Liberator Rocket Heaters

Project # 19-483
Model: RMH-2
Type: Single Burn Rate Pellet Heater
March 7, 2022

ASTM E2779 Standard Test Method for Determining Particulate Matter Emissions from Pellet Heaters

Contact: Mr. Sky Huddleston
350 Farris Spur Rd.
Bourbon, MO 65441
(573) 468-4043

Prepared by: Aaron Kravitz

11785 SE Highway 212 – Suite 305
Clackamas, OR 97015-9050
(503) 650-0088

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Contents

Affidavit

PFS-TECO was contracted by Liberator Rocket Heaters to provide testing services for the RMH-2 Single Burn Rate Pellet Heater per ASTM E2779, *Determining PM Emissions from Pellet Heaters* and the attached alternative test method approval letter shown in Appendix C. All testing and associated procedures were conducted at PFS-TECO's Portland Laboratory on 11/4/2021. PFS-TECO's Portland Laboratory is located at 11785 SE Highway 212 – Suite 305, Clackamas, Oregon 97015. Testing procedures followed ASTM E2779, excepting the approved modifications to the method accounting for the unit's singe burn rate setting. Particulate sampling was performed per ASTM E2515, *Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel,* excepting caveats also described in the attached alternate test method approval letter. A copy of this approval included in Appendix C for reference.

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

Liberator Rocket Heaters contracted with PFS-TECO to perform EPA certification testing on the RMH-2 Single Burn Rate Pellet Heater. All testing was performed at PFS-TECO's Portland Laboratory. Testing was performed by Mr. Aaron Kravitz.

Notes

- Prior to start of testing, 50 hours of conditioning was performed per ASTM E2779.
- Prior to start of testing, the dilution tunnel was cleaned with a steel brush.
- Sample filters were changed on sample train A at one hour for all the test run.
- A total of 1 test run was performed in accordance with ASTM E2779. No anomalies occurred, no further additional tests were performed, see Run Narrative section for further detail.

Wood Heater Identification and Testing

- Appliance Tested: **RMH-2**
- Serial Number: **Un-serialized Prototype – PFS Tracking Number 0116**
- Manufacturer: **Liberator Rocket Heaters**
- Catalyst: **No**
- Heat exchange blower: **None**
- Type: **Single Burn Rate Pellet Heater**
- Style: Free Standing
- Date Received: **Thursday, September 09, 2021**
- Testing Period –
  - Start: **Thursday, November 04, 2021**
  - Finish: **Thursday, November 04, 2021**
- Test Location: **PFS Facility**
  11785 SE Hwy 212 Suite 305
  Clackamas, OR 97015
- Elevation: **≈130 Feet above sea level**
- Test Technician(s): **Aaron Kravitz**
- Observers: **N/A**

Test Procedures and Equipment

All Sampling and analytical procedures were performed by Aaron Kravitz. All procedures used are directly from ASTM E2779 and ASTM E2515. See the list below for equipment used. See Appendix B submitted with this report for calibration data.

Equipment List

Equipment ID#	Equipment Description
53	APEX XC-60 Digital Emissions Sampling Box A
54	APEX XC-60 Digital Emissions Sampling Box B
55	Ambient Sample Box
057	California Analytical ZRE CO2/CO/O2 IR ANALYZER
064	Digital Barometer
095	Anemometer
097	10 lb audit weight
107	Sartorius Analytical Balance
109A/B	Troemner 100mg/200mg Audit Weights
111	Microtector
189	Mettler Toledo 1000x0.02lb Platform Scale
CC106574	Gas Analyzer Calibration Span Gas
CC139173	Gas Analyzer Calibration Mid Gas

Results

The integrated test run emissions rate for the single run performed was measured to be **0.4 g/hr** with a Higher Heating Value efficiency of **68%.** The average CO emission rate was **0.4 g/min.** The Liberator Rocket Heaters RMH-2 meets the 2020 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

EPA Application Table

Run Number	Date	BR (dry kg/hr)	Run Time (min)	Heat Output (BTU/hr)	1st Hr Emissions (g/hr)	Total Emissions (g/hr)	Overall CO Emissions (g/min)	Overall Heating Efficiency (%HHV)
1	11/4/2021	1.59	360	20590	0.8	0.4	0.4	68%

Test Run Narrative

Run 1

Run 1 was performed on 11/4/2021 as an integrated ASTM E2779 test run. The overall test duration was 360 minutes. The particulate emissions rate for the integrated test run was 1.59 g/hr. The run had an overall HHV efficiency of 68%. One of two filter trains was changed at 1 hr. All test results were appropriate and valid and the single burn rate requirement for the integrated test run was achieved as per the attached approval letter. There were no anomalies and all criteria were met.

Test Conditions Summary

Testing conditions for all runs fell within allowable specifications of ASTM E2779 and ASTM E2515. A summary of facility conditions, fuel burned, and run times is listed below.

Run	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	72	47.4	41.7	30.04	3.99	22.42	6.63%	360

Appliance Operation

The appliance was operated according to procedures as described in the Operations Manual. The unit was filled with pellets then lit manually; no further adjustment was required. Detailed run information can be found in Appendix A submitted with this report.

Test Settings

N/A – Singe burn rate appliance.

Appliance Description

Model(s): RMH-2

Appliance Type: Single burn rate, gravity fed pellet heater

Materials: The unit is constructed chiefly of mild steel. The burn basket is stainless steel.

Fuel Introduction System: Fuel is fed from the hopper via gravity to the burn basket located at the bottom of the unit. Fuel can be shut off via a sliding plate, but no user adjustment of fuel delivery other than “on” or “off” is possible.

Combustion Air Flow: Combustion air enters the unit through two ports underneath the hopper, where it flows downwards through a tube coaxial with the fuel feed tube. Combustion takes place beginning at the burn basket, and combustion products then flow horizontally to the heat exchanger and then out through the flue outlet.

Gasketing: The burn basket access door is sealed with fiberglass flat gasketing.

Flue Outlet: 6-inch exhaust outlet exits the heat exchanger near the bottom of the appliance, on the side opposite the hopper and burn chamber.

Catalytic Combustor: N/A

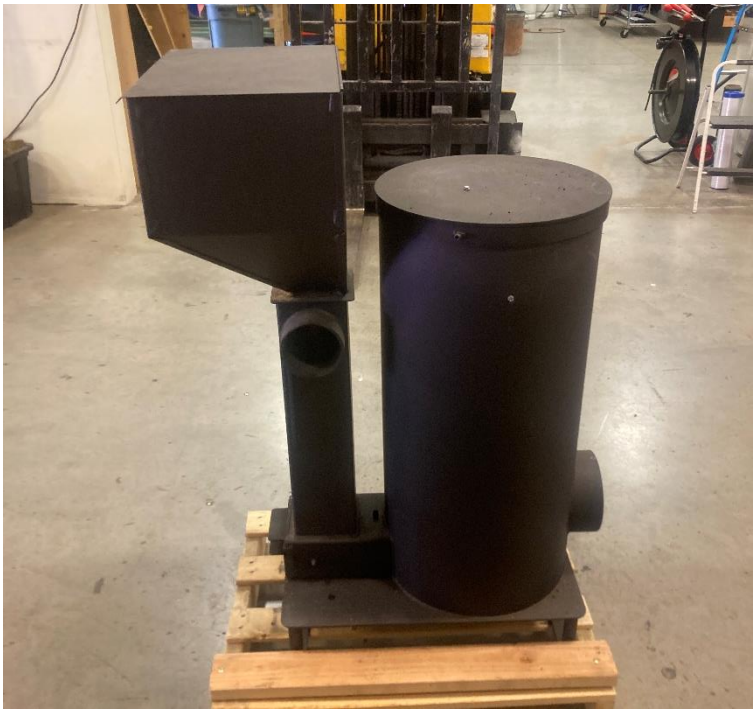
Fan: N/A

Appliance Photos

Appliance Front

Appliance Left

Appliance Right



Appliance Rear

Test Fuel Properties

Test fuel used was GreenTree Wood Pellet Fuel, a PFI Certified Premium Pellet Brand. A sample of pellets was sent to Twin Ports Testing for analysis, see pellet label & report below.

Twin Ports Testing, Inc.
1301 North 3rd Street
Superior, WI 54880
p: 715-392-7114
p: 800-373-2562
f: 715-392-7163
www.twinportstesting.com

Analytical Test Report

Report No: USR:W221-0604-01
Issue No: 1

Client: PFS-TECO
11785 SE Hwy 212 Ste 305
Clackamas, OR 97015
Attention: Sebastian Button

PO No:

Signed: Katy Jahr
Katy Jahr
Chemistry Lab Supervisor
Date of Issue: 10/25/2021

Sample Details

Sample Log No:	W221-0604-01	**Sample Date:**	
Sample Designation:	Pellet Sample	**Sample Time:**	
Sample Recognized As:	Biomass	**Arrival Date:**	10/13/2021

Test Results

	METHOD	UNITS	MOISTURE FREE	AS RECEIVED
Moisture Total	ASTM E871	wt. %		6.21
Ash	ASTM D1102	wt. %	0.39	0.37
Volatile Matter	ASTM D3175	wt. %		
Fixed Carbon by Difference	ASTM D3172	wt. %		
Sulfur	ASTM D4239	wt. %	0.009	0.008
SO_2	Calculated	lb/mmbtu		0.020
Net Cal. Value at Const. Pressure	ISO 1928	GJ/tonne	18.32	17.03
Gross Cal. Value at Const. Vol.	ASTM E711	Btu/lb	8649	8112
Carbon	ASTM D5373	wt. %	47.74	44.78
Hydrogen*	ASTM D5373	wt. %	8.31	7.80
Nitrogen	ASTM D5373	wt. %	< 0.20	< 0.19
Oxygen*	ASTM D3176	wt. %	> 43.34	> 40.65
*Note: As received values do not include hydrogen and oxygen in the total moisture.				
Chlorine	ASTM D6721	mg/kg		
Fluorine	ASTM D3761	mg/kg		
Mercury	ASTM D6722	mg/kg		
Bulk Density	ASTM E873	lbs/ft^3		
Fines (Less than 1/8")	TPT CH-P-06	wt.%		
Durability Index	Kansas State	PDI		
Sample Above 1.50"	TPT CH-P-06	wt.%		
Maximum Length (Single Pellet)	TPT CH-P-06	inch		
Diameter, Range	TPT CH-P-05	inch		to
Diameter, Average	TPT CH-P-05	inch		
Stated Bag Weight	TPT CH-P-01	lbs		
Actual Bag Weight	TPT CH-P-01	lbs		

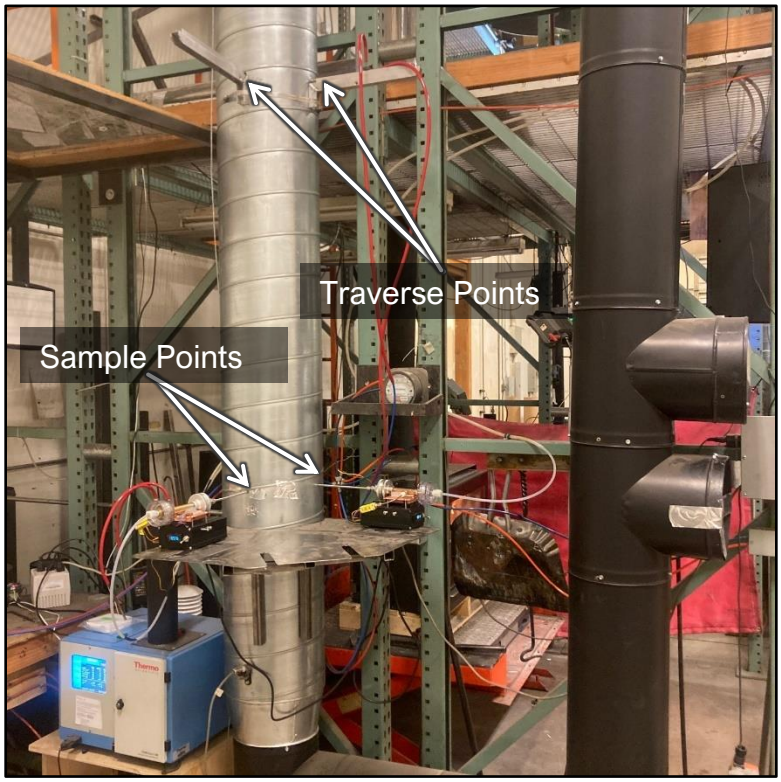
Comments:

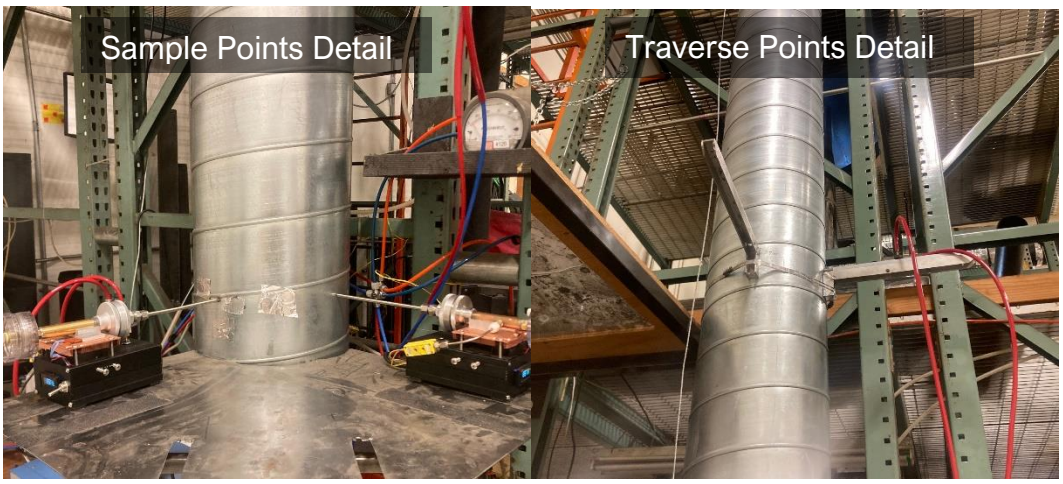
PJLA Testing
Accreditation #60243

Sampling Locations and Descriptions

Sample ports are located 16.5 feet downstream from any disturbances and 2 feet upstream from any disturbances. Flow rate traverse data was collected 8 feet downstream from any disturbances and 4 feet upstream from any disturbances. (See below).

Photos





Sampling Methods

ASTM E2515 was used in collecting particulate samples. The dilution tunnel is 12 inches in diameter. All sampling conditions per ASTM E2515 were followed. No alternate procedures were used with the exception of caveats described in the approval letter: Pall TX40 Emfab filters were used, filter temperatures were maintained between 80 and 90°F for all tests, filters were weighed in pairs where applicable, 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 E2779. 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: 350 Farris Spur Rd. Bourbon, MO 65441, 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 – Equipment Calibration Records

Appendix C – ATM Approval Letter

Appendix D – Labels and Manuals

Appendix E - Design Drawings (CBI Report Only)

Appendix F - Manufacturer QAP (CBI Report Only)

Pre-Conditioning Data

Client:	Liberator	Job #:	19-483
Model:	RHM-2	Tracking #:	116
Date(s):	Oct 4-8, 2021	Technician:	AK

Elapsed Time (hrs)	Flue (°F)	Catalyst Exit (°F)	Notes: Indicate initial air setting and any changes in in setting during conditioning, as well as weight and average moisture content of all fuel additions.
0	158		+40.54 lb, GreenTree premium pellets
1	332		
2	328		
3	340		
4	334		
5	330		
6	326		+38.68 lb, GreenTree premium pellets
7	327		
8	333		
9	331		
10	314		
11	327		
12	333		
13	333		
14	333		
15	324		+41.85 lb, GreenTree premium pellets
16	323		
17	328		
18	325		
19	334		+22.74 lb, GreenTree premium pellets
20	335		
21	324		
22	326		
23	327		
24	343		
25	349		
26	345		
27	354		
28	343		
29	343		
30	332		
31	313		
32	311		
33	320		+40.63 lb, GreenTree premium pellets
34	337		
35	349		
36	349		
37	353		
38	355		
39	350		
40	351		
41	352		+44.35 lb, GreenTree premium pellets
42	341		
43	333		
44	338		
45	320		
46	320		
47	312		
48	320		
49	328		
50	338		

Signature/Date:  *12/6/2021*

PELLET TEST DATA PACKET
ASTM E2779/E2515

Run 1 Data Summary

Client:	Liberator Rocket Heaters
Model:	RMH-2
Job #:	19-483
Tracking #:	116
Test Date:	11/4/2021

Technician Signature

12/6/2021
Date

TEST RESULTS - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK

Date: 11/4/2021

Burn Rate Summary	
Overall Burn Rate (dry kg/hr)	1.59

	Ambient Sample	Sample Train A	Sample Train B	1st Hour Filter
Total Sample Volume (ft^3)	58.937	53.267	53.327	8.878
Average Gas Velocity in Dilution Tunnel (ft/sec)	6.5			
Average Gas Flow Rate in Dilution Tunnel (dscf/hr)	17247.3			
Average Gas Meter Temperature (°F)	71.4	83.6	85.6	83.4
Total Sample Volume (dscf)	58.287	52.150	51.848	8.691
Average Tunnel Temperature (°F)	96.5			
Total Time of Test (min)	360			
Total Particulate Catch (mg)	0.1	1.4	1.1	0.4
Particulate Concentration, dry-standard (g/dscf)	0.0000017	0.0000268	0.0000212	0.0000460
Total PM Emissions (g)	0.18	2.60	2.02	0.76
Particulate Emission Rate (g/hr)	0.03	0.43	0.34	0.76
Emissions Factor (g/kg)	-	0.27	0.21	0.47
Difference from Average Total Particulate Emissions (g)	-	0.29	0.29	-
Difference from Average Total Particulate Emissions (%)	-	12.6%	12.6%	
Difference from Average Emissions Factor (g/kg)	-	0.03	0.03	-

Final Average Results	
Total Particulate Emissions (g)	2.31
Particulate Emission Rate (g/hr)	0.38
Emissions Factor (g/kg)	0.24
HHV Efficiency (%)	67.9%
LHV Efficiency (%)	74.5%
CO Emissions (g/min)	0.37

Quality Checks	Requirement	Observed	Result
Dual Train Precision	Each train within 7.5% of average emissions (in grams), or emission factors within 0.5 g/kg	See Above	OK
Filter Temps	<90 °F	87	OK
Face Velocity	< 30 ft/min	8.0	OK
Leakage Rate	Less than 4% of average sample rate	0 cfm	OK
Ambient Temp	55-90 °F	Min: 68.8 / Max: 73.1	OK
Negative Probe Weight Evaluation	<5% of Total Catch	Probe Catch Not Negative	OK
Pro-Rate Variation	90% of readings between 90-110%; none greater than 120% or less than 80%	See Data Tabs	OK

Overall Pellet Test Efficiency Results

Manufacturer: Liberator Rocket Heaters
Model: RMH-2
Date: 11/04/21
Run: 1
Control #: 19-483
Test Duration: 360
Output Category: Integrated

Test Results in Accordance with CSA B415.1-09

	HHV Basis	LHV Basis
Overall Efficiency	67.9%	74.5%
Combustion Efficiency	99.5%	99.5%
Heat Transfer Efficiency	68.2%	74.9%

Output Rate (kJ/h)	21,706	20,590	**(Btu/h)**
Burn Rate (kg/h)	1.59	3.50	**(lb/h)**
Input (kJ/h)	31,987	30,343	**(Btu/h)**

Test Load Weight (dry kg)	9.54	21.03	**dry lb**
MC wet (%)	6.22		
MC dry (%)	6.63		
Particulate (g)	2.31		
CO (g)	133		
Test Duration (h)	6.00		

Emissions	**Particulate**	**CO**
g/MJ Output	0.02	1.02
g/kg Dry Fuel	0.24	13.90
g/h	0.38	22.09
g/min	0.01	0.37
lb/MM Btu Output	0.04	2.37

Air/Fuel Ratio (A/F)	29.57

VERSION: **2.2** **12/14/2009**

PELLET STOVE PREBURN DATA - ASTM E2779

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1
Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

Recording Interval (min): 1
Run Time (min): 60

		Average:	-0.060	336	70
Elapsed Time (min)	**Scale Reading (lbs)**	**Weight Change (lbs)**	**Flue Draft (in H_2O)**	**Flue (°F)**	**Ambient (°F)**
0	43.1	-	-0.060	329	70
1	43.0	-0.08	-0.050	329	70
2	43.0	-0.07	-0.060	329	70
3	42.9	-0.06	-0.060	332	70
4	42.9	-0.06	-0.060	334	71
5	42.8	-0.07	-0.060	338	70
6	42.7	-0.07	-0.060	342	70
7	42.7	-0.06	-0.060	341	70
8	42.6	-0.07	-0.060	341	70
9	42.5	-0.06	-0.060	335	70
10	42.4	-0.09	-0.060	335	69
11	42.4	-0.06	-0.060	336	70
12	42.3	-0.06	-0.060	337	69
13	42.2	-0.08	-0.060	335	69
14	42.2	-0.06	-0.060	332	70
15	42.1	-0.06	-0.060	330	69
16	42.0	-0.07	-0.060	331	69
17	42.0	-0.06	-0.060	327	70
18	41.9	-0.07	-0.060	334	70
19	41.9	-0.06	-0.060	332	70
20	41.8	-0.05	-0.060	335	70
21	41.7	-0.07	-0.060	338	70
22	41.7	-0.06	-0.060	335	70
23	41.6	-0.07	-0.060	338	70
24	41.5	-0.06	-0.060	339	70
25	41.5	-0.08	-0.060	338	70
26	41.4	-0.07	-0.060	331	70
27	41.3	-0.06	-0.060	330	70
28	41.3	-0.08	-0.060	332	70
29	41.2	-0.06	-0.060	334	70
30	41.1	-0.08	-0.060	340	69
31	41.1	-0.06	-0.060	344	69
32	41.0	-0.08	-0.060	341	69
33	40.9	-0.06	-0.060	339	69
34	40.8	-0.07	-0.060	339	69
35	40.8	-0.07	-0.060	338	69
36	40.7	-0.05	-0.060	341	70
37	40.7	-0.07	-0.060	343	70
38	40.6	-0.07	-0.060	346	70
39	40.5	-0.06	-0.060	340	70
40	40.5	-0.07	-0.060	340	70
41	40.4	-0.07	-0.060	339	70
42	40.3	-0.07	-0.060	337	69
43	40.3	-0.06	-0.060	337	70
44	40.2	-0.07	-0.060	336	70
45	40.1	-0.06	-0.060	339	70
46	40.1	-0.06	-0.060	339	70

PELLET STOVE PREBURN DATA - ASTM E2779

Client: Liberator Rocket Heaters
Job #: 19-483
Model: RMH-2
Tracking #: 116
Run #: 1
Technician: AK
Date: 11/4/2021

47	40.0	-0.07	-0.060	340	69
48	39.9	-0.06	-0.060	341	70
49	39.8	-0.09	-0.060	339	69
50	39.8	-0.06	-0.060	338	69
51	39.7	-0.07	-0.060	342	69
52	39.6	-0.07	-0.060	333	69
53	39.6	-0.07	-0.060	332	69
54	39.5	-0.06	-0.060	334	69
55	39.4	-0.07	-0.060	331	70
56	39.4	-0.06	-0.060	333	70
57	39.3	-0.06	-0.060	329	70
58	39.2	-0.08	-0.060	328	70
59	39.2	-0.06	-0.060	335	70
60	39.1	-0.05	-0.060	333	70

DILUTION TUNNEL & MISC. DATA - ASTM E2779 / E2515

Client:	Liberator Rocket Heaters	Job #:	19-483
Model:	RMH-2	Tracking #:	116
Run #:	1	Technician:	AK
Test Start Time:	10:09	Date:	11/4/2021

1st hour End Time (min):	60
Medium Burn End Time (min):	N/A
Total Sampling Time (min):	360
Recording Interval (min):	1

Meter Box γ Factor:	0.999	(A)
Meter Box γ Factor:	0.996	(B)
Meter Box γ Factor:	0.992	(Ambient)

Induced Draft Check (in. H_2O):	0
Smoke Capture Check (%):	100%
Date Flue Pipe Last Cleaned:	11/3/2021

	Pre-Test	Post Test	Avg.
Barometric Pressure (in. Hg)	30.02	30.05	30.04
Relative Humidity (%)	47.4	41.7	
Room Air Velocity (ft/min)	0	0	
Scale Audit (lbs)	10.0	10.0	
Ambient Sample Volume:		58.937	ft^3

Sample Train Post-Test Leak Checks

(A)	0.000	cfm @	-4	in. Hg
(B)	0.000	cfm @	-5	in. Hg
(Ambient)	0.000	cfm @	-10	in. Hg

DILUTION TUNNEL FLOW

Traverse Data

Point	dP (in H_2O)	Temp (°F)
1	0.006	95
2	0.010	95
3	0.010	95
4	0.010	95
5	0.010	95
6	0.008	95
7	0.006	95
8	0.012	95
9	0.012	95
10	0.010	95
11	0.010	95
12	0.006	95
Center	0.019	95

Static Pressure: -0.050 in. H_2O

Dilution Tunnel H_2O:	2.00	percent
Tunnel Diameter:	12	inches
Pitot Tube Cp:	0.99	[unitless]
Dilution Tunnel MW(dry):	29.00	lb/lb-mole
Dilution Tunnel MW(wet):	28.78	lb/lb-mole
Tunnel Area:	0.7854	ft^2
V_{strav}:	6.67	ft/sec
V_{scent}:	9.35	ft/sec
F_p:	0.714	[ratio]
Initial Tunnel Flow:	284.4	scf/min

TEST FUEL PROPERTIES

Default Fuel Values

Fuel Type:	D. Fir	Oak
HHV (kJ/kg)	19,810	19,887
%C	48.73	50
%H	6.87	6.6
%O	43.9	42.9
%Ash	0.5	0.5

Actual Fuel Used Properties

Pellet Brand:	GreenTree
Pellet Fuel Grade:	PFI Premium
HHV (kJ/kg)	20,118
%C	47.74
%H	8.31
%O	43.56
%Ash	0.39
MC (%DB)	6.63

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
0	0.000		0.019	1.63	83.7	0.67		22.4		96	331	84	70.1
1	0.148	0.148	0.019	2.02	83.4	0.69	98	22.3	-0.1	97	330	83	70.2
2	0.296	0.148	0.019	2.01	83.6	0.71	98	22.3	-0.1	97	331	84	69.2
3	0.444	0.148	0.018	2.01	83.4	0.71	101	22.2	-0.1	96	329	83	69.3
4	0.592	0.148	0.018	2.02	83.5	0.72	101	22.1	-0.1	96	332	84	69.7
5	0.740	0.148	0.018	2.02	83.4	0.7	101	22.1	-0.1	97	341	83	69.8
6	0.888	0.148	0.019	2.03	83.5	0.71	98	22.0	-0.1	97	337	84	69.7
7	1.036	0.148	0.018	2.03	83.5	0.71	101	22.0	-0.1	97	336	84	70
8	1.184	0.148	0.018	2.03	83.6	0.72	101	21.9	-0.1	97	334	84	70
9	1.332	0.148	0.018	2.05	83.3	0.73	101	21.8	-0.1	96	330	83	69.8
10	1.480	0.148	0.018	2.04	83.3	0.72	101	21.8	-0.1	96	333	83	69.8
11	1.628	0.148	0.018	2.05	83	0.7	101	21.7	-0.1	96	332	83	69.8
12	1.776	0.148	0.018	2.05	82.9	0.69	101	21.6	-0.1	96	332	83	68.8
13	1.924	0.148	0.018	2.06	82.9	0.7	100	21.6	-0.1	95	327	83	68.8
14	2.071	0.147	0.019	2.06	82.8	0.73	97	21.5	-0.1	95	330	83	69.1
15	2.219	0.148	0.018	2.06	83	0.72	100	21.5	-0.1	95	332	83	69.3
16	2.367	0.148	0.018	2.06	83.2	0.75	100	21.4	-0.1	95	332	83	69.6
17	2.515	0.148	0.018	2.06	83.4	0.72	100	21.3	-0.1	95	329	83	69.6
18	2.663	0.148	0.018	2.07	83.5	0.77	100	21.3	-0.1	96	332	84	69.5
19	2.811	0.148	0.018	2.08	83.7	0.72	101	21.2	-0.1	97	337	84	69.8
20	2.959	0.148	0.018	2.08	83.7	0.7	101	21.1	-0.1	97	337	84	69.3
21	3.107	0.148	0.018	2.09	83.9	0.75	101	21.1	0.0	97	338	84	69.5
22	3.255	0.148	0.018	2.08	84	0.76	101	21.0	-0.1	97	335	84	69.6
23	3.403	0.148	0.018	2.11	84	0.75	100	20.9	-0.1	96	332	84	69.6
24	3.551	0.148	0.018	2.10	84	0.74	100	20.9	-0.1	97	336	84	69.9
25	3.699	0.148	0.019	2.10	83.9	0.71	98	20.8	-0.1	96	333	84	69.6
26	3.847	0.148	0.018	2.08	84	0.76	100	20.8	-0.1	96	334	84	69.8
27	3.995	0.148	0.018	2.11	84.1	0.76	100	20.7	-0.1	97	338	84	70.2
28	4.143	0.148	0.019	2.11	83.8	0.76	98	20.6	-0.1	97	337	84	69.5
29	4.291	0.148	0.019	2.11	83.4	0.77	98	20.6	-0.1	96	335	83	69.1
30	4.439	0.148	0.018	2.12	83.1	0.71	101	20.5	-0.1	96	331	83	69.5
31	4.587	0.148	0.018	2.12	82.9	0.78	101	20.4	-0.1	95	332	83	69.2
32	4.735	0.148	0.018	2.11	82.9	0.71	101	20.4	-0.1	95	333	83	69

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
33	4.883	0.148	0.018	2.11	82.9	0.76	101	20.3	-0.1	95	331	83	69
34	5.031	0.148	0.018	2.12	83.1	0.74	101	20.2	-0.1	95	328	83	69.1
35	5.179	0.148	0.018	2.12	83.2	0.71	100	20.2	-0.1	95	324	83	69.3
36	5.327	0.148	0.018	2.13	83.3	0.75	100	20.1	-0.1	95	319	83	69.5
37	5.475	0.148	0.018	2.12	83.5	0.77	100	20.1	-0.1	96	326	84	69.8
38	5.623	0.148	0.018	2.14	83.7	0.71	100	20.0	-0.1	96	325	84	69.8
39	5.771	0.148	0.018	2.13	83.7	0.75	100	19.9	0.0	96	327	84	69.8
40	5.919	0.148	0.018	2.13	83.9	0.74	101	19.9	-0.1	97	339	84	69.7
41	6.067	0.148	0.018	2.13	83.8	0.72	101	19.8	-0.1	97	337	84	70.1
42	6.214	0.147	0.018	2.15	83.9	0.77	100	19.8	-0.1	97	339	84	70.1
43	6.362	0.148	0.018	2.13	83.9	0.75	101	19.7	-0.1	98	342	84	69.7
44	6.510	0.148	0.019	2.14	83.9	0.78	98	19.6	-0.1	97	333	84	70.2
45	6.658	0.148	0.018	2.14	83.8	0.77	100	19.6	-0.1	96	324	84	70.1
46	6.806	0.148	0.018	2.14	83.9	0.77	100	19.5	-0.1	95	326	84	70.6
47	6.954	0.148	0.018	2.14	83.8	0.71	100	19.4	-0.1	95	329	84	70.2
48	7.102	0.148	0.018	2.14	83.4	0.75	100	19.4	-0.1	95	327	83	70.2
49	7.250	0.148	0.018	2.14	83.1	0.75	101	19.3	-0.1	96	329	83	70.1
50	7.398	0.148	0.018	2.14	83	0.71	101	19.2	-0.1	97	336	83	69.5
51	7.546	0.148	0.017	2.15	83	0.75	104	19.2	-0.1	96	329	83	70.1
52	7.694	0.148	0.018	2.15	82.8	0.78	101	19.1	-0.1	96	328	83	69.9
53	7.842	0.148	0.018	2.15	82.9	0.78	101	19.0	-0.1	96	326	83	70.1
54	7.990	0.148	0.018	2.14	82.9	0.78	101	19.0	-0.1	96	331	83	69.7
55	8.138	0.148	0.018	2.16	83	0.74	101	18.9	-0.1	96	327	83	69.8
56	8.286	0.148	0.018	2.15	83.2	0.77	101	18.8	-0.1	96	328	83	69.8
57	8.434	0.148	0.018	2.17	83.2	0.73	101	18.8	-0.1	97	330	83	69.5
58	8.582	0.148	0.018	2.16	83.4	0.72	101	18.7	-0.1	97	333	83	69.5
59	8.730	0.148	0.018	2.16	83.5	0.75	101	18.6	-0.1	98	334	84	69.6
60	8.878	0.148	0.018	2.17	83.6	0.71	101	18.6	-0.1	98	334	84	69.5
61	9.026	0.148	0.018	2.20	71.8	0.73	103	18.5	-0.1	98	329	82	69.5
62	9.174	0.148	0.018	2.20	75.5	0.72	102	18.5	-0.1	98	328	86	69.5
63	9.322	0.148	0.018	2.20	77.4	0.76	102	18.4	-0.1	98	330	87	69.5
64	9.470	0.148	0.018	2.20	78.6	0.75	102	18.4	-0.1	98	332	83	69.5
65	9.618	0.148	0.018	2.20	79.8	0.74	101	18.3	-0.1	98	334	80	69.6

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
66	9.766	0.148	0.018	2.21	81	0.72	101	18.2	-0.1	97	333	81	69.3
67	9.914	0.148	0.018	2.20	81.8	0.71	101	18.2	-0.1	96	326	82	69.2
68	10.062	0.148	0.018	2.21	82.2	0.75	101	18.1	-0.1	96	322	82	69.7
69	10.210	0.148	0.018	2.21	82.5	0.72	101	18.0	-0.1	95	320	83	69.6
70	10.357	0.147	0.018	2.21	82.8	0.75	100	18.0	-0.1	95	317	83	69.9
71	10.505	0.148	0.018	2.20	82.8	0.72	101	17.9	-0.1	95	321	83	70.5
72	10.653	0.148	0.018	2.20	82.8	0.71	101	17.9	-0.1	95	325	83	70.6
73	10.801	0.148	0.018	2.21	83.2	0.77	101	17.8	-0.1	97	337	83	70.7
74	10.949	0.148	0.018	2.20	83.3	0.76	101	17.7	-0.1	97	335	83	70.7
75	11.097	0.148	0.018	2.21	83.5	0.75	101	17.7	-0.1	97	337	84	70.8
76	11.245	0.148	0.018	2.21	83.6	0.76	101	17.6	0.0	97	333	84	70.8
77	11.393	0.148	0.018	2.20	83.5	0.71	101	17.6	-0.1	97	336	84	71
78	11.541	0.148	0.018	2.20	83.6	0.71	101	17.5	-0.1	98	336	84	71.2
79	11.689	0.148	0.018	2.20	83.7	0.77	101	17.4	-0.1	98	335	84	70.9
80	11.837	0.148	0.018	2.20	83.7	0.74	101	17.4	-0.1	98	336	84	71
81	11.985	0.148	0.018	2.21	83.7	0.73	101	17.3	-0.1	98	337	84	71.3
82	12.133	0.148	0.018	2.22	83.8	0.74	101	17.2	-0.1	98	333	84	71.4
83	12.281	0.148	0.018	2.22	83.9	0.77	101	17.2	-0.1	98	337	84	71.1
84	12.429	0.148	0.019	2.20	84	0.7	98	17.1	-0.1	98	341	84	71.7
85	12.577	0.148	0.018	2.21	83.8	0.79	101	17.0	-0.1	99	342	84	72
86	12.725	0.148	0.018	2.22	83.5	0.81	101	17.0	-0.1	99	346	84	71.7
87	12.873	0.148	0.018	2.21	83.3	0.72	101	16.9	-0.1	98	338	83	71.4
88	13.021	0.148	0.019	2.21	83	0.73	98	16.8	-0.1	98	338	83	71.5
89	13.169	0.148	0.018	2.21	82.9	0.78	101	16.8	-0.1	98	340	83	71.4
90	13.317	0.148	0.018	2.22	82.8	0.72	101	16.7	-0.1	98	342	83	71.5
91	13.465	0.148	0.019	2.22	82.9	0.71	98	16.7	0.0	97	336	83	71.6
92	13.613	0.148	0.018	2.21	83.1	0.79	101	16.6	-0.1	98	338	83	71.5
93	13.761	0.148	0.018	2.21	83.3	0.72	101	16.5	-0.1	97	332	83	71.5
94	13.909	0.148	0.018	2.21	83.4	0.78	101	16.5	-0.1	98	333	83	71.7
95	14.057	0.148	0.018	2.20	83.6	0.74	101	16.4	-0.1	98	331	84	71.7
96	14.205	0.148	0.018	2.22	83.7	0.78	101	16.3	-0.1	98	328	84	72
97	14.352	0.147	0.018	2.22	83.8	0.72	100	16.3	-0.1	98	333	84	71.8
98	14.500	0.148	0.018	2.22	83.9	0.78	101	16.2	0.0	98	328	84	71.8

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
99	14.648	0.148	0.018	2.22	83.8	0.72	101	16.2	-0.1	98	324	84	72.2
100	14.796	0.148	0.018	2.23	84	0.78	101	16.1	-0.1	98	327	84	71.9
101	14.944	0.148	0.018	2.22	83.9	0.74	101	16.1	-0.1	97	330	84	71.9
102	15.092	0.148	0.018	2.22	84	0.79	101	16.0	-0.1	98	331	84	71.9
103	15.240	0.148	0.018	2.22	84	0.78	101	15.9	-0.1	98	330	84	71.9
104	15.388	0.148	0.018	2.23	83.9	0.75	101	15.9	-0.1	98	332	84	71.9
105	15.536	0.148	0.019	2.22	83.6	0.77	98	15.8	-0.1	97	327	84	71.7
106	15.684	0.148	0.018	2.22	83.4	0.77	101	15.7	-0.1	97	333	83	71.9
107	15.832	0.148	0.018	2.23	83.2	0.79	101	15.7	-0.1	97	327	83	71.7
108	15.980	0.148	0.018	2.23	83.1	0.8	101	15.6	-0.1	96	328	83	71.7
109	16.128	0.148	0.019	2.23	83	0.75	98	15.5	-0.1	96	333	83	71.7
110	16.276	0.148	0.018	2.22	83	0.79	101	15.5	-0.1	97	332	83	71.7
111	16.424	0.148	0.018	2.22	83.1	0.8	101	15.4	-0.1	97	327	83	71.9
112	16.572	0.148	0.019	2.23	83.5	0.75	98	15.4	-0.1	97	323	84	72.3
113	16.720	0.148	0.018	2.23	83.6	0.73	101	15.3	-0.1	97	329	84	71.9
114	16.868	0.148	0.018	2.22	83.8	0.78	101	15.2	-0.1	97	332	84	72.4
115	17.016	0.148	0.018	2.23	83.8	0.78	101	15.2	-0.1	98	330	84	72.3
116	17.164	0.148	0.018	2.22	83.9	0.79	101	15.1	-0.1	97	328	84	72.4
117	17.312	0.148	0.018	2.24	84	0.75	101	15.0	-0.1	98	335	84	72.3
118	17.460	0.148	0.018	2.23	84	0.76	101	15.0	0.0	99	343	84	72.3
119	17.608	0.148	0.018	2.23	84.3	0.76	101	14.9	-0.1	99	341	84	72.5
120	17.756	0.148	0.018	2.23	84.2	0.78	101	14.9	-0.1	99	334	84	72.2
121	17.904	0.148	0.018	2.23	84.1	0.71	101	14.8	-0.1	98	328	84	72.8
122	18.052	0.148	0.018	2.23	84	0.74	101	14.7	-0.1	98	328	84	72.2
123	18.200	0.148	0.018	2.22	83.7	0.74	101	14.7	-0.1	97	332	84	72.2
124	18.348	0.148	0.018	2.24	83.5	0.71	101	14.6	0.0	97	330	84	72.2
125	18.495	0.147	0.019	2.24	83.4	0.77	97	14.5	-0.1	97	335	83	71.9
126	18.643	0.148	0.018	2.23	83.3	0.72	101	14.5	-0.1	97	333	83	72
127	18.791	0.148	0.018	2.24	83.2	0.74	101	14.4	-0.1	97	333	83	71.7
128	18.939	0.148	0.018	2.25	83.2	0.74	101	14.4	-0.1	97	332	83	71.8
129	19.087	0.148	0.018	2.23	83.2	0.79	101	14.3	-0.1	97	333	83	71.9
130	19.235	0.148	0.018	2.25	83.4	0.8	101	14.2	-0.1	96	325	83	72
131	19.383	0.148	0.018	2.24	83.5	0.74	101	14.2	-0.1	97	327	84	72.2

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
132	19.531	0.148	0.018	2.23	83.7	0.73	101	14.1	-0.1	97	328	84	72.4
133	19.679	0.148	0.018	2.24	83.9	0.78	101	14.1	-0.1	97	326	84	72.2
134	19.827	0.148	0.018	2.24	83.9	0.77	101	14.0	-0.1	97	330	84	72.1
135	19.975	0.148	0.018	2.24	84	0.74	101	14.0	-0.1	98	331	84	72.6
136	20.123	0.148	0.018	2.23	84.1	0.72	101	13.9	-0.1	98	329	84	72.3
137	20.271	0.148	0.018	2.24	84	0.72	101	13.8	0.0	98	329	84	72.3
138	20.419	0.148	0.018	2.25	84.1	0.74	101	13.8	-0.1	98	325	84	72.5
139	20.567	0.148	0.019	2.24	84	0.72	98	13.7	-0.1	98	325	84	72.4
140	20.715	0.148	0.018	2.24	84	0.79	101	13.7	-0.1	97	326	84	72.2
141	20.863	0.148	0.018	2.24	83.9	0.73	101	13.6	-0.1	97	327	84	72.3
142	21.011	0.148	0.018	2.24	83.7	0.75	101	13.5	-0.1	97	330	84	72
143	21.159	0.148	0.018	2.23	83.4	0.8	101	13.5	-0.1	97	327	83	71.8
144	21.307	0.148	0.018	2.24	83.2	0.81	101	13.4	-0.1	97	332	83	72.1
145	21.455	0.148	0.018	2.24	83.3	0.74	101	13.3	-0.1	97	334	83	71.8
146	21.603	0.148	0.018	2.23	83.1	0.73	101	13.3	-0.1	97	339	83	72.1
147	21.751	0.148	0.018	2.24	83.1	0.79	101	13.2	-0.1	97	340	83	72.1
148	21.899	0.148	0.018	2.24	83.3	0.78	101	13.1	-0.1	97	332	83	72.2
149	22.047	0.148	0.018	2.24	83.6	0.79	101	13.1	-0.1	97	335	84	72.2
150	22.195	0.148	0.018	2.24	83.7	0.73	101	13.0	0.0	97	333	84	72.4
151	22.343	0.148	0.018	2.24	83.7	0.72	101	13.0	-0.1	97	330	84	72.8
152	22.491	0.148	0.018	2.24	83.6	0.75	101	12.9	-0.1	96	328	84	72.2
153	22.638	0.147	0.018	2.23	83.6	0.79	100	12.9	-0.1	96	331	84	71.9
154	22.786	0.148	0.018	2.24	83.6	0.81	101	12.8	-0.1	97	330	84	71.5
155	22.934	0.148	0.018	2.24	83.8	0.75	101	12.7	0.0	97	331	84	71.6
156	23.082	0.148	0.018	2.25	84	0.74	100	12.7	-0.1	97	330	84	71.7
157	23.230	0.148	0.018	2.25	84.2	0.77	100	12.6	-0.1	97	330	84	71.6
158	23.378	0.148	0.018	2.24	84.4	0.72	100	12.5	-0.1	98	333	84	71.6
159	23.526	0.148	0.018	2.24	84.2	0.76	100	12.5	-0.1	97	331	84	71.8
160	23.674	0.148	0.018	2.23	83.9	0.75	101	12.4	-0.1	97	331	84	71.9
161	23.822	0.148	0.018	2.24	83.6	0.79	101	12.3	-0.1	96	325	84	71.5
162	23.970	0.148	0.018	2.24	83.3	0.77	101	12.3	-0.1	96	329	83	71.6
163	24.118	0.148	0.018	2.24	83.3	0.74	101	12.2	-0.1	96	335	83	71.5
164	24.266	0.148	0.018	2.24	83.2	0.81	101	12.2	-0.1	96	330	83	71.6

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
165	24.414	0.148	0.018	2.24	83.3	0.78	101	12.1	-0.1	96	333	83	71.7
166	24.562	0.148	0.018	2.24	83.2	0.77	101	12.0	-0.1	97	334	83	71.7
167	24.710	0.148	0.018	2.23	83.4	0.81	101	11.9	-0.1	97	333	83	71.9
168	24.858	0.148	0.018	2.24	83.6	0.79	101	11.9	-0.1	97	329	84	71.8
169	25.006	0.148	0.018	2.24	83.7	0.75	101	11.8	-0.1	97	331	84	72.1
170	25.154	0.148	0.018	2.25	83.9	0.74	100	11.8	-0.1	96	323	84	72.3
171	25.302	0.148	0.018	2.25	83.9	0.73	100	11.7	-0.1	97	325	84	72
172	25.450	0.148	0.018	2.25	84.1	0.73	101	11.6	-0.1	97	332	84	72.1
173	25.598	0.148	0.018	2.24	84.1	0.72	101	11.6	-0.1	97	329	84	72.1
174	25.746	0.148	0.018	2.26	84	0.72	100	11.5	-0.1	97	328	84	72.3
175	25.894	0.148	0.018	2.24	84.1	0.78	100	11.4	-0.1	97	329	84	72.2
176	26.042	0.148	0.018	2.25	84.2	0.77	101	11.4	-0.1	98	336	84	72.2
177	26.190	0.148	0.018	2.24	84.2	0.79	101	11.3	-0.1	98	341	84	72.2
178	26.338	0.148	0.018	2.25	84	0.77	101	11.2	-0.1	98	339	84	72.2
179	26.486	0.148	0.018	2.24	83.7	0.77	101	11.2	-0.1	97	334	84	72.2
180	26.634	0.148	0.018	2.24	83.6	0.79	101	11.1	-0.1	97	335	84	72.5
181	26.781	0.147	0.018	2.24	83.4	0.76	100	11.1	-0.1	97	333	83	72
182	26.929	0.148	0.018	2.24	83.4	0.74	101	11.0	0.0	97	334	83	72
183	27.077	0.148	0.018	2.24	83.2	0.8	101	10.9	-0.1	97	333	83	72.5
184	27.225	0.148	0.018	2.25	83.2	0.77	101	10.9	-0.1	97	333	83	72.1
185	27.373	0.148	0.018	2.25	83.4	0.82	101	10.8	-0.1	96	327	83	72.2
186	27.521	0.148	0.019	2.25	83.6	0.79	98	10.7	-0.1	96	326	84	72.1
187	27.669	0.148	0.018	2.25	83.7	0.8	101	10.7	-0.1	97	330	84	72.3
188	27.817	0.148	0.018	2.24	83.9	0.76	101	10.6	-0.1	98	337	84	73.1
189	27.965	0.148	0.018	2.24	84	0.76	101	10.6	-0.1	98	340	84	72.4
190	28.113	0.148	0.019	2.24	84.1	0.74	98	10.5	-0.1	98	333	84	72.5
191	28.261	0.148	0.019	2.25	84	0.78	98	10.4	-0.1	97	333	84	72.5
192	28.409	0.148	0.018	2.26	84	0.75	100	10.4	-0.1	97	334	84	72.9
193	28.557	0.148	0.018	2.25	84	0.78	100	10.3	-0.1	97	333	84	72
194	28.705	0.148	0.019	2.26	84.2	0.75	98	10.2	-0.1	96	331	84	72.3
195	28.853	0.148	0.018	2.25	84.1	0.75	100	10.2	-0.1	97	334	84	72
196	29.001	0.148	0.018	2.25	84.2	0.79	100	10.1	-0.1	96	331	84	71.1
197	29.149	0.148	0.018	2.25	83.8	0.8	101	10.0	-0.1	97	330	84	71.4

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
198	29.297	0.148	0.019	2.25	83.9	0.73	98	10.0	-0.1	97	330	84	71.4
199	29.445	0.148	0.018	2.24	83.8	0.78	101	9.9	-0.1	97	331	84	71.5
200	29.593	0.148	0.018	2.25	83.6	0.77	101	9.8	-0.1	97	337	84	72
201	29.741	0.148	0.018	2.25	83.5	0.71	101	9.8	-0.1	98	339	84	71.5
202	29.889	0.148	0.018	2.25	83.5	0.74	101	9.7	-0.1	98	341	84	71.2
203	30.037	0.148	0.019	2.24	83.5	0.8	98	9.7	-0.1	98	336	84	71.4
204	30.185	0.148	0.018	2.24	83.6	0.74	101	9.6	-0.1	98	336	84	71.8
205	30.333	0.148	0.018	2.25	83.9	0.8	101	9.5	-0.1	98	334	84	71.5
206	30.481	0.148	0.018	2.25	83.8	0.76	101	9.5	-0.1	98	329	84	71.6
207	30.629	0.148	0.018	2.23	84	0.79	101	9.4	-0.1	97	329	84	71.9
208	30.776	0.147	0.018	2.25	83.9	0.79	100	9.4	-0.1	97	331	84	72.2
209	30.924	0.148	0.018	2.25	84.1	0.75	101	9.3	-0.1	98	336	84	72.2
210	31.072	0.148	0.018	2.25	84.1	0.74	101	9.2	-0.1	99	338	84	72
211	31.220	0.148	0.018	2.24	84.1	0.79	101	9.2	-0.1	99	341	84	72
212	31.368	0.148	0.019	2.25	84.1	0.79	98	9.1	-0.1	98	336	84	72.1
213	31.516	0.148	0.019	2.25	84.1	0.79	98	9.0	-0.1	97	336	84	71
214	31.664	0.148	0.019	2.25	83.9	0.76	98	9.0	0.0	96	332	84	70.9
215	31.812	0.148	0.018	2.26	83.6	0.79	100	8.9	-0.1	94	327	84	69.8
216	31.960	0.148	0.019	2.26	83.2	0.73	98	8.9	-0.1	93	326	83	69.8
217	32.108	0.148	0.019	2.26	83.3	0.75	98	8.8	-0.1	93	326	83	69.8
218	32.256	0.148	0.018	2.26	83.3	0.79	100	8.7	-0.1	93	324	83	69.5
219	32.404	0.148	0.018	2.25	83.3	0.77	100	8.7	-0.1	95	324	83	69.7
220	32.552	0.148	0.019	2.25	83.6	0.72	98	8.6	-0.1	95	324	84	70.2
221	32.700	0.148	0.018	2.24	83.6	0.73	100	8.5	-0.1	96	324	84	70
222	32.848	0.148	0.018	2.24	83.8	0.76	100	8.5	0.0	96	325	84	70.4
223	32.996	0.148	0.018	2.24	83.9	0.81	100	8.4	-0.1	97	329	84	70.7
224	33.144	0.148	0.018	2.24	84	0.74	101	8.4	-0.1	97	333	84	70.5
225	33.292	0.148	0.019	2.25	84.1	0.75	98	8.3	-0.1	97	333	84	70.7
226	33.440	0.148	0.018	2.25	84.1	0.77	100	8.3	-0.1	97	330	84	70.9
227	33.588	0.148	0.019	2.24	84.1	0.76	98	8.2	-0.1	98	332	84	71
228	33.736	0.148	0.018	2.25	84.1	0.81	101	8.1	-0.1	97	334	84	70.9
229	33.884	0.148	0.018	2.24	84	0.73	100	8.0	-0.1	97	324	84	71.2
230	34.032	0.148	0.018	2.24	84.1	0.72	100	8.0	-0.1	97	326	84	71.6

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
231	34.180	0.148	0.018	2.24	84	0.76	100	7.9	-0.1	97	324	84	71.8
232	34.328	0.148	0.018	2.25	84.1	0.73	100	7.9	-0.1	97	324	84	71.8
233	34.476	0.148	0.018	2.24	84.1	0.79	101	7.8	-0.1	97	331	84	71.9
234	34.624	0.148	0.019	2.24	83.9	0.81	98	7.7	-0.1	97	332	84	71.6
235	34.772	0.148	0.018	2.25	83.6	0.74	101	7.7	-0.1	96	329	84	71.8
236	34.919	0.147	0.019	2.25	83.3	0.79	97	7.6	-0.1	96	323	83	71.6
237	35.067	0.148	0.018	2.25	83.3	0.78	101	7.6	-0.1	96	326	83	71.8
238	35.215	0.148	0.019	2.25	83.2	0.79	98	7.5	-0.1	96	323	83	71.8
239	35.363	0.148	0.019	2.24	83.2	0.79	98	7.4	-0.1	95	322	83	72.2
240	35.511	0.148	0.019	2.24	83.3	0.79	98	7.4	-0.1	96	326	83	71.9
241	35.659	0.148	0.018	2.25	83.4	0.75	101	7.3	0.0	96	327	83	72.1
242	35.807	0.148	0.018	2.25	83.5	0.75	101	7.3	-0.1	96	327	84	72
243	35.955	0.148	0.018	2.24	83.7	0.75	101	7.2	-0.1	97	329	84	72.3
244	36.103	0.148	0.018	2.24	83.8	0.82	101	7.1	-0.1	97	327	84	72.4
245	36.251	0.148	0.018	2.24	83.8	0.81	101	7.1	-0.1	97	328	84	72.4
246	36.399	0.148	0.019	2.25	83.9	0.74	98	7.0	-0.1	97	325	84	72.1
247	36.547	0.148	0.018	2.25	84	0.74	100	7.0	-0.1	97	323	84	72.3
248	36.695	0.148	0.018	2.25	84	0.81	100	6.9	-0.1	97	324	84	72.3
249	36.843	0.148	0.018	2.24	84	0.78	101	6.8	-0.1	97	331	84	72.4
250	36.991	0.148	0.018	2.25	84.1	0.75	101	6.8	-0.1	97	332	84	72.4
251	37.139	0.148	0.019	2.24	84.1	0.78	98	6.7	-0.1	97	323	84	72.4
252	37.287	0.148	0.019	2.25	83.9	0.74	98	6.6	-0.1	97	327	84	72.2
253	37.435	0.148	0.018	2.25	83.7	0.77	100	6.6	0.0	96	324	84	72.1
254	37.583	0.148	0.018	2.25	83.6	0.8	100	6.5	-0.1	96	325	84	72.1
255	37.731	0.148	0.018	2.25	83.4	0.76	101	6.5	-0.1	96	327	83	72.2
256	37.879	0.148	0.018	2.25	83.4	0.76	101	6.4	-0.1	96	329	83	72.4
257	38.027	0.148	0.019	2.25	83.3	0.76	98	6.4	-0.1	96	332	83	72.4
258	38.175	0.148	0.018	2.24	83.2	0.76	101	6.3	-0.1	96	328	83	72.4
259	38.323	0.148	0.019	2.24	83.3	0.81	98	6.2	-0.1	96	329	83	72.5
260	38.471	0.148	0.019	2.25	83.6	0.78	98	6.2	-0.1	96	333	84	72.9
261	38.619	0.148	0.019	2.25	83.8	0.75	98	6.1	-0.1	97	335	84	73
262	38.767	0.148	0.019	2.25	83.8	0.74	98	6.0	-0.1	97	330	84	72.4
263	38.915	0.148	0.019	2.24	84	0.8	98	6.0	-0.1	97	330	84	72.9

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
264	39.062	0.147	0.018	2.24	84	0.76	100	5.9	-0.1	97	332	84	72.9
265	39.210	0.148	0.018	2.25	84.1	0.76	101	5.9	-0.1	97	332	84	72.8
266	39.358	0.148	0.018	2.24	84.1	0.8	101	5.8	-0.1	97	331	84	72.9
267	39.506	0.148	0.018	2.24	84.1	0.82	101	5.7	-0.1	97	333	84	72.9
268	39.654	0.148	0.018	2.25	84.2	0.79	101	5.7	-0.1	97	332	84	72.5
269	39.802	0.148	0.018	2.26	84.2	0.81	101	5.6	-0.1	98	330	84	72.6
270	39.950	0.148	0.018	2.25	84.3	0.74	101	5.5	-0.1	98	337	84	72.7
271	40.098	0.148	0.018	2.26	83.9	0.78	101	5.5	-0.1	97	335	84	72.6
272	40.246	0.148	0.019	2.25	83.7	0.8	98	5.4	-0.1	97	331	84	72.4
273	40.394	0.148	0.019	2.25	83.4	0.79	98	5.3	-0.1	97	332	83	72.3
274	40.542	0.148	0.019	2.25	83.4	0.77	98	5.3	-0.1	96	326	83	72.2
275	40.690	0.148	0.018	2.22	83.3	0.81	101	5.2	-0.1	96	326	83	71.9
276	40.838	0.148	0.019	2.22	83.3	0.81	98	5.2	-0.1	96	327	83	72.5
277	40.986	0.148	0.018	2.25	83.3	0.8	101	5.1	-0.1	96	330	83	72.2
278	41.134	0.148	0.019	2.23	83.4	0.8	98	5.0	-0.1	97	329	83	72.5
279	41.282	0.148	0.018	2.25	83.5	0.75	101	5.0	-0.1	96	321	84	72.5
280	41.430	0.148	0.018	2.26	83.8	0.77	101	4.9	-0.1	97	325	84	72.3
281	41.578	0.148	0.018	2.25	83.9	0.78	101	4.8	-0.1	97	329	84	72.2
282	41.726	0.148	0.018	2.25	84	0.77	101	4.8	-0.1	98	332	84	72.3
283	41.874	0.148	0.018	2.25	84.1	0.75	100	4.7	-0.1	97	323	84	72.6
284	42.022	0.148	0.018	2.25	84	0.82	100	4.7	-0.1	96	315	84	72.7
285	42.170	0.148	0.019	2.24	84	0.77	98	4.6	-0.1	96	318	84	73.1
286	42.318	0.148	0.018	2.24	84.2	0.81	100	4.6	-0.1	97	326	84	72.9
287	42.466	0.148	0.018	2.25	84.2	0.78	100	4.5	-0.1	96	324	84	72.6
288	42.614	0.148	0.018	2.25	84.2	0.75	100	4.4	-0.1	96	315	84	72.5
289	42.762	0.148	0.019	2.26	84	0.78	98	4.4	-0.1	95	316	84	72.4
290	42.910	0.148	0.018	2.25	83.7	0.81	100	4.3	-0.1	95	321	84	72
291	43.057	0.147	0.018	2.25	83.6	0.82	100	4.3	-0.1	95	322	84	72
292	43.205	0.148	0.018	2.24	83.5	0.81	100	4.2	-0.1	95	323	84	72.1
293	43.353	0.148	0.018	2.25	83.3	0.75	101	4.1	-0.1	96	326	83	71.8
294	43.501	0.148	0.019	2.25	83.2	0.8	98	4.1	0.0	96	329	83	71.9
295	43.649	0.148	0.019	2.24	83.2	0.82	98	4.0	-0.1	96	325	83	71.9
296	43.797	0.148	0.018	2.24	83.4	0.76	100	4.0	-0.1	95	324	83	72.1

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
297	43.945	0.148	0.019	2.24	83.6	0.79	98	3.9	-0.1	96	323	84	72
298	44.093	0.148	0.019	2.25	83.8	0.78	98	3.8	-0.1	96	322	84	72
299	44.241	0.148	0.018	2.25	83.8	0.79	100	3.8	-0.1	96	318	84	72.2
300	44.389	0.148	0.018	2.25	84	0.79	100	3.7	-0.1	96	318	84	72.1
301	44.537	0.148	0.018	2.24	84.1	0.82	100	3.7	-0.1	96	322	84	71.8
302	44.685	0.148	0.018	2.25	84.1	0.8	100	3.6	-0.1	96	324	84	71.9
303	44.833	0.148	0.018	2.25	84.2	0.84	100	3.5	-0.1	96	324	84	72.2
304	44.981	0.148	0.019	2.25	84.3	0.8	98	3.5	-0.1	97	326	84	72.4
305	45.129	0.148	0.018	2.24	84.3	0.82	100	3.4	0.0	97	332	84	72.2
306	45.277	0.148	0.018	2.25	84.4	0.76	100	3.4	-0.1	97	328	84	72.1
307	45.425	0.148	0.019	2.24	84.2	0.81	98	3.3	-0.1	97	325	84	72.7
308	45.573	0.148	0.018	2.25	83.9	0.8	100	3.2	-0.1	96	323	84	72.1
309	45.721	0.148	0.018	2.25	83.8	0.81	100	3.2	0.0	96	329	84	72
310	45.869	0.148	0.019	2.24	83.5	0.82	98	3.1	-0.1	96	328	84	71.9
311	46.017	0.148	0.018	2.25	83.3	0.81	101	3.0	-0.1	96	327	83	71.9
312	46.165	0.148	0.018	2.24	83.2	0.82	100	3.0	-0.1	95	320	83	71.7
313	46.313	0.148	0.018	2.25	83.2	0.8	100	2.9	-0.1	95	322	83	71.9
314	46.461	0.148	0.019	2.25	83.2	0.83	98	2.8	-0.1	95	324	83	72.1
315	46.609	0.148	0.018	2.25	83.4	0.79	100	2.8	-0.1	95	319	83	71.9
316	46.757	0.148	0.018	2.26	83.6	0.77	100	2.7	-0.1	95	318	84	70.9
317	46.905	0.148	0.019	2.26	83.6	0.76	98	2.6	-0.1	95	314	84	71.2
318	47.053	0.148	0.018	2.26	83.7	0.74	100	2.6	-0.1	95	322	84	70.9
319	47.200	0.147	0.018	2.24	83.9	0.78	100	2.5	-0.1	96	324	84	71.7
320	47.348	0.148	0.019	2.25	84.1	0.76	98	2.5	-0.1	96	332	84	71.7
321	47.496	0.148	0.019	2.25	84.2	0.77	98	2.4	-0.1	97	328	84	71.5
322	47.644	0.148	0.018	2.25	84.2	0.82	100	2.3	-0.1	96	322	84	71.9
323	47.792	0.148	0.018	2.25	84.3	0.76	100	2.3	-0.1	96	320	84	72.2
324	47.940	0.148	0.018	2.25	84.2	0.76	100	2.2	-0.1	96	322	84	72.5
325	48.088	0.148	0.018	2.24	84.3	0.8	100	2.2	0.0	96	322	84	72.2
326	48.236	0.148	0.019	2.25	84.1	0.76	98	2.1	-0.1	95	316	84	72
327	48.384	0.148	0.018	2.25	83.8	0.75	100	2.0	-0.1	95	315	84	71.6
328	48.532	0.148	0.018	2.24	83.7	0.82	100	2.0	-0.1	95	311	84	71.7
329	48.680	0.148	0.018	2.24	83.4	0.81	100	1.9	-0.1	94	318	83	71.9

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
330	48.828	0.148	0.018	2.24	83.3	0.84	100	1.9	-0.1	95	321	83	71.9
331	48.976	0.148	0.019	2.24	83.3	0.81	98	1.8	-0.1	94	314	83	71.3
332	49.124	0.148	0.019	2.25	83.2	0.78	98	1.7	0.0	93	313	83	70.4
333	49.272	0.148	0.018	2.25	83.2	0.78	100	1.7	-0.1	93	316	83	70.3
334	49.420	0.148	0.018	2.26	83.5	0.82	100	1.6	-0.1	94	317	84	70.6
335	49.568	0.148	0.019	2.24	83.6	0.82	98	1.6	-0.1	95	321	84	71.5
336	49.716	0.148	0.019	2.24	84	0.75	98	1.5	-0.1	95	322	84	71.5
337	49.864	0.148	0.018	2.24	84.1	0.82	100	1.4	-0.1	96	318	84	71.5
338	50.012	0.148	0.018	2.23	84.3	0.78	100	1.4	-0.1	96	318	84	71.4
339	50.160	0.148	0.019	2.24	84.2	0.79	98	1.3	0.0	95	319	84	71.8
340	50.308	0.148	0.018	2.23	84.3	0.81	100	1.3	-0.1	95	317	84	71.6
341	50.456	0.148	0.018	2.23	84.2	0.76	100	1.2	-0.1	95	320	84	71.8
342	50.604	0.148	0.018	2.22	84.3	0.78	100	1.1	-0.1	96	320	84	72
343	50.752	0.148	0.018	2.25	84.2	0.78	100	1.1	-0.1	95	318	84	72.3
344	50.900	0.148	0.018	2.24	84.1	0.83	100	1.0	-0.1	95	324	84	72.1
345	51.048	0.148	0.018	2.24	83.9	0.8	100	0.9	-0.1	95	323	84	71.6
346	51.196	0.148	0.018	2.24	83.7	0.83	100	0.9	-0.1	95	320	84	71.6
347	51.343	0.147	0.018	2.23	83.6	0.83	100	0.8	-0.1	95	320	84	71.5
348	51.491	0.148	0.018	2.23	83.4	0.77	100	0.7	-0.1	95	323	83	72.2
349	51.639	0.148	0.018	2.24	83.3	0.75	100	0.7	-0.1	95	324	83	71.8
350	51.787	0.148	0.019	2.24	83.3	0.82	98	0.6	-0.1	94	314	83	71.7
351	51.935	0.148	0.018	2.25	83.5	0.75	100	0.5	-0.1	95	319	84	71.8
352	52.083	0.148	0.018	2.24	83.6	0.78	100	0.5	0.0	95	327	84	71.7
353	52.231	0.148	0.018	2.23	83.7	0.8	100	0.4	-0.1	96	330	84	71.8
354	52.379	0.148	0.018	2.24	83.8	0.76	100	0.4	-0.1	96	328	84	71.9
355	52.527	0.148	0.018	2.24	84	0.83	100	0.3	-0.1	96	324	84	72.6
356	52.675	0.148	0.018	2.23	84	0.81	100	0.3	-0.1	96	328	84	72.2
357	52.823	0.148	0.018	2.24	84	0.79	100	0.2	-0.1	96	326	84	72.1
358	52.971	0.148	0.018	2.24	84	0.78	100	0.1	-0.1	96	327	84	71.8
359	53.119	0.148	0.018	2.23	84.1	0.82	100	0.1	-0.1	96	329	84	72
360	53.267	0.148	0.018	2.23	84.2	0.8	100	0.0	-0.1	97	333	84	72.2

BOX A TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Fuel Weight (lb)		Temperature Data (°F)			
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Dilution Tunnel dP (in H_2O)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Scale Reading	Weight Change	Dilution Tunnel	Flue	Filter	Ambient
Avg/Tot	53.267	0.148	0.018	2.21	84	0.76	100			96	329	84	71

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
0	0.000		1.64	85.7	1.36		86	-0.060	4.18	0.06
1	0.148	0.148	2.09	85	1.33	98	85	-0.050	4.40	0.06
2	0.296	0.148	2.09	85.3	1.49	98	85	-0.060	4.68	0.03
3	0.444	0.148	2.09	85.4	1.66	100	85	-0.060	4.54	0.04
4	0.593	0.149	2.08	85.3	1.61	101	85	-0.060	4.22	0.06
5	0.741	0.148	2.09	85.3	1.37	101	85	-0.060	3.90	0.07
6	0.889	0.148	2.09	85.3	1.56	98	85	-0.060	4.13	0.05
7	1.037	0.148	2.10	85.3	1.47	100	85	-0.060	3.91	0.06
8	1.185	0.148	2.10	85.3	1.3	101	85	-0.060	4.05	0.08
9	1.333	0.148	2.09	85.1	1.59	101	85	-0.060	4.16	0.07
10	1.481	0.148	2.10	85	1.68	101	85	-0.060	3.97	0.08
11	1.629	0.148	2.10	85.1	1.62	100	85	-0.060	4.23	0.06
12	1.778	0.149	2.10	85	1.42	101	85	-0.060	3.98	0.07
13	1.926	0.148	2.09	85	1.49	100	85	-0.060	4.15	0.09
14	2.074	0.148	2.10	85.1	1.69	98	85	-0.060	4.29	0.06
15	2.222	0.148	2.11	85.1	1.72	100	85	-0.060	4.13	0.06
16	2.370	0.148	2.10	85.4	1.7	100	85	-0.060	3.84	0.10
17	2.518	0.148	2.11	85.5	1.59	100	86	-0.060	4.17	0.07
18	2.666	0.148	2.10	85.5	1.4	100	86	-0.060	4.85	0.04
19	2.814	0.148	2.11	85.6	1.64	100	86	-0.060	4.15	0.07
20	2.963	0.149	2.11	85.6	1.72	101	86	-0.060	4.00	0.07
21	3.111	0.148	2.12	85.6	1.68	101	86	-0.060	4.07	0.04
22	3.259	0.148	2.11	85.8	1.35	100	86	-0.060	3.73	0.05
23	3.407	0.148	2.12	85.7	1.7	100	86	-0.060	4.36	0.05
24	3.555	0.148	2.11	85.7	1.53	100	86	-0.060	4.23	0.05
25	3.703	0.148	2.11	85.8	1.34	98	86	-0.060	4.64	0.04
26	3.851	0.148	2.12	85.6	1.36	100	86	-0.060	4.26	0.05
27	4.000	0.149	2.12	85.7	1.54	101	86	-0.060	3.82	0.07
28	4.148	0.148	2.12	85.6	1.49	98	86	-0.060	3.81	0.06
29	4.296	0.148	2.11	85.4	1.51	98	85	-0.060	3.86	0.07
30	4.444	0.148	2.11	85.3	1.54	100	85	-0.060	3.95	0.08
31	4.592	0.148	2.12	85.1	1.48	100	85	-0.060	4.22	0.05

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
32	4.740	0.148	2.12	85.2	1.66	100	85	-0.060	3.93	0.06
33	4.888	0.148	2.13	85	1.4	100	85	-0.060	3.76	0.11
34	5.036	0.148	2.12	85.2	1.41	100	85	-0.060	3.96	0.08
35	5.185	0.149	2.12	85.3	1.57	101	85	-0.050	3.99	0.07
36	5.333	0.148	2.12	85.4	1.59	100	85	-0.050	4.15	0.07
37	5.481	0.148	2.12	85.5	1.5	100	86	-0.060	4.09	0.08
38	5.629	0.148	2.13	85.7	1.71	100	86	-0.060	4.17	0.07
39	5.777	0.148	2.12	85.6	1.46	100	86	-0.060	3.85	0.07
40	5.925	0.148	2.13	85.6	1.68	100	86	-0.060	4.08	0.06
41	6.073	0.148	2.13	85.6	1.55	100	86	-0.060	3.00	0.11
42	6.221	0.148	2.13	85.5	1.54	101	86	-0.060	3.80	0.06
43	6.370	0.149	2.13	85.6	1.49	101	86	-0.060	4.02	0.05
44	6.518	0.148	2.13	85.5	1.38	98	86	-0.060	3.73	0.07
45	6.666	0.148	2.13	85.4	1.67	100	85	-0.050	3.96	0.05
46	6.814	0.148	2.13	85.5	1.67	100	86	-0.060	4.24	0.06
47	6.962	0.148	2.13	85.4	1.61	100	85	-0.060	4.00	0.07
48	7.110	0.148	2.14	85.3	1.47	100	85	-0.060	4.67	0.05
49	7.258	0.148	2.13	85.3	1.37	100	85	-0.060	4.70	0.04
50	7.407	0.149	2.14	85.3	1.43	101	85	-0.060	4.29	0.05
51	7.555	0.148	2.14	85.3	1.36	103	85	-0.060	3.90	0.07
52	7.703	0.148	2.14	85.2	1.54	100	85	-0.060	4.36	0.03
53	7.851	0.148	2.14	85.1	1.71	100	85	-0.050	4.52	0.03
54	7.999	0.148	2.13	85.2	1.37	100	85	-0.060	4.05	0.07
55	8.147	0.148	2.14	85.2	1.56	100	85	-0.060	4.14	0.05
56	8.295	0.148	2.14	85.1	1.37	100	85	-0.060	4.44	0.04
57	8.443	0.148	2.14	85.1	1.37	101	85	-0.060	3.80	0.08
58	8.592	0.149	2.14	85.1	1.37	101	85	-0.060	4.00	0.07
59	8.740	0.148	2.14	85.3	1.36	101	85	-0.060	3.76	0.06
60	8.888	0.148	2.14	85.2	1.44	101	85	-0.060	3.92	0.06
61	9.036	0.148	2.14	85.1	1.48	101	85	-0.050	3.89	0.06
62	9.184	0.148	2.14	85.1	1.39	101	85	-0.060	3.86	0.06
63	9.332	0.148	2.14	85.2	1.36	101	85	-0.060	3.76	0.06

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
64	9.480	0.148	2.15	85	1.49	101	85	-0.060	3.63	0.08
65	9.628	0.148	2.14	85.1	1.5	101	85	-0.060	4.21	0.06
66	9.777	0.149	2.14	85.1	1.73	101	85	-0.060	3.83	0.07
67	9.925	0.148	2.14	85	1.53	101	85	-0.060	4.20	0.06
68	10.073	0.148	2.15	85	1.41	100	85	-0.060	3.87	0.07
69	10.221	0.148	2.15	85	1.53	100	85	-0.060	4.46	0.04
70	10.369	0.148	2.15	85	1.39	100	85	-0.050	4.34	0.04
71	10.517	0.148	2.15	85.1	1.76	100	85	-0.050	4.60	0.04
72	10.665	0.148	2.15	85.2	1.65	100	85	-0.060	4.57	0.04
73	10.814	0.149	2.15	85.4	1.55	101	85	-0.060	4.53	0.03
74	10.962	0.148	2.14	85.4	1.72	100	85	-0.060	3.67	0.09
75	11.110	0.148	2.15	85.5	1.73	100	86	-0.060	4.07	0.07
76	11.258	0.148	2.15	85.6	1.57	100	86	-0.060	3.86	0.10
77	11.406	0.148	2.15	85.6	1.51	101	86	-0.060	4.22	0.07
78	11.554	0.148	2.15	85.6	1.49	101	86	-0.060	4.17	0.07
79	11.702	0.148	2.15	85.6	1.71	101	86	-0.060	4.17	0.05
80	11.850	0.148	2.14	85.6	1.66	101	86	-0.060	4.18	0.07
81	11.999	0.149	2.15	85.5	1.38	101	86	-0.060	4.13	0.07
82	12.147	0.148	2.15	85.5	1.44	101	86	-0.060	4.30	0.04
83	12.295	0.148	2.15	85.5	1.66	101	86	-0.060	4.61	0.05
84	12.443	0.148	2.15	85.6	1.48	98	86	-0.060	4.53	0.05
85	12.591	0.148	2.15	85.5	1.71	101	86	-0.060	4.11	0.07
86	12.739	0.148	2.15	85.5	1.68	101	86	-0.060	4.00	0.06
87	12.887	0.148	2.15	85.4	1.52	101	85	-0.060	4.07	0.08
88	13.035	0.148	2.15	85.2	1.7	98	85	-0.060	4.49	0.04
89	13.184	0.149	2.15	85.2	1.45	101	85	-0.060	4.00	0.07
90	13.332	0.148	2.15	85.2	1.66	101	85	-0.060	3.81	0.05
91	13.480	0.148	2.15	85.3	1.43	98	85	-0.060	4.14	0.06
92	13.628	0.148	2.15	85.3	1.44	101	85	-0.060	3.60	0.08
93	13.776	0.148	2.15	85.4	1.57	101	85	-0.060	4.23	0.04
94	13.924	0.148	2.15	85.4	1.7	101	85	-0.060	4.07	0.06
95	14.072	0.148	2.15	85.6	1.45	101	86	-0.060	3.80	0.06

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
96	14.221	0.149	2.15	85.6	1.53	101	86	-0.060	3.73	0.08
97	14.369	0.148	2.15	85.6	1.43	101	86	-0.060	3.57	0.07
98	14.517	0.148	2.15	85.6	1.73	101	86	-0.060	3.26	0.09
99	14.665	0.148	2.15	85.6	1.46	101	86	-0.060	4.07	0.08
100	14.813	0.148	2.15	85.7	1.65	101	86	-0.060	3.66	0.08
101	14.961	0.148	2.15	85.7	1.47	100	86	-0.060	4.07	0.07
102	15.109	0.148	2.14	85.6	1.54	101	86	-0.060	3.95	0.06
103	15.257	0.148	2.14	85.7	1.72	101	86	-0.060	4.00	0.09
104	15.406	0.149	2.15	85.7	1.67	101	86	-0.060	4.31	0.07
105	15.554	0.148	2.15	85.4	1.63	98	85	-0.060	4.28	0.06
106	15.702	0.148	2.15	85.4	1.42	101	85	-0.060	4.11	0.06
107	15.850	0.148	2.15	85.4	1.44	100	85	-0.060	3.90	0.06
108	15.998	0.148	2.16	85.3	1.7	100	85	-0.060	4.33	0.05
109	16.146	0.148	2.16	85.2	1.7	98	85	-0.060	4.51	0.03
110	16.294	0.148	2.16	85.3	1.59	101	85	-0.060	4.20	0.05
111	16.442	0.148	2.15	85.4	1.7	100	85	-0.060	4.41	0.04
112	16.591	0.149	2.15	85.5	1.69	98	86	-0.060	4.55	0.03
113	16.739	0.148	2.15	85.6	1.66	100	86	-0.060	4.32	0.04
114	16.887	0.148	2.15	85.7	1.44	100	86	-0.060	4.25	0.03
115	17.035	0.148	2.16	85.7	1.71	101	86	-0.060	3.88	0.06
116	17.183	0.148	2.15	85.8	1.66	100	86	-0.060	4.33	0.03
117	17.331	0.148	2.16	85.8	1.54	101	86	-0.060	4.05	0.05
118	17.479	0.148	2.15	85.8	1.49	101	86	-0.060	3.85	0.07
119	17.628	0.149	2.15	85.9	1.43	101	86	-0.060	3.03	0.10
120	17.776	0.148	2.15	85.9	1.46	101	86	-0.060	4.04	0.07
121	17.924	0.148	2.16	85.8	1.69	101	86	-0.060	4.36	0.04
122	18.072	0.148	2.15	85.7	1.49	101	86	-0.060	4.53	0.03
123	18.220	0.148	2.15	85.6	1.73	101	86	-0.060	4.78	0.03
124	18.368	0.148	2.15	85.4	1.55	100	85	-0.060	3.94	0.06
125	18.516	0.148	2.15	85.4	1.72	98	85	-0.060	3.82	0.05
126	18.664	0.148	2.15	85.4	1.46	101	85	-0.060	4.02	0.05
127	18.813	0.149	2.15	85.4	1.66	101	85	-0.060	4.00	0.04

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
128	18.961	0.148	2.15	85.3	1.57	101	85	-0.060	3.97	0.04
129	19.109	0.148	2.15	85.4	1.65	101	85	-0.060	4.01	0.06
130	19.257	0.148	2.15	85.5	1.43	100	86	-0.060	4.08	0.05
131	19.405	0.148	2.15	85.6	1.45	100	86	-0.060	4.39	0.04
132	19.553	0.148	2.15	85.7	1.71	100	86	-0.060	3.73	0.06
133	19.701	0.148	2.15	85.6	1.51	100	86	-0.060	4.10	0.06
134	19.849	0.148	2.16	85.7	1.71	100	86	-0.060	3.49	0.07
135	19.998	0.149	2.15	85.8	1.69	101	86	-0.060	3.42	0.09
136	20.146	0.148	2.15	85.7	1.71	101	86	-0.060	3.73	0.06
137	20.294	0.148	2.15	85.9	1.7	101	86	-0.060	3.66	0.08
138	20.442	0.148	2.15	85.8	1.45	101	86	-0.060	3.43	0.07
139	20.590	0.148	2.15	85.8	1.71	98	86	-0.060	4.07	0.04
140	20.738	0.148	2.15	85.8	1.45	100	86	-0.060	3.96	0.06
141	20.886	0.148	2.15	85.7	1.43	100	86	-0.060	4.15	0.05
142	21.035	0.149	2.15	85.7	1.46	101	86	-0.060	3.95	0.04
143	21.183	0.148	2.15	85.4	1.46	100	85	-0.060	4.90	0.02
144	21.331	0.148	2.15	85.4	1.45	100	85	-0.060	4.10	0.05
145	21.479	0.148	2.15	85.3	1.47	101	85	-0.060	3.71	0.08
146	21.627	0.148	2.15	85.4	1.48	101	85	-0.060	3.58	0.06
147	21.775	0.148	2.14	85.3	1.55	101	85	-0.060	4.38	0.04
148	21.923	0.148	2.14	85.4	1.71	101	85	-0.060	4.39	0.03
149	22.071	0.148	2.14	85.7	1.45	100	86	-0.060	4.43	0.02
150	22.220	0.149	2.15	85.7	1.71	101	86	-0.060	3.66	0.06
151	22.368	0.148	2.15	85.6	1.48	100	86	-0.060	3.81	0.04
152	22.516	0.148	2.15	85.6	1.59	100	86	-0.060	3.83	0.04
153	22.664	0.148	2.15	85.6	1.71	100	86	-0.060	3.86	0.05
154	22.812	0.148	2.15	85.5	1.48	100	86	-0.060	3.84	0.05
155	22.960	0.148	2.15	85.5	1.5	100	86	-0.060	4.30	0.05
156	23.108	0.148	2.15	85.6	1.66	100	86	-0.060	3.85	0.06
157	23.256	0.148	2.15	85.7	1.62	100	86	-0.060	4.07	0.06
158	23.405	0.149	2.15	85.8	1.54	101	86	-0.060	4.15	0.04
159	23.553	0.148	2.15	85.9	1.63	100	86	-0.060	4.34	0.04

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
160	23.701	0.148	2.15	85.7	1.46	100	86	-0.060	4.40	0.03
161	23.849	0.148	2.15	85.5	1.46	100	86	-0.060	4.35	0.03
162	23.997	0.148	2.15	85.4	1.7	100	85	-0.060	4.29	0.04
163	24.145	0.148	2.15	85.5	1.46	100	86	-0.060	3.88	0.05
164	24.293	0.148	2.14	85.5	1.46	100	86	-0.060	3.67	0.09
165	24.442	0.149	2.15	85.5	1.72	101	86	-0.060	4.11	0.07
166	24.590	0.148	2.15	85.6	1.69	100	86	-0.060	4.47	0.03
167	24.738	0.148	2.15	85.7	1.48	100	86	-0.060	4.29	0.05
168	24.886	0.148	2.15	85.8	1.67	100	86	-0.060	4.24	0.03
169	25.034	0.148	2.15	85.8	1.7	100	86	-0.060	4.24	0.04
170	25.182	0.148	2.15	85.8	1.75	100	86	-0.060	4.65	0.03
171	25.330	0.148	2.15	85.9	1.68	100	86	-0.060	4.63	0.02
172	25.478	0.148	2.14	86	1.56	100	86	-0.060	4.09	0.03
173	25.627	0.149	2.14	85.9	1.45	101	86	-0.060	4.54	0.03
174	25.775	0.148	2.15	85.9	1.59	100	86	-0.060	5.22	0.02
175	25.923	0.148	2.15	85.9	1.45	100	86	-0.060	4.35	0.04
176	26.071	0.148	2.14	85.9	1.42	100	86	-0.060	4.24	0.04
177	26.219	0.148	2.15	86	1.5	100	86	-0.060	4.22	0.04
178	26.367	0.148	2.14	85.8	1.74	101	86	-0.060	3.85	0.04
179	26.515	0.148	2.13	85.7	1.62	100	86	-0.060	4.25	0.03
180	26.664	0.149	2.14	85.6	1.62	101	86	-0.060	4.02	0.05
181	26.812	0.148	2.14	85.5	1.61	100	86	-0.060	3.80	0.08
182	26.960	0.148	2.14	85.5	1.45	100	86	-0.060	4.12	0.05
183	27.108	0.148	2.14	85.4	1.55	100	85	-0.060	4.44	0.04
184	27.256	0.148	2.14	85.5	1.43	100	86	-0.060	3.89	0.07
185	27.404	0.148	2.14	85.6	1.66	100	86	-0.060	4.31	0.04
186	27.552	0.148	2.14	85.6	1.72	98	86	-0.060	4.50	0.03
187	27.700	0.148	2.14	85.7	1.56	100	86	-0.060	4.49	0.03
188	27.849	0.149	2.14	85.7	1.54	101	86	-0.060	4.23	0.03
189	27.997	0.148	2.14	85.8	1.74	101	86	-0.060	3.72	0.04
190	28.145	0.148	2.14	85.9	1.76	98	86	-0.060	4.21	0.03
191	28.293	0.148	2.14	86	1.47	98	86	-0.060	4.10	0.04

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
192	28.441	0.148	2.14	86	1.74	100	86	-0.060	4.14	0.03
193	28.589	0.148	2.14	85.9	1.46	100	86	-0.060	4.36	0.02
194	28.737	0.148	2.13	85.9	1.61	98	86	-0.060	4.57	0.03
195	28.885	0.148	2.13	85.8	1.66	100	86	-0.060	4.45	0.04
196	29.034	0.149	2.14	85.6	1.72	101	86	-0.060	4.29	0.05
197	29.182	0.148	2.14	85.5	1.49	101	86	-0.060	4.49	0.03
198	29.330	0.148	2.14	85.5	1.48	98	86	-0.060	4.46	0.04
199	29.478	0.148	2.14	85.5	1.68	101	86	-0.060	4.13	0.08
200	29.626	0.148	2.14	85.3	1.71	101	85	-0.060	3.96	0.06
201	29.774	0.148	2.14	85.4	1.45	101	85	-0.060	3.99	0.04
202	29.922	0.148	2.14	85.5	1.43	101	86	-0.060	3.56	0.07
203	30.071	0.149	2.13	85.4	1.69	99	85	-0.060	3.81	0.05
204	30.219	0.148	2.13	85.7	1.7	101	86	-0.060	4.01	0.03
205	30.367	0.148	2.14	85.8	1.43	101	86	-0.060	3.62	0.04
206	30.515	0.148	2.14	85.9	1.45	100	86	-0.060	3.97	0.04
207	30.663	0.148	2.14	85.9	1.46	100	86	-0.060	4.21	0.04
208	30.811	0.148	2.14	85.9	1.47	100	86	-0.060	4.17	0.03
209	30.959	0.148	2.14	85.9	1.54	101	86	-0.060	3.94	0.05
210	31.107	0.148	2.13	85.9	1.52	101	86	-0.060	3.77	0.05
211	31.256	0.149	2.13	86	1.65	101	86	-0.060	3.96	0.06
212	31.404	0.148	2.13	86.1	1.61	98	86	-0.060	4.13	0.06
213	31.552	0.148	2.14	86.2	1.77	98	86	-0.060	4.36	0.03
214	31.700	0.148	2.13	85.9	1.76	98	86	-0.060	4.00	0.04
215	31.848	0.148	2.13	85.5	1.77	100	86	-0.060	3.99	0.05
216	31.996	0.148	2.14	85.3	1.55	98	85	-0.060	3.90	0.04
217	32.144	0.148	2.13	85.1	1.46	98	85	-0.060	3.78	0.05
218	32.292	0.148	2.14	85	1.76	100	85	-0.060	4.00	0.04
219	32.441	0.149	2.13	85.1	1.47	101	85	-0.060	4.64	0.02
220	32.589	0.148	2.12	85.3	1.44	98	85	-0.060	4.23	0.04
221	32.737	0.148	2.13	85.5	1.54	100	86	-0.060	4.16	0.03
222	32.885	0.148	2.13	85.6	1.43	100	86	-0.060	4.03	0.05
223	33.033	0.148	2.13	85.6	1.6	100	86	-0.060	3.95	0.05

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
224	33.181	0.148	2.13	85.7	1.51	100	86	-0.060	3.90	0.05
225	33.329	0.148	2.13	85.9	1.46	98	86	-0.060	3.92	0.04
226	33.478	0.149	2.12	85.9	1.49	101	86	-0.060	3.97	0.04
227	33.626	0.148	2.14	85.8	1.64	98	86	-0.060	3.76	0.05
228	33.774	0.148	2.13	85.8	1.76	100	86	-0.060	3.97	0.04
229	33.922	0.148	2.13	85.8	1.45	100	86	-0.060	4.47	0.04
230	34.070	0.148	2.12	85.8	1.45	100	86	-0.060	3.94	0.06
231	34.218	0.148	2.12	85.8	1.45	100	86	-0.060	4.29	0.04
232	34.366	0.148	2.12	85.8	1.5	100	86	-0.060	4.38	0.04
233	34.514	0.148	2.12	85.8	1.55	100	86	-0.060	4.12	0.03
234	34.663	0.149	2.12	85.7	1.52	98	86	-0.060	4.23	0.06
235	34.811	0.148	2.12	85.6	1.68	100	86	-0.060	4.03	0.04
236	34.959	0.148	2.13	85.5	1.45	98	86	-0.060	4.04	0.05
237	35.107	0.148	2.12	85.4	1.68	100	85	-0.060	4.02	0.04
238	35.255	0.148	2.12	85.4	1.63	98	85	-0.060	4.31	0.06
239	35.403	0.148	2.12	85.3	1.49	98	85	-0.060	4.08	0.08
240	35.551	0.148	2.12	85.4	1.79	98	85	-0.060	3.90	0.06
241	35.699	0.148	2.12	85.5	1.5	100	86	-0.060	3.85	0.04
242	35.848	0.149	2.12	85.6	1.61	101	86	-0.060	3.86	0.05
243	35.996	0.148	2.12	85.6	1.76	100	86	-0.060	3.70	0.05
244	36.144	0.148	2.12	85.7	1.46	100	86	-0.060	3.93	0.03
245	36.292	0.148	2.12	85.8	1.46	100	86	-0.060	3.62	0.07
246	36.440	0.148	2.11	85.7	1.52	98	86	-0.060	3.65	0.06
247	36.588	0.148	2.12	85.7	1.52	100	86	-0.060	4.05	0.04
248	36.736	0.148	2.12	85.7	1.5	100	86	-0.060	4.23	0.03
249	36.885	0.149	2.11	85.7	1.51	101	86	-0.060	4.28	0.04
250	37.033	0.148	2.12	85.8	1.62	100	86	-0.060	3.67	0.05
251	37.181	0.148	2.12	85.7	1.75	98	86	-0.060	4.44	0.02
252	37.329	0.148	2.11	85.7	1.79	98	86	-0.060	4.23	0.03
253	37.477	0.148	2.11	85.5	1.73	100	86	-0.060	4.10	0.05
254	37.625	0.148	2.12	85.4	1.53	100	85	-0.060	3.92	0.07
255	37.773	0.148	2.12	85.4	1.44	100	85	-0.060	3.99	0.06

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
256	37.921	0.148	2.11	85.4	1.53	100	85	-0.060	3.69	0.08
257	38.070	0.149	2.12	85.4	1.72	98	85	-0.060	4.15	0.03
258	38.218	0.148	2.12	85.3	1.67	100	85	-0.060	3.89	0.06
259	38.366	0.148	2.12	85.4	1.55	98	85	-0.060	4.30	0.05
260	38.514	0.148	2.11	85.5	1.48	98	86	-0.060	4.09	0.05
261	38.662	0.148	2.11	85.8	1.67	98	86	-0.060	4.01	0.06
262	38.810	0.148	2.11	85.8	1.74	98	86	-0.060	4.11	0.04
263	38.958	0.148	2.11	85.7	1.69	98	86	-0.060	4.07	0.07
264	39.106	0.148	2.11	85.8	1.59	100	86	-0.060	3.82	0.07
265	39.255	0.149	2.11	85.9	1.45	101	86	-0.060	3.71	0.06
266	39.403	0.148	2.11	85.9	1.47	100	86	-0.060	4.16	0.07
267	39.551	0.148	2.11	85.9	1.5	100	86	-0.060	4.39	0.04
268	39.699	0.148	2.11	85.8	1.53	100	86	-0.060	3.89	0.07
269	39.847	0.148	2.11	86	1.46	100	86	-0.060	3.94	0.07
270	39.995	0.148	2.11	85.8	1.66	100	86	-0.060	4.28	0.04
271	40.143	0.148	2.11	85.8	1.45	100	86	-0.060	3.88	0.04
272	40.292	0.149	2.11	85.6	1.45	98	86	-0.060	3.74	0.03
273	40.440	0.148	2.10	85.5	1.78	98	86	-0.060	3.78	0.04
274	40.588	0.148	2.11	85.5	1.69	98	86	-0.060	3.97	0.04
275	40.736	0.148	2.10	85.4	1.74	100	85	-0.060	3.90	0.05
276	40.884	0.148	2.10	85.3	1.51	98	85	-0.060	4.01	0.06
277	41.032	0.148	2.10	85.4	1.46	100	85	-0.060	4.24	0.03
278	41.180	0.148	2.10	85.6	1.66	98	86	-0.060	3.86	0.05
279	41.328	0.148	2.11	85.6	1.59	100	86	-0.060	4.54	0.02
280	41.477	0.149	2.11	85.6	1.81	101	86	-0.060	4.20	0.03
281	41.625	0.148	2.11	85.7	1.54	100	86	-0.060	4.12	0.03
282	41.773	0.148	2.11	85.7	1.47	101	86	-0.060	3.35	0.08
283	41.921	0.148	2.11	85.8	1.79	100	86	-0.060	4.16	0.04
284	42.069	0.148	2.10	85.8	1.63	100	86	-0.060	4.25	0.02
285	42.217	0.148	2.11	85.9	1.8	98	86	-0.060	4.16	0.03
286	42.365	0.148	2.10	85.9	1.48	100	86	-0.060	4.11	0.03
287	42.513	0.148	2.10	85.8	1.52	100	86	-0.060	3.93	0.05

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
288	42.662	0.149	2.10	85.8	1.73	101	86	-0.050	4.39	0.03
289	42.810	0.148	2.10	85.8	1.8	98	86	-0.060	4.34	0.02
290	42.958	0.148	2.10	85.6	1.83	100	86	-0.060	4.35	0.02
291	43.106	0.148	2.10	85.4	1.48	100	85	-0.060	3.87	0.05
292	43.254	0.148	2.10	85.5	1.61	100	86	-0.060	3.83	0.05
293	43.402	0.148	2.10	85.5	1.8	100	86	-0.060	3.38	0.08
294	43.550	0.148	2.10	85.4	1.57	98	85	-0.060	3.59	0.06
295	43.699	0.149	2.10	85.5	1.49	98	86	-0.060	3.60	0.07
296	43.847	0.148	2.10	85.6	1.47	100	86	-0.060	4.21	0.06
297	43.995	0.148	2.10	85.6	1.57	98	86	-0.060	4.01	0.04
298	44.143	0.148	2.10	85.6	1.47	98	86	-0.060	3.99	0.05
299	44.291	0.148	2.09	85.7	1.49	100	86	-0.060	4.23	0.03
300	44.439	0.148	2.10	85.7	1.79	100	86	-0.060	4.67	0.03
301	44.587	0.148	2.10	85.8	1.53	100	86	-0.060	4.29	0.05
302	44.735	0.148	2.09	85.8	1.79	100	86	-0.060	3.75	0.04
303	44.884	0.149	2.10	85.8	1.76	101	86	-0.060	4.04	0.05
304	45.032	0.148	2.10	85.9	1.51	98	86	-0.060	3.74	0.06
305	45.180	0.148	2.09	85.9	1.48	100	86	-0.060	4.09	0.03
306	45.328	0.148	2.09	85.9	1.5	100	86	-0.060	3.47	0.08
307	45.476	0.148	2.09	85.9	1.8	98	86	-0.060	4.22	0.07
308	45.624	0.148	2.09	85.7	1.53	100	86	-0.060	4.31	0.06
309	45.772	0.148	2.09	85.6	1.69	100	86	-0.060	4.49	0.03
310	45.920	0.148	2.09	85.6	1.66	98	86	-0.060	4.06	0.05
311	46.069	0.149	2.10	85.5	1.63	101	86	-0.060	4.54	0.03
312	46.217	0.148	2.09	85.4	1.48	100	85	-0.060	4.37	0.03
313	46.365	0.148	2.10	85.4	1.49	100	85	-0.060	4.30	0.03
314	46.513	0.148	2.09	85.4	1.47	98	85	-0.060	4.42	0.02
315	46.661	0.148	2.09	85.6	1.69	100	86	-0.060	4.47	0.03
316	46.809	0.148	2.09	85.6	1.65	100	86	-0.060	4.79	0.02
317	46.957	0.148	2.09	85.6	1.7	98	86	-0.060	4.48	0.02
318	47.106	0.149	2.09	85.7	1.84	101	86	-0.060	3.80	0.05
319	47.254	0.148	2.09	85.7	1.77	100	86	-0.060	4.08	0.03

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
320	47.402	0.148	2.09	85.8	1.78	98	86	-0.060	3.48	0.06
321	47.550	0.148	2.09	85.9	1.74	98	86	-0.060	3.74	0.06
322	47.698	0.148	2.09	85.9	1.79	100	86	-0.060	4.22	0.05
323	47.846	0.148	2.09	85.9	1.48	100	86	-0.060	3.94	0.06
324	47.994	0.148	2.08	85.9	1.46	100	86	-0.060	3.80	0.05
325	48.142	0.148	2.09	85.9	1.71	100	86	-0.060	3.30	0.07
326	48.291	0.149	2.08	85.7	1.5	98	86	-0.060	4.76	0.03
327	48.439	0.148	2.08	85.6	1.52	100	86	-0.060	4.06	0.04
328	48.587	0.148	2.08	85.4	1.73	100	85	-0.060	4.19	0.03
329	48.735	0.148	2.09	85.4	1.79	100	85	-0.060	4.69	0.02
330	48.883	0.148	2.08	85.5	1.5	100	86	-0.060	3.95	0.05
331	49.031	0.148	2.09	85.4	1.52	98	85	-0.060	4.04	0.04
332	49.179	0.148	2.09	85.5	1.68	97	86	-0.060	4.11	0.03
333	49.327	0.148	2.08	85.3	1.61	100	85	-0.060	4.47	0.03
334	49.476	0.149	2.08	85.5	1.78	101	86	-0.060	3.83	0.04
335	49.624	0.148	2.09	85.5	1.59	98	86	-0.060	4.18	0.04
336	49.772	0.148	2.08	85.8	1.78	98	86	-0.060	3.89	0.06
337	49.920	0.148	2.08	85.9	1.66	100	86	-0.060	4.19	0.03
338	50.068	0.148	2.08	85.9	1.52	100	86	-0.060	3.82	0.06
339	50.216	0.148	2.08	85.9	1.71	98	86	-0.060	4.45	0.03
340	50.364	0.148	2.08	85.8	1.7	100	86	-0.060	4.52	0.03
341	50.513	0.149	2.08	85.7	1.66	101	86	-0.060	4.30	0.04
342	50.661	0.148	2.08	85.8	1.76	100	86	-0.060	4.25	0.04
343	50.809	0.148	2.08	85.8	1.53	100	86	-0.060	4.20	0.04
344	50.957	0.148	2.07	85.8	1.72	100	86	-0.060	4.07	0.07
345	51.105	0.148	2.08	85.7	1.81	100	86	-0.060	4.43	0.03
346	51.253	0.148	2.07	85.7	1.51	100	86	-0.060	3.36	0.06
347	51.401	0.148	2.08	85.4	1.51	100	85	-0.060	4.77	0.02
348	51.549	0.148	2.08	85.4	1.49	100	85	-0.060	4.23	0.04
349	51.698	0.149	2.08	85.5	1.81	101	86	-0.060	4.16	0.03
350	51.846	0.148	2.07	85.5	1.8	98	86	-0.060	4.51	0.02
351	51.994	0.148	2.08	85.5	1.55	100	86	-0.060	4.39	0.03

BOX B TEST DATA - ASTM E2779 / ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

	Particulate Sampling Data							Flue Gas Data		
Elapsed Time (min)	Gas Meter (ft^3)	Sample Rate (cfm)	Orifice dH (in H_2O)	Meter Temp (°F)	Meter Vacuum (in Hg)	Pro. Rate (%)	Filter (°F)	Flue Draft (in H_2O)	CO_2 (%)	CO (%)
352	52.142	0.148	2.07	85.6	1.65	100	86	-0.060	3.75	0.06
353	52.290	0.148	2.08	85.8	1.5	100	86	-0.060	3.74	0.05
354	52.438	0.148	2.07	85.8	1.83	100	86	-0.060	3.80	0.06
355	52.586	0.148	2.07	85.9	1.63	100	86	-0.060	4.16	0.04
356	52.734	0.148	2.07	85.8	1.66	100	86	-0.060	4.32	0.03
357	52.883	0.149	2.07	85.8	1.8	101	86	-0.060	4.33	0.03
358	53.031	0.148	2.07	85.9	1.7	100	86	-0.060	4.18	0.03
359	53.179	0.148	2.07	85.8	1.58	100	86	-0.060	4.01	0.04
360	53.327	0.148	2.07	85.9	1.66	100	86	-0.060	4.03	0.04
Avg/Tot	53.327	0.148	2.12	86	1.58	100			4.09	0.05

LAB SAMPLE DATA - ASTM E2515

Client: Liberator Rocket Heaters
Model: RMH-2
Run #: 1

Job #: 19-483
Tracking #: 116
Technician: AK
Date: 11/4/2021

		Sample ID	Tare, mg	Total, mg	Final, mg	Catch, mg
Filters	**A**	H0050	191.8		192.2	0.4
	B	H0051	182.3		183.1	0.8
	C	H0052	178.4		179.3	0.9
	Amb	H0053	180.9		181.0	0.1
Probes	**A**	13A	117317.3		117317.3	0.0
	B	13B	116944.0		116944.2	0.2
	C	14A	116634.6		116634.6	0.0
O-rings	**A**	13A	3359.7		3359.7	0.0
	B	13B	3445.0		3445.1	0.1
	C	14A	3367.3		3367.4	0.1

Placed in Dessicator on:	11/4/2021

Filters	**A**	192.2	11/8 10:30	192.2	11/10 9:00				
	B	182.9	11/8 10:30	183.1	11/10 9:00				
	C	179.1	11/8 10:30	179.3	11/10 9:00				
	Amb	181.0	11/8 10:30	181.0	11/10 9:00				
Probes	**A**	117317.3	11/8 10:49	117317.3	11/10 9:13				
	B	116944.1	11/8 10:51	116944.2	11/10 9:13				
	C	116634.6	11/8 10:49	116634.6	11/10 9:13				
O-Rings	**A**	3359.7	11/8 10:47	3359.7	11/10 9:14				
	B	3444.9	11/8 10:47	3445.1	11/10 9:14	3445.1	11/11 10:00		
	C	3367.2	11/8 10:47	3367.4	11/10 9:14				

Train A Sub-total, mg	0.4
Train C Sub-Total, mg:	1.0
Train 1 Aggregate, mg:	**1.4**
Train 2 Aggregate, mg:	**1.1**
Ambient Aggregate, mg:	0.1

Equations and Sample Calculations – ASTM E2779 & E2515

Client	Liberator Rocket Heaters
Model:	RMH-2
Tracking #:	116
Run:	1

Equations used to calculate the parameters listed below are described in this appendix. Sample calculations are provided for each equation. The raw data and printout results from a sample run are also provided for comparison to the sample calculations.

M_{Bdb} – Weight of test fuel burned during test run, dry basis, kg

M_{BSidb} – Weight of test fuel burned during test run segment *i* , dry basis, kg

BR – Average dry burn rate over full integrated test run, kg/hr

BR_{Si} – Average dry burn rate over test run segment *i* , kg/hr

V_s – Average gas velocity in the dilution tunnel, ft/sec

Q_{sd} – Average gas flow rate in dilution tunnel, dscf/hr

$V_{m(std)}$ – Volume of Gas Sampled Corrected to Dry Standard Conditions, dscf

m_n – Total Particulate Matter Collected, mg

C_s - Concentration of particulate matter in tunnel gas, dry basis, corrected to STP, g/dscf

E_T – Total Particulate Emissions, g

PR - Proportional Rate Variation

PM_R – Average particulate emissions for full integrated test run, g/hr

PM_F – Average particulate emission factor for full integrated test run, g/dry kg of fuel burned

M_{Bdb} – Weight of test fuel burned during test run, dry basis, kg
ASTM E2779 equation (1)

$$M_{Bdb} = (M_{Swb} - M_{Ewb})(100/(100 + FM))$$

Where,

FM = average fuel moisture of test fuel, % dry basis
M_{Swb} = weight of test fuel in hopper at start of test run, wet basis, kg
M_{Ewb} = weight of test fuel in hopper at end of test run, wet basis, kg

Sample Calculation:

FM = 6.63 %
M_{Swb} = 22.4 lbs
M_{Ewb} = 0.0 lbs
0.4536 = Conversion factor from lbs to kg

M_{Bdb} = [(22.4 x 0.4536) - (0.0 x 0.4536)] (100/(100 + 6.63)

M_{Bdb} = **9.54** kg

M_{BSidb} – Weight of test fuel burned during test run segment *i* , dry basis, kg
ASTM E2779 equation (2)

$$M_{BSidb} = (MS_{Siwb} - M_{ESiwb})(100/(100 + FM))$$

Where,

M_{SSiwb} = weight of test fuel in hopper at start of test run segment *i* , wet basis, kg

M_{ESiwb} = weight of test fuel in hopper at end of test run segment *i* , wet basis, kg

Sample Calculation (from medium burn rate segment):

FM = 6.63 %

M_{SSiwb} = 18.6 lbs

M_{ESiwb} = 0.0 lbs

0.4536 = Conversion factor from lbs to kg

M_{BSidb} = [(18.6 x 0.4536) - (0.0 x 0.4536)] (100/(100 + 7)

M_{BSidb} = **7.9** kg

BR – Average dry burn rate over full integrated test run, kg/hr
ASTM E2779 equation (3)

$$BR = \frac{60\ M_{Bdb}}{\theta}$$

Where,

θ = Total length of full integrated test run, min

Sample Calculation:

M_{Bdb} = 9.54 kg
θ = 360 min

$$BR = \frac{60 \times 9.54}{360}$$

BR = **1.59** kg/hr

BR_{Si} – Average dry burn rate over test run segment *i* , kg/hr
ASTM E2779 equation (4)

$$BR_{Si} = \frac{60\ M_{BSidb}}{\theta_{Si}}$$

Where,

θ_{Si} = Total length of test run segment *i* , min

Sample Calculation (from medium burn rate segment):

M_{BSidb} = 7.90 kg
θ = #VALUE! min

$$BR = \frac{60 \text{ x } 7.9}{\text{#VALUE!}}$$

BR = **#VALUE!** kg/hr

V_s – Average gas velocity in the dilution tunnel, ft/sec
ASTM E2515 equations (9)

$$V_s = F_p \times K_p \times C_P \times \left(\sqrt{\Delta P}\right)_{avg} \times \sqrt{\frac{T_s}{P_s \times M_s}}$$

Where:

F_p = Adjustment factor for center of tunnel pitot tube placement, Fp = $\frac{V_{strav}}{V_{scent}}$, ASTM E2515 Equation (1)

v_{scent} = Dilution tunnel velocity calculated after the multi-point pitot traverse at the center, ft/sec

v_{strav} = Dilution tunnel velocity calculated after the multi-point pitot traverse, ft/sec

k_p = Pitot tube constant, 85.49

C_p = Pitot tube coefficient: 0.99, unitless

ΔP* = Velocity pressure in the dilution tunnel, in H_2O

T_s = Absolute average gas temperature in the dilution tunnel, °R; (°R = °F + 460)

P_s = Absolute average gas static pressure in dilution tunnel, = $P_{bar} + P_g$, in Hg

P_{bar} = Barometric pressure at test site, in. Hg

P_g = Static pressure of tunnel, in. H_20; (in Hg = in H_20/13.6)

M_s = **The dilution tunnel wet molecular weight; M_s = 28.78 assuming a dry weight of 29 lb/lb-mole

Sample calculation:

$$Fp = \frac{6.67}{9.35} = 0.714$$

$$V_s = 0.714 \times 85.49 \times 0.99 \times 0.135 \times \left(\frac{96.5 + 460}{(30.04 + \frac{-0.05}{13.6}) \times 28.78} \right)^{1/2}$$

V_s = **6.54** ft/s

*The ASTM test standard mistakenly has the square root of the average delta p instead of the average of the square root of delta p. The current EPA Method 2 is also incorrect. This was verified by Mike Toney at EPA.

**The ASTM test standard mistakenly identifies Ms as the dry molecular weight. It should be the wet molecular weight as indicated in EPA Method 2.

Q_{sd} – Average gas flow rate in dilution tunnel, dscf/hr
ASTM E2515 equation (3)

$$Q_{sd} = 3600 \times (1 - B_{ws}) \times v_s \times A \times \frac{T_{std}}{T_s} \times \frac{P_s}{P_{std}}$$

Where:

3600	=	Conversion from seconds to hours (ASTM method uses 60 to convert in minutes)
B_{ws}	=	Water vapor in gas stream, proportion by volume; assume 2%
A	=	Cross sectional area of dilution tunnel, ft^2
T_{std}	=	Standard absolute temperature, 528 °R
P_s	=	Absolute average gas static pressure in dilution tunnel, = P_{bar} + P_g , in Hg
T_s	=	Absolute average gas temperature in the dilution tunnel, °R; (°R = °F + 460)
P_{std}	=	Standard absolute pressure, 29.92 in Hg

Sample calculation:

$$Q_{sd} = 3600 \times (1 - 0.02) \times 6.54 \times 0.7854 \times \frac{528}{96.5 + 460} \times \frac{30.04 + \frac{-0.05}{13.6}}{29.92}$$

Q_{sd} = **17247.3** dscf/hr

$V_{m(std)}$ – Volume of Gas Sampled Corrected to Dry Standard Conditions, dscf

ASTM E2515 equation (6)

$$V_{m(std)} = K_1 \times V_m \times Y \times \frac{P_{bar} + \left(\frac{\Delta H}{13.6}\right)}{T_m}$$

Where:

K_1	=	17.64 °R/in. Hg
V_m	=	Volume of gas sample measured at the dry gas meter, dcf
Y	=	Dry gas meter calibration factor, dimensionless
P_{bar}	=	Barometric pressure at the testing site, in. Hg
ΔH	=	Average pressure differential across the orifice meter, in. H_2O
T_m	=	Absolute average dry gas meter temperature, °R

Sample Calculation:

Using equation for Train A:

$$V_{m(std)} = 17.64 \times 53.267 \times 0.999 \times \frac{\left(30.04 + \frac{2.21}{13.6}\right)}{(83.6 + 460)}$$

$V_{m(std)}$ = **52.150** dscf

Using equation for Train B:

$$V_{m(std)} = 17.64 \times 53.327 \times 0.996 \times \frac{\left(30.04 + \frac{2.12}{13.6}\right)}{(85.6 + 460)}$$

$V_{m(std)}$ = **51.848** dscf

Using equation for ambient train:

$$V_{m(std)} = 17.64 \times 58.94 \times 0.992 \times \frac{\left(30.04 + \frac{0.00}{13.6}\right)}{(71.4 + 460)}$$

$V_{m(std)}$ = **58.287** dscf

m_n – Total Particulate Matter Collected, mg
ASTM E2515 Equation (12)

$$m_n = m_p + m_f + m_g$$

Where:

m_p = mass of particulate matter from probe, mg

m_f = mass of particulate matter from filters, mg

m_g = mass of particulate matter from filter seals, mg

Sample Calculation:

Using equation for Train A (first hour):

m_n = 0.0 + 0.0 + 0.0

m_n = 0.0 mg

Using equation for Train A (remainder):

m_n = 0.2 + 0.1 + 0.0

m_n = 0.3 mg

Train A Aggregate = **0.3** mg

Using equation for Train B:

m_n = + + 0.0

m_n = ##### mg

C_s - Concentration of particulate matter in tunnel gas, dry basis, corrected to standard conditions, g/dscf
ASTM E2515 equation (13)

$$C_s = K_2 \times \frac{m_n}{V_{m(std)}}$$

Where:

K_2	=	Constant, 0.001 g/mg
m_n	=	Total mass of particulate matter collected in the sampling train, mg
$V_{m(std)}$	=	Volume of gas sampled corrected to dry standard conditions, dscf

Sample calculation:

For Train A:

$$C_s = 0.001 \times \frac{0.3}{52.15}$$

C_s = **0.00001** g/dscf

For Train B:

$$C_s = 0.001 \times \frac{\#VALUE!}{51.85}$$

C_s = **#VALUE!** g/dscf

For Ambient Train

$$C_r = 0.001 \times \frac{1.1}{58.29}$$

C_r = **0.000019** g/dscf

E_T – Total Particulate Emissions, g
ASTM E2515 equation (15)

$$E_T = (c_s - c_r) \times Q_{std} \times \theta$$

Where:

C_s	=	Concentration of particulate matter in tunnel gas, g/dscf
C_r	=	Concentration particulate matter room air, g/dscf
Q_{std}	=	Average dilution tunnel gas flow rate, dscf/hr
θ	=	Total time of test run, minutes

Sample calculation:

For Train A

E_T = (0.000006 - 0.000019) x 17247.3 x 360 /60

E_T = -1.36 g

For Train B

E_T = (#VALUE! - 0.000019) x 17247.3 x 360 /60

E_T = #VALUE! g

Average

E = #VALUE! g

Total emission values shall not differ by more than 7.5% from the total average emissions

7.5% of the average =	#VALUE!
Train A difference =	#VALUE!
Train B difference =	#VALUE!

PR - Proportional Rate Variation

ASTM E2515 equation (16)

$$PR = \left[\frac{\theta \times V_{mi} \times V_s \times T_m \times T_{si}}{\theta_i \times V_m \times V_{si} \times T_{mi} \times T_s} \right] \times 100$$

Where:

θ = Total sampling time, min

θ_i = Length of recording interval, min

V_{mi} = Volume of gas sample measured by the dry gas meter during the “ith” time interval, dcf

V_m = Volume of gas sample as measured by dry gas meter, dcf

V_{si} = Average gas velocity in the dilution tunnel during the "ith" time interval, ft/sec

V_s = Average gas velocity in the dilution tunnel, ft/sec

T_{mi} = Absolute average dry gas meter temperature during the "ith" time interval, ^oR

T_m = Absolute average dry gas meter temperature, ^oR

T_{si} = Absolute average gas temperature in the dilution tunnel during the "ith" time interval, ^oR

T_s = Absolute average gas temperature in the dilution tunnel, ^oR

Sample calculation (for the first 1 minute interval of Train A):

$$PR = \left(\frac{360 \times 0.148 \times 6.54 \times (83.6 + 460) \times (96.7 + 460)}{1 \times 53.267 \times 6.68 \times (96.5 + 460) \times (83.4 + 460)} \right) \times 100$$

PR = 98 %

PM_R – Average particulate emissions for full integrated test run, g/hr
ASTM E2779 equation (5)

$$PM_R = 60 (E_T/\theta)$$

Where,

E_T = Total particulate emissions, grams

θ = Total length of full integrated test run, min

Sample Calculation:

E_T (Dual train average) = ##### g

θ = 360 min

PM_R = 60 x (##### / 360)

PM_R = ##### g/hr

PM_F – Average particulate emission factor for full integrated test run, g/dry kg of fuel burned
ASTM E2779 equation (6)

$$PM_F = E_T/M_{Bdb}$$

Where,

E_T = Total particulate emissions, grams

M_{Bdb} = Weight of test fuel burned during test run, dry basis, kg

Sample Calculation:

E_T (Dual train average) = ###### g

M_{Bdb} = 9.54 kg

PM_F = ###### / 9.54)

PM_F = ###### g/kg

Twin Ports Testing, Inc.
1301 North 3rd Street
Superior, WI 54880
p: 715-392-7114
p: 800-373-2562
f: 715-392-7163
www.twinportstesting.com

Analytical Test Report

Report No: USR:W221-0604-01
Issue No: 1

Client: PFS-TECO
11785 SE Hwy 212 Ste 305
Clackamas, OR 97015
Attention: Sebastian Button

PO No:

Signed: Katy Jahr
Katy Jahr
Chemistry Lab Supervisor
Date of Issue: 10/25/2021

Sample Details

Sample Log No:	W221-0604-01	**Sample Date:**	
Sample Designation:	Pellet Sample	**Sample Time:**	
Sample Recognized As:	Biomass	**Arrival Date:**	10/13/2021

Test Results

	METHOD	UNITS	MOISTURE FREE	AS RECEIVED
Moisture Total	ASTM E871	wt. %		6.21
Ash	ASTM D1102	wt. %	0.39	0.37
Volatile Matter	ASTM D3175	wt. %		
Fixed Carbon by Difference	ASTM D3172	wt. %		
Sulfur	ASTM D4239	wt. %	0.009	0.008
SO_2	Calculated	lb/mmbtu		0.020
Net Cal. Value at Const. Pressure	ISO 1928	GJ/tonne	18.32	17.03
Gross Cal. Value at Const. Vol.	ASTM E711	Btu/lb	8649	8112
Carbon	ASTM D5373	wt. %	47.74	44.78
Hydrogen*	ASTM D5373	wt. %	8.31	7.80
Nitrogen	ASTM D5373	wt. %	< 0.20	< 0.19
Oxygen*	ASTM D3176	wt. %	> 43.34	> 40.65
*Note: As received values do not include hydrogen and oxygen in the total moisture.				
Chlorine	ASTM D6721	mg/kg		
Fluorine	ASTM D3761	mg/kg		
Mercury	ASTM D6722	mg/kg		
Bulk Density	ASTM E873	lbs/ft^3		
Fines (Less than 1/8")	TPT CH-P-06	wt.%		
Durability Index	Kansas State	PDI		
Sample Above 1.50"	TPT CH-P-06	wt.%		
Maximum Length (Single Pellet)	TPT CH-P-06	inch		
Diameter, Range	TPT CH-P-05	inch		to
Diameter, Average	TPT CH-P-05	inch		
Stated Bag Weight	TPT CH-P-01	lbs		
Actual Bag Weight	TPT CH-P-01	lbs		

Comments:

Accreditation #60243

ASTM E2515 - PTFE Filter Pairs

Sample	Weight 1	Weight 2	Weigth 3	Weight 4	Initial	Project	Run
H0038	184.3	184.5	-	-	A	21-720	#1
H0039	185.81	185.0	-	-	A	↓	↓
H0040	185.2	185.0	-	-	A		
H0041	187.1	186.9	-	-	A		
H0042	193.3	193.1	-	-	A	21-720	#2
H0043	192.5	192.4	-	-	A	↓	↓
H0044	186.8	186.7	-	-	A	↓	↓
H0045	188.3	188.3	-	-	A	↓	↓
H0046	187.5	187.6	-	-	A	21-720	#3
H0047	188.4	188.2	-	-	A	↓	↓
H0048	192.5	192.4	-	-	A	↓	↓
H0049	192.6	192.7	-	-	A	↓	↓
H0050	191.6	191.8	-	-	A	19-483	#1
H0051	182.5	182.3	-	-	A	↓	↓
H0052	178.2	178.4	-	-	A	↓	↓
H0053	180.7	180.9	-	-	A	↓	↓
H0054	181.6	181.5	-	-	A	21-733	#1
H0055	192.9	192.0	-	-	A	↓	↓

Weight 1 Date/Time:
9/11/21 21:38
Weight 2 Date/Time:
9/13/21 0730
Weight 3 Date/Time:
Weight 4 Date/Time:

Sample	Weight 1	Weight 2	Weigth 3	Weight 4	Initial	Project	Run
H0056	191.5	191.4	-	-	SB	21-733	#1
H0057	180.7	180.8	-	-	SB	↓	↓
H0058	181.3	181.2	-	-	SB	↓	↓
H0059	188.3	188.2	-	-	SB	21-733	#2
H0060	191.7	191.9	-	-	SB	↓	↓
H0061	181.0	181.2	-	-	SB	↓	↓
H0062	191.9	191.9	-	-	SB	↓	↓
H0063	184.5	184.6	-	-	SB	21-733	#3
H0064	187.1	187.0	-	-	SB	↓	↓
H0065	184.7	184.5	-	-	SB	↓	↓
H0066	184.6	184.7	-	-	SB	↓	↓
H0067	172.0	172.0	-	-	SB	21-733	#4
H0068	190.6	190.6	-	-	SB	↓	↓
H0069	189.6	189.8	-	-	SB	↓	↓
H0070	190.8	190.7	-	-	SB	↓	↓
H0071	178.9	178.8	-	-	SB	21-733	#5
H0072	185.8	185.9	-	-	SB	↓	↓
H0073	189.9	189.0	-	-	SB	↓	↓

Weight 1 Date/Time:
11/10 - 15:00
Weight 2 Date/Time:
11/11 - 11:00
Weight 3 Date/Time:
Weight 4 Date/Time:

ASTM E2515 - ~~Probe~~ O-Rings Samples 11-20

Date:	10/27	11/1	11/2				
Time:	14:30	8:30	7:20				
	Weight 1	Weight 2	Weigth 3	Weight 4	Initial	Project	Run
11A	3424.8	3424.3	3424.3	–	SB	21-683	A2-3-DF
11B	4234.9	4234.6	4234.6	–	SB		
11C	–	–	–	–	–		
12A	3404.2	3403.9	3403.9	–	SB	21-683	A1-3-DF
12B	3396.7	3396.3	3396.2	–	SB		
12C	–	–	–	–	–		
13A	3360.0	3359.7	3359.7	–	SB	19-483	#1
13B	3445.3	3445.1	3445.0	–	SB		
13C	–	–	–	–	–		
14A	3367.6	3367.1	3367.3	–	SB	19-483	#1
14B	3342.4	3342.2	3342.2	–	SB	21-733	#1
14C	–	–	–	–	–		
15A	3570.8	3570.4	3570.4	–	SB	21-733	#1
15B	3571.4	3571.1	3571.3	–	SB		
15C	–	–	–	–	–		

Date:	11/10	11/11	11/12				
Time:	15:00	11:00	9:00				
	Weight 1	Weight 2	Weigth 3	Weight 4	Initial	Project	Run
16A	3572.6	3572.8	–	–	SB	21-733	#2
16B	3638.5	3638.4	–	–	SB		
16C	–	–	–	–	SB		
17A	3612.8	3612.9	–	–	SB	21-733	#2
17B	3569.6	3569.7	–	–	SB	21-733	#3
17C	–	–	–	–	SB		
18A	3397.8	3397.8	–	–	SB	21-733	#3
18B	3369.0	3369.1	–	–	SB		
18C	–	–	–	–	SB		
19A	3366.9	3367.5	3367.5	–	SB	21-733	#4
19B	3440.3	3440.3	–	–	SB		
19C	–	–	–	–	SB		
20A	3394.0	3393.9	–	–	SB	21-733	#4
20B	3427.5	3427.6	–	–	SB		
20C	–	–	–	–	SB		

ASTM E2515 - ~~O-Ring~~ Probe Samples 11-20

	Date:	10/27	11/1					
	Time:	14:30	8:30					
		Weight 1	Weight 2	Weigth 3	Weight 4	Initial	Project	Run
11A		116868.1	116868.0	–	–	SB	21-683	A2-3-DF
11B		117340.3	117340.2	–	–	SB		
11C		–	–	–	–	–		
12A		116707.8	116707.9	–	–	SB	21-683	A1-3-DF
12B		117774.2	117774.1	–	–	SB		
12C		–	–	–		–		
13A		117317.2	117317.3	–	–	SB	19-483	#1
13B		116944.1	116944.0	–	–	SB		
13C		–	–	–	–	SB		
14A		116634.6	116634.6	–	–	SB	19-483	#1
14B		116619.4	116619.3	–	–	SB	21-737	#1
14C		–	–	–	–	–		
15A		117241.1	117241.3	–	–	SB	21-733	#1
15B		116753.2	116753.0	–	–	SB		
15C		–	–	–	–	SB		

	Date:	11/10	11/11	11/12				
	Time:	15:00	11:00	9:00				
		Weight 1	Weight 2	Weigth 3	Weight 4	Initial	Project	Run
16A		116380.8	116380.7	–	–	SB	21-733	#2
16B		115863.5	115863.5	–	–	SB		
16C		–	–	–	–	SB		
17A		116809.2	116809.4	–	–	SB	21-733	#2
17B		117139.1	117139.1	–	–	SB	21-733	#3
17C		–	–	–	–	SB		
18A		117496.9	117497.0	–	–	SB	21-733	#3
18B		117329.5	117329.7	–	–	SB		
18C		–	–	–	–	SB		
19A		117024.7	117024.8	–	–	SB	21-733	#4
19B		117010.3	117010.4	–	–	SB		
19C		–	–	–	–	SB		
20A		115625.1	115624.8	115624.9	–	SB	21-73	#4
20B		115964.4	115964.5	–	–	SB		
20C		–	–	–	–	SB		

Certificate of Calibration

Certificate Number: **743897**

JJ Calibrations, Inc.
7724 SE Aspen Summit Drive
Portland, OR 97266-9217
Phone 503.786.3005
FAX 503.786.2994

PFS TECO
11785 SE Hwy 212
Suite 305
Clackamas, OR 97015

ACCREDITED
0723.01
Calibration

PO: **1033**
Order Date: **03/08/2021**
Authorized By: **N/A**

Property #: **064**
User: **N/A**
Department: **N/A**
Make: **Control Company**
Model: **4198**
Serial #: **80531676**
Description: **Digital Temp. / Barometer**
Procedure: **404323**
Accuracy: **±1°C ±0.2362Hg(±8mb)**

Calibrated on: **03/18/2021**
*Recommended Due: **03/18/2022**
Environment: **22** °C **37** % RH
* As Received: **Within Tolerance**
* As Returned: **Within Tolerance**
Action Taken: **Calibrated w/Parts**
Technician: **146**

Remarks: * Many factors may cause the unit to drift out of calibration before the recommended due date. Any reported error is the absolute value between the reference and the unit. Uncertainties include the effects of the unit.

Replaced batteries.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
644A	Thunder Scientific	1200	Two Pressure Humidity Generator	11/17/2021	734190
847A	Fluke	RPM4	Reference Pressure Monitor	12/30/2021	738139

Measurement Data

Parameter / Measurement Description	Range Unit	Reference	Min	Max	*Error	UUT	Uncertainty (Accredited = ü)
Before/After							
Temperature							
	℃	20.00	19.0	21.0	0.1	20.1 ℃	8.1E-02 ü
	℃	30.00	29.0	31.0	0.2	30.2 ℃	8.1E-02 ü
	℃	40.00	39.0	41.0	0.7	39.3 ℃	8.1E-02 ü
Barometer							
	mbar	1013.0	1005	1021	8	1005 mbar	6.2E-01 ü

This instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual and is traceable to either the SI or to National Institute of Standards and Technology (NIST). The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2017, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. Unless stated in the comments, certificates reflect the "Simple Acceptance Rule" as specified by JCGM 106:2012. Unless otherwise stated, a test accuracy ratio (TAR) of 4:1, if achievable, is maintained. The results reported herein apply only to the calibration of the item described above. This report may not be reproduced, except in full, without written approval of JJ Calibrations.

Reviewer

3 Issued 03/25/2021 Rev # 15

Inspector

Certificate of Calibration

Certificate Number: 743892

JJ Calibrations, Inc.
7724 SE Aspen Summit Drive
Portland, OR 97266-9217
Phone 503.786.3005
FAX 503.786.2994

PFS TECO
11785 SE Hwy 212
Suite 305
Clackamas, OR 97015

ACCREDITED
0723.01
Calibration

PO: 1033
Order Date: 03/08/2021
Authorized By: N/A

Property #: 097
User: N/A
Department: N/A
Make: Unknown
Model: 10 Lbs.
Serial #: 097
Description: Mass
Procedure: DCN 500901
Accuracy: Raw Data

Calibrated on: 03/18/2021
*Recommended Due: 03/18/2026
Environment: 19 °C 41 % RH
* As Received: Other - See Remarks
* As Returned: Other - See Remarks
Action Taken: Calibrated
Technician: 126

Remarks: * Many factors may cause the unit to drift out of calibration before the recommended due date. Any reported error is the absolute value between the reference and the unit. Uncertainties include the effects of the unit.

Data is provided for your determination of acceptability. Received/returned without accessories.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
484A	Rice Lake	1kg-10kg (Class ASTM 1)	Mass Set,	05/28/2021	699197
503A	Rice Lake	1mg-200g (Class 0)	Mass Set,	09/11/2021	729241
550A	And (A&D) Co.	HP-30K	Balance 30 Kg	12/31/2021	739307
723A	Rice Lake	1mg-200g (Class 0)	Mass Set,	06/09/2021	723431

Measurement Data

Parameter / Measurement Description	Range	Unit	Reference	Min	Max	*Error	UUT	Uncertainty
Before/After								Accredited = ü
Mass								
Raw Data		g	4535.92370000	0.0000000	0.0000000	0.1785299	4536.1022299 g	3.5E-01 ü

This instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual and is traceable to either the SI or to National Institute of Standards and Technology (NIST). The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2017, ISO 10012-1, the ISO 9000 family and QS 9000. The expanded uncertainties of measurements for this calibration are based upon 95% (2 sigma) confidence limits. Unless stated in the comments, certificates reflect the "Simple Acceptance Rule" as specified by JCGM 106:2012. Unless otherwise stated, a test accuracy ratio (TAR) of 4:1, if achievable, is maintained. The results reported herein apply only to the calibration of the item described above. This report may not be reproduced, except in full, without written approval of JJ Calibrations.

Reviewer

3 Issued 03/25/2021 Rev # 15

Inspector

DICK MUNNS COMPANY
LIQUID & GAS FLOW CALIBRATION

ISO 17025:2017
ACCREDITED LABORATORY
Cert# CL-122

IAS ACCREDITED
Calibration Laboratory

CERTIFICATE OF CALIBRATION

CUSTOMER:	**PFS-TECO :** CLACKAMAS, OR	**CALIBRATION DATE:**	05/25/2021
PO NUMBER:	1047	**CALIBRATION DUE:**	05/25/2022
INST. MANUFACTURER:	DWYER	**PROCEDURE:**	T.O.33K6-4-1769-1
INST. DESCRIPTION:	VELOMETER	**CALIBRATION FLUID:**	AIR @ 14.7 PSIA 70°F
MODEL NUMBER:	471	**RECEIVED CONDITION:**	WITHIN MFG. SPECS.
SERIAL NUMBER:	CP288559 (ID# 095)	**LEFT CONDITION:**	WITHIN MFG. SPECS.
RATED ACCURACY:	SEE NOTES BELOW.	**AMBIENT CONDITIONS:**	763mm HGA 49% RH 72°F
UNCERTAINTY GIVEN:	± 0.43% RD ; k=2	**CERTIFICATE FILE #:**	490265.2021

NOTES: ± 3% FS (0-500 / 0-1500) *** ± 4% F.S. (0-5000) ***± 5% F.S. (0-15000) *** ± 2 °F

Q.MANUAL IM 1.5 REV 2017.1 DATED 7-18-2017 ** DECISION RULE : NO PFA%**

UUT INDICATED FT/MIN	DM.STD. ACTUAL FT/MIN	UUT INDICATED DEG. F	DM STD. ACTUAL DEG. F
53	55	0 TO 200°F	0 TO 200°F
118	120	45.1	44.3
244	249	70.6	69.9
493	503	100.3	99.8
517	522		
1062	1076		
1494	1517		
560	565		
3129	3164		
4996	5082		
6251	6374		
14829	15148		

STANDARDS USED:		
A220: 12" WIND TUNNEL 0 - 8000 FPM | CMC ± 0.203% RD | TRACE# 1329407628	DUE	02/18/2022
A800: FLOW-DYNE SONIC NOZZLE SYSTEM | 0 – 1086 CFM ± 0.46% RD. | TRACE# 1329407628, 89576, 152043238	DUE	01/26/2022

All instruments used in the performance of the shown calibration have traceability to the National Institute of Standards and Technology (NIST). The uncertainty ratio between the calibration standards (DM.STD.) and the Unit Under Test (UUT) is a minimum of 4:1, unless otherwise noted. Calibration has been performed according to the shown procedure. The use of IAS/ILAC logo indicates calibrations are in accordance to ISO/IEC 17025:2017.

Dick Munns Company · 11133 Winners Circle, Los Alamitos, CA 90720
Phone: 714-827-1215 · www.dickmunns.com

Issuing Date: 05/25/2021 Approved By: Cristina Lima Cal. Technician: D. C.

Calibrated at: ✓ Lab
___ On-Site (Customer's)

Established 1974

QUALITY CONTROL SERVICES

LABORATORY EQUIPMENT • SALES • SERVICE • CALIBRATION • REPAIRS

2340 SE 11TH Ave. Portland, Oregon 97214 • Box 14831 Portland, Oregon 97293

(503) 236-2712 • FAX (503) 235-2535 • www.qc-services.com

ACCREDITED

Calibration Services

Certificate Number: 1550.01

Laboratory code: 115953

Report of Calibration

Firm: Dirigo Laboratories
Address: 11785 SE Hwy 212, Ste 305
City/State/Zip: Clackamas, OR 97015

Test Completed: 03/21/17
Submitted By: John Steiner
Traceable Number: 20170468

Test Item: 200mg and 100mg Individual Weights
Serial No.: Listed in Table

Manufacturer: Troemner

Material	Assumed Density	Range	Tolerance Class
Stainless Steel	7.95 g/cm^3	200mg & 100mg	ASTM Class 1

Method and Traceability
The procedure used for this calibration is NIST IR 6969 SOP 4 Double Substitution Weighing Design. Standards used for comparison are traceable to the National Institute of Standards and Technology (reports on file) and are part of a comprehensive measurement assurance program for ensuring continued accuracy and traceability within the level of uncertainty reported. The Traceable Number listed above is Traceable to National Standards through an unbroken chain of comparison each having stated uncertainties.

Standards Used:
100g to 1mg Working Standards Were Calibrated: 03/03/17 Due: 03/31/18 Standards ID: 723318
Mass Comparators Used: MET-05 **Tested by:** D. Thompson

Conventional Mass: "The conventional value of the result of weighing a body in air is equal to the mass of a standard, of conventionally chosen density, at a conventionally chosen temperature, which balances this body at this reference temperature in air of conventionally chosen density. International Recommendation 33 (OIML IR 33 1973, 1979). "Conventional Value of the Result of Weighing in Air" **(Previously known as "Apparent Mass vs. 8.0g/cm^3).**

Uncertainty Statement: The uncertainty conforms to the ISO Guide to the Expressions of Uncertainty in Measurement. Uncertainty as reported is based on a coverage factor k=2 for an approximate 95 percent level of uncertainty. Uncertainty components include the standard deviation of the process, the uncertainty of the standard used, an uncertainty component associated with the potential drift of the standard used, and the estimated uncertainty related to measuring and determining the air buoyancy effect.

Conventional Mass Values are listed on page 2 of this report.

Quality Control Services, Inc.
Metrology Laboratory Manager
E-mail dthompson@qc-services.com

Date: 03/21/17

Signature David S. Thompson

Established 1974

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ACCREDITED

Calibration Services

Certificate Number: 1550.01

Laboratory code: 115953

Report of Calibration

Firm: Dirigo Laboratories
Address: 11785 SE Hwy 212, Ste 305
City/State/Zip: Clackamas, OR 97015

Test Completed: 03/21/17
Submitted By: John Steiner
Traceable Number: 20170468

Test Item: 200mg and 100mg Individual Weights
Serial No.: Listed in Table

Manufacturer: Troemner

Laboratory Environment at time of test

Temperature °C	Pressure mmHg	Humidity %RH
21.967	753.44	49.44

Conventional Mass Value

Nominal Value	As Found grams	As Found Correction* (mg)	Uncertainty (mg)	Tolerance (mg)
200mg SN 1000101395	0.2000061	0.0061	0.0026	0.01
100mg SN 1000126267	0.1000046	0.0046	0.0028	0.01

*Correction is the difference between the conventional mass value of a weight and its nominal value.

Comments: These weights were new from the manufacturer and were within ASTM Class 1 tolerances As Found. No adjustments or changes were made so As Found values should be considered to be As Left values.

Accredited by the American Association for Laboratory Accreditation (A2LA) under Calibration Laboratory Code 115953 and Certificate Number 1550.01. This laboratory meets the requirements of ISO/IEC 17025:2005 *General Requirements for the Competence of Testing and Calibration Laboratories.* This laboratory also meets the requirements of ANSI/NCSL Z540-1-1994 and any additional program requirements in the field of calibration.

Quality Control Services, Inc.
Metrology Laboratory Manager
E-mail dthompson@qc-services.com

Date: 03/21/17

Signature David S. Thompson

Established 1974

QUALITY CONTROL SERVICES

LABORATORY EQUIPMENT • SALES • SERVICE • CALIBRATION • REPAIRS

2340 SE 11TH Ave. Portland, Oregon 97214 • Box 14831 Portland, Oregon 97293

(503) 236-2712 • FAX (503) 235-2535 • www.qc-services.com

ACCREDITED
Calibration Services
Certificate Number: 1550.01
Laboratory code: 115953

PFS Teco
11785 SE Hwy 212 STE#305
Clackamas, OR 97015

Report Number: DIRI0134307497210625

A2LA ACCREDITED
CERTIFICATE OF CALIBRATION WITH DATA

INSTRUMENT INFORMATION

Item	Make	Model	Serial Number	Customer ID	Location
Balance	Sartorius	ENTRIS224-1S	34307497	#107	Lab

Units	Readability	SOP	Cal Date	Last Cal Date	Cal Due Date
g	0.0001	QC012	6/25/21	12/8/20	6/2022

FUNCTIONAL CHECKS

ECCENTRICITY
Test Wt: 100 Tol: 0.0003
As-Found: Pass: ☑ Fail: ☐
As-Left: Pass: ☑ Fail: ☐

LINEARITY
Test Wt: 50 x 4 Tol: 0.0002
As-Found: Pass: ☑ Fail: ☐
As-Left: Pass: ☑ Fail: ☐

STANDARD DEVIATION
Test Wt: 100 Tol: 0.0001

1. 99.9999	5. 99.9999	9. 99.9999
2. 99.9999	6. 99.9999	10. 100.0000
3. 99.9999	7. 100.0000	Result
4. 99.9999	8. 100.0000	0.00004

ENVIRONMENTAL CONDITIONS
☑ Good ☐ Fair ☐ Poor
Temperature: 22.1°C

A2LA ACCREDITED SECTION OF REPORT

Standard	As-Found	As-Left	Expanded Uncertainty
200	199.9995	200.0000	0.00016
100	99.9999	100.0000	0.00016
50	50.0002	50.0000	0.00015
20	20.0000	20.0000	0.00015
1	.9999	.9999	0.00015
0.1	.0999	.0999	0.00015

CALIBRATION STANDARDS

Item	Make	Model	Serial Number	Cal Date	Cal Due Date	NIST ID
Weight Set	R.L./Troemner	10kg to 1mg	G782	4/30/21	4/2022	20210012

Permanent Information Concerning this Equipment:

6 month calibration cycle
12/20 Extra checkpoint to encapsulate user range 0.05g.
AF= 0.0499g A/L= 0.0500

Comments/Info Concerning this Calibration:

6/21: RH 44.7%

Report prepared/reviewed by: R.B. **Date:** 6-25-21 **Technician:** K. Dexter

Signature: Kyle Dexter

The uncertainty is calculated according to the ISO Guide to the Expression of Uncertainty in Measurement and includes the uncertainty of standards used combined with the observed standard deviation and readability of the unit under test. The uncertainty is expanded with a k factor of 2 for an approximate 95% level of confidence. Instruments listed above were calibrated using standards traceable to the National Institute of Standards and Technology (NIST). Calibration data reflect results at the time and location of calibration. Calibration data should be reviewed to insure that the instrument is performing to its required accuracy. Calibrations comply with ISO/IEC 17025 and ANSI/Z540-1-1994 quality standards.

Emissions Sampling System Thermocouple Calibration Check

Calibration based on NIST Monograph 175 per ASTM E2515-11
All thermocouples are type "K"

Date: 3/10/2021 Sampling System ID Numbers: 053/054

Performed By: A. Kravitz Calibration Instrument ID Number: 165

Reference Temperature (F)	Acceptable Error (F)	Thermocouple Location						
		FB Left	FB Right	FB Back	FB Top	FB Bottom	Catalyst Exit	Flue
0	± 4.0	0	0	0	0	0	0	0
200	± 4.0	200	200	200	200	200	200	200
400	± 4.0	400	400	400	400	400	400	400
600	± 4.5	600	600	600	600	600	600	600
800	± 6.0	800	800	800	800	800	800	800

Reference Temperature (F)	Acceptable Error (F)	Thermocouple Location					
		Ambient	Filter A	Filter B	Meter A	Meter B	Dilution Tunnel
0	± 4.0	0	0	0	0	0	1
200	± 4.0	200	200	201	200	200	200
400	± 4.0	400	400	401	400	400	400
600	± 4.5	600	600	601	600	600	600
800	± 6.0	800	800	801	800	800	800

Technician Signature:  Date: 3/10/2021

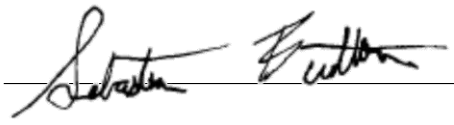
Pressure Gauge Calibration Work Sheet

Gauge Manufacturer:	Apex
Maximum Range (inH_2O):	1
Instrument ID #:	053 (dP)
Calibration Date:	9/13/2021
Calibration Expiration:	9/13/2022
Barometric Pressure:	30.08 in. Hg

Reference Standard Gauge	
Manufacturer:	Dwyer
Model:	475-000
Instrument ID#:	76
Calibration Expiration Date:	8/3/2022

Calibration Point (inH_2O)	Reference Gauge Reading (inH2O)	Pressure Gauge Reading (inH2O)	Difference (Reference - UUT)	% Error of Full Range
0.0 - 0.2	0.19	0.16	0.03	3.0%
0.2 - 0.4	0.39	0.35	0.04	4.0%
0.4 - 0.6	0.50	0.47	0.03	3.0%
0.6 - 0.8	0.74	0.73	0.01	1.0%
0.8 - 1.0	0.96	0.95	0.01	1.0%

Acceptable tolerance is 4%

Technican Signature:  Date: 9/13/2021

Uncertainty is 0.4 inH_2O, based on minumum uncertainity ration of 4:1 between standard reference meter and unit under test.

Dry Gas Meter Calibration

Meter Manufacturer:	Apex
Model:	XC-60
Lab ID #:	53
Serial #:	1902130
Calibration Date:	9/10/2021
Calibration Expiration:	3/10/2022
Barometric Pressure:	29.97 in. Hg

Reference Standard DGM	
Manufacturer:	Apex
Model:	SK25DA
Lab ID#:	47
Serial #:	1101001
Calibration Expiration Date:	3/22/2022
Calibration γ Factor:	0.998

Unit Under Test Previous Calibration	
Date	3/10/2021
γ Factor:	0.996
Allowable Deviation (±5%):	0.0498
Actual Deviation:	0.01
Result:	PASS

Calibration Data	Run 1	Run 2	Run 3
Standard DGM Initial Volume (L)	0.000	0.000	0.000
Standard DGM Final Volume (L)	181.377	213.253	216.905
Standard DGM Temperature (°F)	70.0	69.0	69.0
Standard DGM Pressure (in H_2O)	0.00	0.00	0.0
DGM Initial Volume (ft^3)	0.000	6.327	0.000
DGM Final Volume (ft^3)	6.327	13.957	7.869
DGM Temperature (°F)	77.0	85.0	92.0
DGM Pressure (in H_2O)	2.95	3.79	1.4
Time (min)			
Net Volume for Standard DGM (ft^3)	6.405	7.531	7.660
Net Volume for DGM (ft^3)	6.327	7.630	7.869

Dry Gas Meter γ Factor	1.016	1.005	1.010
γ Factor Deviation From Average	1.016	1.005	1.010

Average Gas Meter γ Factor: 1.011

Calculations:

1. Deviation = |Average value for all runs - current run value|
2. $\gamma = [V_{std} \times (\gamma_{Std}) \times (P_{bar}+P_{std}/13.6) \times (T_{DGM} + 460)] / [V_{DGM} \times (T_{std} + 460) \times (P_{bar} + P_{DGM}/ 13.6)]$

Standard Reference Meter is calibrated to NIST traceable standards. Uncertainty of measurement is ±0.5%.

Pressure Gauge Calibration Work Sheet

Gauge Manufacturer:	Apex
Maximum Range (inH_2O):	1
Instrument ID #:	054 (dP)
Calibration Date:	9/13/2021
Calibration Expiration:	9/13/2022
Barometric Pressure:	30.08 in. Hg

Reference Standard Gauge	
Manufacturer:	Dwyer
Model:	475-000
Instrument ID#:	76
Calibration Expiration Date:	8/3/2022

Calibration Point (inH_2O)	Reference Gauge Reading (inH2O)	Pressure Gauge Reading (inH2O)	Difference (Reference - UUT)	% Error of Full Range
0.0 - 0.2	0.07	0.07	0	0.0%
0.2 - 0.4	0.31	0.31	0	0.0%
0.4 - 0.6	0.44	0.43	0.01	1.0%
0.6 - 0.8	0.67	0.66	0.01	1.0%
0.8 - 1.0	0.99	0.98	0.01	1.0%

Acceptable tolerance is 4%

Technican Signature: _____ Date: 9/13/2021

Uncertainty is 0.4 inH_2O, based on minumum uncertainity ration of 4:1 between standard reference meter and unit under test.

Dry Gas Meter Calibration

Meter Manufacturer:	Apex
Model:	XC-60
Lab ID #:	54
Serial #:	1902133
Calibration Date:	9/9/2021
Calibration Expiration:	3/9/2022
Barometric Pressure:	30.06 in. Hg

Reference Standard DGM	
Manufacturer:	Apex
Model:	SK25DA
Lab ID#:	47
Serial #:	1101001
Calibration Expiration Date:	3/22/2022
Calibration γ Factor:	0.998

Unit Under Test Previous Calibration	
Date	3/10/2021
γ Factor:	1.017
Allowable Deviation (±5%):	0.05085
Actual Deviation:	0.02
Result:	PASS

Calibration Data	Run 1	Run 2	Run 3
Standard DGM Initial Volume (L)	0.000	0.000	0.000
Standard DGM Final Volume (L)	151.729	153.305	137.314
Standard DGM Temperature (°F)	71.0	72.0	60.0
Standard DGM Pressure (in H_2O)	0.00	0.00	0.0
DGM Initial Volume (ft^3)	0.000	5.422	10.992
DGM Final Volume (ft^3)	5.422	10.992	16.089
DGM Temperature (°F)	82.0	88.0	89.0
DGM Pressure (in H_2O)	2.80	5.65	1.1
Time (min)			
Net Volume for Standard DGM (ft^3)	5.358	5.414	4.849
Net Volume for DGM (ft^3)	5.422	5.570	5.097

Dry Gas Meter γ Factor	1.000	0.986	1.000
γ Factor Deviation From Average	1.000	0.986	1.000

Average Gas Meter γ Factor: 0.995

Calculations:

1. Deviation = |Average value for all runs - current run value|
2. $\gamma = [V_{std} \times (\gamma_{Std}) \times (P_{bar}+P_{std}/13.6) \times (T_{DGM} + 460)] / [V_{DGM} \times (T_{std} + 460) \times (P_{bar} + P_{DGM}/ 13.6)]$

Standard Reference Meter is calibrated to NIST traceable standards. Uncertainty of measurement is ±0.5%.

Dry Gas Meter Calibration

Meter Manufacturer:	Apex
Model:	Apex-AK-600
Lab ID #:	55
Serial #:	810016
Calibration Date:	10/8/2021
Calibration Expiration:	10/8/2022
Barometric Pressure:	29.91 in. Hg

Reference Standard DGM	
Manufacturer:	Apex
Model:	SK25DA
Lab ID#:	47
Serial #:	1101001
Calibration Expiration Date:	3/22/2022
Calibration γ Factor:	0.998

Unit Under Test Previous Calibration	
Date	3/31/2021
γ Factor:	1.010
Allowable Deviation (±5%):	0.0505
Actual Deviation:	0.01
Result:	PASS

Calibration Data	Run 1	Run 2	Run 3
Standard DGM Initial Volume (L)	0.000	0.000	0.000
Standard DGM Final Volume (L)	152.577	230.297	211.876
Standard DGM Temperature (°F)	68.0	68.0	68.0
Standard DGM Pressure (in H_2O)	0.00	0.00	0.0
DGM Initial Volume (ft^3)	0.000	0.000	0.000
DGM Final Volume (ft^3)	5.384	8.132	7.488
DGM Temperature (°F)	70.0	70.0	70.0
DGM Pressure (in H_2O)	2.14	2.14	2.1
Time (min)	28.0	42.0	39.0
Net Volume for Standard DGM (ft^3)	5.388	8.133	7.482
Net Volume for DGM (ft^3)	5.384	8.132	7.488

Dry Gas Meter γ Factor	0.997	0.997	0.996
γ Factor Deviation From Average	0.997	0.997	0.996

Average Gas Meter γ Factor: 0.997

Calculations:

1. Deviation = |Average value for all runs - current run value|
2. $\gamma = [V_{std} \times (\gamma_{Std}) \times (P_{bar}+P_{std}/13.6) \times (T_{DGM} + 460)] / [V_{DGM} \times (T_{std} + 460) \times (P_{bar} + P_{DGM}/ 13.6)]$

Standard Reference Meter is calibrated to NIST traceable standards. Uncertainty of measurement is ±0.5%.

Technician

Model 1430 Microtector® Electronic Point Gage

Installation and Operating Instructions

Model 1430 Microtector® Portable Electronic Point Gage combines modern, solid-state integrated circuit electronics with a time-proven point gage manometer to provide fast, accurate pressure measurements.

SPECIFICATIONS AND FEATURES

- Accurate and repeatable to ± .00025 inches water column
- Pressure range: 0 - 2″ w.c., positive, negative, or differential pressures
- Non-toxic and inexpensive gage fluid consists of distilled water mixed with a small amount of fluorescein green color concentrate
- Convenient, portable, lightweight and self-contained, the unit requires no external power connections and is operated by a 1.5 volt penlight cell
- A.C. detector current eliminates point plating, fouling and erosion
- Micrometers are manufactured in accordance with ASME B89.1.13-2001, and are traceable to a standard at the National Institute of Standards and Technology
- Three-point mounting, dual leveling adjustment, and circular level vial assure rapid setup
- Durablock® precision-machined acrylic plastic gage body
- Sensitive 0 - 50 microamp D.C. meter acts as a detector and also indicates battery and probe condition
- Heavy 2″ thick steel base plate provides steady mounting
- Top-quality glass epoxy circuit board and solid-state, integrated circuit electronics
- Electronic enclosure of tough, molded styrene acrylonitrile provides maximum protection to components yet allows easy access to battery compartment
- Rugged sheet steel cover and carrying case protects the entire unit when not in use
- Accessories included are (2) 3-foot lengths Tygon® tubing, (2) 1/8″ pipe thread adapters and 3/4 oz. bottle of fluorescein green color concentrate with wetting agent

Maximum pressure: 100 psig with optional pipe thread connections.

Tygon® is a registered trademark of Saint-Gobain Corporation

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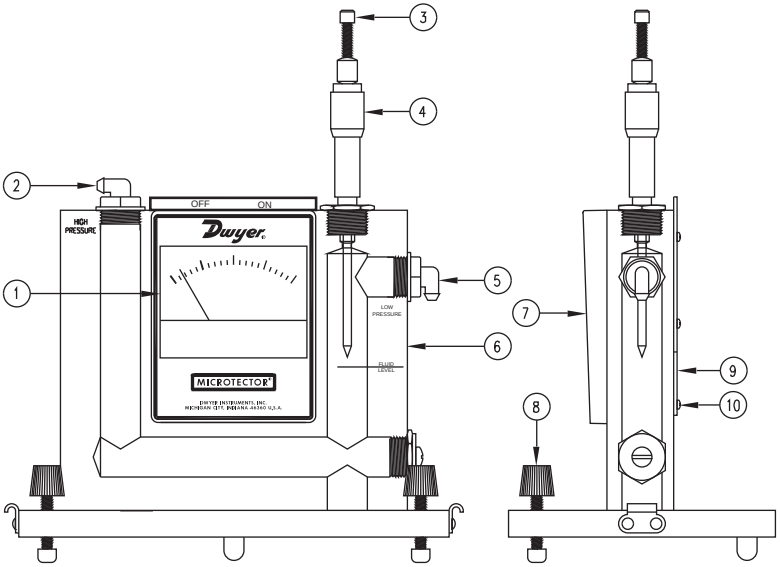

Microtector® Gage

Precision Pressure Measurement

The Microtector® Gage combines the time-proven principles of the Hook Gage type manometer and modern solid-state integrated circuit electronics. It provides an inexpensive means of achieving accuracy and repeatability within ± .00025 inches water column throughout its 0 to 2 inches w.c. range. It is truly a new standard in precision measuring devices.

Principles of Operation

A pressure to be measured is applied to the manometer fluid which is displaced in each leg of the manometer by an amount equal to 1/2 the applied pressure. A micrometer mounted point is then lowered until it contacts the manometer gage fluid. The instant of contact is detected by completion of a low-power A.C. circuit. Current for this circuit is supplied by a 1.5 volt penlight cell feeding two semiconductor amplifiers which act as a free-running multivibrator operating at a frequency of approximately two kilohertz. Completion of the A.C. circuit activates a bridge rectifier which provides the signal for indication on a sensitive (0 to 50 microamps) D.C. microammeter.

On indication of contact, the operator stops lowering the point and reads the micrometer which indicates one half the applied pressure. By interpolating eight divisions (each being .000125″ w.c.) between .001 micrometer graduations, a total accuracy of .00025 can easily be achieved. The micrometer complies with Federal Specification GGG-C-105A and is traceable to a master at the NIST.

Locating and Opening

Stand the Microtector® Gage and case on a firm flat level surface. Remove cover by releasing the latches and lifting it straight up. If it is necessary to move the gage without case, handle only the base plate or clear acrylic block. (**CAUTION:** Do not handle gage by grasping meter-electronic package housing Item 7 on drawing.)

Fluid Level

Level the gage by adjusting the two front leveling screws (Item 8 on drawing) until the bubble in the spirit level is centered in the small circle. After leveling the gage, open both rapid shut-off valve tube connectors (Items 2 and 5). Back off the micrometer (Item 4), if necessary, to make sure that the point is not immersed in the gage fluid. The fluid level in the gage should now coincide with the mark on the right hand bore (Item 6) plus or minus approximately 1/32 inch. If the level of fluid is too high, fluid can be removed with an eye dropper pipette or carefully poured out of the right connection (Item 5).

If the level is too low, remove the top left rapid shut-off valve tube connector (Item 2) and add distilled water pre-mixed with the proper amount of green concentrate. (See maintenance instructions for proportions. After correcting the fluid level, re-install the rapid shut-off connectors and, with these in the open position, re-level the Microtector® Gage. The gage is now ready to be zeroed.

Zeroing

Turn the Micrometer barrel (Item 4) until its lower end just coincides with the zero mark on the scale and the zero on the barrel scale coincides with the vertical line on the internal scale. Note that the internal scale is graduated every .025″ from 0 to 1.00 inch and the barrel scale is graduated in one thousandths from 0 to .025″. Turn the meter circuit switch at the top of gage to the “on” position. While holding the barrel at the zero position (and with gage level), raise or lower the point by turning the knurled knob (Item 3) until the point is above, but near, the fluid.

Check to be sure that the meter registers zero. Watch the meter, hold the barrel, and lower the point slowly by turning the top knurled knob. As the knob is turned, the point will contact the fluid and the meter pointer will move from zero to some upscale position.

After making contact, turn the point out of the fluid by turning the micrometer barrel counterclockwise to a reading of .010 or more. Again, watch the meter and, this time, lower the point by turning the micrometer barrel. The point position where the meter pointer begins to move up scale is the zero position. This position should correspond to the zero reading on the micrometer. Adjust the point in relation to the micrometer barrel by turning the top knob while holding the barrel steady. Repeat lowering the point, watching the meter for contact, and adjusting the point until the zero position and zero reading exactly coincide. The gage is now zeroed and should not be moved.

An alternative method of zeroing and reading can be used wherein, instead of zeroing the gage completely, a zero correction reading is taken and recorded, then subtracted from the final reading. Comparable results can be obtained with either method.

Positive Pressure Measurement

With the fluid at its proper level, a pressure of 2.0″ water column maximum can be measured. Positive pressure should be applied to the top left connection (Item 2) with the micrometer zeroed as described above. This will permit a simple direct reading to be taken.

After an unknown pressure has been applied at the top left connection, the fluid level will drop in the left bore and rise over the point in the right bore. Note that the indicating meter point has moved upscale because the point is immersed in the fluid. Turn the micrometer counter-clockwise until the point leaves the fluid as indicated by the meter pointer dropping to zero on its scale. Then slowly turn the micrometer down until its point just touches the fluid surface, causing movement of the meter pointer. Withdraw the point and repeat several times, noting each time the micrometer reading where the meter pointer begins. The average of these readings multiplied by two is the pressure applied to the gage. (Avg. reading x 2 = pressure applied in inches w.c. The degree of uncertainty for the operator is indicated by the difference in these readings.

When the readings are complete, the pressure should be removed and the zero setting of Microtector® Gage rechecked. Any change in the zero position will indicate inaccurate readings. Should this happen, the zero-set and pressure measurement procedure should be repeated.

Negative Pressure or Vacuum Measurement

Zero the gage. Connect the source of vacuum or negative pressure to the right-side gage connection (Item 5) and proceed as described under Positive Pressure Measurement section. Remember that the pressure measured in this way is negative.

Differential Pressure Measurement

Differential pressures may be measured by connecting the higher (more positive) pressure to the left connection (Item 2) and the lower pressure to the right connection (Item 5).

Storage

Turn meter circuit switch to "off" position and withdraw the point well clear of fluid (by turning micrometer clockwise) when gage is not in use. This will conserve the batteries and minimize build-up of oxides, etc., on the point. Keep the unit covered and in an area free of strong solvent fumes.

Maintenance

When the meter reading becomes reduced or the pointer movement gets sluggish (with the circuit on and the point in fluid), the following should be done:

(1) Remove the point (by unscrewing) and clean the tip lightly using fine crocus cloth. Wipe off all grit and dirt with a clean rag; reassemble and recheck meter operation.

(2) If the meter operation continues to be sluggish, replace the size AA, 1.5 volt battery. (Replace the battery at least once a year to avoid deterioration of battery and damage to gage. Leakproof alkaline battery is recommended.)

To replace the battery, remove center screw (Item 10) located in the back of the electronic enclosure. Cover (Item 9) will come off, exposing the battery. Pull the old battery out and push a new battery into the battery holder with the positive (center) terminal to the right (to the end marked with + on the holder).

If the fluid becomes contaminated and requires replacement: empty old fluid from gage; flush out with clear water and replace with distilled water and A-126 fluorescein green color concentrate mixed with 3/4 oz. concentrate to each quart of water.

CAUTION:

1. Do not substitute other gage fluids, as proper gage operation depends on use of the specified gage fluid to provide proper surface tension, wetting ability and electrolyte capability with unity specific gravity.

If the gage bore is very dirty, a mild soap solution may be used to aid in cleaning prior to flushing with clear water.

2. Do not clean with liquid soaps, special solvent, de-greasers, aromatic hydrocarbons, etc. Such cleaners and solvents may contain chlorine, fluorine, acetone and related compounds that will permanently damage the gage and prevent proper operation.

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Calibration Certificate ID
072731-240-041621-ACC-USI

METTLER TOLEDO

Mettler Toledo
Service Business Unit Industrial
1900 Polaris Parkway
Columbus, OH 43240
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Accredited by the American Association for Laboratory Accreditation (A2LA)
CALIBRATION CERT #1902.01

ISO 17025 Registered
ANSI/NCSL Z540-1 Accredited

Accuracy Calibration Certificate

Customer

Company:	PFS-TECO		
Address:	11785 SE Hwy 212; Ste 305		
City:	Clackamas	**Contact:**	John Steinert
Zip / Postal:	97015-9050		
State / Province:	Oregon		

Weighing Device

Manufacturer:	Mettler Toledo	**Instrument Type:**	Weighing Instrument
Model:	PFD774-US11	**Asset Number:**	2
Serial No.:	C112381343	**Terminal Model:**	IND570
Building:	N/A	**Terminal Serial No.:**	C101887029
Floor:	N/A	**Terminal Asset No.:**	N/A
Room:	N/A		

Range	Max. Capacity	Readability (d)
1	1000 lb	0.02 lb

Procedure

Calibration Guideline:	ASTM E898 - 20
METTLER TOLEDO Work Instruction:	30260953

This calibration certificate including procedures and uncertainty estimation also complies with EURAMET cg-18 v 4.0.

This calibration certificate contains measurements for As Found and As Left calibrations.

The sensitivity/span of the weighing instrument was adjusted before As Left calibration with an external weight.

	Temperature		Humidity	
As Found	Start: 20.0 °C	End: 20.0 °C	Start: 28.0 %	End: 28.0 %
As Left	Start: 20.0 °C	End: 20.0 °C	Start: 28.0 %	End: 28.0 %

Environmental conditions have been verified to ensure the accuracy of the calibration.

This certificate is issued in accordance with the conditions of accreditation granted by A2LA, which is based on ISO/IEC 17025. A2LA has assessed the measurement capability of the laboratory and its traceability to recognized national standards.

As Found Calibration Date:	16-Apr-2021	**Authorized A2LA Signatory:**	Gary Sargent
As Left Calibration Date:	16-Apr-2021		
Issue Date:	16-Apr-2021		
Requested Next Calibration Date:	30-Apr-2022		

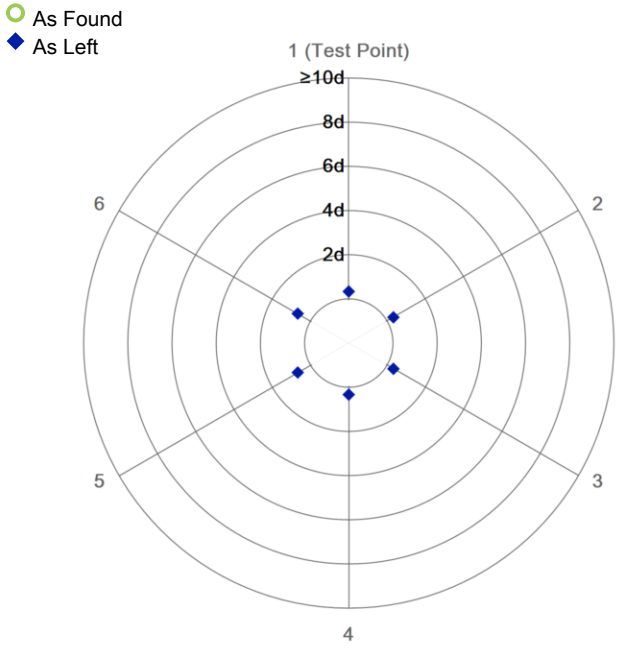
Measurement Results

Repeatability

Test Load: 500 lb

	As Found	As Left
1	N/A	500.00 lb
2	N/A	500.00 lb
3	N/A	500.00 lb
4	N/A	500.00 lb
5	N/A	500.02 lb
6	N/A	500.02 lb

Standard Deviation	**N/A**	**0.010 lb**



The "d" in the graph represents the readability of the range/interval in which the test was performed.

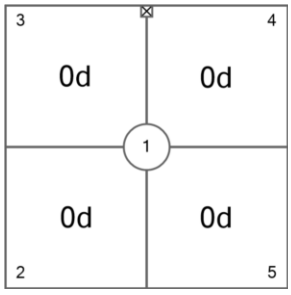
The results of this graph are based upon the absolute values of the differences from the mean value.

Eccentricity

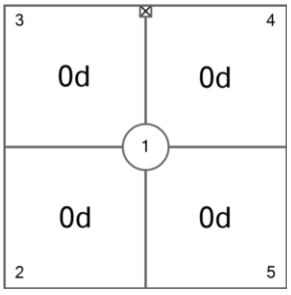
Test Load: 325 lb

Position	As Found	As Left
1	325.00 lb	325.00 lb
2	325.00 lb	325.00 lb
3	325.00 lb	325.00 lb
4	325.00 lb	325.00 lb
5	325.00 lb	325.00 lb

Maximum Deviation	**0.00 lb**	**0.00 lb**



As Found



As Left

The "d" in the graph represents the readability of the range/interval in which the test was performed.

Error of Indication

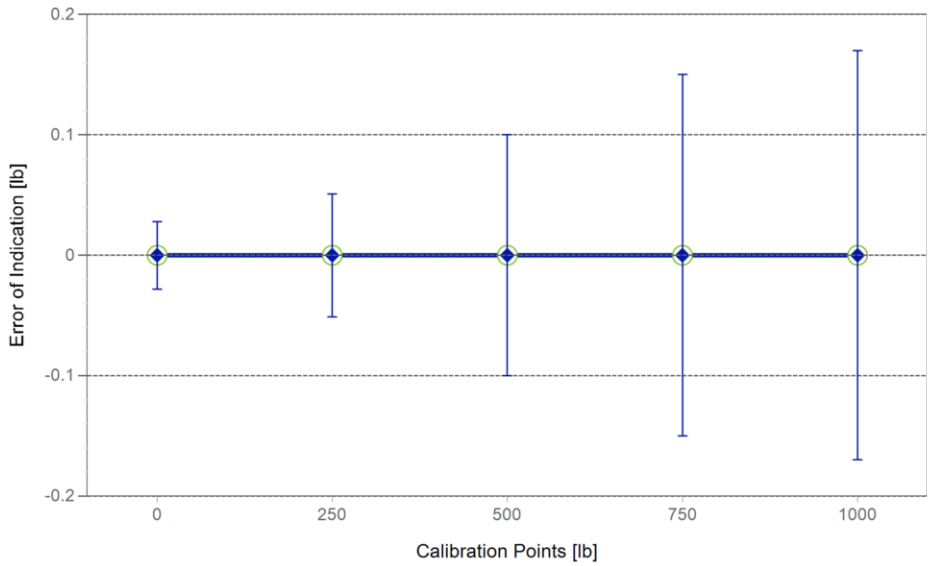
As Found

	Reference Value	Indication	Error of Indication	Expanded Uncertainty	k
1	0 lb	0.00 lb	0.00 lb	N/A	N/A
2 [1]	250 lb	250.00 lb	0.00 lb	N/A	N/A
3 [1]	500 lb	500.00 lb	0.00 lb	N/A	N/A
4 [1]	750 lb	750.00 lb	0.00 lb	N/A	N/A
5	1000 lb	1000.00 lb	0.00 lb	N/A	N/A
6 [1]	750 lb	750.00 lb	0.00 lb	N/A	N/A
7 [1]	500 lb	500.00 lb	0.00 lb	N/A	N/A
8 [1]	250 lb	250.00 lb	0.00 lb	N/A	N/A
9	0 lb	0.00 lb	0.00 lb	N/A	N/A

As Left

	Reference Value	Indication	Error of Indication	Expanded Uncertainty	k
1	0 lb	0.00 lb	0.00 lb	0.028 lb	2.37
2 [1]	250 lb	250.00 lb	0.00 lb	0.051 lb	2
3 [1]	500 lb	500.00 lb	0.00 lb	0.10 lb	2
4 [1]	750 lb	750.00 lb	0.00 lb	0.15 lb	2
5	1000 lb	1000.00 lb	0.00 lb	0.17 lb	2.05
6 [1]	750 lb	750.00 lb	0.00 lb	0.15 lb	2
7 [1]	500 lb	500.00 lb	0.00 lb	0.10 lb	2
8 [1]	250 lb	250.00 lb	0.00 lb	0.051 lb	2
9	0 lb	0.00 lb	0.00 lb	0.028 lb	2.37

[1]The calculated uncertainty was replaced by the CMC (Calibration and Measurement Capabilities) value because the calculated uncertainty was smaller than the CMC value.



For improved legibility of the graphics only increasing measurement points are shown and measurement points close to zero are not displayed.

The uncertainty stated is the expanded uncertainty at calibration obtained by multiplying the standard combined uncertainty by the coverage factor k - which can be larger than 2 according to ASTM E898 and EURAMET cg-18. The value of the measurand lies within the assigned range of values with a probability of approximately 95%.

The user is responsible for maintaining environmental conditions and the settings of the weighing instrument when it was calibrated.

Test Equipment

All weights used for metrological testing are traceable to national or international standards. The weights were calibrated and certified by an accredited calibration laboratory.

Weight Set 1: NIST NIST-F

Weight Set No.:	182 50's & 25's	Date of Issue:	25-Jun-2019
Certificate Number:	OR-19-186-F	Calibration Due Date:	30-Jun-2021

Remarks

Equipment condition: Good

Calibration after installation

The recording of false fictitius or fradulent statements or entries on this document may be punishable as a felony under fedral Statue

End of Accredited Section

The information below and any attachments to this calibration certificate are not part of the accredited calibration.

Measurement Uncertainty of the Weighing Instrument in Use

Stated is the expanded uncertainty with k=2 in use. The formula shall be used for the estimation of the uncertainty under consideration of the errors of indication. The value R represents the net load indication in the unit of measure of the device.

Temperature coefficient for the evaluation of the measurement uncertainty in use: $10.0 \cdot 10^{-6}$ / K

Temperature range on site for the evaluation of the measurement uncertainty in use: 10 K

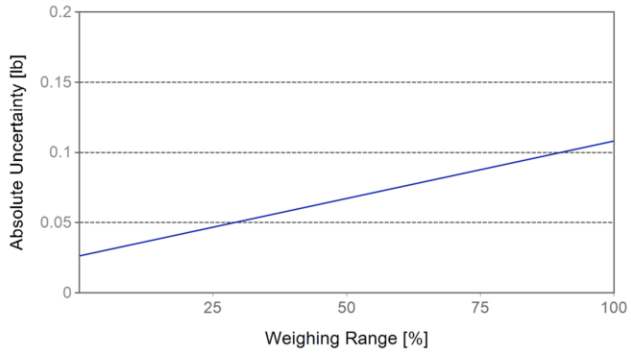
Linearization of Uncertainty Equation

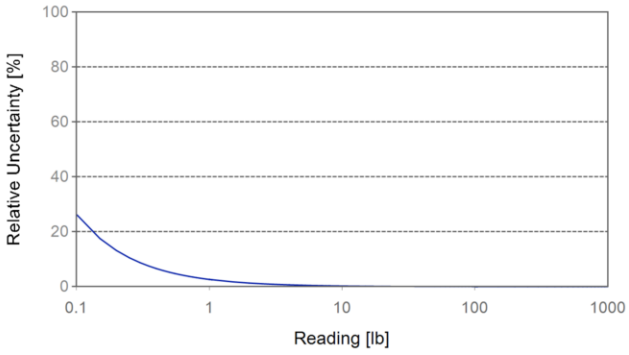
	Range		As Found	As Left
	d	Max		
1	0.02 lb	1000 lb	N/A	U_1 = 0.026 lb + 0.0000818 lb/lb · R

To optimize the stability of the linearization, besides of the zero load only increasing measurement points with a test load of 5% of the measurement range or larger are taken for the calculation of the linear equation.

Absolute and Relative Measurement Uncertainty in Use for Various Net Indications (Examples)

Net Indication	As Found		As Left	
1.00 lb	N/A	N/A	0.026 lb	2.6%
10.00 lb	N/A	N/A	0.027 lb	0.27%
100.00 lb	N/A	N/A	0.034 lb	0.034%
500.00 lb	N/A	N/A	0.067 lb	0.013%
1000.00 lb	N/A	N/A	0.11 lb	0.011%





As Found As Left

METTLER TOLEDO Service

Handbook 44 Tolerance Assessment (Acceptance)

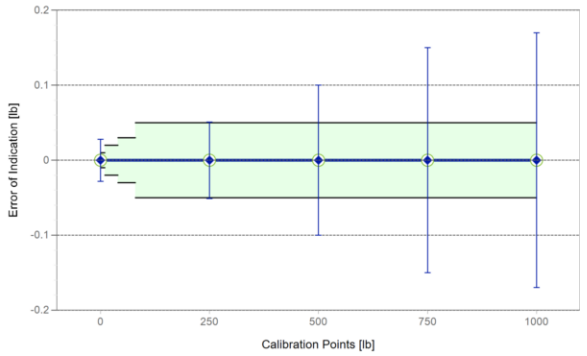
Assessment done without considering measurement uncertainty.
The measurements from the attached calibration certificate were assessed against the Tolerances defined by NIST Handbook 44.
The range of measurements for both Eccentricity and Repeatability (if performed) tests is assessed against Maintenance Tolerances.

	As Found	As Left
Overall	✓	✓

✓ = Passed
✗ = Failed

Weighing Device

Range	Max. Capacity	Readability (d)	Verification Scale Interval (e)	Class
1	1000 lb	0.02 lb	0.02 lb	III



Tolerances according to NIST Handbook 44

Test Load		Tolerance
From	To	
0.00 lb	0.00 lb	0.005 lb
0.02 lb	10.00 lb	0.01 lb
10.02 lb	40.00 lb	0.02 lb
40.02 lb	80.00 lb	0.03 lb
80.02 lb	1000.00 lb	0.05 lb

○ As Found
◆ As Left
— Tolerance

Eccentricity and Repeatability

Test	Test Load	Tolerance	As Found		As Left	
			Max. Error / Range	Result	Max. Error / Range	Result
Eccentricity (Max. Error)	325 lb	0.05 lb	0.00 lb	✓	0.00 lb	✓
Eccentricity (Range)	325 lb	0.1 lb	0.00 lb	✓	0.00 lb	✓
Repeatability (Max. Error)	500 lb	0.05 lb	N/A	N/A	0.02 lb	✓
Repeatability (Range)	500 lb	0.10 lb	N/A	N/A	0.02 lb	✓

Max. Error: Maximum of the absolute values of the individual errors.
Range: Difference between largest and smallest measurement value.

Error of Indication

	Reference Value	Tolerance	As Found		As Left	
			Error of Indication	Result	Error of Indication	Result
1	0 lb	0.01 lb	0.00 lb	✓	0.00 lb	✓
2	250 lb	0.05 lb	0.00 lb	✓	0.00 lb	✓
3	500 lb	0.05 lb	0.00 lb	✓	0.00 lb	✓
4	750 lb	0.05 lb	0.00 lb	✓	0.00 lb	✓
5	1000 lb	0.05 lb	0.00 lb	✓	0.00 lb	✓
6	750 lb	0.05 lb	0.00 lb	✓	0.00 lb	✓
7	500 lb	0.05 lb	0.00 lb	✓	0.00 lb	✓
8	250 lb	0.05 lb	0.00 lb	✓	0.00 lb	✓
9	0 lb	0.01 lb	0.00 lb	✓	0.00 lb	✓

PRAXAIR
Making our planet more productive

DocNumber: 271687

Praxair Distribution, Inc.
5700 S. Alameda Street
Los Angeles CA 90058
Tel: 323-585-2154
Fax: 714-542-6689
PGVP ID: F22019

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS

Customer & Order Information

PXPKG TUALATIN OR H
10450 SW TUALATIN SHERWOOD ROAD
TUALATIN OR 97062-9547

Certificate Issuance Date: 10/16/2019
Praxair Order Number: 71120745
Part Number: NI CD10CO33E-AS
Customer PO Number: 79106732

Fill Date: 10/08/2019
Lot Number: 70086928102
Cylinder Style & Outlet: AS CGA 590
Cylinder Pressure and Volume: 2000 psig 140 ft3

Certified Concentration

ProSpec EZ Cert

Expiration Date: 10/16/2027		NIST Traceable
Cylinder Number: CC139173		Expanded Uncertainty
10.09 %	Carbon dioxide	± 0.4 %
2.53 %	Carbon monoxide	± 0.6 %
10.48 %	Oxygen	± 0.4 %
Balance	Nitrogen	

Certification Information:

Certification Date: 10/16/2019 *Term:* 96 Months *Expiration Date:* 10/16/2027

This cylinder was certified according to the 2012 EPA Traceability Protocol, Document #EPA-600/R-12/531, using Procedure G1.
Do Not Use this Standard if Pressure is less than 100 PSIG.
CO2 responses have been corrected for Oxygen IR Broadening effect. O2 responses have been corrected for CO2 interference.

Analytical Data:

(R=Reference Standard, Z=Zero Gas, C=Gas Candidate)

1. ***Component:*** **Carbon dioxide**

Requested Concentration: 10 %
Certified Concentration: 10.09 %
Instrument Used: Horiba VIA-510 S/N 20C194WK
Analytical Method: NDIR
Last Multipoint Calibration: 09/18/2019

First Analysis Data:						Date	10/16/2019
Z:	0	R:	14	C:	10.09	Conc:	10.09
R:	14	Z:	0	C:	10.1	Conc:	10.1
Z:	0	C:	10.1	R:	14.01	Conc:	10.1
UOM:	%				Mean Test Assay:		10.09 %

Reference Standard: Type / Cylinder #: GMIS / CC164230
Concentration / Uncertainty: 14.00 % ±0.265%
Expiration Date: 04/16/2027
Traceable to: SRM # / Sample # / Cylinder #: SRM 1675b / 6-F-51 / CAL014538
SRM Concentration / Uncertainty: 13.963% / ±0.034%
SRM Expiration Date: 05/16/2022

Second Analysis Data:						Date	
Z:	0	R:	0	C:	0	Conc:	0
R:	0	Z:	0	C:	0	Conc:	0
Z:	0	C:	0	R:	0	Conc:	0
UOM:	%				Mean Test Assay:		%

2. ***Component:*** **Carbon monoxide**

Requested Concentration: 2.5 %
Certified Concentration: 2.53 %
Instrument Used: Horiba VIA-510 S/N UB9UCSYX
Analytical Method: NDIR
Last Multipoint Calibration: 09/19/2019

First Analysis Data:						Date	10/16/2019
Z:	0	R:	5	C:	2.53	Conc:	2.53
R:	5	Z:	0	C:	2.53	Conc:	2.53
Z:	0	C:	2.54	R:	5.01	Conc:	2.54
UOM:	%				Mean Test Assay:		2.53 %

Reference Standard: Type / Cylinder #: GMIS / CC242633
Concentration / Uncertainty: 5.00 % ±0.543%
Expiration Date: 04/03/2025
Traceable to: SRM # / Sample # / Cylinder #: SRM 2642a / 51-D-23 / FF23106
SRM Concentration / Uncertainty: 7.859% / ±0.039%
SRM Expiration Date: 07/15/2019

Second Analysis Data:						Date	
Z:	0	R:	0	C:	0	Conc:	0
R:	0	Z:	0	C:	0	Conc:	0
Z:	0	C:	0	R:	0	Conc:	0
UOM:	%				Mean Test Assay:		%

3. ***Component:*** **Oxygen**

Requested Concentration: 10.5 %
Certified Concentration: 10.48 %
Instrument Used: OXYMAT 5E
Analytical Method: Paramagnetic
Last Multipoint Calibration: 09/18/2019

First Analysis Data:						Date	10/16/2019
Z:	0	R:	9.88	C:	10.49	Conc:	10.48
R:	9.88	Z:	0	C:	10.49	Conc:	10.48
Z:	0	C:	10.5	R:	9.89	Conc:	10.49
UOM:	%				Mean Test Assay:		10.48 %

Reference Standard: Type / Cylinder #: NTRM / DT0010384
Concentration / Uncertainty: 9.875 % ±0.4%
Expiration Date: 11/18/2022
Traceable to: SRM # / Sample # / Cylinder #: NTRM / 170701 / NTRM DT0010384
SRM Concentration / Uncertainty: 9.875% / ±0.040%
SRM Expiration Date: 11/18/2022

Second Analysis Data:						Date	
Z:	0	R:	0	C:	0	Conc:	0
R:	0	Z:	0	C:	0	Conc:	0
Z:	0	C:	0	R:	0	Conc:	0
UOM:	%				Mean Test Assay:		%

Analyzed By: Jose Vasquez

Certified By: Jenna Lockman

PRAXAIR
Making our planet more productive

DocNumber: 271681

Praxair Distribution, Inc.
5700 S. Alameda Street
Los Angeles CA 90058
Tel: 323-585-2154
Fax: 714-542-6689
PGVP ID: F22019

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS

Customer & Order Information

PXPKG TUALATIN OR H
10450 SW TUALATIN SHERWOOD ROAD
TUALATIN OR 97062-9547

Certificate Issuance Date: 10/16/2019
Praxair Order Number: 71120745
Part Number: NI CD17CO8E-AS
Customer PO Number: 79106732

Fill Date: 10/07/2019
Lot Number: 70086928009
Cylinder Style & Outlet: AS CGA 590
Cylinder Pressure and Volume: 1300 psig 99 ft3

Certified Concentration

ProSpec EZ Cert

Expiration Date:	10/16/2027	NIST Traceable
Cylinder Number:	CC106574	Expanded Uncertainty
17.00 %	Carbon dioxide	± 0.5 %
4.31 %	Carbon monoxide	± 0.6 %
16.95 %	Oxygen	± 0.2 %
Balance	Nitrogen	

Certification Information:

Certification Date: 10/16/2019 *Term:* 96 Months *Expiration Date:* 10/16/2027

This cylinder was certified according to the 2012 EPA Traceability Protocol, Document #EPA-600/R-12/531, using Procedure G1.

Do Not Use this Standard if Pressure is less than 100 PSIG.

CO2 responses have been corrected for Oxygen IR Broadening effect. O2 responses have been corrected for CO2 interference.

Analytical Data:

(R=Reference Standard, Z=Zero Gas, C=Gas Candidate)

1. ***Component:*** **Carbon dioxide**

Requested Concentration: 17 %
Certified Concentration: 17.00 %
Instrument Used: Horiba VIA-510 S/N 20C194WK
Analytical Method: NDIR
Last Multipoint Calibration: 09/18/2019

First Analysis Data: **Date** 10/16/2019

Z:	0	R:	19.98	C:	17	Conc:	17
R:	19.98	Z:	0	C:	17	Conc:	17
Z:	0	C:	17.01	R:	19.99	Conc:	17.01

UOM: % **Mean Test Assay:** 17 %

Reference Standard: Type / Cylinder #: GMIS / CC149981
Concentration / Uncertainty: 19.98 % ±0.279%
Expiration Date: 06/07/2026
Traceable to: SRM # / Sample # / Cylinder #: RGM#CC28033 / N/A / RGM#CC28033
SRM Concentration / Uncertainty: 19.67% / ±0.04%
SRM Expiration Date: 07/15/2021

Second Analysis Data: **Date**

Z:	0	R:	0	C:	0	Conc:	0
R:	0	Z:	0	C:	0	Conc:	0
Z:	0	C:	0	R:	0	Conc:	0

UOM: % **Mean Test Assay:** %

2. ***Component:*** **Carbon monoxide**

Requested Concentration: 4.25 %
Certified Concentration: 4.31 %
Instrument Used: Horiba VIA-510 S/N UB9UCSYX
Analytical Method: NDIR
Last Multipoint Calibration: 09/19/2019

First Analysis Data: **Date** 10/16/2019

Z:	0	R:	5	C:	4.31	Conc:	4.31
R:	5	Z:	0	C:	4.31	Conc:	4.31
Z:	0	C:	4.32	R:	5.01	Conc:	4.32

UOM: % **Mean Test Assay:** 4.31 %

Reference Standard: Type / Cylinder #: GMIS / CC242633
Concentration / Uncertainty: 5.00 % ±0.543%
Expiration Date: 04/03/2025
Traceable to: SRM # / Sample # / Cylinder #: SRM 2642a / 51-D-23 / FF23106
SRM Concentration / Uncertainty: 7.859% / ±0.039%
SRM Expiration Date: 07/15/2019

Second Analysis Data: **Date**

Z:	0	R:	0	C:	0	Conc:	0
R:	0	Z:	0	C:	0	Conc:	0
Z:	0	C:	0	R:	0	Conc:	0

UOM: % **Mean Test Assay:** %

3. ***Component:*** **Oxygen**

Requested Concentration: 17 %
Certified Concentration: 16.95 %
Instrument Used: OXYMAT 5E
Analytical Method: Paramagnetic
Last Multipoint Calibration: 09/18/2019

First Analysis Data: **Date** 10/16/2019

Z:	0	R:	20.88	C:	16.96	Conc:	16.95
R:	20.88	Z:	0	C:	16.96	Conc:	16.95
Z:	0	C:	16.97	R:	20.9	Conc:	16.96

UOM: % **Mean Test Assay:** 16.95 %

Reference Standard: Type / Cylinder #: GMIS / CC506521
Concentration / Uncertainty: 20.87 % ±0.108%
Expiration Date: 12/14/2026
Traceable to: SRM # / Sample # / Cylinder #: SRM 2659a / 71-E-19 / FF22331
SRM Concentration / Uncertainty: 20.863% / ±0.021%
SRM Expiration Date: 08/23/2021

Second Analysis Data: **Date**

Z:	0	R:	0	C:	0	Conc:	0
R:	0	Z:	0	C:	0	Conc:	0
Z:	0	C:	0	R:	0	Conc:	0

UOM: % **Mean Test Assay:** %

Analyzed By Jose Vasquez

Certified By Jenna Lockman

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Mr. Sky Huddleston
Liberator LLC
350 Farris Spur
Bourbon, MO 65411

09/09/2021

Dear Mr. Huddleston,

I am writing in response to the request, dated August 2, 2021, from John Steinert of PFS-TECA on your behalf regarding certification testing of your Liberator Rocket Model RMH-2 pellet fuel heater. You are planning to demonstrate compliance with 40 CFR 60, Subpart AAA - Standards of Performance for New Residential Wood Heaters (Subpart AAA) using the test method ASTM E2779-10 "Standard Test Method for Determining Particulate Matter Emissions from Pellet Heaters." You are requesting an alternative certification testing procedure for your RMH-2 pellet heater because it cannot meet the consecutive high, medium, and low burn rate requirements as specified in ASTM E2779-10, Section 9.4.1.2, Table 1.

In your correspondence, you state that the RMH-2 is a single burn rate pellet heater that is gravity fed with no blower and can only be operated at a single burn rate. You mention that ASTM E2779-10 requires testing at three consecutive burn rates, a high burn rate for 1 hour, a medium burn rate for 2 hours, and a low burn rate for 3 hours for a total test time of 6 hours. You state that ASTM E2779-10 does not have a provision for single burn rate appliances, therefore, you propose to operate the RMH-2 heater at the single burn rate for a total of 6 hours as required in ASTM E2779-10 with no other changes to the method.

With the caveats set forth below, we are approving your alternative method request for certification testing of the Liberator Rocket Model RMH-2 pellet heater at the single burn rate for a total test time of 6 hours. This approval is based on the understanding that the RMH-2 design incorporates only one setting, which is the lowest heat output (Btu/hr) setting available to the user, and corresponds to the lowest burn rate to be evaluated during certification testing; this is consistent with 40 CFR part 60, Subpart AAA, section 60.534, which states: "The burn rate for the low burn category must be no greater than the rate that an operator can achieve in home use and no greater than is advertised by the manufacturer or retailer."

As required in Subpart AAA, section 60.534(d), the manufacturer/approved test laboratory must also measure the first hour of particulate matter emissions for each test run using a separate set of filters in one of the two parallel sampling trains. These results must be reported separately and also included in the total particulate matter emissions per run. Also, as required in Subpart AAA, section 60.534(e), the manufacturer/approved test laboratory must measure the efficiency, heat output, and carbon monoxide emissions of the tested wood heater using CSA Method B415.1-10. Disregard sections 8.3.1 and 8.4 in CSA Method B415.1-10 regarding the use of Douglas fir

lumber in a crib wood configuration for this testing. For particulate matter emission concentrations, ASTM E2515-11 "Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel" must be used; four inch filters are acceptable.

The following changes to ASTM E2515-11 must be followed for the certification testing:

1. Filters must be weighed in pairs (**front and rear filters together**) to reduce weighing error propagation. See ASTM E2515-11, Section 10.2.1, Analytical Procedure.
2. Sample filters must be Pall TX-40 or equivalent Teflon-coated glass fiber filters, and 47 mm, 90 mm, 100 mm, or 110 mm in diameter.
3. Only one point is allowed outside the +/- 10 percent proportionality range per test run.

A copy of this letter must be included in each certification test report. The emission limit in the rule remains intact and time weighted averaging is not allowed. This alternative method approval is valid until such time that Subpart AAA is revised or replaced to require a different certification method for these units, and at such time, this alternative will be reconsidered and possibly withdrawn.

If you have additional questions regarding this approval, please contact Michael Toney of my staff at 919-541-5247 or *toney.mike@epa.gov*.

Sincerely,

Steffan M Johnson

Steffan M. Johnson, Group Leader
Measurement Technology Group

cc: Rochelle Boyd, EPA/OAQPS/SPPD
Angelina Brashear, EPA/OAQPS/AQAD
Chuck French, EPA/OAQPS/SPPD
Rafael Sanchez, EPA/OECA
Michael Toney, EPA/OAQPS/AQAD

GUARDIAN

GUARDIAN FIRE TESTING LABORATORIES INC
WWW.FIRETESTING.COM

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CERTIFIÉ EPA
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UL-1482, ULC-S627, ASTM-E-1509

MADE IN USA
FABRIQUÉ AUX ÉTATS-UNIS

MODEL # RMH - 2.0
MODÈLE # RMH - 2.0
DATE OF MANUFACTURE/
DATE DE FABRICATION:

_____

SERIAL/SÉRIE #

_____

UNLESS USING WOOD FUEL PELLETS, DO NOT USE GRATE OR ELEVATE FIRE. BUILD WOOD FIRE DIRECTLY ON HEARTH. PREVENT HOUSE FIRES. INSTALL AND USE ONLY IN ACCORDANCE WITH THE MANUFACTURERS INSTALLATION AND OPERATING INSTRUCTIONS. CONTACT LOCAL BUILDING AND/OR FIRE OFFICIALS ABOUT RESTRICTIONS AND INSTALLATION INSPECTION IN YOUR AREA. INSPECT CHIMNEY CONNECTORS AND CHIMNEY AT LEAST ONCE EVERY TWO MONTHS AND CLEAN WHEN NECESSARY. UNDER CERTAIN CONDITIONS OF USE CREOSOTE BUILDUP MAY OCCUR RAPIDLY. DO NOT CONNECT THE UNIT TO A CHIMNEY FLUE SERVING ANOTHER APPLIANCE. FLOOR PROTECTOR MATERIAL: A NRTL LISTED OR A NON-COMBUSTIBLE MATERIAL WITH A MINIMUM INSULATIVE VALUE OF R-VALUE OF 2.0. DO NOT OVERFIRE – IF HEATER OR CHIMNEY CONNECTOR GLOWS, YOU ARE OVERFIRING. MOBILE HOME APPROVED.

INSTALLATION IN RESIDENTIAL TYPE HOME

USE 6" INCH DIAMETER SINGLE WALL 24 GAUGE MINIMUM BLACK OR BLUED STEEL CHIMNEY CONNECTOR PIPE WITH NRTL LISTED 6" INCH CLASS A HT-103 CHIMNEY SYSTEM OR MASONRY RESIDENTIAL TYPE CHIMNEY. SPECIAL METHODS ARE REQUIRED WHEN PASSING THROUGH A WALL OR CEILING. SEE INSTRUCTIONS AND LOCAL BUILDING CODES. INSTALL AND USE ONLY IN ACCORDANCE WITH THE OWNERS MANUAL.

U.S. ENVIRONMENTAL PROTECTION AGENCY
CERTIFIED TO COMPLY WITH 2020 PARTICULATE EMISSIONS STANDARDS.

CERTIFIED TEST EMISSIONS VALUE: 0.4 G/HR. TESTED USING PELLET FUEL TO ASTM E2779 WITH LIBERATOR RMH2 ATM FOR SINGLE BURN RATE PELLET HEATERS DATE 9/9/21 EPA OAQPS

THIS WOOD HEATER NEEDS PERIODIC INSPECTION AND REPAIR FOR PROPER OPERATION. CONSULT THE OWNER'S MANUAL FOR FURTHER INFORMATION. IT IS AGAINST FEDERAL REGULATIONS TO OPERATE THIS WOOD HEATER IN A MANNER INCONSISTENT WITH THE OPERATING INSTRUCTIONS IN THE OWNERS MANUAL.

À MOINS D'UTILISER DES GRANULÉS DE BOIS, N'UTILISEZ PAS DE GRILLE ET NE FAITES PAS DE FEU SURÉLEVÉ. CONSTRUISEZ UN FEU DE BOIS DIRECTEMENT SUR LE FOYER. PRÉVENEZ LES INCENDIES DE MAISON. INSTALLEZ ET UTILISEZ UNIQUEMENT CONFORMÉMENT AUX INSTRUCTIONS D'INSTALLATION ET D'UTILISATION DU FABRICANT. COMMUNIQUEZ AVEC LES RESPONSABLES LOCAUX DES BÂTIMENTS ET/OU DES INCENDIES AU SUJET DES RESTRICTIONS ET DE L'INSPECTION DES INSTALLATIONS DANS VOTRE RÉGION. INSPECTEZ LES CONNECTEURS DE CHEMINÉE ET LA CHEMINÉE AU MOINS UNE FOIS TOUS LES DEUX MOIS ET NETTOYEZ SI NÉCESSAIRE. DANS CERTAINES CONDITIONS D'UTILISATION, L'ACCUMULATION DE CRÉOSOTE PEUT SE PRODUIRE RAPIDEMENT. NE CONNECTEZ PAS L'APPAREIL À UN CONDUIT DE CHEMINÉE DESSERVANT UN AUTRE APPAREIL. MATÉRIAU PROTECTEUR DE SOL: UN MATÉRIAU RÉPERTORIÉ NRTL OU UN MATÉRIAU INCOMBUSTIBLE AVEC UNE VALEUR ISOLANTE MINIMALE DE R-VALUE DE 2,0. NE TIREZ PAS TROP – SI LE RADIATEUR OU LE CONNECTEUR DE CHEMINÉE BRILLE, VOUS ÊTES EN SURCHAUFFE.APPROUVÉ POUR LES MAISONS MOBILES.

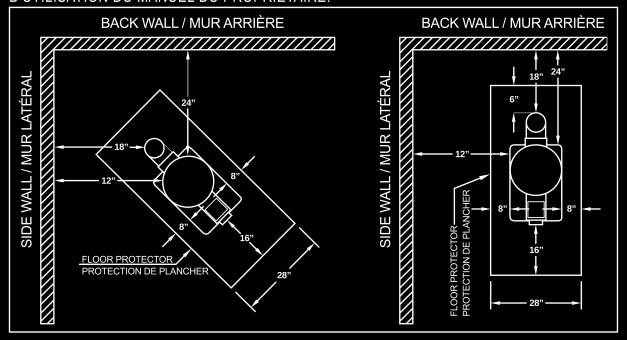
INSTALLATION DANS UNE MAISON DE TYPE RÉSIDENTIEL

UTILISEZ UN TUYAU DE RACCORDEMENT DE CHEMINÉE EN ACIER NOIR OU BLEU DE 6 POUCES DE DIAMÈTRE MINIMUM DE CALIBRE 24 AVEC UN SYSTÈME DE CHEMINÉE HT-103 DE CLASSE A DE 6 POUCES RÉPERTORIÉ NRTL OU UNE CHEMINÉE DE TYPE RÉSIDENTIEL EN MAÇONNERIE. DES MÉTHODES SPÉCIALES SONT NÉCESSAIRES LORS DU PASSAGE À TRAVERS UN MUR OU UN PLAFOND. VOIR LES INSTRUCTIONS ET LES CODES DU BÂTIMENT.

AGENCE AMÉRICAINE DE PROTECTION DE L'ENVIRONNEMENT
CERTIFIÉ CONFORME AUX NORMES D'ÉMISSION DE PARTICULES 2020.

VALEUR D'ÉMISSION D'ESSAI CERTIFIÉE : 0,4 g/h. TESTÉ EN UTILISANT DU COMBUSTIBLE À GRANULES SELON ASTM E2779 AVEC LIBERATOR RMH2 ATM POUR LES CHAUFFAGES À GRANULES À UN SEUL TAUX DE COMBUSTION DATE 9/9/21 EPA OAQPS

CE POÊLE À BOIS A BESOIN D'UNE INSPECTION ET D'UNE RÉPARATION PÉRIODIQUES POUR UN FONCTIONNEMENT CORRECT. CONSULTEZ LE MANUEL DU PROPRIÉTAIRE POUR PLUS D'INFORMATIONS. IL EST CONTRE LES RÈGLEMENTS FÉDÉRAUX D'UTILISER CE POÊLE À BOIS D'UNE MANIÈRE INCONFORME AUX INSTRUCTIONS D'UTILISATION DU MANUEL DU PROPRIÉTAIRE.



SIDE WALL TO UNIT	12" (305 mm)	PAROI LATÉRALE À L'UNITÉ	305 mm (12")
BACK WALL TO UNIT	24" (610 mm)	MUR ARRIÈRE À L'UNITÉ	610 mm (24")
CORNER WALL TO UNIT	24" (610 mm)	MUR D'ANGLE À L'UNITÉ	610 mm (24")
SIDE WALL TO CONNECTOR	18" (457 mm)	PAROI LATÉRALE AU CONNECTEUR	457 mm (18")
BACK WALL TO CONNECTOR	18" (457 mm)	MUR ARRIÈRE AU CONNECTEUR	457 mm (18")
CORNER WALL TO CONNECTOR	18" (457 mm)	MUR D'ANGLE AU CONNECTEUR	457 mm (18")
CEILING TO UNIT	36" (914 mm)	PLAFOND À L'UNITÉ	914 mm (36")
CEILING TO PIPE	16" (406 mm)	DU PLAFOND AU TUYAU	406 mm (16")
IN FRONT OF UNIT	24" (610 mm)	DEVANT L'UNITÉ	610 mm (24")

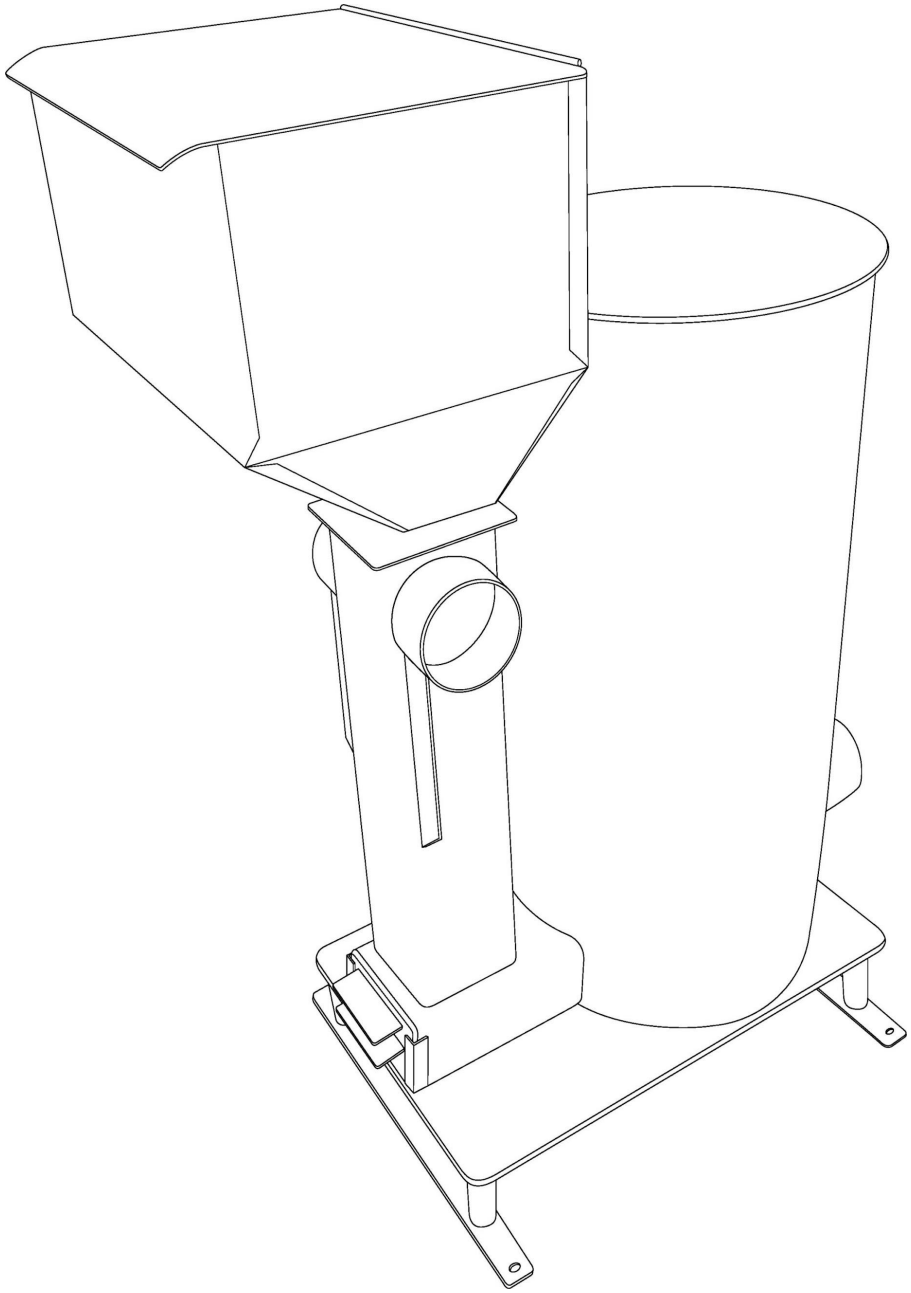
LIBERATOR ROCKET HEATERS
WWW.ROCKETHEATER.COM

OWNERS MANUAL

LIBERATOR ROCKET HEATER

Model: RMH-2

SAVE THIS MANUAL FOR FUTURE REFERENCE



ROCKETHEATER.COM
139 Old Hwy 66, Bourbon MO 65441
(573)-468-4043

Table of Contents

Specifications

Height: 36.5”

Depth: 26”

Width: 20”

Weight: 185 lbs.

Shipping Dimensions (With Pellet Hopper)

Height: 56”

Length: 32”

Width: 24”

Weight: 265 lbs

Liberator Rocket Heater
Warranty

Liberator Rocket Heater warrants to the original consumer of the product the following:

3 years parts (1 year Labor)
-Fuel Feed Tube, Cooktop, Flue Collar Burn Chamber, Ash Cleanout and Door, Air intake Assembly
1 year parts and Labor
-Ceramic Tiles

Conditions

The warranty of the manufacturer extends only to the original consumer purchaser and is not transferable. Proof of purchase (date, bill of sale), model name and serial number must be supplied when making a warranty claim to Liberator Rocket Heater. This warranty covers brand new products only, which have not been altered, modified nor repaired since shipment from factory. This warranty applies to normal residential use only.

Exclusions

-Damages caused by misuse, abuse, improper installation, lack of maintenance, over firing, negligence, accident during transportation, power failures, downdrafts, or venting problems are not covered by this warranty.

-This warranty does not cover any scratch, corrosion, warping, or discoloration caused by over firing, abrasive or chemical cleaners.

-Any deflect or damage caused by the use of unauthorized parts void this warranty.

-An authorized qualified technician must perform the installation in accordance with the instructions supplied with this product and all local and national building codes.

-Any service call related to an improper installation is not covered by this warranty.

The manufacturer may require that defective products be returned or that digital pictures be provided to support the claim. Returned products are to be shipped prepaid to the manufacturer or agent for investigation. If a product is found to be defective, the manufacturer will repair or replace (at the manufacturer's discretion) such defect.

The manufacturer may, at its discretion, fully discharge all obligations with respect to this warranty by refunding the wholesale price of any warranted but defective part(s). The manufacturer shall in no event be responsible for any special, indirect, consequential damages of any nature, which are in excess of the original purchase price of the product.

A one-time replacement limit applies to all parts benefiting from warranty coverage.

Thank you for your purchase of the Liberator Rocket Heater. As you may already know, the Rocket Heater is among the cleanest burning stoves available in the North American market, possessing a HHV ranging from 68.5% to 79.7%, an emissions output of 0.38 to 1.66 grams per hour of solid particulate, 0.02 to 0.37 grams per minute of CO, and combustion efficiency of up to 99.5%. As such, this heater is compliant to EPA 2020 NSPS standards. The tests were conducted by PFS Teco using pellet fuel in accordance with ASTM E2779 with Liberator RMH2 ATM single burn rate pellet heaters dated 09/09/2021 EPA OAQPS. According to independent testing from Aprovecho Research and PFS Teco, the heat output range varies from 27,000 BTU's to 33,000 BTU's per hour. This owners manual will assist you in the proper use, maintenance, installation, and safety precautions to undertake in the heater's operation and installation.

WARNING! READ ALL INSTRUCTIONS CAREFULLY BEFORE USING OR INSTALLING! SAFETY PRECAUTIONS!

-Do not touch the appliance while it is hot, in operation or thereafter. Educate all children of the danger of high temperature appliances and maintain supervision of children at all times when children are in the same room as the appliance.

-As a stand alone Pellet Heater, this appliance is only suitable for burning fuel pellets. Never use flammable liquids, artificial logs containing any petroleum derived products of any kind, or any other fuels not covered in this manual at any time under any circumstances. Plastics, foam material, or any other material not mentioned are never to be used in any way as a fuel or for other purposes with this appliance. Do not burn garbage, lawn clipping or similar yard waste, materials containing plastic, waste petroleum products, paints or paint thinners, asphalt products, materials containing asbestos, construction or demolition debris, railroad ties or pressure treated lumber, manure or animal remains, salt water driftwood or other salt water saturated materials, unseasoned wood, or paper products such as cardboard, plywood, or particleboard. The prohibition of these materials does not prohibit the use of fire starters made from paper, cardboard, saw dust, wax, and similar. Burning prohibited materials may result in the release of toxic fumes or render the heater ineffective and cause smoke.

-Never use gasoline, gasoline-type lantern fuel, kerosene, charcoal lighter fluid or similar liquids to start or 'freshen up' a fire in this heater. Keep all such liquids well away from the heater while it is in use.

-The ash cleanout door must never be opened while in operation.

-Do not install in a sleeping room.

-Ashes must be disposed of only when completely cooled with absolutely no embers, cinders, or other signs of combustion in a metal airtight container and the closed container of ashes should be placed on a non combustible floor or on the ground well away from any combustible materials pending final disposal. If the ashes are to be disposed of by burial in soil or otherwise locally dispersed, they should be retained in the closed container until all cinders have thoroughly cooled.

-Always review the local, state, and federal laws before installing this appliance. If applicable in your area, contact your local building officials to obtain a permit and information on any installation restrictions and inspection requirements in your area. If you have insurance, notify your insurance company and provider.

-This appliance must be properly installed to reduce the chance of house fires. The installation instructions must be adhered to. Never use makeshift methods or materials to install this appliance. It is highly recommended that you hire or consult an accredited expert with experience in wood stoves in this appliance installation.

-This appliance must be connected to an approved or nationally recognized testing laboratory listed chimney or flue pipe specifically designed for wood burning/heating and high temperatures, with a flue no less than 6" inches in diameter. This heater requires an approved masonry or UL or other NRTL listed residential type and building heating appliance chimney. Use a 6" inch diameter chimney that is high enough to give a good draft.

-Creosote – Formation and Need for Removal. When wood burns slowly, it produces tar and other organic vapors, which combine with expelled moisture to form creosote. The creosote vapors condense in the relatively cool chimney flue of a slow-burning fire. As a result, creosote residue accumulates on the flue lining. When ignited this creosote makes an extremely hot fire. The chimney connector and chimney should be inspected at least once every two months during the heating season to determine if a creosote buildup has occurred. If creosote has accumulated it should be removed to reduce the risk of a chimney fire.

-Never vent to another room or inside a building.

-The special paints used on your heater may give off some smoke and fumes that are not safe to breathe while they are curing during the first few fires. If possible, open windows to vent out the fumes for the first three (3) hours of operation, or until the paint is cured.

-Never place clothing or other flammable material on or near this appliance.

-This heater must be connected to an appropriate chimney and vented outside.

-Never overfire this appliance. If any portion of this appliance or the chimney flue glow, and/or reach the point of incandescence, or exceed 800 degrees Fahrenheit (427 degrees Celsius) this appliance is being overfired and action must be taken to eliminate this effect. Generally, if overfiring is occurring the best course of action is to stop feeding fuel in this appliance and turn the flue damper to reduce draft.

-Never connect this unit to a chimney flue serving another appliance.

-Save this manual for future reference.

-To prevent injury, do not allow anyone to use this heater who is unfamiliar with the correct operation of the heater.

-For your safety, we strongly recommend installing both smoke and carbon monoxide detectors throughout the house or structure this appliance is installed in, particularly in the room the heater is installed in, pellet fuel bulk storage areas, and sheds containing flammable materials/fuels. Carbon Monoxide detectors usually necessitate installation at floor level, as CO is denser than ambient atmospheric air.

-Do not connect a wood burning heater to a Type B gas vent. Doing so is not safe and is prohibited by the National Fire Protection Association Code.

-Liberator LLC grants no warranties, implied or stated, for the installation or maintenance of your appliance, and assumes no responsibility for any consequential damage. Safety, damage to property, injury, et cetera, is the sole responsibility of the owner(s) of this appliance.

-This wood heater has a manufacturer-set minimum low burn rate that must not be altered. It is against federal regulation to alter this setting or otherwise operate this wood heater in a manner inconsistent with operating instructions in this manual.

-Attempts to achieve heat output rates that exceed heater design specifications can result in permanent damage to the heater.

-This wood heater needs periodic inspection and repair for proper operation. It is against federal regulations to operate this wood heater in a manner inconsistent with operating instructions in this manual.

-You are the only one who is responsible for your safety, your property, and your actions-
-Caveat Emptor-

This heater is tested and listed to UL-1482, ULC-S627, and ASTM E1509

by Guardian Fire Testing Laboratories.

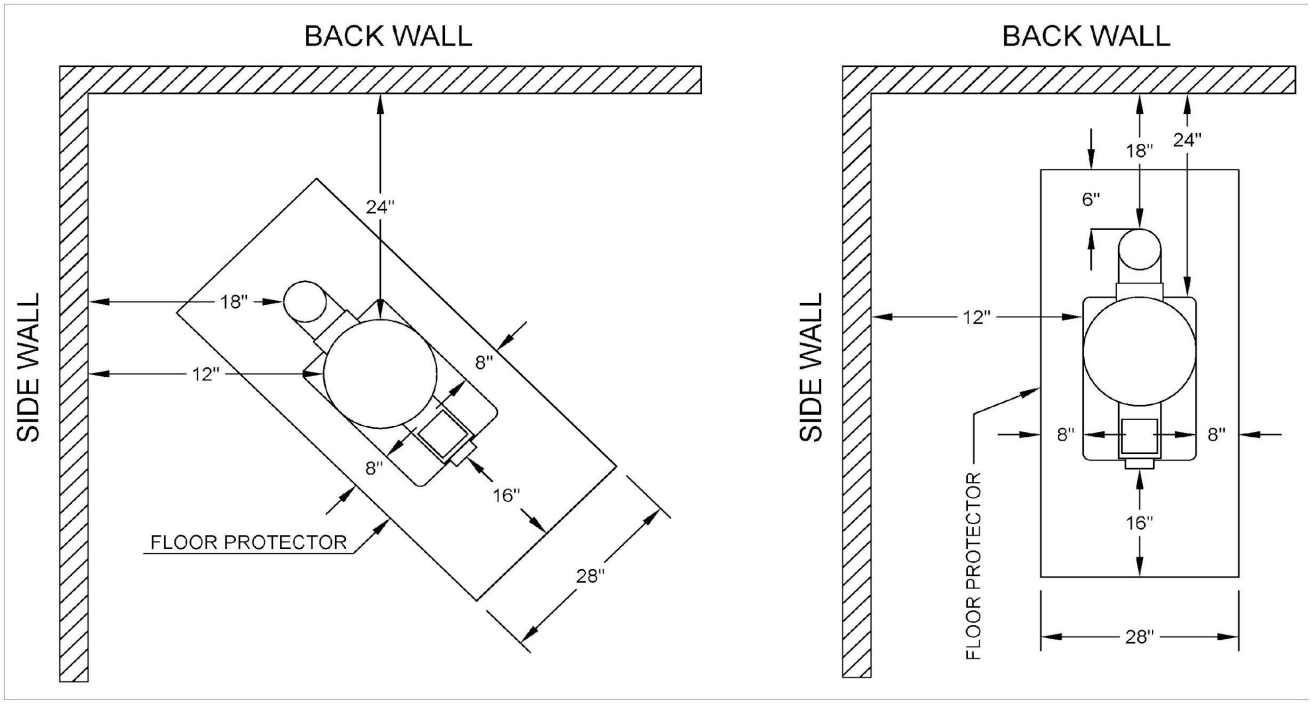
It is a violation of US Federal Code to burn wood in this heater as a standalone wood stove.

SAFETY NOTICE: IF THIS HEATER IS NOT PROPERLY INSTALLED, A HOUSE FIRE MAY RESULT. FOR YOUR SAFETY, FOLLOW THE INSTALLATION DIRECTIONS. CONTACT LOCAL BUILDING OR FIRE OFFICIALS ABOUT RESTRICTIONS AND INSTALLATION INSPECTION REQUIREMENTS IN YOUR AREA.

Clearances to Walls

Place the heater on solid masonry or solid concrete. When the heater is used on a combustible floor, use an Underwriters Laboratory Listed or equivalent Type 2 floor protector. The floor protector must comply with NRTL Standards. The floor protector should extend at least 16" inches beyond the front of the cleanout door of the heater, 8" inches beyond each side of the door, and at least 6" inches past the back of the chimney pipe. In addition the floor protector should extend under and 2" inches beyond each side of the chimney connector. There must be at least 36" inches from the top of the stove to the ceiling.

1. Install a stovepipe and/or chimney if you do not have one. Only use a cleaned and inspected masonry chimney that is properly lined for wood burning appliances, or a UL or other NRTL Listed chimney designed for wood burning appliances.
2. Place the stove in accordance with the diagrams minimum clearances. Once the stove is connected to the flue pipe and chimney, mechanically lock all joints by using at least three (3) sheet metal screws at each joint. Always install the flue and chimney connectors with the crimped (smaller) end of the joints and elbows pointing down, toward the wood stoves exhaust collar. This to ensure that, in the event of excessive creosote buildup, that creosote will not run or flow onto the outside of the chimney or flue thus creating an external fire hazard.
3. Check the illustrations below for clearances of the heater to the walls. If you have a solid brick, solid stone, concrete or otherwise non-combustible inert wall, then you may place your heater as you wish regarding those surfaces and walls. However, if the wall in question is only faced with brick, stone, metal, and the like then you must consider them as combustible walls.



Chimney Connection

Masonry Chimney

The masonry chimney must comply with UL or equivalent NRTL and NFPA 211 standards and codes. Before using an existing masonry chimney, clean the chimney and inspect the flue liner to be absolutely sure it is safe to use.

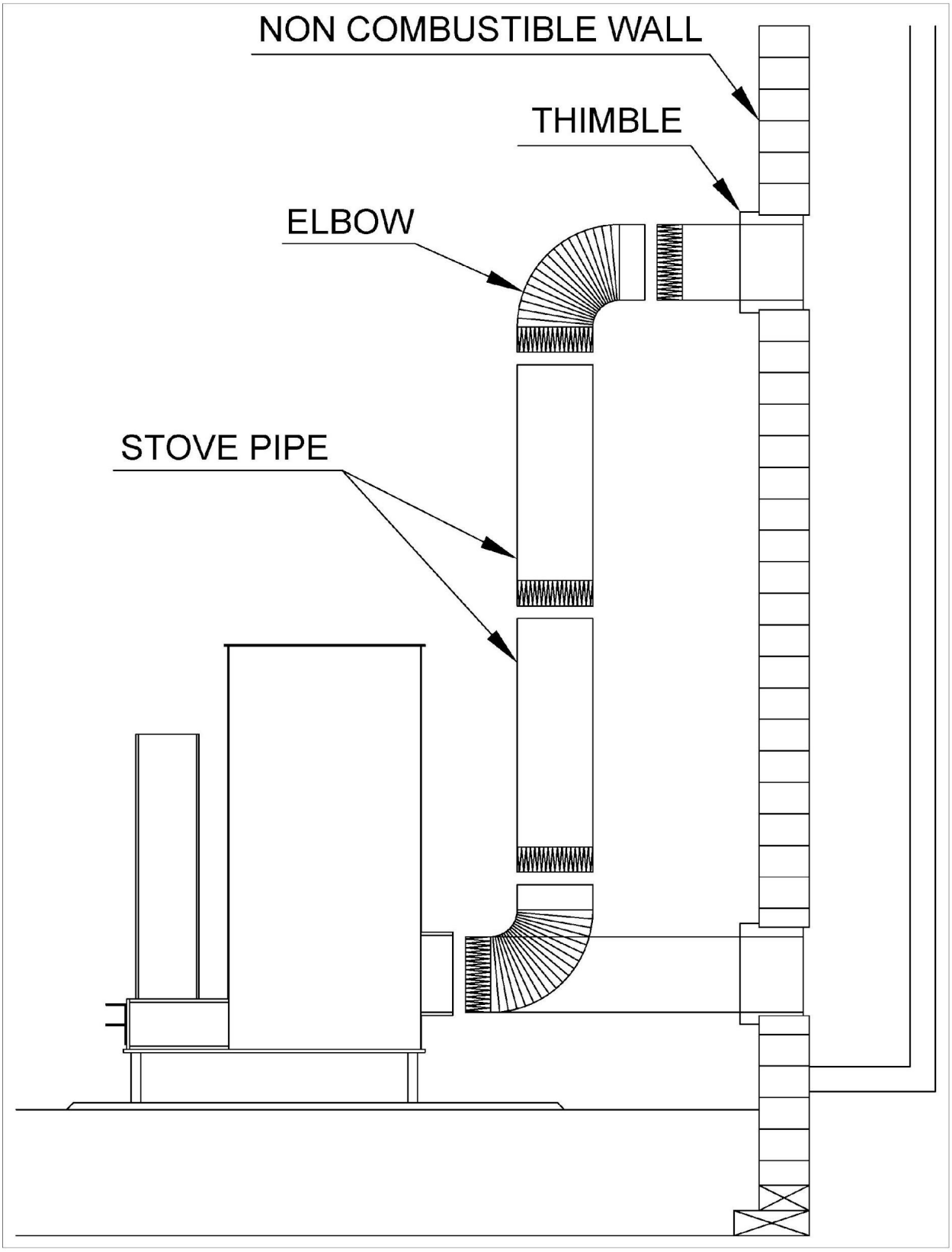
Rules For Connecting To A Masonry Chimney

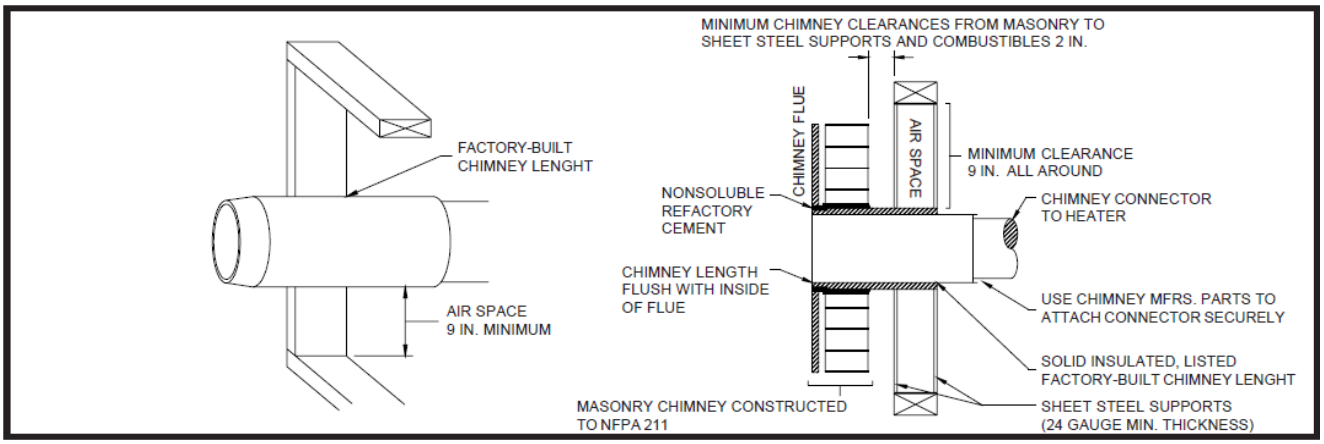
1. Use a minimum of 3-1/2" inch brick masonry wall framed to a combustible wall. A fireclay liner (ASTM 135 or equivalent) having a 5/8" inch minimum wall thickness must be used and it must be at least 12" inches (1' foot) away from any material that could catch fire. The inside diameter of the fire clay liner shall be sized for the proper snug fit to a 6" inch diameter chimney connector pipe. The fireclay liner shall run to, but not beyond, the inner surface of the chimney flue and be firmly cemented in place.
2. Use a solid insulated listed factory built chimney length having an inside diameter of 6" inches and having 1" inch or more of solid insulation. There must be at least a 9" inch air space between the outer wall of the chimney length and any combustible materials. The inner end of the chimney length shall be flush with the inside of the masonry chimney flue which shall be sealed to the flue and to the brick masonry penetration with non water-soluble refractory cement. Flash sheet steel supports which are at least 24 gauge (0.025" inches) in thickness shall be securely fastened to wall surfaces on all sides. Fasteners between supports and the chimney length shall not penetrate the chimney liner.
3. Use a 10" inch diameter ventilated thimble made of at least 24 gauge (0.025" inch) steel having two (2) 1" inch air channels. The ventilated thimble must be separated from combustible materials by at least 6" inches of glass fiber insulation. The opening in the combustible wall shall be covered and the thimble supported with sheet steel supports which are at least 24 gauge (0.025" inch) in thickness. The sheet steel supports shall be securely fastened to wall surfaces on all sides and shall be sized to fit and hold the chimney section. Fasteners used to secure chimney sections shall not penetrate the chimney flue liner.
4. Use an 8" inch diameter solid insulated listed factory-built chimney length which has 1" inch or more solid insulation. The minimum length of the chimney section shall be 12" inches and will serve a pass through for the 6" inch diameter chimney connector. There must be at least a 12" inch air space between the outer wall and the chimney section and any combustible materials. The chimney section shall be concentric with and spaced 1" inch away from the chimney connector by means of sheet steel support plates on both ends of the chimney section. The opening in the combustible wall shall be covered and the chimney section supported on both sides with sheet metal supports which are at least 24 gauge (0.025" inches) in thickness. The sheet steel supports shall be securely fastened to wall surfaces on all sides and shall be sized to fit and hold the chimney section. Features used to secure chimney sections shall not penetrate chimney flue liner.
5. A UL or NRTL listed factory-built wall pass-through system may be purchased and installed according to the instruction supplied with it to provide a safe method of passing the chimney connector through a combustible wall for connection to a masonry chimney.

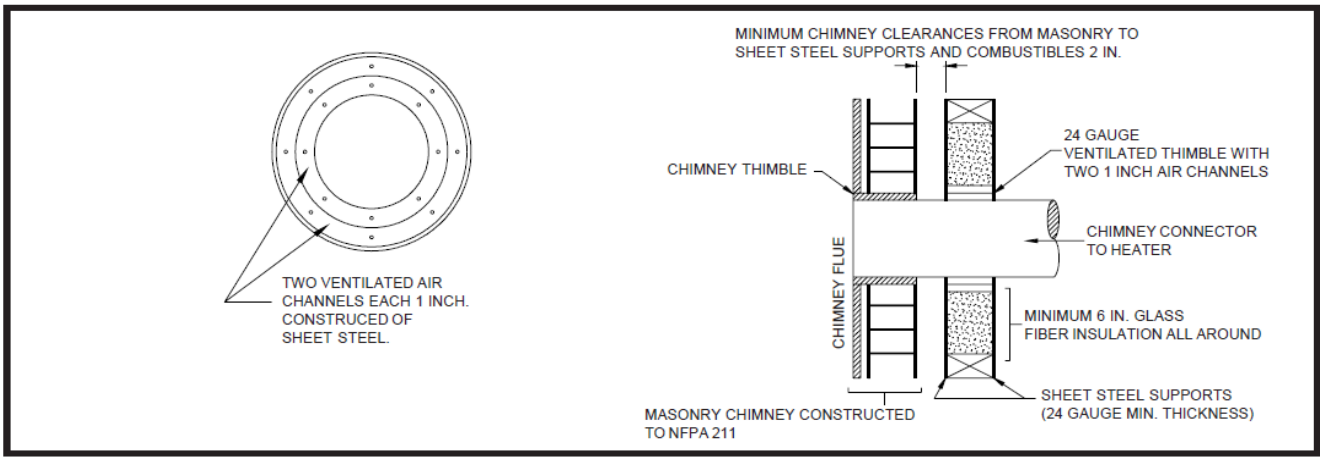
Please See the Following Pages for Diagrammatic Details

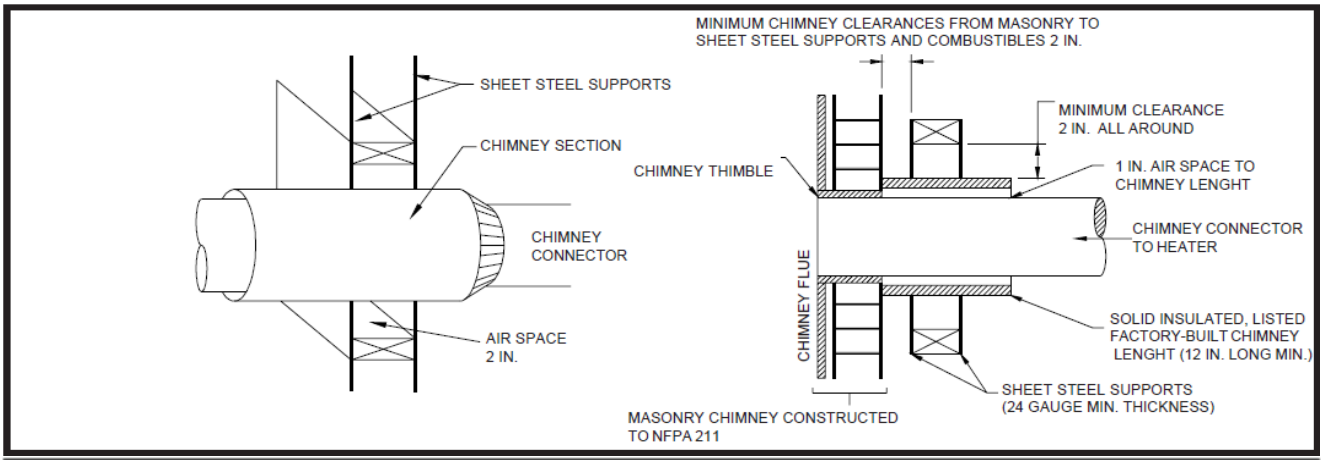
and Clearances for Masonry Chimney Installation

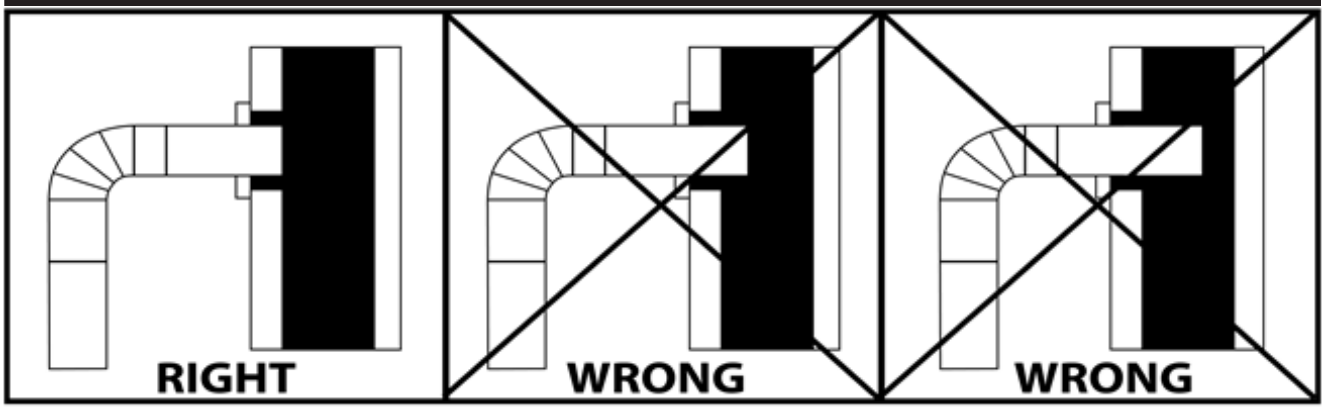
Flue Connection Through a Non-Combustible Wall




FACTORY-BUILT
CHIMNEY LENGHT
AIR SPACE
9 IN. MINIMUM
MINIMUM CHIMNEY CLEARANCES FROM MASONRY TO
SHEET STEEL SUPPORTS AND COMBUSTIBLES 2 IN.
CHIMNEY FLUE
AIR SPACE
MINIMUM CLEARANCE
9 IN. ALL AROUND
NONSOLUBLE
REFACTORY
CEMENT
CHIMNEY CONNECTOR
TO HEATER
CHIMNEY LENGTH
FLUSH WITH INSIDE
OF FLUE
USE CHIMNEY MFRS. PARTS TO
ATTACH CONNECTOR SECURELY
SOLID INSULATED, LISTED
FACTORY-BUILT CHIMNEY LENGHT
MASONRY CHIMNEY CONSTRUCTED
TO NFPA 211
SHEET STEEL SUPPORTS
(24 GAUGE MIN. THICKNESS)


TWO VENTILATED AIR
CHANNELS EACH 1 INCH.
CONSTRUCED OF
SHEET STEEL.
MINIMUM CHIMNEY CLEARANCES FROM MASONRY TO
SHEET STEEL SUPPORTS AND COMBUSTIBLES 2 IN.
CHIMNEY THIMBLE
24 GAUGE
VENTILATED THIMBLE WITH
TWO 1 INCH AIR CHANNELS
CHIMNEY CONNECTOR
TO HEATER
CHIMNEY FLUE
MINIMUM 6 IN. GLASS
FIBER INSULATION ALL AROUND
SHEET STEEL SUPPORTS
(24 GAUGE MIN. THICKNESS)
MASONRY CHIMNEY CONSTRUCTED
TO NFPA 211


SHEET STEEL SUPPORTS
CHIMNEY SECTION
CHIMNEY
CONNECTOR
AIR SPACE
2 IN.
MINIMUM CHIMNEY CLEARANCES FROM MASONRY TO
SHEET STEEL SUPPORTS AND COMBUSTIBLES 2 IN.
MINIMUM CLEARANCE
2 IN. ALL AROUND
CHIMNEY THIMBLE
1 IN. AIR SPACE TO
CHIMNEY LENGHT
CHIMNEY CONNECTOR
TO HEATER
CHIMNEY FLUE
SOLID INSULATED, LISTED
FACTORY-BUILT CHIMNEY
LENGHT (12 IN. LONG MIN.)
SHEET STEEL SUPPORTS
(24 GAUGE MIN. THICKNESS)
MASONRY CHIMNEY CONSTRUCTED
TO NFPA 211


RIGHT
WRONG
WRONG

NRTL Listed (Class A) Chimney

Carefully follow the chimney manufacturers instructions. Use only listed type HT per UL 103, 6" inch diameter black or blued chimney connector with a minimum thickness of no less than 24 gauge. If your chimney starts at the ceiling you will need enough 6" inch pipe to reach the ceiling. The top of the chimney must be at least 3' feet above the roof and be at least 2' feet higher than any point of the roof within 10' feet.

Rules For Connector Pipe Installation

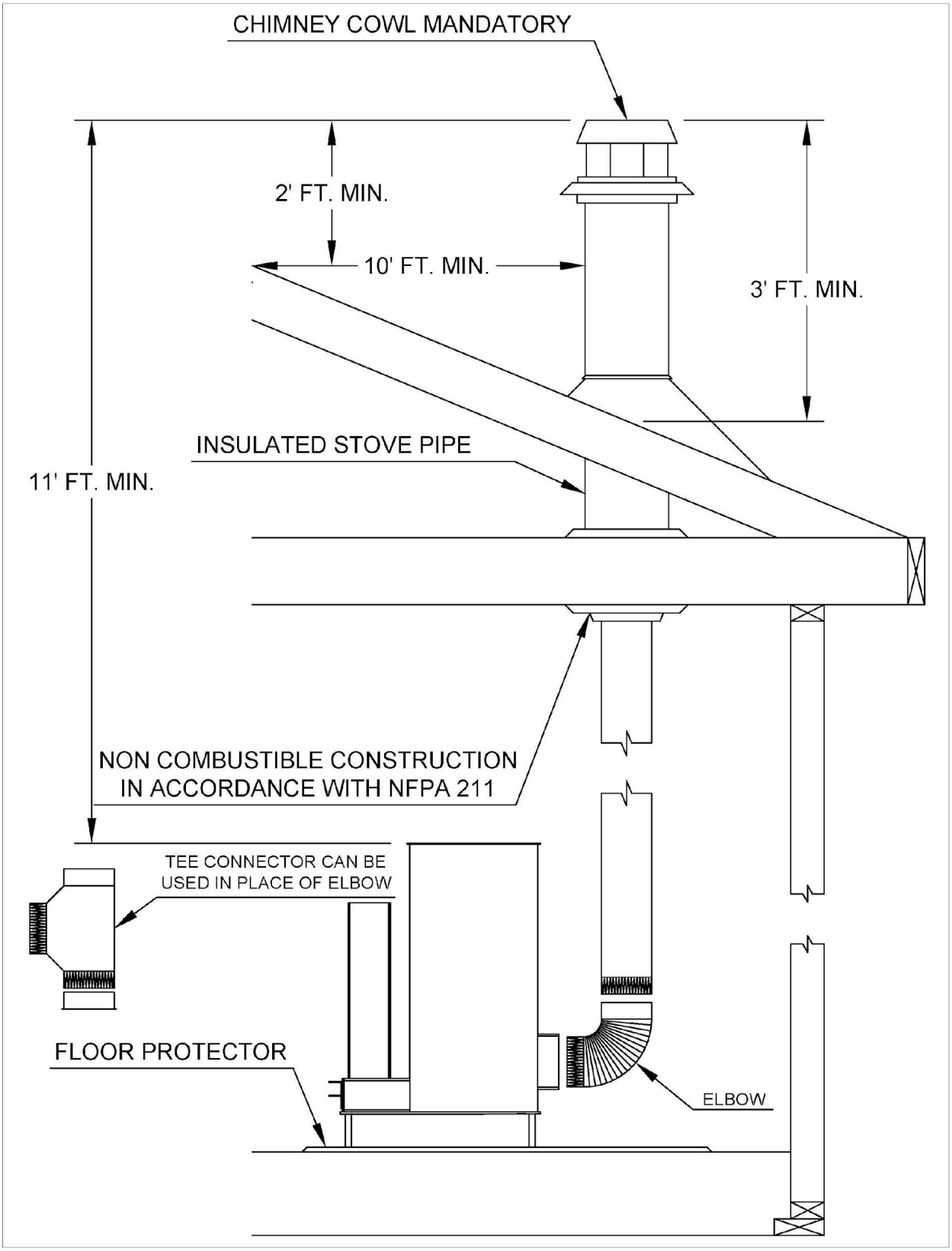
1. Crimped end of the pipe must always be installed towards the heater. The pipe should slide into the flue collar. The pipe should fit firmly inside and be mechanically attached to the flue collar, locked with at least three (3) screws and sealed with furnace cement
2. If you have a pipe running horizontally, the horizontal length can not exceed 12' feet regardless of the height of the chimney. If the chimney is 24' feet or less in height, the height of the chimney must be at least twice the length of the horizontal run.
3. You must have at least 18" inches of clearance between any horizontal piping and the ceiling.
4. Secure any connector pipe joint with at least three (3) sheet metal screws and seal with furnace cement, including the joint(s) at the chimney.
5. It is recommended that not more than four (4) bends of 90 degrees OR any amount of bends regardless of direction exceeding a total of 360 degrees be used in the pipe installation as more than that can cause a decrease in draw and may cause back draft or smoke spillage.
6. The chimney connector shall not pass through an attic, roof space, floor, wall ceiling, or any other similar concealed space. Where passage through a wall or partition of combustible is desired, the installation must conform with NFPA 211.

*It is highly recommended that an insulated double wall pipe is used instead of a triple wall pipe. Though a triple wall pipe can and has been used successfully, in situations where the pipe is exposed outside the structure for long rises (such as a through wall installation) triple wall pipe does not have nearly as effective of a draft as insulated double wall pipe. Triple wall pipe does not insulate the chimney, instead it works via convection of cold air to cool the pipe. Due to the Rocket Heaters low exhaust gas temperatures the cooling effect of triple wall pipes design often prevents proper draft from being established in some installations.

Placement of the heater in a structure can also affect overall efficiency. For example, placing the heater in a main living area or towards the center of a home is typically more efficient than installing a heater in a basement, garage, or an outdoor area. This is because the outer rooms, such as bedrooms and attached garages, act as baffles to hold heated air inside the structure.

Please Go to the Next Page for Diagrammatic Details and Clearances for NRTL Listed Class A Chimney Installation

Through Ceiling Installation

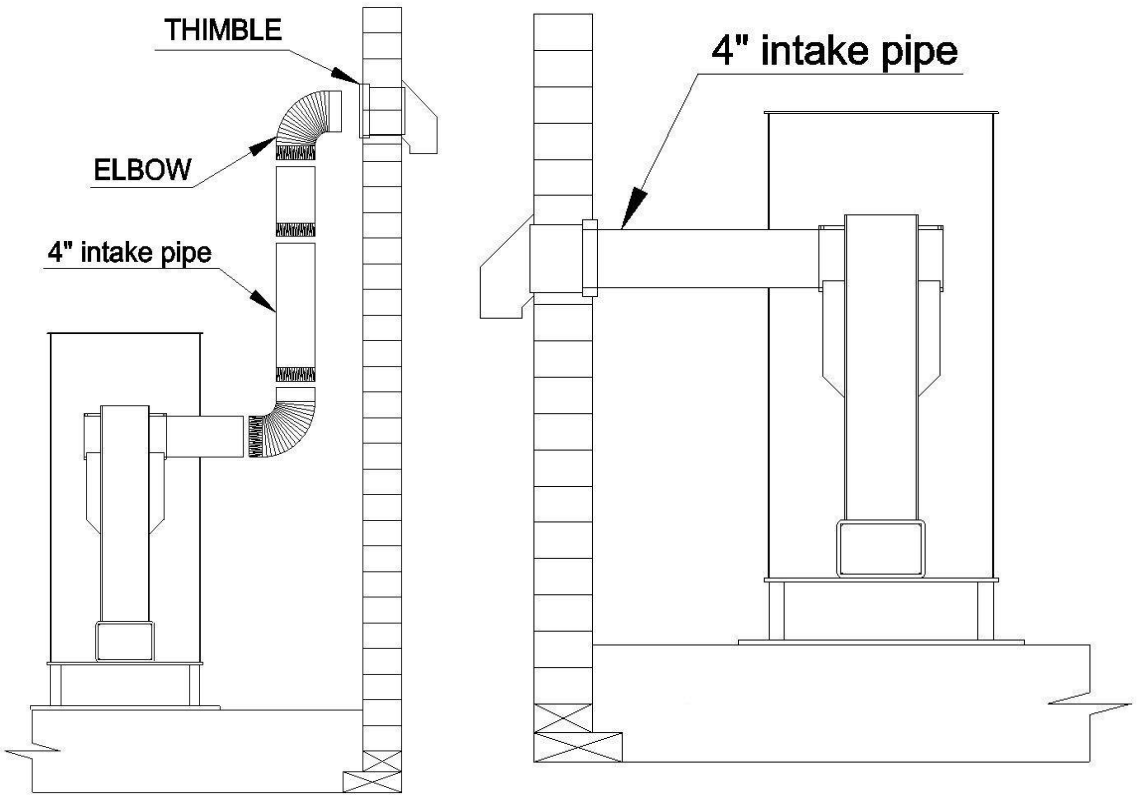


Installation Of Combustion Air Inlet

The Rocket Heater has a 4" combustion air inlet on each side of the fuel feed tube. If the heater is to be installed in a mobile home a combustion air inlet (commonly/alternatively referred to as a "fresh air intake" or "outside air intake") the heater must draw its combustion air from outside the structure via the combustion air inlet. If the heater is being installed in a structure other than a mobile home you can but are not required to install a combustion air inlet. It is recommended that a combustion air inlet be installed as doing so increases the heater's efficiency.

Rules For Installation of Combustion Air Inlet

1. Only one combustion air inlet is used at any given time. The other combustion air inlet must be capped off by inserting a crimped metal pipe cap and secured via sheet metal screws through the two screw holes.
2. When installing the combustion air inlet duct/pipework it is recommended to keep the pipe horizontal with as few bends as possible.
3. If you do use elbow(s), the sum of the angles of intake ductwork bends should not exceed 180 degrees. It is always recommended to keep the bends as gradual as practical. For example: two 45 degree angles are better than a 90 degree angle. No angles at all is almost always preferable.
4. All duct/pipe connections are to be secured with three sheet metal screws at the joints spaced approximately 120 degrees from each other. The only exception is where the intake pipe connects to the combustion air inlet collar. The collar has 2 holes spaced 180 degrees from each other. Secure the pipe to the collar using 2 sheet metal screws through those respective holes.
5. Never use flexible pipe such as dryer vent hose/pipe including (but not limited to) flexible pipes with a reflective/metallic appearance. Only rigid steel pipe is suitable for the air inlet.



Integration of Rocket Heater to Thermal Mass

The Liberator RMH-2.0 can be integrated to thermal mass, which converts it into a masonry heater. The benefits of using thermal mass is a thermal battery/flywheel effect which allows the stove to keep the structure warm without necessitating a continuous 24/7 firing. However, there are many variations of thermal mass integration and each installation is almost inherently a custom designed and built to the customers needs. It is highly recommended that an experienced mason, masonry heater, and rocket mass heater builder be contacted for individual assessment, assistance, and consulation.

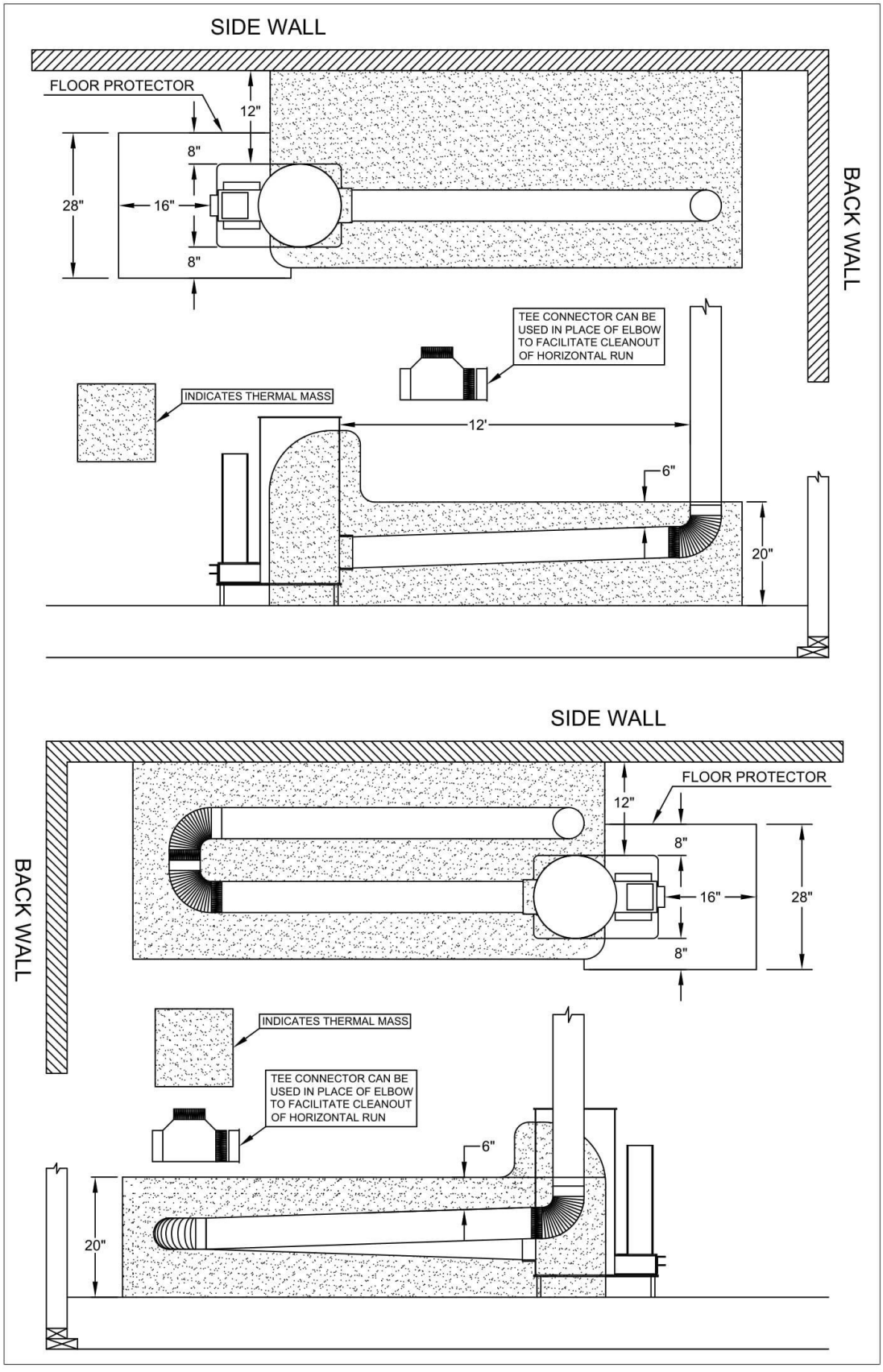
Rules For Integration of Rocket Heater to Thermal Mass

1. Do not encase the burn chamber of the RMH-2.0 with thermal mass.
2. When routing an exhaust pipe horizontally through thermal mass the horizontal section of pipe should have a rise going upwards towards the chimney of at least 3 degrees.
3. All clearances to combustibles guidelines must be adhered to. Thermal mass will not insulate, shield, or protect combustibles from the stove or exhaust pipe.
4. The floor must be capable of supporting the heavy thermal mass. A slab foundation is recommended. Contact a civil engineer if the thermal mass is NOT going to be installed on a slab and reinforce the floor as necessary.
5. The heat exchanging pipe should be at least 6” beneath any surface of the thermal mass.
6. The thermal mass must be made exclusively of non-combustible and non-flammable materials.
7. Do not use corrugated pipe. Keep bends to a minimum. You will still need to install the heater to a chimney as recommended in this manual. Use black stove pipe at least 24 gauge thick, secured by at least 3 screws at the joints. Do NOT route an exhaust vent directly out of the wall. You need a chimney for a proper draft! Use one of the chimney types described in pages 6-11 of this manual.
8. You can use a combustion air inlet when integrating the heater to thermal mass. In fact, we recommend it as it will increase the heater's efficiency.
9. The horizontal length running through the thermal mass can not exceed 12' feet regardless of the height of the chimney. If the chimney is 24' feet or less in height, the height of the chimney must be at least twice the length of the horizontal run.
10. Thermal mass can partially encase the RMH-2.0 directly in addition to encasing the horizontal run of the pipe. However, do NOT cover the cooktop, ash cleanout door, combustion chamber, or the top lid/fuel feed tube with thermal mass.
11. It is highly recommended that you be mindful of cleaning out the heat exchanging pipes and the chimney. Install T-connectors at convenient locations to give yourself access to the inside of the heat exchanging pipes of the thermal mass. Only use elbows in areas where a T-connector would not give you any added accessibility.

It is highly recommended that you consult experienced professionals in the construction of a true Rocket Mass Heater/Masonry Heater. Integrating a rocket heater to thermal mass is inherently a custom job that requires utmost care, consideration, knowledge, experience, and talent to design, construct, and operate. Though every installation and integration to thermal mass is by definition different and unique, on the next page are some example diagrams of some examples of basic installation layouts.

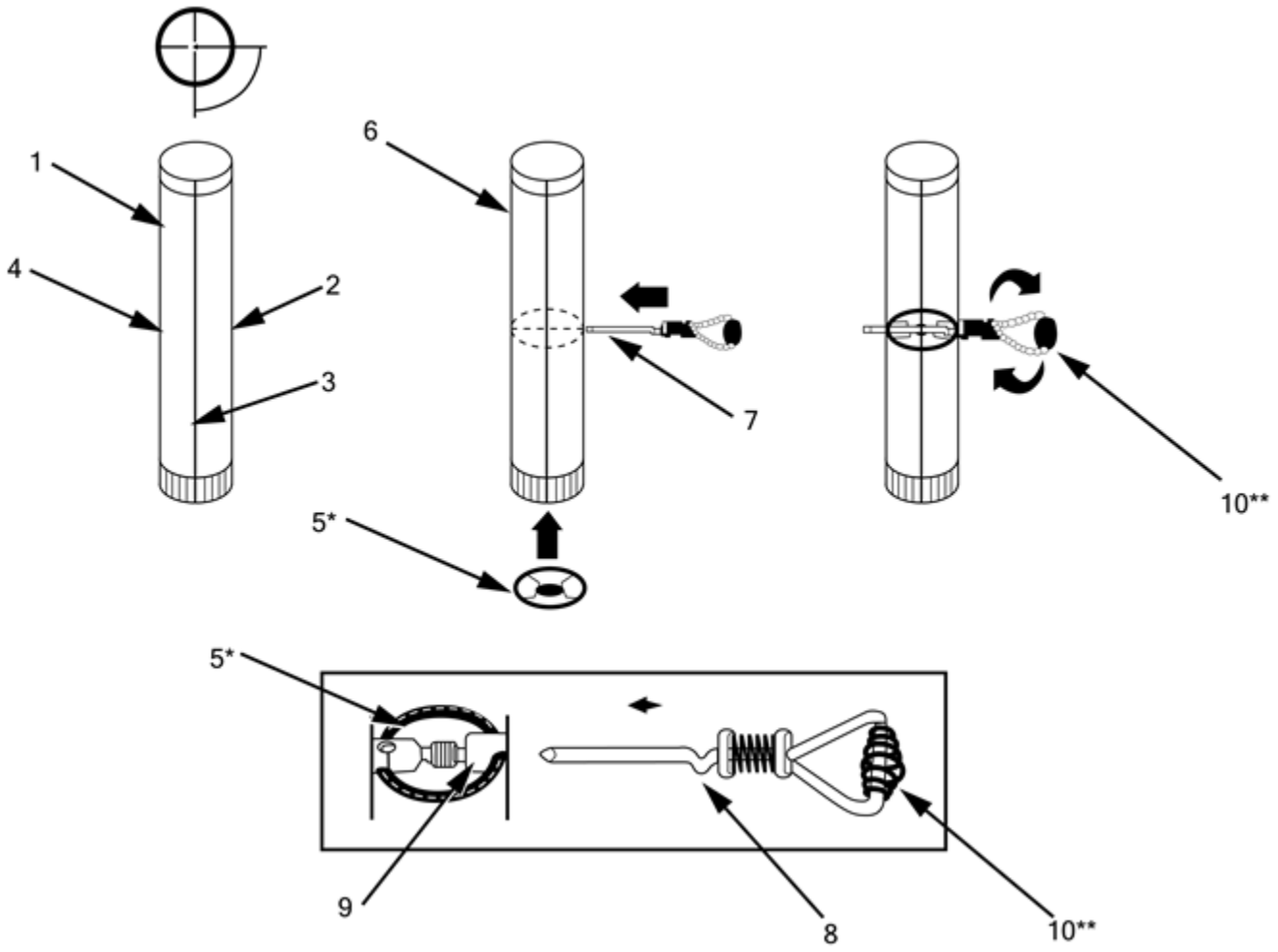
If you decide to integrate thermal mass to the Rocket Heater, RMH-2.0 we highly recommend reading “The Rocket Mass Heater Builder's Guide” by Ernie and Erica Wisner, ISBN: 0865718237 and contacting experienced masonry heater and rocket mass heater builders. The Masonry Heater Association of North America provides more information on masonry heaters and installers in your area.

DIAGRAMMATIC DETAILS FOR THERMAL MASS



Installation and Use of Flue/Chimney Damper

1. To install the flue damper, select one of the assembled sections of pipe (1) and measure its length. Make a mark (2) halfway down the length of the section at a point 90 degrees away from the section seam (3). Make a second mark (4) directly opposite the first mark (2) on the other side of the stack section (1). Drill (or punch) a ¼-inch hole at each mark. After drilling the two holes, insert the flue damper (5) inside the modified section (6) and align the holes passing through the flue damper with the holes drilled in the side of the stack section.
2. Thread the flue damper shaft (7) through the holes, locking the curved shank (8) of the flue damper shaft (7) into the center slot (9) of the flue damper. When properly locked together, the flue damper and operating handle (10) will be parallel.



How to Use Flue/Chimney Damper

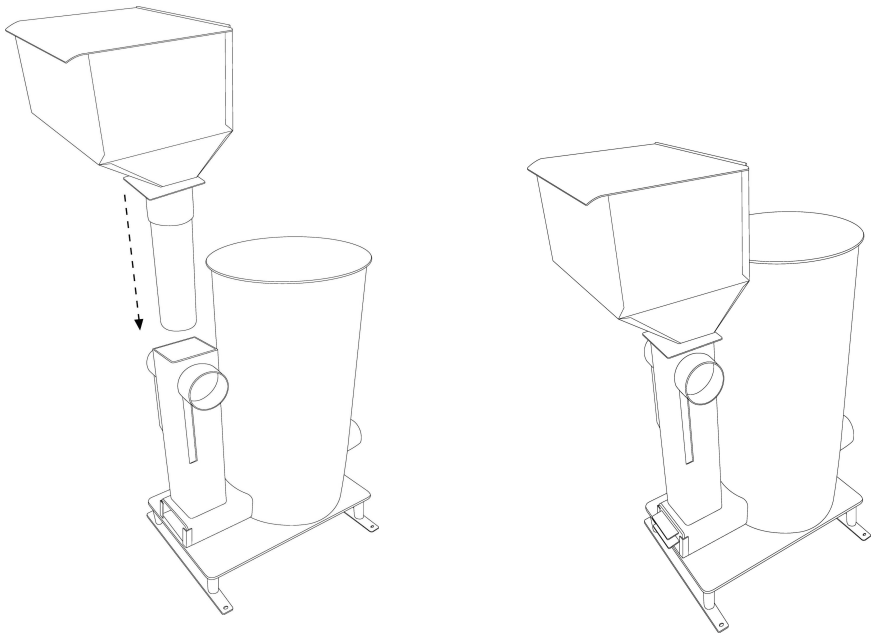
A flue damper must be used responsibly and with caution. When lighting/starting the heater make sure to open the flue damper entirely for maximum draft. When the operating handle (10) is parallel with the vertical rise of the chimney, that is the open position. When it is perpendicular, it is closed. Be sure to first let the heater warm up to its maximum temperature and flow for at least 30 minutes. Then slowly and over a period of at least 10 minutes start to damper the stove. Dampering the stove slowly prevents backdrafting. Make sure the damper is open for the last 30 minutes of run time. Using a damper is especially beneficial in situations where there is too much draft.

Installation Of The Pellet Hopper

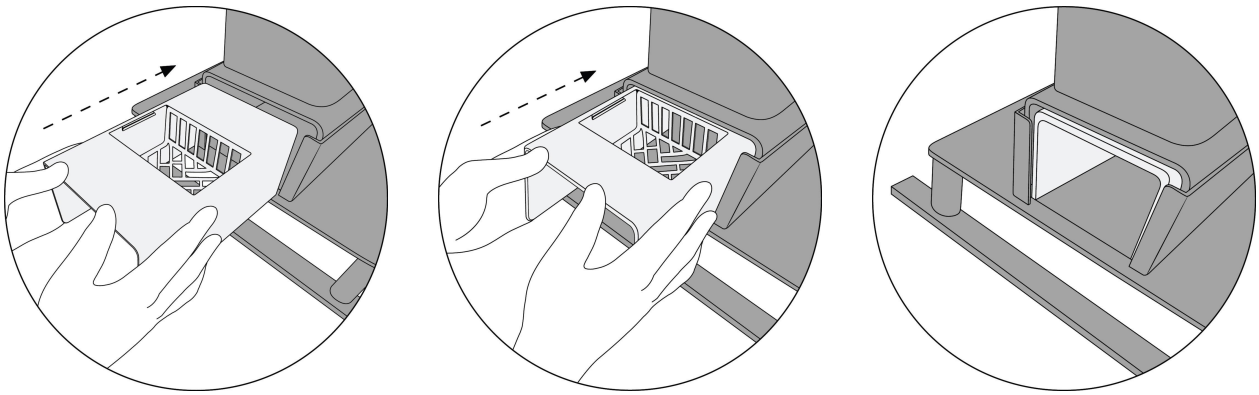
The Pellet Hopper allows the Liberator RMH-2 to burn pellets without electricity, as it is a gravity fed single burn rate system.

Steps to Attach the Pellet Hopper

1. Install the Pellet Feed Tube on to the Pellet Hopper by inserting the tube into the Coupler located on the bottom of the hopper.
2. Tighten the set screw (size 5/16" X 18 TPI) with the provided allen wrench.



3. Place the Pellet Hopper on top of the fuel feed tube of the Rocket Heater. Make sure that the hopper is well seated and centered, and ensure that the pellet hoppers retainers (see next page) are properly set within the tube. Make sure that the hopper always has the lid flip up from the front with the hinge facing towards the back of the heater.

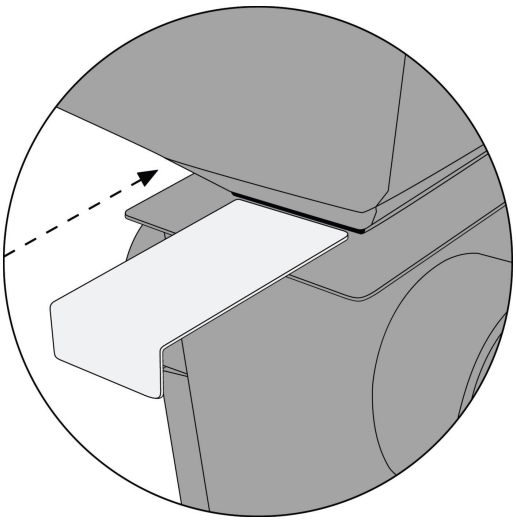


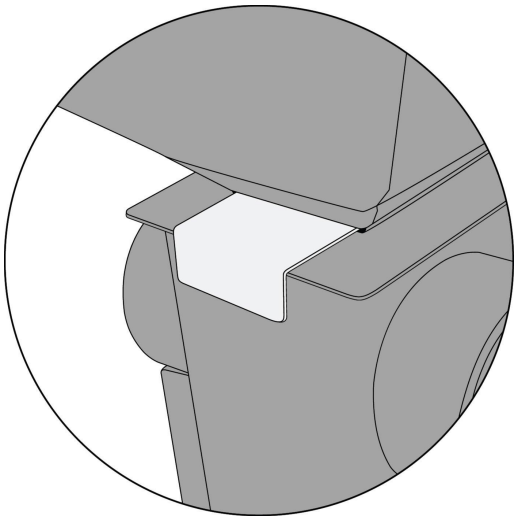
4. Open the ash cleanout door and insert the burn grate until the edge of the metal is within the tube just enough to allow the ash cleanout door to close again, ideally as close to making contact with the ash cleanout door as possible. Check and ensure that the Ash Cleanout Door can be fully closed. Close the door.

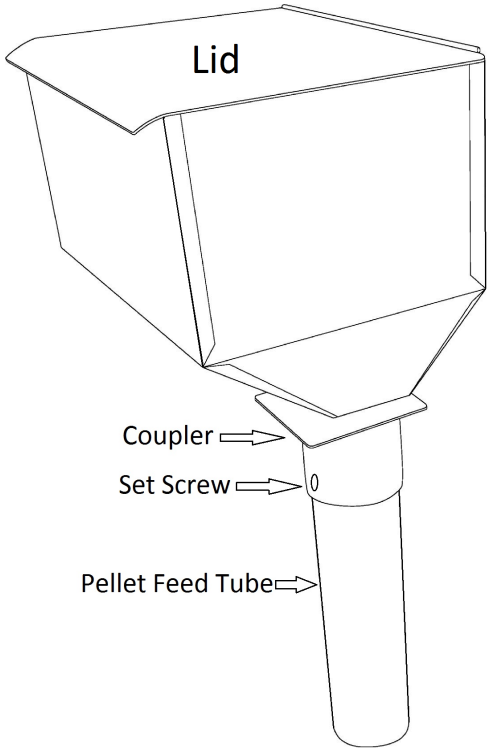
Steps to Start the Heater on Pellets

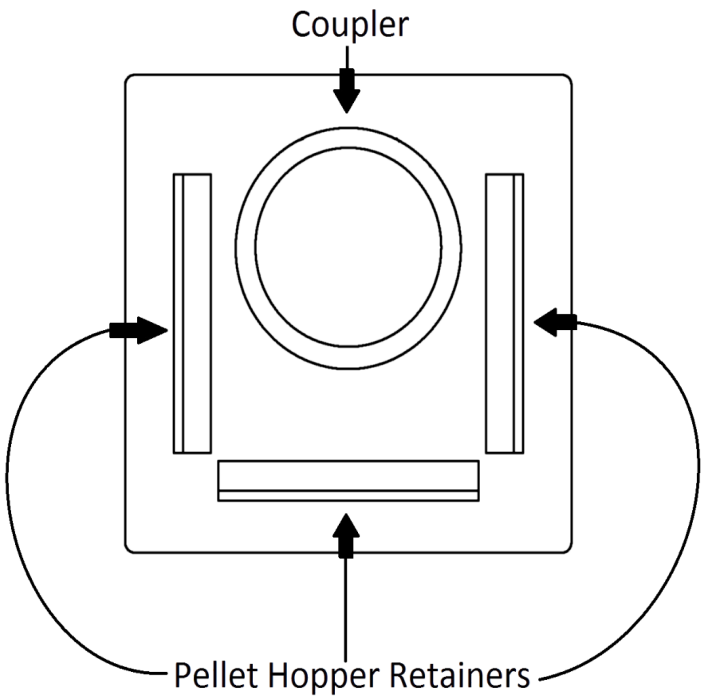
1. Fill the hopper with pellets, then open the Ash Cleanout Door.
2. Use a propane torch to ignite the pellets. Make sure that the torch's flame is making contact with the fuel pellets and use a left to right sweeping motion across the bottom of the burn grate for approximately 25 to 30 seconds or until there is a steady draft.
3. Turn off the torch and place it well away from the heater. Leave the Ash Cleanout Door off for about 1 minute. Then close the ash cleanout door. The stove is now burning pellets.

Shutoff Valve illustrated directly below









Note that there is a Shutoff Valve provided with the Pellet Hopper. This allows you to stop the flow of pellets down the pellet feed tube. The heater will run out of pellets in approximately 30 minutes to an hour from

the time you push in the Shutoff Valve. This is a Shutoff Valve, do not attempt to control the pellet flow or burn rate with the valve.

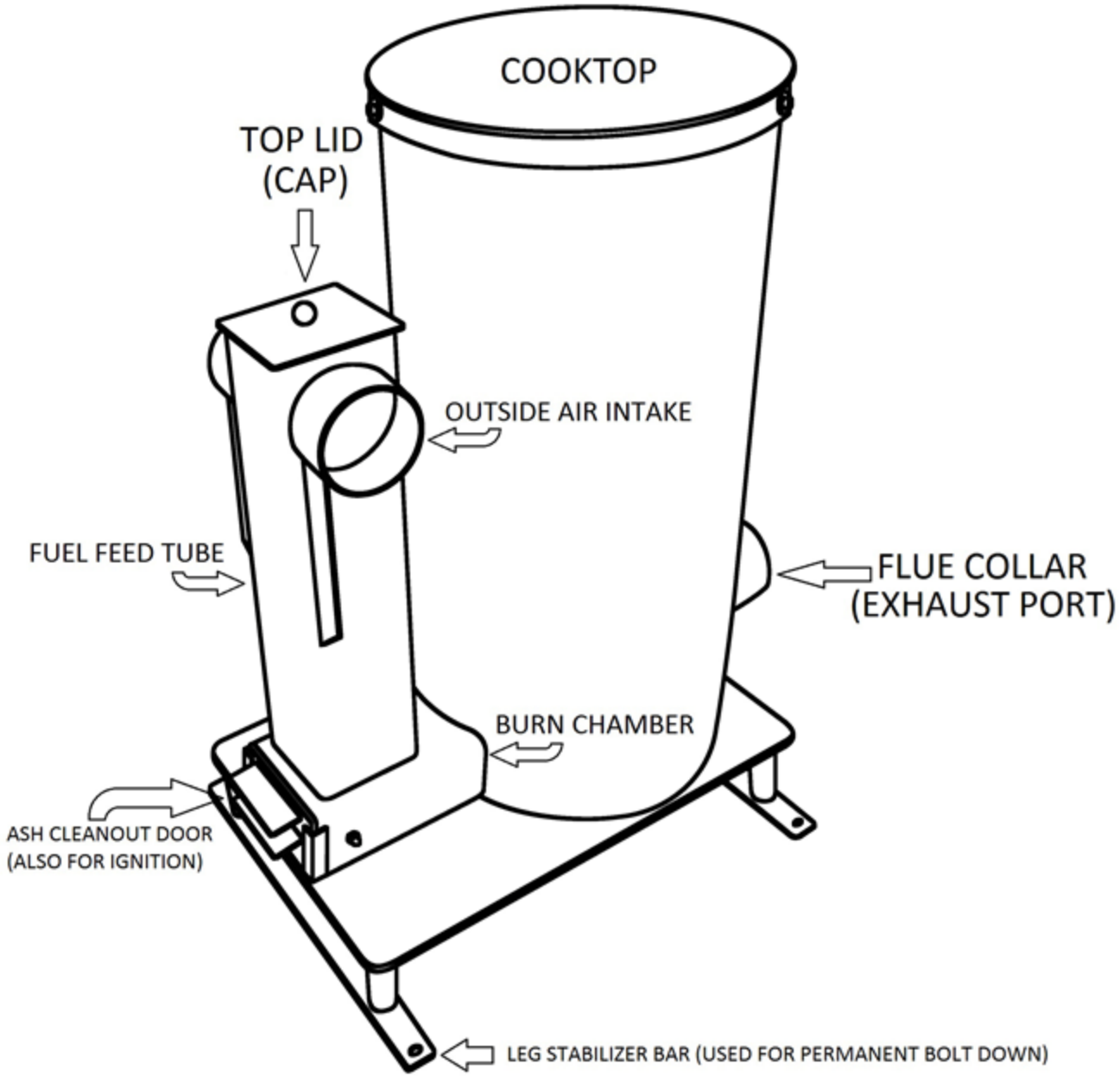
Final Draft Inspection

Draft is the force which moves air from the appliance up through the chimney. The amount of draft in your chimney depends on the height of the chimney, local geography, nearby obstructions, and other factors. To check if your chimney is drafting correctly, open the lighting/cleanout door and put a lit match or cigarette lighter in front of the burn chamber. Then do the same (with the door closed) on top of the fuel feeding area. If the flame is being pulled into the stove it is regarded as safe. If there is no change in the flames direction, the draft is neutral. If the flame is being pushed away, the draft is negative. If the draft is neutral or negative, then you must reinstall the heater with less horizontal run. If you don't have a horizontal run, please call us (the manufacturer) or an expert for further advice. If the draft is too strong, the heater will either overfire and produce too much heat, which can damage the heater, or it can burn fuel seemingly fine but will not get up to the expected temperature/heat output as there is too much excess air that is inducing a cooling effect on the combustion process. In such an event, install a flue damper to reduce draft. Inadequate draft will cause the appliance to leak smoke into the room through appliance and chimney connector joints.

Gasket/Fiberboard Replacement & Maintenance

This wood heater needs periodic inspection and repair for proper operation. It is against federal regulations to operate this wood heater in a manner inconsistent with operating instructions in this manual. The Liberator RMH-2 is lined with ceramic refractory fiberboard to protect the steel, increase efficiency, and increase the longevity of the heater. The refractory fiberboard is held in place by a combination of refractory cement, and mechanical stainless steel fasteners. There are a total of 9 refractory boards, 4 equally sized boards for the internal chimney, each being held in place by 2 stainless steel carriage bolts. The combustion chamber has 5 pieces of fiberboards, the top one being held in place by two stainless steel carriage bolts and the side pieces being held in place via mechanical fixation by two stainless steel elevator bolts. To access the internal chimney, you will need to remove the cooktop by loosening the three set screws that mechanically retain the cooktop on the heater, and then lift the cooktop off the heater. To replace the board, first remove all the old hardware and fiberboard, and thoroughly clean the surfaces of the steel combustion chamber. Apply lines of refractory cement to the new fiberboard, and press them on to the inside of the steel combustion chamber. Drill ¼” holes through the fiberboard, using the holes that are drilled into the steel as a guide. Place the washers on the carriage bolts, and press the bolts through the board and steel combustion chamber from the inside out, clean any debris from the threads of the bolt, lubricate the threads with oil, and tighten the nuts until the heads/washers of the bolts are flush with the refractory fiber board. The elevator bolts do not need washers. Do not overtighten, as that can weaken the mechanical strength of the board.

The cooktop gasket uses ⅝” diameter fiberlgass rope seal. Alternatively, cryostile and/or asbestos may be used if The gasket will need to be replaced if damaged or if sealing ability is lost. Remove the cooktop by loosening the three set screws that mechanically retain the cooktop on the heater. Lift the cooktop off the heater, and remove the gasket using an appropriate tool, and be cautious of any sharp edges. Thoroughly clean the slot that gasket is seated into, and apply a thin bead of refractory cement at the bottom of the gasket slot. When placing the gasket into the slot, ensure to apply a light inward pushing pressure in line with the gasket, this will but the gasket under slight linear compression so as to puff out the gasket orthogonal to its direction as it is pressed into the slot. Do not pull or stretch the gasket as you insert it, as that can compromise the gasket's ability to form a proper seal.



NEVER load fuel from the front door (the one that slides up and down). This door is only for lighting/startup and cleaning. Only load fuel from the top of the pellet hopper, or vertical tube if installed as a masonry heater. Specifically for the event of an emergency or chimney fire, keep a five gallon bucket of sand handy to pour into the fuel chamber. This will limit available oxygen to the chimney fire. Always have a fire extinguisher close by and at the ready. Remember, if the situation at hand could cause personal injury by attempting to close off the air supply, do not attempt to close the air supply, extinguish, or fight the fire. In such situations, evacuate the building, call 911, and let professional firefighters handle the situation. REMEMBER that your safety and the safety of others are of utmost concern and safety is the number one priority in any dangerous situation. Your well being and safety of others nearby in these circumstances should be the only determining factor for any actions to be taken. For more information and advice on fire safety, safety precautions, and what to do in an emergency contact your local fire department and/or the National Fire Protection Association.