
Jøtul North America Inc.

Project # 18-425

Model: F 500 V3

Type: Catalytic Wood Fired Heater

November 16, 2018

EPA Test Method 28R for Certification and Auditing of Wood Heaters

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Affidavit

PFS-TECO was contracted by Jøtul North America Inc. (Jøtul) to provide testing services for the F 500 V3 Catalytic Wood-Fired Room Heater per EPA Method 28R, *Certification and Auditing of Wood Heaters*. All testing and associated procedures were conducted at PFS-TECO's Portland Laboratory beginning on 10/1/2018 and ending on 10/16/2018. PFS-TECO's Portland Laboratory is located at 11785 SE Highway 212 – Suite 305, Clackamas, Oregon 97015. Testing procedures followed EPA Method 28R and ASTM E2780, *Standard Test Method for Determining Particulate Matter Emissions from Wood Heaters*. 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, By A2LA to ISO 17025:2005 "Requirements for Testing Laboratories", and 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.

Sebastian Button, Laboratory Supervisor

Introduction

Jøtul of Gorham, ME, contracted with PFS-TECO to perform EPA certification testing on the F 500 V3 Catalytic Wood-Fired Room Heater. All testing was performed at PFS-TECO's Portland Laboratory. Testing was performed by Mr. Sebastian Button.

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 6 test runs.
- A total of 6 test runs were performed in accordance with EPA Method 28R, 1 at the maximum burn rate category, 1 at the medium high burn rate category, 2 at the medium low burn rate category, one of which was meets the 1.00 kg/hr or less requirement for stoves operating at minimum air setting, 1 fan confirmation test, and another attempted medium low category test, during which the fire went out, and the test was not completed. All test runs, other than the one during which the fire went out, met validity requirements, and all of those but the fan confirmation test are included in the weighted average. See Run Narrative section for further detail on each run.

Wood Heater Identification and Testing

- Appliance Tested: **F 500 V3**
- Serial Number: **Un-serialized Prototype – PFS Tracking Number 0011**
- Manufacturer: **Jøtul North America, Inc.**
- Catalyst: **Yes**
- Heat exchange blower: **Optional**
- Type: **Wood Stove**
- Style: **Free Standing**
- Date Received: **Monday, September 24, 2018**
- Wood Heater Aging: **September 25, 2018 – September 28, 2018**
- Testing Period – Start: **Monday, October 01, 2018** Finish: **Tuesday, October 16, 2018**
- Test Location: **PFS-TECO Portland Laboratory, 11785 SE HWY 212 - Suite 305, Clackamas, OR 97015**
- Elevation: **≈131 Feet above sea level**
- Test Technician(s): **Sebastian Button**
- Observers: **[REDACTED] of Jøtul (Test Runs 1 through 5 only).**

Test Procedures and Equipment

All Sampling and analytical procedures were performed by Sebastian Button. 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
040	Delmhorst J-2000 Wood Moisture Meter
041	Rice Lake 3'x3' floor scale w/digital weight indicator
050	Digiweigh DWP12i Platform Scale
053	APEX XC-60 Digital Emissions Sampling Box A
054	APEX XC-60 Digital Emissions Sampling Box B
055	APEX Ambient sampling box
057	California Analytical ZRE CO2/CO/O2 IR ANALYZER
109A/B	Troemner 100mg/200mg Audit Weights
107	Sartorius Analytical Balance
051	10 lb audit weight
090	Dewalt Tape Measure
092	Digital Calipers
095	Anemometer
111	Microtector
CC144992	Gas Analyzer Calibration Span Gas
CC332147	Gas Analyzer Calibration Mid Gas

Results

A total of 6 test runs were performed on the F 500 V3. Run #3, the fire went out, and Run #6, a fan confirmation test, are not used in any weighted average results calculations. The weighted average emissions rate for the 4 run test series was measured to be **0.5 g/hr** with a Higher Heating Value efficiency of **78.4%**. The average CO emission rate for the 4 tests was **0.5 g/min**. The Jøtul F 500 V3 Catalytic Wood-Fired Room Heater meets the 2020 crib wood PM emission standard of ≤ 2.0 g/hr per CFR 40 part 60, §60.532 (b).

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

Summary Table

	Cat. 2 ≤ 1.00 kg/hr.	Attempted Cat. 2 ≤ 1.00 kg/hr. ¹	Cat. 2 0.80 - 1.25 kg/hr.	Cat. 3 1.25 - 1.90 kg/hr.	Cat. 4 Max Burn Rate	Fan Confirmation (Cat. 2) ²
Date	10/4/2018	10/3/2018	10/2/2018	10/1/2018	10/5/2018	10/16/2018
Run Number	4	3	2	1	5	6
Emission Rate (g/hr).	0.28	N/A	0.40	0.52	0.93	0.45
Burn Rate (kg/hr)	0.91	N/A	1.17	1.46	2.96	1.21
Heat Output (Btu/hr)	14,001	N/A	17,565	20,500	38,804	17,437
Overall Efficiency (% HHV)	83.2	N/A	80.6	75.7	70.5	77.5
CO Emissions (g/MJ Output)	0.46	N/A	0.31	0.01	2.81	0.10
CO Emissions (g/kg Dry Fuel)	7.60	N/A	4.90	0.16	39.20	1.58
CO Emissions (g/min)	0.11	N/A	0.09	0.00	1.91	0.03
ASTM E2515 Emissions – First Hour (g/hr)	0.33	N/A	0.55	0.64	0.41	0.66
Weighted particulate emission average of 4 test runs: 0.5 grams per hour.						
Weighted average HHV efficiency of 4 test runs: 78.4%.						
Average CO emissions of 4 test runs: 0.5 g/min						

¹ Fire went out during test

² Fan Confirmation test not included in weighted average calculations.

Weighted Average Calculation Summary

28R Weighted Average.xlsm

EPA Method 28R Weighted Average Emissions

Client: Jotul
 Stove Model: F 500 V3
 Test Dates: 10/1/2018 - 10/5/2018
 Job Number: 18-425

Signature/Date: 

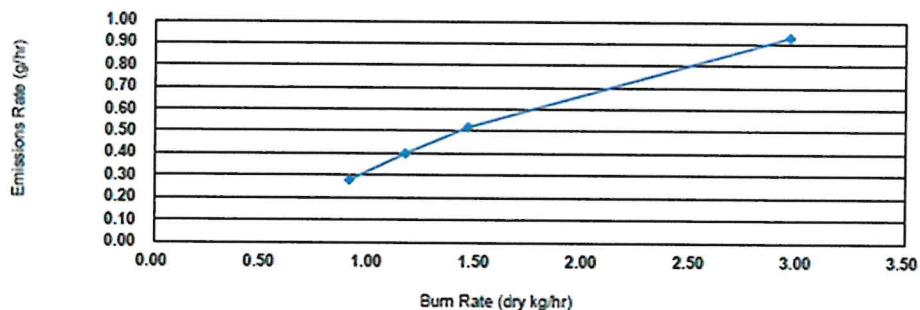
10/17/2018

Weighted Average Particulate Emissions (g/hr):	0.5
Weighted Average HHV Efficiency (%):	78.4%
Weighted Average LHV Efficiency (%):	84.7%
Average CO Emissions (g/min):	0.5

Individual Run Summaries

Run Number: 4	Run Number: 2
Burn Rate (dry kg/hr): 0.91	Burn Rate (dry kg/hr): 1.17
Emissions Rate (g/hr): 0.28	Emissions Rate (g/hr): 0.40
HHV Efficiency (%): 83.2%	HHV Efficiency (%): 80.6%
LHV Efficiency (%): 89.9%	LHV Efficiency (%): 87.1%
Weighting Percentage (%): 30.62%	Weighting Percentage (%): 25.14%
Run Number: 1	Run Number: 5
Burn Rate (dry kg/hr): 1.46	Burn Rate (dry kg/hr): 2.96
Emissions Rate (g/hr): 0.52	Emissions Rate (g/hr): 0.93
HHV Efficiency (%): 75.7%	HHV Efficiency (%): 70.5%
LHV Efficiency (%): 81.9%	LHV Efficiency (%): 76.2%
Weighting Percentage (%): 28.00%	Weighting Percentage (%): 18.23%

Emission Rate vs Burn Rate Plot



Test Run Narrative

Run 1

Run 1 was performed on 10/1/2018 as a category 3 test, per EPA Method 28R. The total test time was 250 minutes. The particulate emissions rate for the test was 0.52 g/hr, the burn rate was 1.46 kg/hr with an HHV efficiency of 75.7%. 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 10/2/2018 as a category 2 test, per EPA Method 28R. The total test time was 300 minutes. The particulate emissions rate for the test was 0.40 g/hr, the burn rate was 1.17 kg/hr with an HHV efficiency of 80.6%. 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 3

Run 3 was performed on 10/3/2018 as an attempted category 2 test, per EPA Method 28R. During testing this fire went out as defined in EPA Method 28 8.1.1.3.2, more than 30 minutes elapsed without any measurable weight loss. Another category 2 test (Run 4) was performed in lieu of this test.

Run 4

Run 4 was performed on 10/4/2018 as a category 2 test, per EPA Method 28R. The total test time was 410 minutes. The particulate emissions rate for the test was 0.28 g/hr, the burn rate was 0.91 kg/hr with an HHV efficiency of 83.2%. 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.

This test meets the burn rate requirements described in EPA Method 28 Section 8.1.1.3.2 as a category 2 test with a burn rate of 1.00 kg/hr or less for wood stoves that cannot be operated at burn rates less than 0.8 kg/hr. This test was performed with the air control set to its lowest setting, it is not possible to operate the stove at a lower air setting. Therefore, this test will be used in lieu of a category 1 test.

Run 5

Run 5 was performed on 10/5/2018 as a category 4 test, per EPA Method 28R. The total test time was 120 minutes. The particulate emissions rate for the test was 0.93 g/hr, the burn rate was 2.96 kg/hr with an HHV efficiency of 70.5%. 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 6

Run 6 was performed on 10/16/2018 as a category 2 fan confirmation test, per EPA Method 28R. The total test time was 300 minutes. The particulate emissions rate for the test was 0.45 g/hr with a burn rate of 1.21 kg/hr. All test results were appropriate and valid. There were no anomalies and all test criteria were met. Since the particulate emissions rate is within 1.0 g/hr of the other category 2 test (run 2, 0.40 g/hr) the blower is determined not to have a significant impact on emissions performance and may therefore be approved as an optional accessory. This test run is not included in the weighted average calculations presented in the results summary.

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	73	76	45.6	33.1	29.67	13.10	16.20	22.5	250
2	73	74	42.0	22.5	29.65	18.56	15.61	22.1	300
3	73	74	28.6	22.4	29.76	17.04	15.90	21.6	590
4	72	74	30.6	20.4	29.91	19.53	16.42	21.6	410
5	75	77	27.7	25.4	29.92	17.75	15.52	20.1	120
6	73	77	21.7	15.8	30.10	19.05	15.94	20.5	300

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.

Settings & Run Notes

	Pre-Burn Air Setting	Test Run Air and Fan Settings*
Run 1	Adjustable Primary Air Control (PAC) open 0.383" from fully closed	Adjustable PAC open 0.383" from fully closed, fan on turned on to low setting.
Run 2	Adjustable PAC open 0.133"	Adjustable PAC open 0.133", fan on turned on to low setting.
Run 3	Adjustable PAC open 5/64"	Adjustable PAC open 5/64", fan on turned on to low setting.
Run 4	Adjustable PAC open 0.126"	Adjustable PAC open 0.126", fan on turned on to low setting.
Run 5	Adjustable PAC fully open	Adjustable PAC fully open fan on high setting.
Run 6	Adjustable PAC open 0.126"	Adjustable PAC open 0.126", fan off, fan confirmation test.

*The fixed stop on this prototype design was moved several times during testing in attempts to meet burn rate requirements. All measurements above are references from a completely closed position, production models have a fixed stop at 0.126" from completely closed, see Appendix D for further detail.

Appliance Description

Model(s): F 500 V3

Additional Models Discussion: None

Appliance Type: Catalytic Wood-Fired Room Heater

Firebox Volume: 2.41 ft³

Air Introduction System: Primary Air enters the firebox from the rear bottom of the appliance and is channeled up the sides of the appliance and down through the air wash, as well as through a fixed pilot air opening in the front of the firebox, and a small amount of bleed air up through the ash grate. Primary air is controlled via a damper arm located above the ashlip which moves right (open) to left (closed). Secondary air is pulled through an opening in the back of the appliance and channeled up through the secondary air baffle. Secondary air is automatically metered into the firebox fire a control damper that opens and closes via a bimetallic damper. Dimensions on all these features can be found in Appendix D.

Baffles: A secondary air manifold/baffle plate is constructed of 0.075" thick Stainless Steel.

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

Flue Outlet: 6-inch exhaust outlet located on the top of the appliance.

Catalytic Combustor: [REDACTED] corrugated metal combustor, measuring [REDACTED]" x [REDACTED]" x [REDACTED]", [REDACTED] cells per square inch.

Fan: The appliance is optionally offered with a convection fan that attached to the bottom rear on the appliance.

Gasketing: The cast iron appliance utilizes and assortment of gasket material for sealing of various seems, see drawings in Appendix D for a full breakdown.

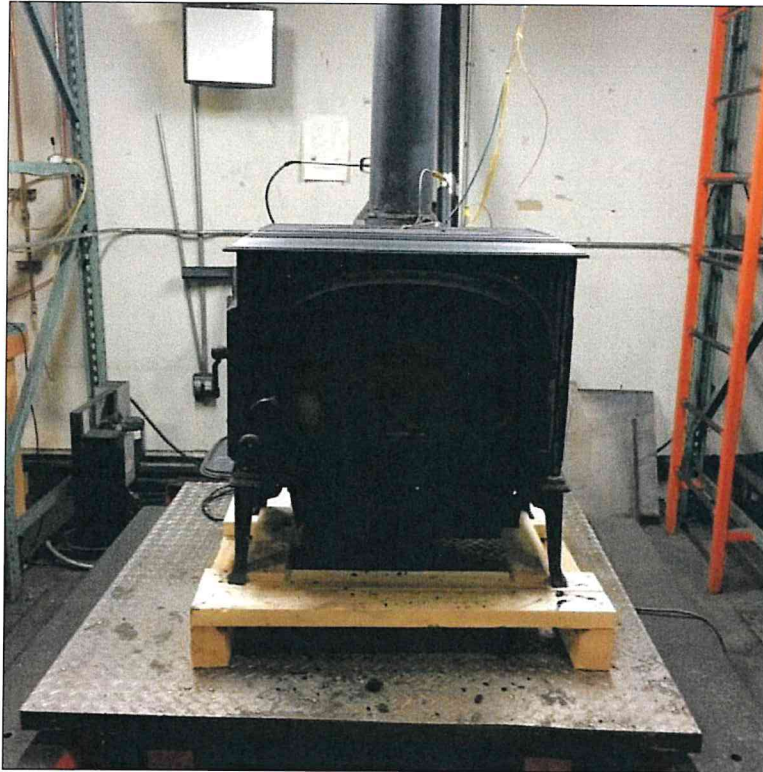
Appliance Dimensions

F 500 V3 Unit Dimensions

Height	Width	Depth	Firebox Volume
28.12"	28.2"	17.42"	2.41 ft ³

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

Appliance Front



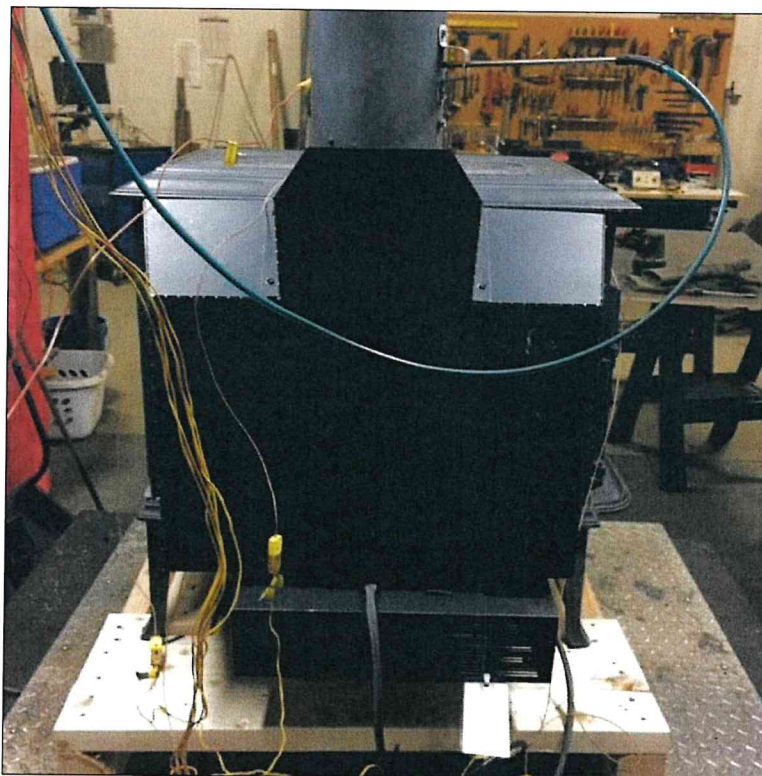
Appliance Left



Appliance Right



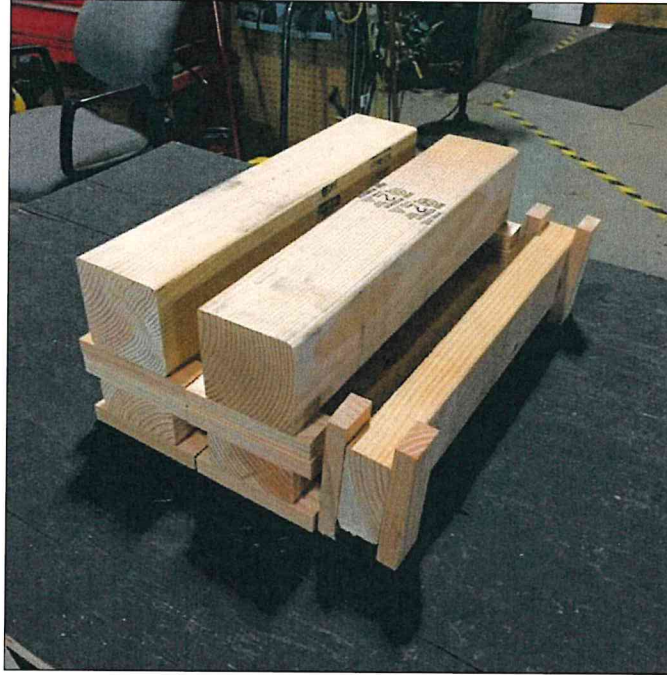
Appliance Rear



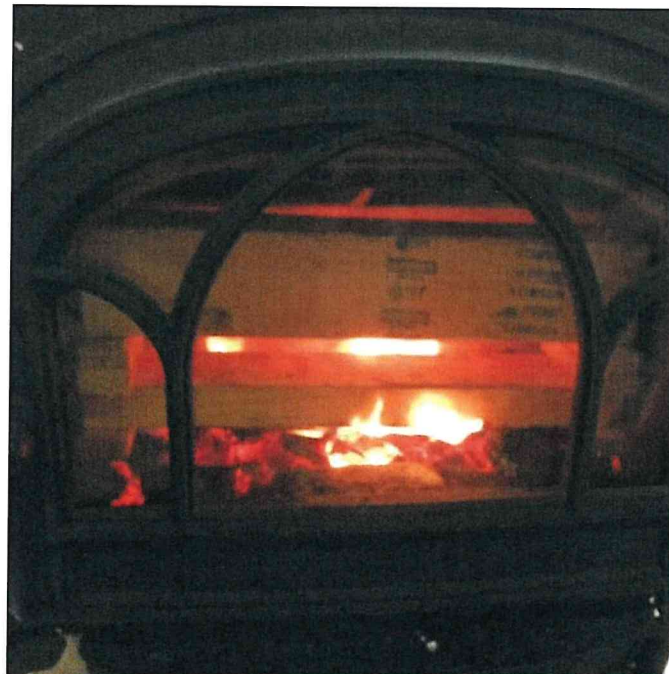
Test Fuel Properties

Test fuel used was dimensional Doug fir lumber, air-dried to the specified moisture content range. Typical fuel loads are pictured below:

Typical Test Fuel Load Configuration



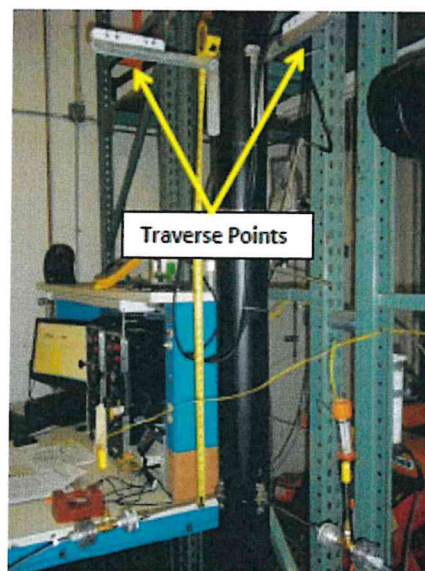
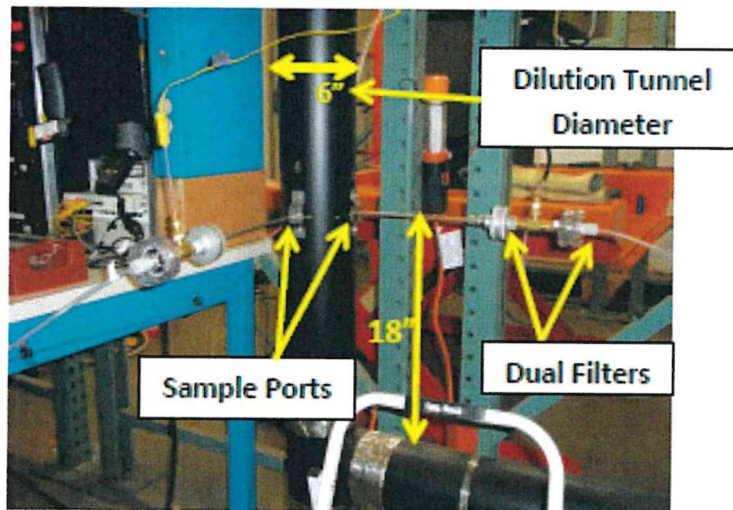
Typical Test Fuel Loaded in Test Stove



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: 55 Hutcherson Drive, Gorham, ME 04038, 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 Photos

Appendix B – Labels and Manuals

Appendix C –Equipment Calibration Records

Appendix D – Design Drawings (CBI Report Only)

Appendix E – Manufacturer QAP (CBI Report Only)