MF Fire

Project # 20-606
Model: Nova 2
Type: Single Burn Rate Catalytic Wood-Fired Heater
July 7, 2020

ASTM E2780 – 10
Standard Test Method for Determining Particulate Matter Emissions from Wood Heaters

Issued to: Mr. Taylor Myers
MF Fire
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Affidavit

PFS-TECO was contracted by MF Fire to provide testing services for the Nova 2 Wood-Fired Room Heater per ASTM E2780, *Standard Test Method for Determining Particulate Matter Emissions from Wood Heaters.* All testing and associated procedures were conducted at PFS-TECO's Hearth Products laboratory beginning on 6/10/2020 and ending on 6/18/2020. The laboratory is located at 11785 SE Hwy 212, Clackamas OR 97015. Testing procedures followed ASTM E2780. Particulate sampling was performed per ASTM E2515, *Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel.*

PFS-TECO is accredited by the U.S. Environmental Protection Agency for the certification and auditing of wood heaters pursuant to subpart AAA of 40 CFR Part 60, New Source Performance Standards for Residential Wood Heaters and subpart QQQQ of 40 CFR Part 60, Standards of Performance for New Hydronic Heaters and Forced Air Furnaces, Methods 28R, 28WHH, 28 WHH-PTS, and all methods listed in Sections 60.534 and 60.5476. PFS-TECO holds EPA Accreditation Certificate Numbers 4 and 4M (mobile). PFS-TECO is accredited by IAS to ISO 17020:2012 "Criteria for Bodies Performing Inspections", and ISO 17025:2005 "Requirements for Testing Laboratories." PFS-TECO is also accredited by Standards Council of Canada to ISO 17065:2012 "Requirements for Bodies Operating Product Certification Systems."

The following people were associated with the testing, analysis and report writing associated with this project.

Aaron Kravitz, Testing Supervisor

Introduction

MF Fire of Baltimore, MD contracted with PFS-TECO to perform EPA certification testing on the model Nova 2 Wood-Fired Room Heater. All testing was performed at PFS-TECO's Portland Laboratory in Clackamas, OR. All testing was performed by Aaron Kravitz.

Notes

- Prior to start of testing, 50 hours of conditioning was performed per ASTM E2780.
- Prior to start of testing, the dilution tunnel was cleaned with a steel brush.
- Front filters were changed on sample train A at one hour for all 5 test runs.
- A total of 5 test runs were completed. Test runs were performed in accordance with ASTM E2780 for a single burn rate appliance. The first two runs were conducted without a critical emissions control component installed, so these runs were not included in the average. Certification runs consisted of two replicate runs and one fan confirmation run. See the Run Narrative section for further detail on each run.

Wood Heater Identification and Testing

- Appliance Tested: ***Nova 2***
- Serial Number: ***Un-serialized Prototype – PFS Tracking Number 0074***
- Manufacturer***: MF Fire***
- Catalyst: ***Yes***
- Variable Burn Rate: ***No***
- Heat exchange blower: ***Optional***
- Type: ***Wood Stove***
- Style: ***Free Standing***
- Date Received: ***Wednesday, June 03, 2020***
- Testing Period – Start: ***Wednesday, June 10, 2020***
  Finish: ***Thursday, June 18, 2020***
- Test Location: ***PFS-TECO***
  11785 SE Hwy 212, Suite 305
  Clackamas, OR 97015
- Elevation: ***~131 Feet above sea level***
- Test Technician(s): ***Aaron Kravitz***
- Observers: ***None***

Test Procedures and Equipment

All Sampling and analytical procedures were performed by Aaron Kravitz. All procedures used are directly from ASTM E2780 and ASTM E2515. See the list below for equipment used. See Appendix C submitted with this report for calibration data.

Equipment List:

Equipment ID#	Equipment Description
041	Rice Lake 3'x3' floor scale w/digital weight indicator
132	Digiweigh DWP-440 Platform Scale
53	APEX XC-60-ED Digital Emissions Sampling Box A
54	APEX XC-60-ED Digital Emissions Sampling Box B
57	California Analytical ZRE CO2/CO/O2 IR ANALYZER
064	Digital Barometer
109A/B	Troemner 100mg/200mg Audit Weights
107	Sartorius Analytical Balance
051	10 lb audit weight
101	Dewalt Tape Measure
117	Digital Calipers
095	Anemometer
111	Microtector
115	Delmhorst Wood Moisture Meter
92302052	Gas Analyzer Calibration Span Gas
91005049	Gas Analyzer Calibration Mid Gas

Results

The average emissions rate for the 2 run test series was measured to be **1.9 g/hr** with a Higher Heating Value efficiency of **75%.** The average CO emission rate for the 2 tests was **0.8 g/min.** The MF Fire model Nova 2 Wood-Fired Room Heater meets the 2020 crib wood PM emission standard of ≤ 2.0 g/hr per CFR 40 part 60, §60.532 (c).

Detailed individual run data can be found in Appendix A submitted with this report.

Summary Table

	Run 1 *Not used**	**Run 2** *Not used**	**Run 3** Certification #1	**Run 4** Certification #2	**Run 5** Fan Confirmation
Date	*6/10/2020*	*6/11/2020*	6/16/2020	6/17/2020	6/18/2020
Run Number	*1*	*2*	3	4	5
Emission Rate (g/hr)	*3.03*	*2.67*	2.08	1.78	1.96
Burn Rate (kg/hr)	*2.74*	*2.76*	2.23	2.70	2.29
Heat Output (Btu/hr)	*35,011*	*36,968*	31,529	38,037	31,205
Overall Efficiency (% HHV)	*68.5%*	*71.9%*	75.1%	75.3%	75.5%
CO Emissions (g/MJ Output)	*3.19*	*3.32*	1.03	1.42	0.53
CO Emissions (g/kg Dry Fuel)	*43.34*	*47.24*	15.39	21.12	7.88
CO Emissions (g/min)	*1.97*	*2.15*	0.57	0.95	0.29
Emissions Rate – First Hour (g/hr)	*4.84*	*3.24*	4.01	2.31	1.84
Particulate emission average of 2 test runs: 1.9 grams per hour.					
Weighted average HHV efficiency of 2 test runs: 75%.					
Average CO emissions of 2 test runs: 0.8 g/min.					

*Runs 1 and 2 were conducted without the catalyst shield installed due to technician oversight. As this shield is a critical emissions control component, these runs are not acceptable for certification use and are shown here for information only.

Test Run Narrative

Run 1

Run 1 was performed on 6/10/2020, in accordance with the procedures specified in ASTM E2780 for a single burn rate appliance. The total test time was 137 minutes. The particulate emissions rate for the test was 3.03 g/hr, the burn rate was 2.74 kg/hr with an HHV efficiency of 68.5%. The Train A front filter was changed at 1 hr to determine 1st hour emissions. All test results were appropriate and valid. There were no anomalies and all test criteria were met.

Run 2

Run 2 was performed on 6/11/2020, in accordance with the procedures specified in ASTM E2780 for a single burn rate appliance. The total test time was 136 minutes. The particulate emissions rate for the test was 2.67 g/hr, the burn rate was 2.76 kg/hr with an HHV efficiency of 71.9%. The Train A front filter was changed at 1 hr to determine 1st hour emissions. All test results were appropriate and valid. There were no anomalies and all test criteria were met.

Following Run 2

After the completion of test run #2, the manufacturer requested that the unit be examined for potential causes of higher than anticipated emissions rates. This examination revealed that the catalyst heat shield (shown below in its proper position) was not installed.

This was determined to be an oversight in setting the stove up for testing after shipment. This shield is a critical emissions component, so testing was halted, and the EPA contacted for approval to restart certification testing. With this approval, the shield was installed in accordance with the manufacturer's instructions and testing continued.

Run 3

Run 3 was performed on 6/16/2020, in accordance with the procedures specified in ASTM E2780 for a single burn rate appliance. The total test time was 163 minutes. The particulate emissions rate for the test was 2.08 g/hr, the burn rate was 2.23 kg/hr with an HHV efficiency of 75.1%. The Train A front filter was changed at 1 hr to determine 1st hour emissions. All test results were appropriate and valid. There were no anomalies and all test criteria were met.

Run 4

Run 4 was performed on 6/17/2020, in accordance with the procedures specified in ASTM E2780 for a single burn rate appliance. The total test time was 126 minutes. The particulate emissions rate for the test was 1.78 g/hr, the burn rate was 2.70 kg/hr with an HHV efficiency of 75.3%. The Train A front filter was changed at 1 hr to determine 1st hour emissions. All test results were appropriate and valid. There were no anomalies and all test criteria were met.

Run 5

Run 5 was performed to confirm emissions performance without a fan (fan confirmation) on 6/18/2020, in accordance with the procedures specified in ASTM E2780 for a single burn rate appliance. The total test time was 147 minutes. The particulate emissions rate for the test was 1.96 g/hr, the burn rate was 2.29 kg/hr with an HHV efficiency of 75.5%. The Train A front filter was changed at 1 hr to determine 1st hour emissions. All test results were appropriate and valid. There were no anomalies and all test criteria were met. Since the emissions rate is within 1.0 g/hr of the other test runs used for determining the average rate, the fan is not considered to have an effect on emissions and can therefore be sold as optional equipment.

Test Conditions Summary

Testing conditions for all runs fell within allowable specifications of ASTM E2780 and ASTM E2515. A summary of facility conditions, fuel burned, and run times is listed below.

Runs	Ambient (°F)		Relative Humidity (%)		Average Barometric Pressure (In. Hg.)	Preburn Fuel Weight (lbs)	Test Fuel Weight (lbs)	Test Fuel Moisture (%DB)	Test Run Time (Min)
	Pre	Post	Pre	Post					
1	74	79	65.5	48.7	30.10	14.3	16.68	21.3	137
2	78	80	51.4	37.8	30.05	14.5	16.69	22.2	136
3	70	71	51.7	40.0	30.01	14.6	16.16	21.1	163
4	70	76	45.5	29.4	29.95	13.8	15.22	22.2	126
5	77	80	62.2	36.5	30.10	14.2	14.98	22.1	147

Appliance Operation and Test Settings

The appliance was operated according to procedures as described in the Operations Manual, found in Appendix B submitted with this report. Detailed run information can be found in Appendix A submitted with this report.

Appliance Description

Model(s): Nova 2

Appliance Type: Wood-Fired Room Heater

Firebox Volume: 2.4 ft^3

Air Introduction System: All combustion air enters through a hole at the rear of the firebox and is channeled from there to the primary and secondary air systems. The primary air consists of an air wash over the loading door, while the secondary air enters through numerous perforations in a secondary air manifold that acts as the top of the firebox.

Baffles: The only baffling is the main catalyst enclosure/secondary air manifold

Refractory Insulation: The firebox is lined with 1.25" thick firebrick.

Flue Outlet: 6-inch exhaust outlet located on the top (configurable to rear) of the appliance.

Catalytic Combustor: Metallic substrate combustor located at the top of the firebox, mounted in the secondary manifold behind a shield.

Fan: The Nova 2 is available with a convection fan that attaches to the lower rear of the appliance.

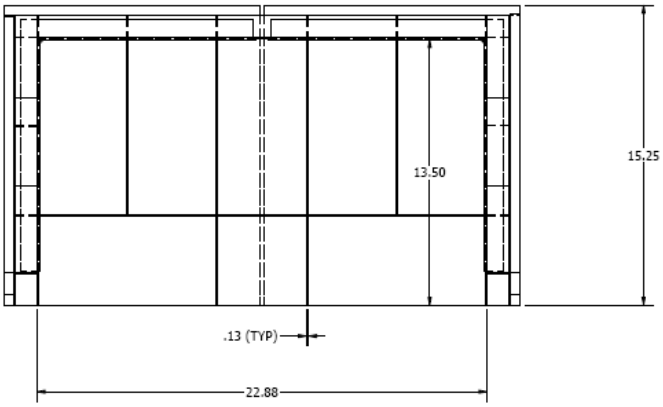
Appliance Dimensions

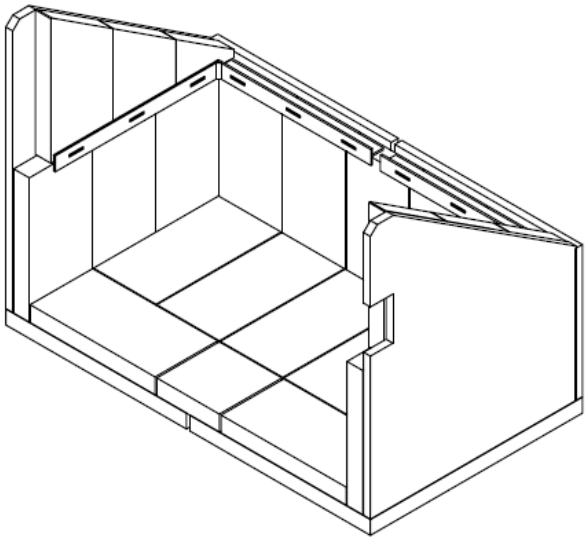
Nova 2 Unit Dimensions

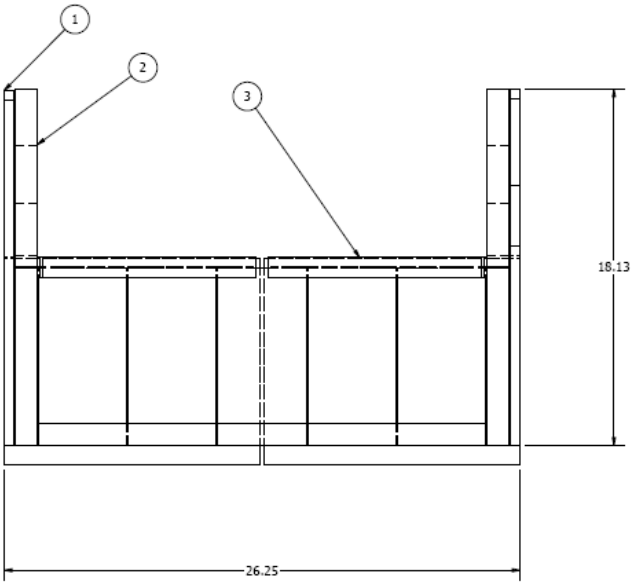
Height	Width	Depth	Firebox Volume
26.5"	27"	19"	2.4 ft^3

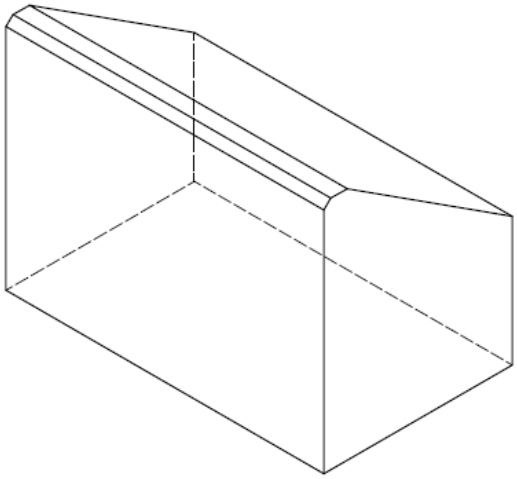
Appliance design drawings can be found in Appendix D submitted with the CBI copy of this report.

Firebox Drawing

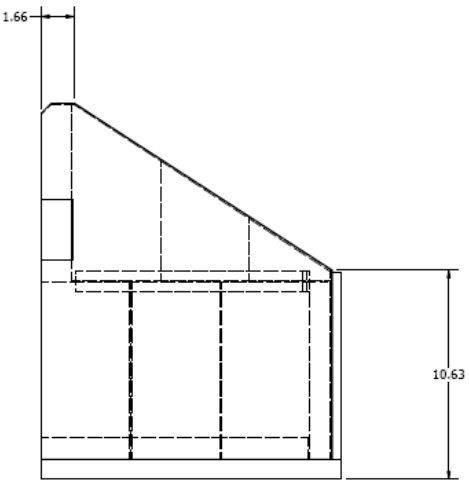








SKETCH OF FIREBOX
FREE-SPACE VOLUME
FireBox Volume: 4,208.5 in^3
2.4 ft^3



Appliance Front

Appliance Left

Appliance Right

Appliance Rear

Test Fuel Properties

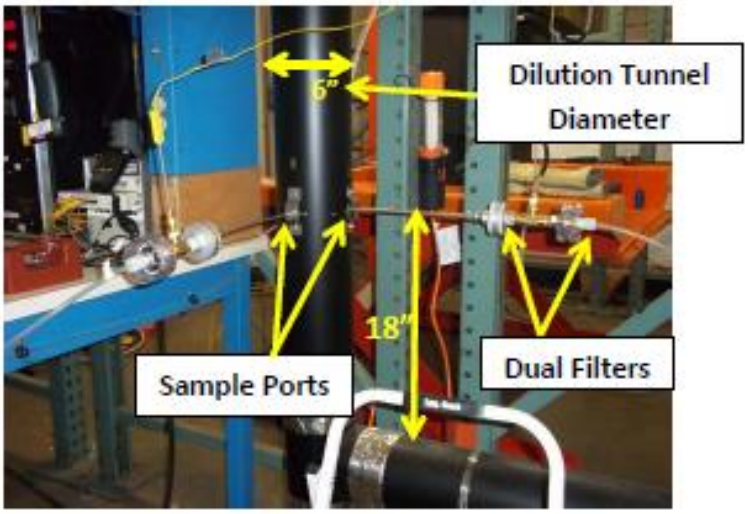
Test fuel used was dimensional Douglas fir lumber in 2” x 4” (nominal) and 4” x 4” (nominal). Test fuel was air dried to the specified moisture range of 19-25% dry basis. A typical fuel load is pictured below:

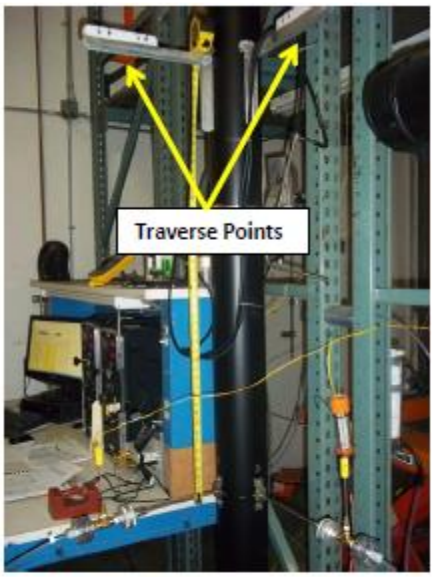
Typical Fuel Load

Sampling Locations and Descriptions

Sample ports are located 16.5 feet downstream from any disturbances and 1 foot upstream from any disturbances. Flow rate traverse data was collected 12 feet downstream from any disturbances and 5.5 feet upstream from any disturbances. (See below).

Sample Points





Sampling Methods

ASTM E2515 was used in collecting particulate samples. The dilution tunnel is 6 inches in diameter. All sampling conditions per ASTM E2515 were followed. No alternate procedures were used and no sampling intervals fell outside of proportional rates of +/- 10%.

Analytical Methods Description

All sample recovery and analysis procedures followed ASTM E2515 procedures. At the end of each test run, filters, O-Rings and probes were removed from their housings, dessicated for a minimum of 24 hours, and then weighed at 6 hour intervals to a constant weight per ASTM E2515-11 Section 10.

Calibration, Quality Control and Assurances

Calibration procedures and results were conducted per EPA Method 28R, ASTM E2515-11 and ASTM E2780. Test method quality control procedures (leak checks, volume meter checks, stratification checks, proportionality results) followed the procedures outlined.

Appliance Sealing and Storage

Upon completion of testing, the appliance was secured with metal strapping and the seal below was applied, the appliance was then returned to the manufacturer's location at: 3031 Washington Blvd, Suite G, Baltimore, MD 21230 for archival.

Sealing Label

ATTENTION:

THIS SEAL IS NOT TO BE BROKEN WITHOUT PRIOR AUTHORIZATION FROM THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY.

THIS APPLIANCE HAS BEEN SEALED INACCORDANCE WITH REQUIREMNTS OF 40CFR PART 60 SUBPART AAA §60.535 (a)(2)(vii)

REPORT #_____ DATE SEALED_____

MANUFACTURER_____ MODEL #_____

Sealed Unit

List of Appendices

The following appendices have been submitted electronically in conjunction with this report:

Appendix A – Test Run Data, Technician Notes, Sample Analysis, and Alternate Test Method Approval

Appendix B – Labels and Manuals

Appendix C –Equipment Calibration Records

Appendix D – Design Drawings (CBI Report Only)

Appendix E – Manufacturer QAP (CBI Report Only)