

The run 5 was performed on October 21, 2014.
After one load of warm up period with 15.75 lb to burn, ashes were removed to do a "0 scale". 2.25 lb of ashes was put back in the firebox as well as 18.0 lbs of Pre-burn load. The door was shut after 8min, bypass closed at 21min. and the air control to minimum setting at 29 min. After this final setting, the Pre-burn lasted 1h33min.

The EPA run started at the upper range (25%) with 18.56 lbs of the test fuel load.
The run lasted 390 minutes. The run was performed with the FAN ON condition. The average of the wood heater surface temperatures (5 T/C) from start to end (delta T) was 56°F.
The burn rate achieved is a Category 2 at 1.05 kg/h, with the primary air control adjusted to the minimum setting. This run was a repeat of run #1. The unit did not achieve the category 1. See "Note" at the end of this section.

Refer to the last page of test run data #5 in Appendix A for the detailed test sequence.

Run #6

The run 6 was performed on October 22, 2014.
After one load of warm up period with 16.3 lb to burn, ashes were removed to do a "0 scale". 2.1 lb of ashes was put back in the firebox as well as 18.02 lbs of Pre-burn load. The door was shut after 6min, bypass closed at 14min. and the air control to med-high setting at 42.5 min. After this final setting, the Pre-burn lasted 1h50min.

The EPA run started at 0.45lb below the upper range (25%) with 18.25 lbs of the test fuel load.
The run lasted 260 minutes. The run was performed with the FAN ON condition. The average of the wood heater surface temperatures (5 T/C) from start to end (delta T) was 29°F.
The burn rate achieved is a Category 3 at 1.56 kg/h, with the primary air control adjusted to the medium-high setting.

Refer to the last page of test run data #6 in Appendix A for the detailed test sequence.

Run #7

The run 7 was performed on November 11, 2014. This run replaces run 3 which was not conformed.
After one load of warm up period with 16.54 lb to burn, ashes were removed to do a "0 scale". 2.3 lb of ashes was put back in the firebox as well as 17.72 lbs of Pre-burn load. The door was shut after 5min, bypass closed at 24min. and the air control stayed to the maximum setting. After this final setting, the Pre-burn lasted 1h18min.
The EPA run started closed (0.3lb) to the upper range (25%) with 17.65 lbs of the test fuel load.

The run lasted 180 minutes. The run was performed with the FAN ON condition. The average of the wood heater surface temperatures (5 T/C) from start to end (delta T) was 22°F.
The burn rate achieved is a Category 4 at 2.18 kg/h, with the primary air control adjusted to the maximum setting.

Refer to the last page of test run data #7 in Appendix A for the detailed test sequence.

Run #8

The run 8 was performed on November 13, 2014. This run was done to replace run 5 trying to get better emission results.
After one load of warm up period with 17.07 lb to burn, ashes were removed to do a "0 scale". 2.15 lb of ashes was put back in the firebox as well as 18.15 lbs of Pre-burn load. The door was shut after 13.5min, bypass closed at 24min. and the air control to minimum setting at 43 min. After this final setting, the Pre-burn lasted 1h03min.
The EPA run started at the upper range (25%) with 18.62 lbs of the test fuel load.

The run lasted 410 minutes. The run was performed with the FAN ON condition. The average of the wood heater surface temperatures (5 T/C) from start to end (delta T) was 96°F.
The burn rate achieved is a Category 2 at 1.00 kg/h, with the primary air control adjusted to the minimum setting.

Refer to the last page of test run data #8 in Appendix A for the detailed test sequence.

Note: Test on category one not achieved.

Runs #1, 2, 4, and 5 were performed with the primary air control adjusted at the minimum setting. Two of those runs (1 and 5) were also performed with the FAN in operation. None of these 4 runs achieved the category 1 burn rate (<0.80kg/hr), but achieved a category 2. Run #1 and #2 achieved a burn rate just below 1kg/hr
These results show evidence that the unit cannot reach the category 1 in normal operation.

3.5 START-UP OPERATION

3.5.1 and 3.5.2 Procedure for FF-032 Model (Category 1 and Category 2)

3.5.1.1 and 3.5.1.2 Warm up/lighting procedure

Applies to all Burn Rate Categories, Fan ON or Fan OFF

This section outlines the warm up procedures. The rational for the warm up load is to take out moisture from refractory bricks, heat the bricks and firebox uniformly. The complete coals are taken out at the end in order to get the "0 Scale" prior to put the Pre-burn load.

1. Put crumpled piece of paper in the fireplace.
2. Add some kindling (crisscross) in 3 or 4 different levels. Weight of paper and kindling should be between 1.75 and 2.5 lbs approx. See photo below as an example.
3. 
4. Light up the fire, door open, bypass open and primary air set to full open. Leave the door cracked for 1 inch approx. for about 1 or 2 minutes.

5. When the kindling is burnt for approximately its half weight (about 1 lb), add a warm up load of dry Douglas Fir (moisture not measured), between 15.5-17 lbs. Use the following pattern as shown below: 4-2-4-x, (x=1,2,3).

6. After few minutes when the flames cover at least the first row, close the door.
7. When the fire has reached the total warm up load, close the bypass.
8. Let the wood burning completely. Poke and stir coal as necessary to get a uniform charcolization (no solid piece).
9. Open the door and bypass, crunch coals in small parts (1 to 2 inches).
10. Put the red hottest coals (1.75 to 2.25 lb) in the homemade shovel (or steel bucket). Put the rest of the coals and a separate container.

11. Once the fireplace is completely empty, tare the scale to "0" (or take the scale reading if the tare is not used).

3.5.1.2 and 3.5.2.2 Pre Test fuel load:

1. With the door open, bypass open and primary air control set to maximum; put the hot coals from the shovel in the fireplace. Coals should weigh about 1.75 to 2.5 lbs. Level the coal uniformly.
2. Take the scale reading. The scale reading gives you the weight of coals back in.
3. At this stage, make a "Time 0" for reference. We will refer to this time for the door and bypass. Put the Pre-burn load inside the fireplace. The pre burn should weigh between 18 to 18.5 lb preferably, which is close to the test fuel load weight. Use the following pattern as shown below: 5-2-5-x, (x=1,2).

4. After few minutes, when the flames cover at least the first row, close the door (by experience, it is between 6 and 10 minutes.

High Burn: Close bypass when you have about 10 lbs to burn before the test fuel range upper limit. Start EPA test between the lower and upper limit range. Target to have the 5 t/c/ avg around 485-510°F (Fan ON) or 515-540°F (Fan OFF). The EPA test will probably start between the upper and lower limit.

Med-High Burn: Close bypass around 14-15 minutes. The flames should cover the fuel load.

When you have about 5 lbs to burn before the test fuel range upper limit, close primary air to med-hi setting which is at 1 3/8" from the maximum position.

Target to have the 5 t/c/ avg around 400-425°F (Fan ON) or 420-450°F (Fan OFF). The EPA test will then start between the upper and lower limit.

Med-Low Burn: Close bypass around 20 minutes. The flames should cover the fuel load.

When you have about 5 lbs to burn before the test fuel range upper limit, close primary air to the lower setting.

Target to start the test as close as possible to the upper limit range, having the 5 t/c/ avg around 400-425°F (Fan ON) or 430-450°F (Fan OFF).

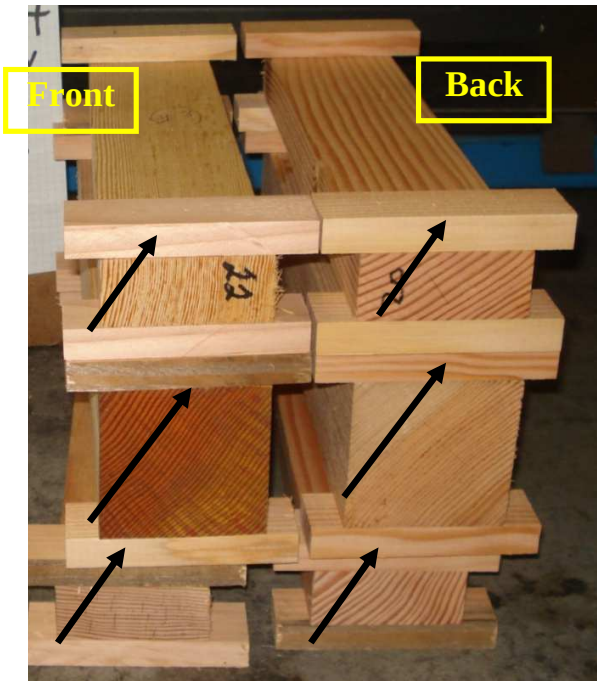
Reset the timer to "0". This starts the required 60 minute period before EPA test.

5. At 0.1lb before loading the test fuel and if at least 58 min of Pre-burn is reached: Open the door, carefully crush all coals to small parts (about 1 inch size), spread them evenly on the whole surface of the bottom of the hearth, ready to receive the Test Fuel load. Close door. The door can be open for a maximum of 1 minute.

6. Insert Train 1 and 2 in the dilution tunnel; take starting test conditions (ambient, barometric pressure,

%RH). During step 7 and 8, the 0.1 lb missing (if it's the case) will have time to burn.

3.5.1.3 and 3.5.2.3 Test fuel load:

7. 

This is a typical fuel load, 16" long. Align the wood grain to the back of appliance.

Target to have the fuel load weight and moisture the following specs:

High Burn: 17.9-18.5 lbs, 19-22% moisture avg. Lighter/dryer 2x4 at the bottom.

Med-High Burn: 18-18.8 lbs, 21-23% moisture avg. Lighter/dryer 2x4 at the bottom.

Med-Low Burn: 18-18.8 lbs, 23-24.5% moisture avg. Lighter/dryer 2x4 at the bottom, 4x4 with 23.5% RH min.

8. Open the bypass first, open the door and insert the fuel load to the following way:

- Bottom back 2x4, about 5-10° inclined to the back and sink it into the coals;
- Bottom front 2x4, lean spacers against back crib spacer, 5-10° inclined to the back and sink it into the coals;
- Loading the bottom row first will help to start the fire faster;
- Back middle 4x4 and top 2x4 lean to the back refractory;
- Front middle 4x4 and top 2x4 lean to the back cribs;

9. Test fuel is loaded, close the bypass.

10. With a poker rod (3/8" Ø), make a trench in center under the two bottom 2x4's. The trench is 3" appx, 1/2" deep under the two bottom 2x4's.

11. Leave the door cracked for 1 inch approx. to light the fuel load:

High Burn: If the fire is well lit, the door may be closed after 3 to 3m30s. Primary air setting stays at maximum.

Med-High Burn: If the fire is well lit, the door may be closed after 3m to 3m45s. Set Primary air control to medium-low setting between 3m30s to 4m45s.

Med-Low Burn: If the fire is well lit, the door may be closed after 3m30s to 4min. Set Primary air control to minimum setting between 4m45s to 5min.

4.0 SAMPLING SYSTEMS

4.1 SAMPLING LOCATIONS

(Particulate) Samples are collected from the dilution tunnel at a point 30 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 13-foot section of 6-inch diameter pipe straight over the entire length. A standard pitot tube located 70 inches from the start of the sampling section determines tunnel velocity pressure. Thermocouple is installed on the pilot tube to measure the dry bulb temp. MC is assumed, as allowed, to be 4%. Tunnel samplers are located 49 inches downstream of the pitot tube and 36 inches upstream from the end of this section.

4.2 DRAWINGS

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

4.3 EMISSIONS/EFFICIENCY TESTING EQUIPMENT LIST

See appendix D for calibration data and list of equipment

5.0 SAMPLING METHODS

5.1 PARTICULATE SAMPLING

Particulates were sampled in strict accordance with EPA Method 5G-3. 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.

6.0 QUALITY ASSURANCE

6.1 INSTRUMENT CALIBRATION

6.1.1 Dry Gas Meters

At the conclusion of each test program the dry 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 .001 ft^3, the resolution is .1%, giving accuracy higher than the $\pm$2% required by the standard.

6.1.2 Stack Sample Rotameter

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

6.1.3 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 span gas (values are recorded only). The drift in each meter is then calculated and must not exceed 5% of the scale used for the test.

6.2 TEST METHOD PROCEDURES

6.2.1 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.

6.2.2 Tunnel Velocity/Flow Measurement

The tunnel velocity is calculated from a center point pilot 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.)

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

6.2.3 Pm Sampling Proportionality (5g-3)

Proportionality was calculated in accordance with EPA Method 5G-3. The data and results are kept in file for future reference.

Tested by:
Claude Pelland, P-Eng.
Project Engineer

Reviewed by:
Bruce Davis.
Associate Engineer