
Hearth and Home Technologies

Project # 19-530

Model: 21M-ACC-C

AKA: Discovery-I-C

Type: Residential Non-catalytic Wood
Fired Heater

January 20, 2020

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

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Affidavit

PFS-TECO was contracted by Hearth & Home Technologies (HHT) to provide testing services for the 21M-ACC-C Non-Catalytic Wood-Fired Room Heater per EPA Method 28R, *Certification and Auditing of Wood Heaters*. All testing and associated procedures were conducted at HHT's Bethel, VT laboratory beginning on 12/9/2019 and ending on 12/13/2019. HHT's Bethel Laboratory is located at 62 Vermont Castings Road, Bethel, VT 05032. 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", 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.



Sebastian Button, Laboratory Supervisor

Introduction

Hearth and Home Technologies of Halifax, PA, contracted with PFS-TECO to perform EPA certification testing on 21M-ACC-C Non-Catalytic Wood-Fired Room Heater. All testing was performed at HHT's Bethel, VT 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 7 test runs.
- A total of 7 test runs were performed in accordance with EPA Method 28R, 2 at the maximum burn rate category, 1 at the medium high burn rate category, 3 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, and 1 fan confirmation test, see Run Narrative section for further detail on each run.

Wood Heater Identification and Testing

- Appliance Tested: **21M-ACC-C**
- Serial Number: **Un-serialized Prototype – PFS Tracking Number 0039**
- Manufacturer: **Hearth and Home Technologies**
- Catalyst: **No**
- Heat exchange blower: **Optional**
- Type: **Wood Stove**
- Style: **Free Standing**
- Date Received: **Monday, December 09, 2019**
- Wood Heater Aging: **October 23 – December 4, 2019**
- Testing Period – Start: **Monday, December 09, 2019** Finish: **Friday, December 13, 2019**
- Test Location: **HHT's Bethel Laboratory, 62 Vermont Castings Rd, Bethel, VT 05032**
- Elevation: **≈551 Feet above sea level**
- Test Technician(s): **Sebastian Button**
- Observers: **Dan Whitcomb of HHT**

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
VC-GSE350	Floor scale w/digital weight indicator
053	APEX XC-60 Digital Emissions Sampling Box A
054	APEX XC-60 Digital Emissions Sampling Box B
057	California Analytical ZRE CO2/CO/O2 IR ANALYZER
109A/B	Troemner 100mg/200mg Audit Weights
097	10 lb audit weight
107	Sartorius Analytical Balance
095	Anemometer
111	Microtector
040	Delmhorst J-2000 Wood Moisture Meter
064	Digital Barometer
101	Dewalt Tape Measure
102	Digital Calipers

Results

A total of 7 test runs were performed on the 21M-ACC-C. Run #1 and 2 were excluded from the weighted average due to failed average surface temperature delta requirements, and Run #5, a fan confirmation test, was not used in any weighted average results calculations. The weighted average emissions rate for the 4 run test series was measured to be **1.7 g/hr** with a Higher Heating Value efficiency of **76.1%**. The average CO emission rate for the 4 tests was **1.5 g/min**. The HHT 21M-ACC-C Non-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.	Cat. 2 0.80 - 1.25 kg/hr. ¹	Cat. 2 0.80 - 1.25 kg/hr.	Cat. 3 1.25 - 1.90 kg/hr.	Cat. 4 Max Burn Rate ¹	Cat. 4 Max Burn Rate	Fan Confirmation (Cat. 2) ²
Date	12/11/19	12/10/19	12/11/19	12/12/19	12/9/19	12/13/19	12/12/19
Run Number	3	2	4	6	1	7	5
Emission Rate (g/hr).	1.67	0.93	1.27	1.06	4.06	2.72	1.20
Burn Rate (kg/hr)	0.97	1.11	1.20	1.34	2.22	2.13	1.11
Heat Output (Btu/hr)	13,585	15,304	17,141	18,893	27,784	29,322	15,670
Overall Efficiency (% HHV)	76.1%	75.2%	77.1%	76.7%	66.9%	74.7%	76.2%
CO Emissions (g/MJ Output)	5.66	4.67	4.26	3.96	3.44	4.10	4.57
CO Emissions (g/kg Dry Fuel)	85.35	69.66	64.97	60.08	45.62	60.70	69.09
CO Emissions (g/min)	1.35	1.26	1.28	1.31	1.68	2.11	1.26
ASTM E2515 Emissions – First Hour (g/hr)	4.25	1.94	2.42	1.31	5.43	2.89	2.09
Weighted particulate emission average of 4 test runs: 1.7 grams per hour.							
Weighted average HHV efficiency of 4 test runs: 76.1%.							
Average CO emissions of 4 test runs: 1.5 g/min.							

¹Test not included in weighed average, delta T exceeded 126°F.

²Fan Confirmation test not included in weighted average calculations.

Weighted Average Calculation Summary

28R Weighted Average.xlsm

EPA Method 28R Weighted Average Emissions

Client: HHT
 Stove Model: 21M-ACC-C
 Test Dates: 12/9/19 - 12/13/19
 Job Number: 19-530

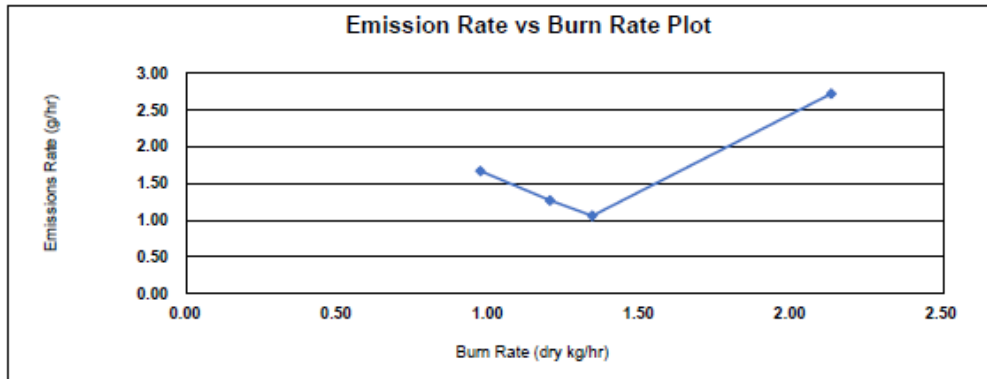
Signature/Date: 

Weighted Average Particulate Emissions (g/hr):	1.7
Weighted Average HHV Efficiency (%):	76.1%
Weighted Average LHV Efficiency (%):	82.3%
Average CO Emissions (g/min):	1.5

Individual Run Summaries

Run Number: 3	Run Number: 4
Burn Rate (dry kg/hr): 0.97	Burn Rate (dry kg/hr): 1.20
Emissions Rate (g/hr): 1.67	Emissions Rate (g/hr): 1.27
HHV Efficiency (%): 76.1%	HHV Efficiency (%): 77.1%
LHV Efficiency (%): 82.3%	LHV Efficiency (%): 83.3%
Weighting Percentage (%): 34.80%	Weighting Percentage (%): 18.88%
Run Number: 6	Run Number: 7
Burn Rate (dry kg/hr): 1.34	Burn Rate (dry kg/hr): 2.13
Emissions Rate (g/hr): 1.06	Emissions Rate (g/hr): 2.72
HHV Efficiency (%): 76.7%	HHV Efficiency (%): 74.7%
LHV Efficiency (%): 82.8%	LHV Efficiency (%): 80.7%
Weighting Percentage (%): 23.99%	Weighting Percentage (%): 22.32%

Emission Rate vs Burn Rate Plot



Test Run Narrative

Run 1

Run 1 was performed on 12/9/2019 as a category 4 test, per EPA Method 28R. The total test time was 105 minutes. The particulate emissions rate for the test was 4.06 g/hr, the burn rate was 2.22 kg/hr with an HHV efficiency of 66.9%. The Train A front filter was changed at 1 hr to determine 1st hour emissions. Per ASTM E2780 Section 9.5.10, the average of the wood heater surface temperatures at the end of the test shall agree with the average surface temperature at the start of the test run within 126°F, or the test is invalid. The difference in surface temperature between the beginning and end of this test was 127°F, therefore this test is invalid and is not included in the weighted average calculations.

Run 2

Run 2 was performed on 12/10/2019 as a category 2 test, per EPA Method 28R. The total test time was 200 minutes. The particulate emissions rate for the test was 0.93 g/hr, the burn rate was 1.11 kg/hr with an HHV efficiency of 75.2%. The Train A front filter was changed at 1 hr to determine 1st hour emissions. Per ASTM E2780 Section 9.5.10, the average of the wood heater surface temperatures at the end of the test shall agree with the average surface temperature at the start of the test run within 126°F, or the test is invalid. The difference in surface temperature between the beginning and end of this test was 130°F, therefore this test is invalid and is not included in the weighted average calculations.

Run 3

Run 3 was performed on 12/11/2019 as a category 2 test, per EPA Method 28R. The total test time was 240 minutes. The particulate emissions rate for the test was 1.67 g/hr, the burn rate was 0.97 kg/hr with an HHV efficiency of 76.1%. 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.

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 4

Run 4 was performed on 12/11/2019 as a category 2 test, per EPA Method 28R. The total test time was 180 minutes. The particulate emissions rate for the test was 1.27 g/hr, the burn rate was 1.20 kg/hr with an HHV efficiency of 77.1%. 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 5

Run 5 was performed on 12/12/2019 as a category 2 fan confirmation test, per EPA Method 28R. The total test time was 195 minutes. The particulate emissions rate for the test was 1.20 g/hr with a burn rate of 1.11 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 another category 2 test (run 4, 1.27 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.

Run 6

Run 6 was performed on 12/12/2019 as a category 3 test, per EPA Method 28R. The total test time was 160 minutes. The particulate emissions rate for the test was 1.06 g/hr, the burn rate was 1.34 kg/hr with an HHV efficiency of 76.7%. 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 7

Run 7 was performed on 12/13/2019 as a category 4 test, per EPA Method 28R. The total test time was 105 minutes. The particulate emissions rate for the test was 2.72 g/hr, the burn rate was 2.13 kg/hr with an HHV efficiency of 74.7%. 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.

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	70	70	89.1	78.6	29.86	12.45	10.50	23.2	105
2	73	72	83.0	93	29.16	11.5	9.70	22.0	200
3	71	71	53.0	40	28.18	12.5	10.10	20.9	240
4	70	70	42.0	56	29.73	12.5	9.40	20.1	180
5	72	73	43.0	38	30.12	12.65	9.60	22.5	195
6	71	72	38.0	71	30.12	12.5	9.50	23.8	160
7	72	73	66.0	70	29.93	12.8	9.65	19.7	105

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) fully open, Automatic Combustion Control (ACC) set to High	Adjustable PAC fully open, fan turned on high setting, ACC set to High
Run 2	Adjustable PAC fully closed; ACC set to timed close at start of preburn	Adjustable PAC fully closed, fan turned on low setting, ACC set to timed close at start of test.
Run 3	Adjustable PAC fully closed; ACC set to timed close at start of preburn	Adjustable PAC fully closed, fan turned on low setting, ACC set to timed close at start of test.
Run 4	Adjustable PAC open 1/16" from fully closed; ACC set to timed close at start of preburn	Adjustable PAC open 1/16" from fully closed, fan turned on low setting, ACC set to timed close at start of test.
Run 5	Adjustable PAC fully closed; ACC set to timed close at start of preburn	Adjustable PAC fully closed, fan turned on low setting, ACC set to timed close at start of test.
Run 6	Adjustable PAC open halfway; ACC set to timed close at start of preburn	Adjustable PAC open halfway, fan turned on high setting, ACC set to timed close at start of test.
Run 7	Adjustable PAC fully open; (ACC) set to High	Adjustable PAC fully open, fan turned on high setting, ACC set to High

Appliance Description

Model(s): 21M-ACC-C

Additional Models Discussion: In addition to the 21M-ACC-C, the manufacturer also offers the model Discovery-I-C, which is identical in firebox construction and air intake/control. The difference between the two models is that the 21M-ACC-C has pedestal base, while the Discovery-I-C features a wood storage area under the firebox with decorative panels on the side on the appliance. The difference between to two models is not expected to cause the appliance to exceed the required emissions limit.

Appliance Type: Non-Catalytic Wood-Fired Room Heater

Firebox Volume: 1.48 ft³

Air Introduction System: Primary Air enters the appliance through an opening located on the right side of the firebox near the top of the appliance. Air is regulated via a control arm extending out towards the front of the appliance, which moves up (open) and down (closed). Secondary combustion air enters a manifold near the rear of the appliance and is channeled to three air tubes mounted in the top of the firebox directly under the baffle. A third air source is located on the right side of the appliance near the bottom of the firebox. The control for this air source extends out the front of the appliance near the bottom right. Pushing the control in and releasing locks the control open providing combustion air to openings in the rear of the firebox and to an opening located in the front of the firebox near the floor. If this control is pushed in and then pulled out it activates a timer that slowly closes these openings over a time of approximately 22 minutes. Dimensions on all these features can be found in Appendix D.

Baffles: A pair of mating 8.13" x 13" x 0.50" C-Cast baffle boards mate together to form a baffle which rests on top of the secondary air tubes, a 1/2" ceramic fiber blanket rest on top of the baffle boards.

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

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

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

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



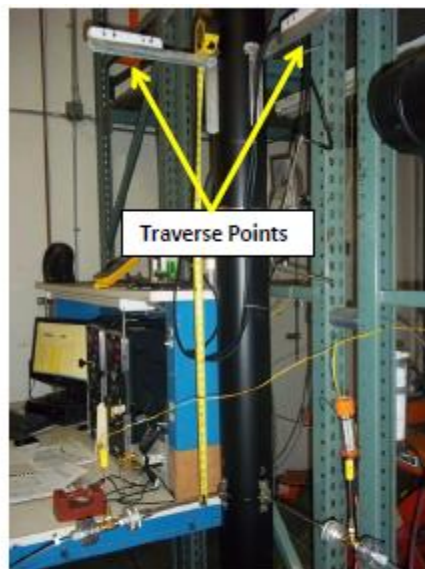
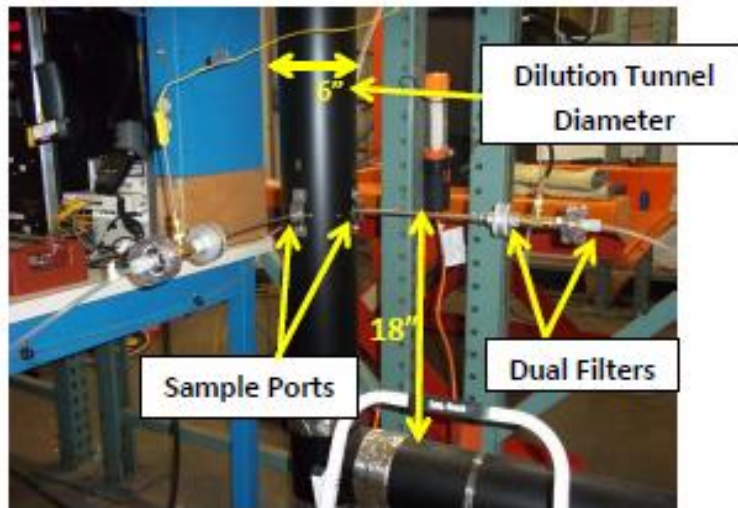
Typical Test Fuel Loaded in Test Stove



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: 352 Mountain House Road, Halifax, PA 17032, 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)