TEST REPORT

SCOPE: EMISSIONS

FUEL: EPA TEST FUEL (CRIBS)

TEST STANDARD: EPA

MODEL: Solution 2.9 WOOD STOVE

Notice to reader: Our Solution 2.9 wood stove was tested as part of our Chancelier firebox. Therefore, the Chancelier is referenced throughout the attached test report.

Inchcape Testing Services
Warnock Hersey

Warnock Hersey
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8810 Elmslie Street
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TEST REPORT

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

MODEL: Chancelier

Emission: 4.4 g/hr

Client: METAL M.D.R. INC.
536 Guy Street
Granby, Québec
J2G 7J8

Attention: Mr. Marc Tétreault

TESTED BY:
Warnock Hersey Professionnal Services Ltd
8810 Elmslie
LaSalle, Québec
H8R 1V8

TEST DATES: From August 31 to September 7, 1995
REPORT DATE: October 31, 1995
Project number: 192-5110

Tested by :

Claude Paré, Technician

Gaétan Piédalue, Eng.

Verified by:

Claude Pelland, Eng.
Regional Manager,
Certification & Physical Testing

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1.0. INTRODUCTION

1.1 General

From August 31 to September 7, 1995, Inchcape-Warnock Hersey, LaSalle, Québec, conducted a series of tests on the "Chancelier" stove, to determine compliance with U.S. EPA emissions regulations.

Tests were conducted by Claude Paré and Gaétan Piédalue. The tests were conducted at the Warnock Hersey laboratory located at 8810 Elmslie, LaSalle, Québec. The laboratory elevation is 860 feet above sea level. Tests were conducted to EPA method 28 and 5G-3 criterias.

1.2. Test unit description

The "Chancelier" solid fuel burning stove is a non-catalytic unit having air combustion intakes located at the bottom of the unit with its controls located on the right of the unit. It was delivered for testing with no fan device.

1.3. Results

The unit as tested produced a weighted average emissions rate of 4.4 grams/hour and did not exceed any of the emissions rate caps specified in the EPA regulations. The unit thus meets EPA certification requirements for 1990.

1.4. Pretest information

The test unit was received at Warnock Hersey in LaSalle Québec on June 13, 1995 via Transport Haute Yamaska. The unit was inspected upon reception and found to be defective. Manufacturer was then contacted to perform the necessary repairs and adjustments on the unit. The repairs consisted mainly in changing the air intake obstruction plate, replacing the refractories and readjusting the air intake control so it could slide freely. In the course of shipping, the unit had tilted on its face. The unit was then 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 data logging system. Prior to emission testing, a ten (10) hour break-in period was then 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 satisfactory.

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

On August 31, 1995, 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.

Due to the unavailability of the gas analyzers and to the fact that this series of tests was performed prior to receiving the final approval from EPA, this report will not contain information relating to efficiency of the unit, nor will it conclude to its certification to the EPA certification program. It is intended that additional testing will have to be performed on the "Chancelier" in order for it to be fully accepted and recognized by the EPA authorities.

2.0. SUMMARY OF TEST RESULTS

2.1 Emissions

Test number	Test Date	Burn Rate (Kg/hr)	Emission Rate (g/hr)	Adjusted Emission Rate (g/hr)	Heating Efficiency (% Overall)
1	07/09/95	1.252	3.16	4.72	n/a
2	05/09/95	1.260	1.75	2.90	n/a
3	31/08/95	2.699	3.70	5.39	n/a
4	04/09/95	2.861	1.74	2.88	n/a

2.2. Weighted average calculation

Test Number	Burn Rate	Adjusted Emission Rate (g/hr)	(OHE)	Output (BTU/hr)	Prob.	(K) Weighting Factor
1	1.252	4.724	n/a	n/a	0.5739	0.5816
2	1.260	2.899	n/a	n/a	0.5816	0.4030
3	2.699	5.391	n/a	n/a	0.9770	0.3996
4	2.861	2.879	n/a	n/a	0.9812	0.0230
					Sums:	1.4073

Weighted Average Emissions Rate: 4.3605 g/hr

2.3 Test Facility Conditions

	Room Temperature		Barometric pressure		Relative humidity		Air Velocity	
Test Number	Before (°F)	After (°F)	Before (in. Hg)	After (in.Hg)	Before (%)	After (%)	Before (ft/min)	After (ft/min)
1	77	82	29.90	30.11	48	42	0	0
2	80	82	30.25	30.19	44	48	0	0
3	78	82	30.40	30.28	42	33	0	0
4	78	82	29.83	30.11	42	40	0	0

2.4. Fuel Qualities

	Pre-test load			Test load					
Test Number	Loading Weight Wet Basis (lbs)	Corrected Moisture Content Dry basis (%)	Coal bed Weight (lbs)	Weight Wet basis (lb)	Density Wet Basis (lbs/ft^3)	Corrected Moisture Content Dry basis (%)	Piece Length (in)	Number of 2 x 4's	Number of 4 x 4's
1	16.20	18.9	2.90	14.15	6.29	18.9	15-3/4	3	2
2	15.00	18.8	3.00	14.25	6.33	18.8	15-3/4	3	2
3	15.85	18.6	2.90	14.20	6.31	18.6	15-3/4	3	2
4	14.80	18.6	3.05	15.25	6.78	18.6	15-3/4	3	2

2.5 Dilution Tunnel Flow Rate Measurements And Sampling Data (5g-3)

Average dilution tunnel measurements				Sample Data			
Run number	Burn Time (Min)	Volumetric Flow Rate (DSCF/min)	Average Temperatures (^oR)	Volume sampled (DSCF)		Particulate catch (mg)	
				1	2	1	2
1	120	134.587	541.604	28.15	25.44	123.0	122.0
2	250	104.650	543.836	82.30	79.10	218.0	232.0
3	110	114.987	543.112	31.89	31.65	790.0	810.0
4	270	138.605	543.091	88.46	84.54	343.0	353.0

2.6. Dilution Tunnel Dual Train Precision

Run Number	Sample Ratio		Total Emission (g)		
	Train 1	Train 2	Train 1	Train 2	% Deviation
1	573.664	634.919	7.056	7.746	1.93
2	317.882	330.757	6.930	7.674	2.11
3	396.653	399.610	3.134	3.237	0.67
4	398.688	417.154	13.675	14.726	1.54

2.7 General Summary of Results

Run Number	Burn Rate (Kg/hr)	Average Temperature Surface (°C)	Change in Surface Temperature (°C)	Initial Draft (in. H^2O)	Primary Air Setting	Run Time (min)
1	2.699	282	44	<.005	Shut	120
2	1.260	170	36	<.005	Shut	250
3	2.861	234	46	<.005	9mm from open	110
4	1.252	167	39	<.005	Open	270

3.0 PROCESS DESCRIPTION

3.1 Discussion

Run #1:

This run lasted for 110 minutes. It was performed on October 2, 1995. Pre-load was introduced at 14:42h and door was opened for 40 seconds at 15:47h to poke fire. At 16:30h, wood was added (0.64 lbs of Douglas Fir 2 x 4 x 5). Test fuel of 11.70 lbs was loaded at 16:48h and door was opened for 2 minutes.

The burn rate achieved is a Category 4 with 2.36 kg/h.

Run #2:

This run lasted 240 minutes. It was performed on October 3, 1995. Pre-load was introduced at 10:25h. At 11:07h, door was opened for 40 seconds to poke fire and control was closed. At 12:50h, wood was added (3.8 lbs of Douglas Fir 2 x 4 x 5). At 13:55h, wood was added again (0.5 lbs of Douglas Fir 2 x 4 x 5). Test fuel of 11.65 lbs was loaded at 14:16h and door was opened for 2 minutes.

The burn rate achieved is a Category 2 with 1.08 kg/h.

Run #3:

This run lasted for 260 minutes. It was performed on October 11, 1995. Pre-load was introduced at 12:20h. At 13:10h, door was opened for 40 seconds to poke fire and control was closed. At 14:25h, wood was poked once again. Test fuel of 11.60 lbs was loaded at 14:47h and door was opened for 2 minutes.

The burn rate achieved is a Category 2 with 1.00 kg/h.

Run #4:

This run lasted for 150 minutes. It was performed on October 12, 1995. Pre-load was introduced at 10:40h. and door was opened for 40 seconds at 11:23h to poke fire and control was closed up to 56mm. Test fuel of 11.50 lbs was loaded at 12:15h and door was opened for 2 minutes.

The burn rate achieved is a Category 3 with 1.71 kg/h.

3.2 Unit Dimensions

Unit is 33-½" high by 25" wide by 28" deep.

3.3 Air Supply System

Main air intake is a rectangular opening being 25% blocked by an adjustable metallic plate. The surface of the opening varies from 0 to 4.5 sq. in. It is located under the unit towards the front.

Secondary air intakes are non-adjustable and are via:

- A tube located under the unit. It has an internal diameter of 0.25".
- Circular hole located behind the unit with an interior diameter of 0.25".
- A square opening located under the unit towards the rear. It has a surface of 3.06 sq. in.

3.4 Operation During Test

Unit was defective upon reception. Manufacturer performed some repairs and adjustments on it. They were as follows:

- Replaced the refractory bricks
- Changed the air intake adjustment plate
- Lubricated and realigned the air intake adjustment push rod
- Corrected the door tightness

3.5 Start-Up Operation

For each test, the unit is started with approximately 5 lbs of kindling and a small quantity of newspaper. For the first five (5) minutes, the doors remained opened; so do the air intakes.

4.0 SAMPLING SYSTEMS

4.1. Sampling Locations

Particulate samples are collected from the dilution tunnel at a point 20 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 feet section of 6 inch diameter pipe straight over its entire length. Tunnel velocity pressure is determined by

a standard pitot tube located 60 inches from the beginning of the sampling section. A thermocouple is installed on the pitot tube to measure the dry bulb temperature. Moisture content (MC) is assumed, as allowed, to be 4%. Tunnel samplers are located 60 inches downstream of the pitot tube and 36 inches upstream from the end of this section.

4.2 Emissions/efficiency testing equipment list

ITEM DESCRIPTION	WH #	MANUFACTURER	MODEL	SERIAL #
1. CO, CO_2 & O_2 Analyzer	180-099	NOVA	375 TWP	2897
2. Dry Gas Meter 1	180-127	Canadian Meter Co. Ltd	AS-11-1	70-662906
3. Dry Gas Meter 2	180-128	Canadian Meter Co. Ltd	AS-11-1	71-668929
4. Rotameter (1)	180-092	Omega	FL38395T	—
5. Rotameter (2)	180-131	Omega	FL38395T	—
6. Rotameter (3)	180-132	Omega	FL38395T	—
7. Hot Wire Anemometer	180-076	Alnor	8525	—
8. Inclined Manometer	180-139	Dwyer	125-AV	—
9. Pitot Tube	180-154	—	—	—
10. Pressure gages (3)	180-133 à 180-135	Basco	0-15 PSI	—
11. Vacuum gages (3)	180-136 à 180-138	Basco	-30 - 0 in. Hg	—
12. Draft Indicator	180-156	Dwyer	2000-00	W42F
13. Scale, 1000lbs Cap./Record.	180-130	Papp	30" x 30"	—
14. Readout for 1000lbs Scale	180-129	Papp	UMC600AAAC	L6990
15. Scale, 150lbs Capacity	180-084	Avery	—	—
16. Analytical Balance	180-079	Sartorius	2443	—
17. Diaphragm Pumps (3)	180-125	Barnant	400-1901	L94001630
	180-126	Barnant	400-1901	L94001743
	180-160	Barnant	400-1901	L94001618
18. Gases; Calibration, Zero, Span	—	Matheson	—	—
19. Moisture Meter	180-009	Delmhorst	RC-1C	12527
20. Humidity Chamber	—	Shop Built	—	—
21. Dilution Tunnel	180-142	Shop Built	—	—
22. Spirometer	—	Shop Built	—	—
23. Data Acquisition System	180-151	Shop Built	—	—
24. Drying Oven	180-159	Quincy Lab. Inc.	21-350	—
25. Filter Holders, 47 mm (8)	180-157 et 180-158	Millipore	SX0004700	—
26. Type J T/C Plugs	—	Gordon	HMP	—
27. Sling Psychrometer	180-113	Bacharach	UYQ	—
28. Chart Recorder	180-085	Omega	CT-428-7	74041
29. Infrared Pyrometer	180-003	Omega	OS-2000A	A5719
30. Dessicator cabinet	—	Nalgene	5317-0180	—
31. Exhaust blower	180-141	—	—	—
32. Drying culumns	180-143	W.A. Hammond	—	—
	180-144	Drierite Co.	26800	—
33. Impinger train	180-140	Shop Built	—	—

Prepared June 20, 1995 by Gaétan Piédalue

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 spirometer method. This process involves sampling the train operation for 1 cubic foot of volume. With readings made to .001 ft^3, the resolution is 0.1%, giving an 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 utilized (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.

At the conclusion of each unit test program, a five point calibration check is made and must meet accuracy requirements of the applicable standards. Consistent deviations between analyzer readings and calibration gas concentrations are used to correct data before computer processing.

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.

6.2.2 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 reading of the tunnel's velocity as prescribed in EPA method 1. Final tunnel velocities and flow rates are calculated from EPA method 2, equations 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.

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.