



TEST REPORT

SCOPE: EMISSIONS

FUEL: EPA TEST FUEL (CRIBS)

TEST STANDARD: EPA

MODEL: NXT-1 WOOD STOVE

Notice to reader: Our NXT-1 wood stove was tested as part of our Chancelier firebox. Therefore, the Chancelier is referenced throughout the attached test report.



Inchcape Testing Services

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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
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Attention: Mr. Marc Tétreault

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

Tested by :

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Gaétan Piédalue, Eng.

Verified by:

Claude Pelland, Eng.
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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

| Test 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 | 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

| Test Number | Pre-test load | | | Test load | | | | | |
|-------------|--------------------------------|--|-----------------------|-----------------------|--|--|-------------------|-------------------|-------------------|
| | 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 (°R) | 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) | | % Deviation |
|------------|--------------|---------|--------------------|---------|-------------|
| | Train 1 | Train 2 | Train 1 | Train 2 | |
| 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 ² O) | 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

| <u>ITEM DESCRIPTION</u> | <u>WH #</u> | <u>MANUFACTURER</u> | <u>MODEL</u> | <u>SERIAL #</u> |
|--|--------------------|------------------------|----------------|-----------------|
| 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 | DeImhorst | 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 columns | 180-143 | W.A. Hammond | --- | --- |
| | 180-144 | Drierite Co. | 26800 | --- |
| 33. Impinger train | 180-140 | Shop Built | --- | --- |

Prepared June 20, 1995 by Gaétan Piédaluc

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 ft³, 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.