Non-Confidential Business Information (Non-CBI)

Certification Test Report

Froling GmBH

Wood-Fired Boiler

Model: S3 Turbo 50

Prepared for:	Froling GmBH Industriestraβe 12 Grieskirchen A-4710 Austria
Prepared by:	OMNI-Test Laboratories, Inc. 13327 NE Airport Way Portland, OR 97230 (503) 643-3788
Test Period:	March 7, 2016 – March 10, 2016
Report Date:	July 2016
Report Number:	0456WB005E

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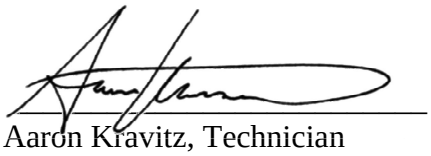
AUTHORIZED SIGNATORIES

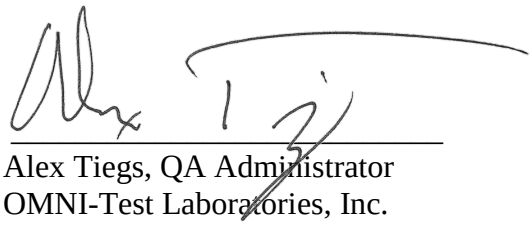
This report has been reviewed and approved by the following authorized signatories:

Technician:



Aaron Kravitz, Technician
OMNI-Test Laboratories, Inc.

QA Review:



Alex Tiegs, QA Administrator
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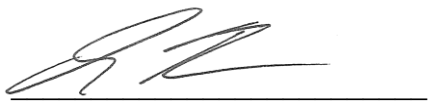
Evaluation Decision:



Sebastian Button, Testing Supervisor
OMNI-Test Laboratories, Inc.

July 21, 2015

Issue Date

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Section 1

Sampling Procedures and Test Results

INTRODUCTION

Froling GmBH retained *OMNI* to perform U.S. Environmental Protection Agency (EPA) certification testing on the S3 Turbo 50 wood-fired boiler. The S3 Turbo 50 boiler is a manually-fueled hydronic heater utilizing a partial thermal storage system. The firebox is constructed of steel. Usable firebox volume was measured to be 6.78 cubic feet and the stove is vented through a 6" flue located at the top of the unit.

The testing was performed at *OMNI's* facility in Portland, Oregon. The altitude of the laboratory is 30 feet above sea level. The unit was received in good condition and logged in on February 26, 2016, then assigned and labeled with *OMNI* ID #2152. *OMNI* representatives Sebastian Button and Aaron Kravitz conducted the certification testing and completed all testing by March 10, 2016.

This report is organized in accordance with the EPA-recommended outline and is summarized in the Table of Contents immediately preceding this section. The results in this report are limited to the item submitted.

SAMPLING PROCEDURE

The S3 Turbo 50 boiler was tested in accordance with the U.S. EPA 40 CFR Part 60, Subpart QQQQ – Standards of Performance for New Residential Wood Heaters using ASTM E2515 and ASTM E2618. Testing proceeded in accordance with requirements for the cordwood alternative compliance option. Additional requirements for use of partial thermal storage systems were also observed. Particulate emissions were measured using sampling trains consisting of two filters (front and back).

The model S3 Turbo 50 was tested for thermal efficiency and carbon monoxide (CO) emissions in accordance with CSA B415.1-10.

SUMMARY OF RESULTS

The S3 Turbo 50 furnace meets 40 CFR 60 Subpart QQQQ Step 2 emissions limit of 0.15 lb/mmBtu heat output for each burn rate, using the cord wood alternative compliance option.

Emissions (lb/mmbtu output)	
Category I	0.142
Category II	0.119
Category II	0.081
Category IV	0.076

The proportionality results for all four test runs were acceptable. Quality check results for each test run are presented in Section 4 of this report.

RUN NARRATIVE

Run 1 was a category 4 maximum output test. The target output rate was the manufacturer's specified rating of 165,000 BTU/hr, but the boiler was operated to produce maximum output with no modulation to operate at a lower firing rate. The partial thermal storage system was partially isolated from the boiler and load loops and acted simply as a pass-through for output heat energy. This test was performed as a hot start in accordance with procedures specified by ASTM 2618-13, Annex A2. All acceptance criteria for a category 4 test were met by this run, so its results are valid.

Run 2 was a category 1 test with a target heat output below 15% of maximum. This test was performed as a cordwood cold start in accordance with the ASTM 2618-13, Annex A2 and the manufacturer's startup instructions. The partial thermal storage system was utilized during this run to absorb excess heat energy not absorbed by the load. All acceptance criteria for a category 1 test were met by this run, so its results are valid.

Run 3 was a category 2 test with a target heat output below 25% of maximum. This test was performed as a cordwood cold start in accordance with the ASTM 2618-13, Annex A2 and the manufacturer's startup instructions. The partial thermal storage system was utilized during this run to absorb excess heat energy not absorbed by the load. All acceptance criteria for a category 2 test were met by this run, so its results are valid.

Run 4 was a category 3 test with a target heat output below 50% of maximum. This test was performed as a hot start in accordance with procedures specified by ASTM 2618-13, Annex A2. The partial thermal storage system was utilized during this run to absorb excess heat energy not absorbed by the load. All acceptance criteria for a category 3 test were met by this run, so its results are valid.

Table 1 – Particulate Emissions & Delivered Heat Output

Run	**Heat Input** (BTU/hr)	**Delivered Efficiency** (%)	**Delivered Heat Output*** (BTU/hr)	**ASTM E2515 Emissions** (g/hr)	**Emissions Rate (**lb/mmBtu Output)
1	207,042	82.2	170,204	5.9	0.076
2	169,988	67.8	116,843	7.5	0.142
3	177,532	67.9	120,539	6.5	0.119
4	194,011	83.5	161,958	5.9	0.081

*Represents total heat output to system including load water, appliance steel and water, and storage system steel and water

Table 2 – Burn Rate Categories

Run	**Burn Rate Category**	**Load Heat Output*** (BTU/hr)	**Load Percentage** (% of Max)
1	IV	166,194	100.0
2	I	22,882	13.8
3	II	36,681	22.1
4	III	76,317	45.9

*Represents heat output to load water only

Table 3 – Particulate Emissions (First Hour)

Run	**ASTM E2515 Emissions – First Hour** (g/hr)
1	3.5
2	12.2*
3	6.8*
4	4.8

*cold start test runs

Table 4 – B415.1 Efficiency and CO Emissions

Run	Heat Output (BTU/hr)	HHV Efficiency (%)	LHV Efficiency (%)	CO Emissions (g/MJ Output)	CO Emissions (g/kg Dry Fuel)	CO Emissions (g/hr)
1	167,387	80.7	86.9	0.61	9.77	106.8
2	138,140	80.7	86.9	1.69	27.23	245.6
3	140,387	79.0	85.0	2.33	36.78	344.6
4	157,157	80.9	87.1	0.29	4.68	47.9

Table 5 – Test Facility Conditions

Run	Room Temperature (°F)		Barometric Pressure (Hg)		Air Velocity (ft/min)	
	Before	After	Before	After	Before	After
1	68	66	30.00	30.02	<50	<50
2	68	69	30.00	30.03	<50	<50
3	66	69	29.80	29.84	<50	<50
4	67	66	29.94	29.98	<50	<50

Table 6 – Startup Procedures

Run	Five-Minute Startup Procedures
1	Fuel Loading: Done by 0:50 Door: Closed by 1:00 Notes: Hot start test.
2	Ignition Complete: By 3:00 Door: Closed at 4:30 Notes: Cold start test with propane torch and 2 newspaper broadsheets.
3	Ignition Complete: By 2:00 Door: Closed at 3:20 Notes: Cold start test with propane torch and 2 newspaper broadsheets.
4	Fuel Loading: Done by 0:40 Door: Closed by 0:50 Notes: Hot start test.

Table 7.1 – Fuel Measurement and Load Description Summary – Hot Start Tests

Run	**Test Fuel Wet Basis** (lbs)	**Fuel Loading Density Wet Basis** (lbs/ft^3)	**Test Fuel Dry Basis** (lbs)	**Pieces in 80% Range**	**Pieces out of 80% Range**
1	68.1	10.0	55.4	8	1
4	68.0	10.0	54.9	7	2

Table 7.2 – Fuel Measurement and Load Description Summary – Cold Start Tests

Run	**Test Fuel Wet Basis** (lbs)	**Kindling Wet Basis** (lbs)	**Start up Wet Basis** (lbs)	**Loading Density Wet Basis** (lbs/ft^3)	**Test Fuel Dry Basis** (lbs)	**Pieces in 60% Range**	**Pieces out of 80% Range**
2	60.2	4.5	6.6	10.5	58.0	8	1
3	61.3	5.7	6.7	10.9	60.2	6	3

Table 8 – Dilution Tunnel Gas Measurements and Sampling Data Summary

Run	**Length of Test** (min)	**Average Dilution Tunnel Gas Measurements**		
		Velocity (ft/sec)	**Flow Rate** (dscf/min)	**Temperature** (°F)
1	138	10.10	434.4	108
2	175	9.52	417.4	97
3	175	10.08	438.6	98
4	146	9.74	421.2	104

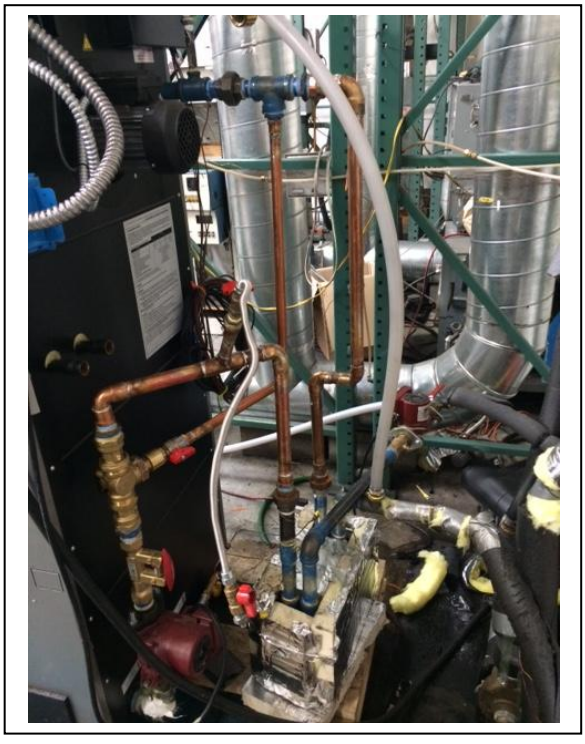
Section 2

Photographs/Appliance Description/Drawings

Froling GmBH

S3 Turbo 50

Test Dates: 3/7/2016 – 3/10/2016



Froling GmBH
S3 Turbo 50

Run 1 – Fuel

Run 1 – Newly Loaded Boiler

Run 2 – Fuel

Run 2 – Newly Loaded Boiler

Froling GmBH
S3 Turbo 50

Run 3 – Fuel

Run 3 – Newly Loaded Boiler

Run 4 – Fuel

Run 4 – Newly Loaded Boiler

WOOD HEATER DESCRIPTION

The S3 Turbo 50 is a wood fired indoor boiler/hydronic heater. It is designed to heat and circulate water in a closed loop, supplying energy to an existing system. Its heavy gauge stainless steel structure consists of a large, roughly rectangular firebox surrounded by a water jacket with an integrated heat exchanger. The water jacket and associated plumbing is designed to operate at a pressure of 15 psi. The unit is well insulated and protected by an outer sheet metal skin.

Combustion air is regulated by a blower, and flue gasses are routed through the heat exchanger and exit through a 6" flue opening at the top of the unit. The S3 Turbo 50 responds to heat demand using an advanced computerized control system. This control system monitors water temperatures within the boiler, water temperatures in the storage tanks, flue temperatures, and flue gas oxygen content. Based on these parameters in varies circulation pump operation, combustion fan speed, and primary and secondary air intake openings.

The manufacturer requires several additional plumbing features. Primarily, a partial thermal storage system is specified, with a minimum capacity of 600 gallons. This system is documented thoroughly in the following pages. Also required is an automatically actuated recirculation valve that prevents boiler water inlet temperature from dropping below a minimum value.

The firebox of the S3 Turbo 50 is approximately 22" deep, 17" wide, and 32" high. Firebox volume is 6.78 ft^3. The dry weight of the unit is 1814 lb and the approximate capacity of the water jacket is 50 gallons.

WOOD HEATER OPERATING INSTRUCTIONS

Specific Written Instructions: See Section 5 of this report. All markings and instruction materials were reviewed for content prior to printing.

PARTIAL THERMAL STORAGE SYSTEM DESCRIPTION

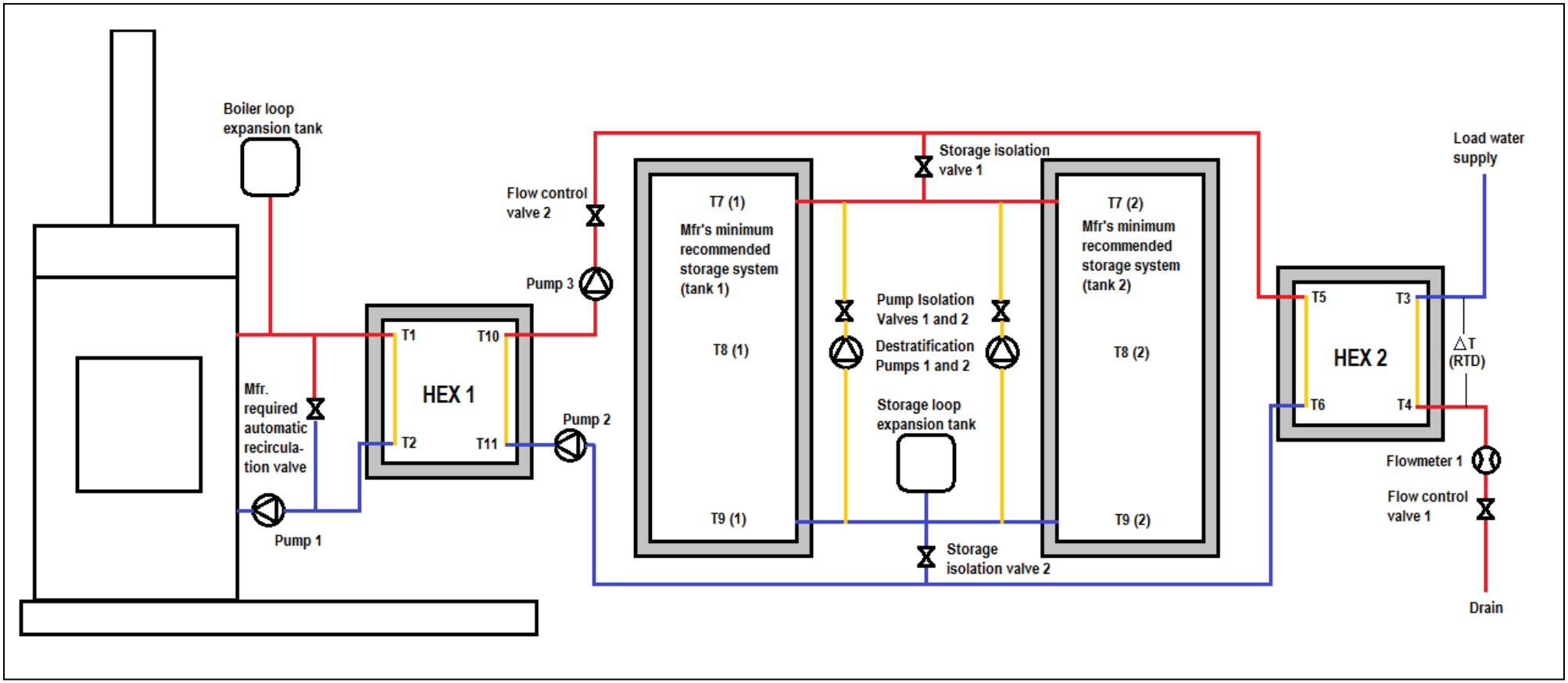
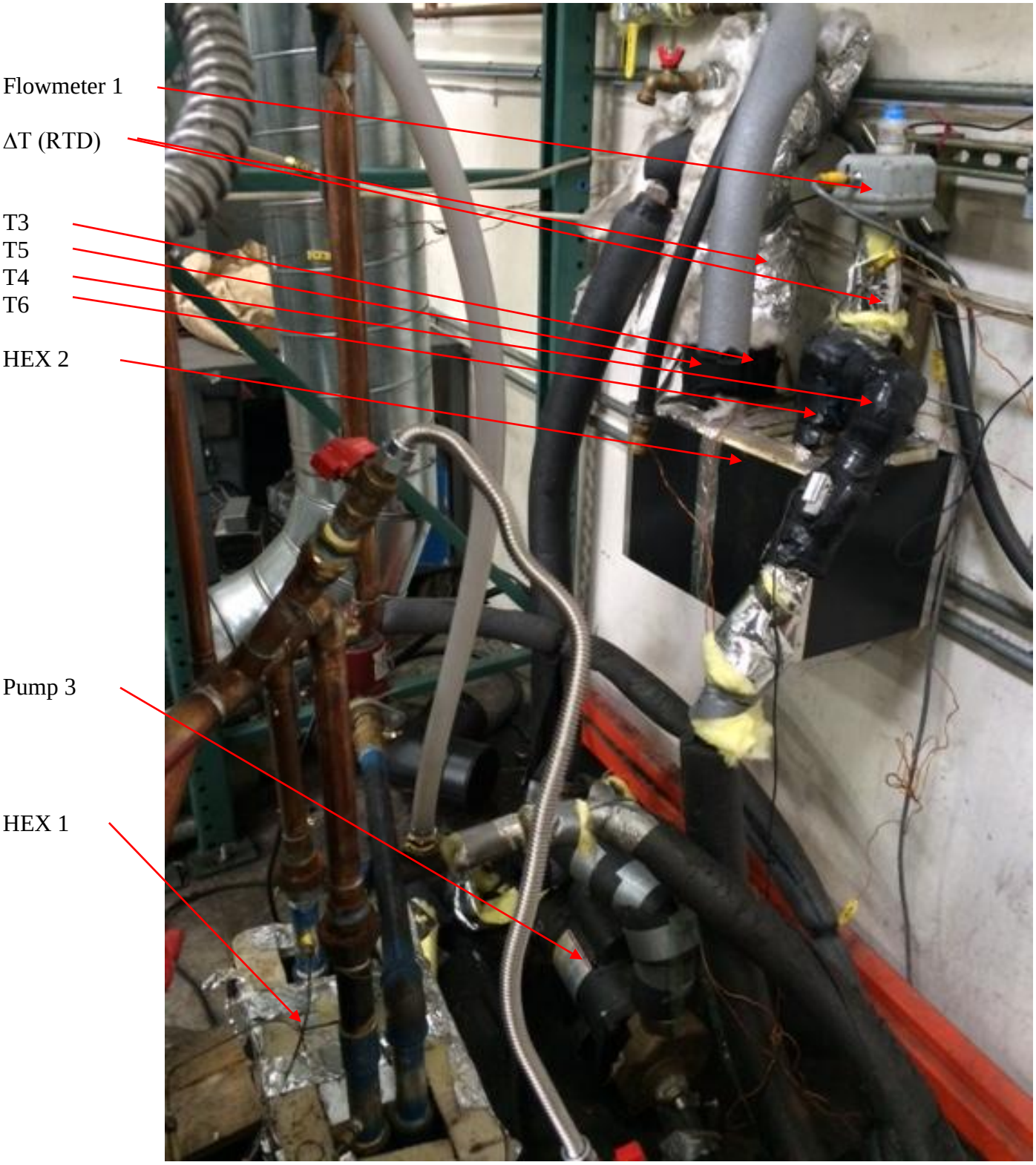
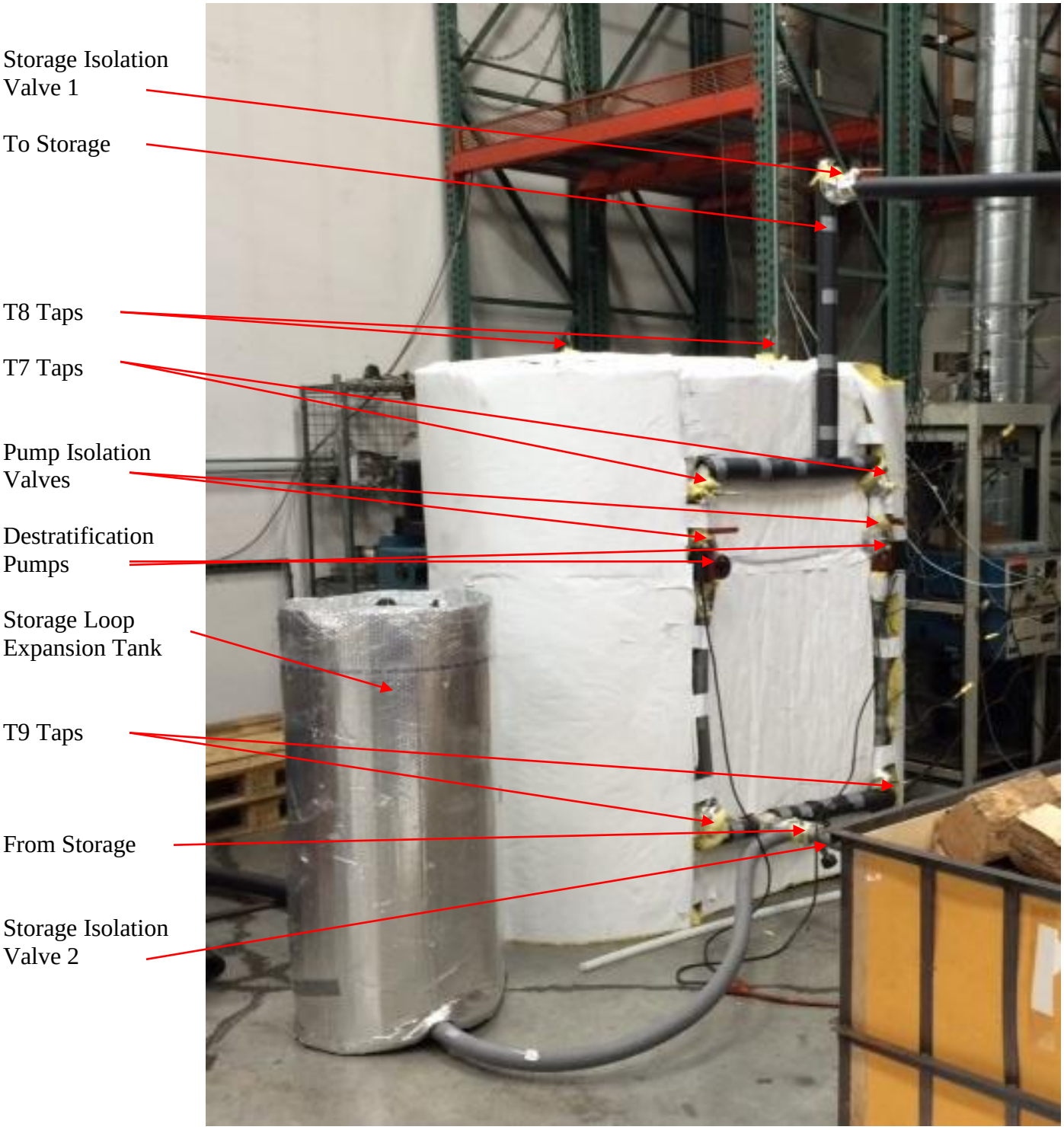


Diagram shows the principle elements of the partial thermal storage system conforming to the Manufacturer's written instructions and the requirements of ASTM E2618. This arrangement was used for all four test runs.

To Storage
Pump 2
From Storage
Mfgr. Required Recirculation
T1
T11
HEX 1
T2
T10
Pump 3
Pump 1


Flowmeter 1
ΔT (RTD)
T3
T5
T4
T6
HEX 2
Pump 3
HEX 1


Storage Isolation Valve 1
To Storage
T8 Taps
T7 Taps
Pump Isolation Valves
Destratification Pumps
Storage Loop Expansion Tank
T9 Taps
From Storage
Storage Isolation Valve 2

Section 3

Test Data by Run

(Note – Some of the run notes incorrectly indicate the model name of the tested appliance as the "S3 Large", the official model name for the tested appliance is the "S3 Turbo 50" as indicated on the cover page of this report.)

Run 1

Hydronic Heating Appliances - Test Methods ASTM E2515-11 & E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Run: 1
Test Date: March 7, 2016

Burn Rate	**10.92 kg/hr dry**
Average Tunnel Temperature	108 degrees F
Average Gas Velocity in Dilution Tunnel - vs	10.1 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	26062 dscf/hour
Average Delta p	0.028 inches H20
Average Delta H	1.33 inches H20
Total Time of Test	138 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**3.54** g/hr
	0.32 g/kg
Complete Run:	**5.88** g/hr
	0.54 g/kg
	0.08 lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	17.14 cubic feet	16.89 cubic feet	0.00 cubic feet
Average Gas Meter Temperature	71 degrees F	71 degrees F	0 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	17.0 dscf	16.7 dscf	0.0 dscf
Total Particulates - mn	3.6 mg	4 mg	0 mg
Particulate Concentration (dry-standard)	0.000211 grams/dscf	0.000240 grams/dscf	0.000000 grams/dscf
Particulate Emissions	12.66 grams	14.39 grams	
Difference from Average	0.87 grams	0.87 grams	

Results Are Acceptable

	AVERAGE
Total Sample Volume - Vm	17.02 cubic feet
Average Gas Meter Temperature	71 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	16.9 dscf
Particulate Concentration (dry-standard)	0.00023 grams/dscf
Particulate Emissions	13.53 grams
7.5% of the average particulate emissions	1.01 grams

ADDITIONAL ACCEPTANCE CRITERIA

Boiler Water Return Temperature >120 °F	**Acceptable**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	7.41 cubic feet
Average Gas Meter Temperature	71 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	7.37 dscf
Total Particulates - mn	1 mg
Particulate Concentration (dry-standard)	0.00014 grams/dscf
Particulate Emissions	3.54 grams
Burn Rate	11.10 (dry kg/hr)

ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2152
Project No.:	0456WB005E
Technician:	AK/SB
Comments:	

Parameters:

Run Number:	1
Test Date:	3/7/16
Total Fuel Weight (lb):	68.1
Average Moisture of Fuel (% dry):	23.0
Average Moisture of Fuel (% wet):	18.69
Average Temperature of Appliance Water at Start of Test (°F):	157.0
Average Temperature of Appliance Water at End of Test (°F):	152.5
Average Thermopile Reading (°F):	73.0
Average Load Side Liquid Flow Rate (gal/min):	4.6
Time Interval (min):	138
Burn Rate (kg/hr):	10.92
Emissions (g):	13.5
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

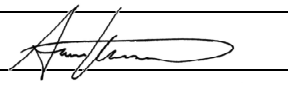
Calculations:

HHV Heat Input (Btu):	476197
Net HHV Heat Input (Btu):	476197
Net HHV Heat Input Rate (Btu/hr):	207042
LHV Heat Input (Btu):	442309
Net LHV Heat Input (Btu):	442309
Net LHV Heat Input Rate (Btu/hr):	192308
Appliance Water Specific Heat (Btu/lb^{o}F):	1.001
Tank Water Specific Heat (Btu/lb^{o}F):	1.001
Q_{unit} (Btu):	-2730
Q_{Load} (Btu):	382247
$Q_{Storage}$ (Btu):	11952
Total Heat Output (Btu):	391468
Total Heat Output Rate (Btu/hr):	170204
Load Output Rate (Btu/hr):	166194
Emissions Factor(g/kg):	0.54
Total Particulate Emissions Rate (g/MJ):	0.033
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.076**
Total Particulate Emissions (g/hr):	5.88
Delivered Efficiency, HHV (%):	82.2
First Hour Emissions Factor (g/kg):	0.32
First Hour Emissions Rate (g/hr):	3.54

OMNI-Test Laboratories, Inc.

Manufacturer:	Froling
Model:	S3 Large
Date:	03/07/16
Run:	1
Control #:	2152
Test Duration:	138
Output Category:	IV

Technicians: A. Kravitz



Test Results in Accordance with CSA B415.1-09

	HHV Basis	LHV Basis
Overall Efficiency	80.7%	86.9%
Combustion Efficiency	99.5%	99.5%
Heat Transfer Efficiency	81%	87.4%

Output Rate (kJ/h)	176,456	167,387	**(Btu/h)**
Burn Rate (kg/h)	10.93	24.08	**(lb/h)**
Input (kJ/h)	218,551	207,320	**(Btu/h)**

Test Load Weight (dry kg)	25.13	55.39	**dry lb**
MC wet (%)	18.67		
MC dry (%)	22.96		
Particulate (g)	0		
CO (g)	246		
Test Duration (h)	2.30		

Emissions	**Particulate**	**CO**
g/MJ Output	0.00	0.61
g/kg Dry Fuel	0.00	9.77
g/h	0.00	106.79
lb/MM Btu Output	0.00	1.41

Air/Fuel Ratio (A/F)	10.41

VERSION: **2.3** **3/23/2010**

Client: Froling Project Number: 0456WB005E Run Number: 1
Model: S3 Tracking Number: 2152 Date: 3/7/16
Test Crew: A. Kravitz, S. Button
OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Run Notes

Preburn Settings

Target Output (%): 100%
Target Output (BTU/hr): 165,000

Preburn Notes

TIME	NOTES
80 min	Added 24 lbs of fuel

Test Settings

Target Output (%): 100%
Target Output (BTU/hr): 165,000

Start-Up Timeline

Fuel Loaded by: 50 Sec
Door Closed at: 1 min
Notes: N/A

Test Notes

TIME	NOTES
N/A	None

Technician Signature: _____ Date: 3/7/16

ASTM 2618-13 Hydronic Heater Run Sheets

Client: Froling Project Number: 0456WB005E Run Number: 1
Model: S3 Tracking Number: 2152 Date: 3/7/16
Test Crew: A. Kravitz, S. Button
OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Supplemental Data

Start Time: 11:53 Booth #: E3
Stop Time: 14:11

Stack Gas Leak Check:
Initial: 0 Final: 6

Sample Train Leak Check:
A: 0.001 @-4 "Hg
B: 0.000 @-4 "Hg

Calibrations: Span Gas CO_2: 16.89 CO: 4.293

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	9:51	9:56	14:29	14:32
CO_2	0.08	16.91	0.06	17.01
CO	-0.007	4.296	-0.016	4.313

Air Velocity (ft/min): Initial: <50 Final: <50
Scale Audit (lbs): Initial: 10 Final: 10
Pitot Tube Leak Test: Initial: 0 Final: 0
Stack Diameter (in): 6
Induced Draft: 0
% Smoke Capture: 100%
Flue Pipe Cleaned Prior to First Test in Series:
Date: 3/4/16 Initials: SB

	Initial	Middle	Ending
P_b (in/Hg)	30.00	30.01	30.02
Ambient (°F)	68	68	66

Background Filter Volume (ft^3): N/A

Tunnel Traverse	
dP (in H_2O)	T(°F)
0.022	108
0.026	108
0.024	108
0.028	108
0.024	108
0.012	108
0.018	104
0.026	104
0.028	104
0.022	104
0.020	104
0.014	104
Static P:	-0.26

Center 0.028/107

Technician Signature: Date: 3/7/16

Client: Froling Project Number: 0456WB005E Run Number: 1
Model: S3 Tracking Number: 2152 Date: 3/7/16
Test Crew: A. Kravitz, S. Button
OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Fuel Data

Fuel Load Prepared by: A. Kravitz

Fuel: Cordwood meeting ASTM 2618 Requirements, Oak, Ash, Alder, & Maple

Firebox Volume (ft^3): 6.78 Test Fuel Piece Length (in): Varies

Pre-test fuel total weight: 72 lb

Test Fuel

CALIBRATION: Cal Value (1) = 12% Actual Reading: 12.0
Cal Value (2) = 22% Actual Reading: 22.0

Fuel Piece: Wet Weight: Moisture Readings:

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Main Test Fuel	10.5	19.6	26.1	27.0	22.4	27.1
Main Test Fuel	7.4	21.3	19.6	18.8	26.9	24.7
Main Test Fuel	7.8	23.2	19.0	27.1	24.8	25.1
Main Test Fuel	6.6	18.4	18.0	19.3	19.7	19.9
Main Test Fuel	9.3	27.3	26.7	23.8	24.7	22.4
Main Test Fuel	6.8	18.7	20.5	18.8	18.8	20.7
Main Test Fuel	7.4	27.4	21.2	25.4	22.0	26.8
Main Test Fuel	8.1	19.7	22.0	22.1	26.6	26.1
Main Test Fuel	4.2	27.7	18.7	21.5	22.3	25.2

Total Wet Weight: 68.1

TIME (CLOCK): 10:30 TEMPERATURE (F): 68 INITIALS: A

Technician Signature: Date: 3/7/16

Hydronic Heating Appliances - Test Method ASTM E2618-13
Fuel Moisture

Manufacturer:	Froling
Model:	S3
Tracking No.:	2152
Project No.:	0456WB005E
Technician:	AK/SB
Run #:	1
Test Date:	March 7, 2016

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Main Test Fuel	10.5	19.6	26.1	27.0	22.4	27.1
Main Test Fuel	7.4	21.3	19.6	18.8	26.9	24.7
Main Test Fuel	7.8	23.2	19.0	27.1	24.8	25.1
Main Test Fuel	6.6	18.4	18.0	19.3	19.7	19.9
Main Test Fuel	9.3	27.3	26.7	23.8	24.7	22.4
Main Test Fuel	6.8	18.7	20.5	18.8	18.8	20.7
Main Test Fuel	7.4	27.4	21.2	25.4	22.0	26.8
Main Test Fuel	8.1	19.7	22.0	22.1	26.6	26.1
Main Test Fuel	4.2	27.7	18.7	21.5	22.3	25.2

Total Weight of Load (lb):	68.1
Total Moisture of Load (%):	22.99

Equipment Numbers:
340, 353, 431

Hydronic Heating Appliances - Test Method ASTM E2515-11

Emissions Sampling Data

Run: 1

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Test Date: March 7, 2016
Technician: AK/SB
Beginning Clock Time: 11:53
Recording Interval: 1 min.
Total Sampling Time: 138 min.

Velocity Traverse Data	Pt.1	Pt.2	Pt.3	Pt.4	Pt.5	Pt.6	Pt.7	Pt.8	Pt.9	Pt.10	Pt.11	Pt.12	Center	
Initial dP	0.022	0.026	0.024	0.028	0.024	0.012	0.018	0.026	0.028	0.022	0.020	0.014	0.028	"H2O
Initial Temp.	108	108	108	108	108	108	104	104	104	104	104	104	107	oF

Air Velocity: Initial: <50 Final: <50
Scale Audit: Pre: 10.0 Post: 10.0
Pitot Tube Leak Test: Pre: 0 Post: 0
Flue Pipe Cleaned Prior to First Test in Series: Date: 3/4/2016

Induced Draft: 0
% Smoke Capture: 100

V_{strav} 10.09 ft/sec
V_{scent} 11.48 ft/sec
F_p 0.879

	(1)	(2)	(amb)	
Meter Box Y Factor:	0.995	0.985	1	
Barometric Pressure:	Begin	Middle	End	Average
	30.00	30.01	30.02	30.01 "Hg

PM Control Module: 428A/B
Dilution Tunnel MW(dry): 29.00 lb/lb-mole
Dilution Tunnel MW(wet): 28.78 lb/lb-mole
Dilution Tunnel H2O: 2.00 percent
Dilution Tunnel Static: -0.260 "H2O
Pitot Tube Cp: 0.99

Tunnel Velocity: 10.10 ft/sec.
Intial Tunnel Flow: 435.6 scfm
Average Tunnel Flow: 434.4 scfm
Tunnel Area: 0.785 ft2

Post-Test Leak Check (1): 0.001 cfm @ -4 in. Hg
Post-Test Leak Check (2): 0.000 cfm @ -4 in. Hg
Fuel Moisture (dry basis %): 23.0
Total Particulate (1): 3.6
Total Particulate (2): 4.0

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
0	0.000	0.000	0.000			-0.01	0.01	0.00	67	68	0	1.60	1.00	106	0.028			68.1		310	68	67	68	-0.061	0.12	10.11
1	0.107	0.110	0.000	0.11	0.11	1.30	1.53	0.00	68	68	0	0.80	0.20	118	0.028	87	91	67.6	0.50	299	71	70	68	-0.071	0.19	8.03
2	0.231	0.231	0.000	0.12	0.12	1.33	1.56	0.00	68	68	0	0.80	0.20	112	0.028	101	100	67.0	0.60	297	71	70	68	-0.062	0.09	13.16
3	0.355	0.352	0.000	0.12	0.12	1.34	1.57	0.00	69	68	0	0.80	0.20	109	0.028	100	99	66.5	0.50	301	71	70	68	-0.062	0.01	13.15
4	0.478	0.473	0.000	0.12	0.12	1.34	1.57	0.00	69	68	0	0.80	0.20	107	0.028	99	99	66.0	0.50	302	71	70	68	-0.062	0.01	12.80
5	0.602	0.595	0.000	0.12	0.12	1.34	1.58	0.00	69	68	0	0.79	0.20	106	0.028	100	100	65.6	0.40	302	71	70	68	-0.062	0.01	12.68
6	0.725	0.716	0.000	0.12	0.12	1.33	1.58	0.00	69	68	0	0.79	0.20	105	0.028	99	99	65.1	0.50	302	72	70	68	-0.062	0.01	12.49
7	0.849	0.837	0.000	0.12	0.12	1.34	1.57	0.00	69	68	0	0.80	0.20	105	0.028	100	99	64.7	0.40	302	72	71	68	-0.062	0.01	12.36
8	0.973	0.958	0.000	0.12	0.12	1.33	1.58	0.00	70	68	0	0.79	0.20	105	0.028	100	99	64.2	0.50	302	72	71	68	-0.062	0.01	12.27
9	1.097	1.080	0.000	0.12	0.12	1.33	1.59	0.00	70	68	0	0.79	0.20	105	0.028	100	100	63.9	0.30	303	72	71	68	-0.062	0.01	12.25
10	1.221	1.202	0.000	0.12	0.12	1.34	1.58	0.00	70	68	0	0.80	0.20	105	0.028	100	100	63.4	0.50	303	72	71	68	-0.061	0.01	12.15
11	1.344	1.324	0.000	0.12	0.12	1.33	1.57	0.00	70	68	0	0.79	0.20	105	0.028	99	100	62.9	0.50	303	72	71	68	-0.062	0.01	12.05
12	1.467	1.446	0.000	0.12	0.12	1.33	1.58	0.00	70	68	0	0.79	0.20	105	0.028	99	100	62.4	0.50	302	72	71	68	-0.062	0.02	11.74
13	1.591	1.568	0.000	0.12	0.12	1.34	1.59	0.00	70	69	0	0.79	0.20	105	0.028	100	100	62.1	0.30	303	73	71	68	-0.062	0.02	11.83
14	1.715	1.690	0.000	0.12	0.12	1.33	1.58	0.00	71	69	0	0.79	0.20	105	0.028	100	100	61.6	0.50	305	73	72	68	-0.062	0.02	11.86
15	1.839	1.812	0.000	0.12	0.12	1.34	1.58	0.00	71	69	0	0.80	0.20	105	0.028	100	100	61.1	0.50	306	73	72	68	-0.061	0.02	11.76
16	1.963	1.933	0.000	0.12	0.12	1.34	1.60	0.00	71	69	0	0.79	0.20	106	0.028	100	99	60.7	0.40	306	73	72	68	-0.062	0.02	11.80
17	2.086	2.055	0.000	0.12	0.12	1.33	1.59	0.00	71	69	0	0.79	0.20	106	0.028	99	100	60.3	0.40	307	73	72	68	-0.061	0.02	11.74
18	2.210	2.178	0.000	0.12	0.12	1.34	1.58	0.00	71	69	0	0.79	0.20	106	0.028	100	101	59.9	0.40	310	73	72	68	-0.061	0.02	11.75
19	2.333	2.300	0.000	0.12	0.12	1.33	1.59	0.00	71	69	0	0.80	0.20	107	0.028	99	100	59.3	0.60	316	74	72	68	-0.062	0.02	12.28
20	2.456	2.422	0.000	0.12	0.12	1.33	1.58	0.00	71	69	0	0.79	0.20	107	0.028	99	100	58.9	0.40	316	74	72	68	-0.062	0.02	12.64
21	2.581	2.545	0.000	0.13	0.12	1.33	1.59	0.00	71	69	0	0.79	0.20	107	0.028	101	101	58.4	0.50	315	74	72	68	-0.062	0.02	12.32
22	2.705	2.667	0.000	0.12	0.12	1.33	1.59	0.00	72	69	0	0.79	0.20	107	0.028	100	100	58.0	0.40	315	74	72	68	-0.062	0.02	12.13

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
23	2.828	2.790	0.000	0.12	0.12	1.33	1.59	0.00	71	69	0	0.79	0.20	107	0.028	99	101	57.5	0.50	315	74	73	68	-0.060	0.02	11.84
24	2.952	2.912	0.000	0.12	0.12	1.33	1.59	0.00	72	69	0	0.79	0.20	107	0.028	100	100	57.1	0.40	314	74	73	68	-0.062	0.03	11.56
25	3.075	3.035	0.000	0.12	0.12	1.32	1.60	0.00	72	69	0	0.79	0.20	107	0.028	99	101	56.6	0.50	314	74	73	68	-0.061	0.03	11.57
26	3.198	3.157	0.000	0.12	0.12	1.33	1.60	0.00	71	70	0	0.79	0.20	107	0.028	99	100	56.2	0.40	308	75	73	68	-0.061	0.03	11.69
27	3.323	3.279	0.000	0.13	0.12	1.33	1.60	0.00	71	70	0	0.79	0.20	105	0.028	100	100	55.8	0.40	297	75	73	68	-0.061	0.04	11.49
28	3.447	3.402	0.000	0.12	0.12	1.33	1.59	0.00	72	70	0	0.79	0.20	104	0.028	99	100	55.3	0.50	293	75	73	68	-0.060	0.05	11.43
29	3.571	3.525	0.000	0.12	0.12	1.33	1.60	0.00	72	70	0	0.79	0.20	103	0.028	99	100	54.9	0.40	291	75	73	68	-0.060	0.04	11.68
30	3.694	3.648	0.000	0.12	0.12	1.33	1.60	0.00	72	70	0	0.79	0.20	103	0.028	98	100	54.5	0.40	289	75	73	68	-0.060	0.05	11.71
31	3.818	3.771	0.000	0.12	0.12	1.33	1.60	0.00	72	70	0	0.79	0.20	102	0.028	99	100	54.1	0.40	287	75	73	68	-0.060	0.05	11.58
32	3.941	3.894	0.000	0.12	0.12	1.34	1.60	0.00	72	70	0	0.79	0.20	102	0.028	98	100	53.6	0.50	290	75	73	68	-0.061	0.03	12.74
33	4.066	4.017	0.000	0.13	0.12	1.33	1.60	0.00	72	70	0	0.79	0.20	103	0.028	100	100	53.1	0.50	292	75	73	68	-0.061	0.03	13.43
34	4.190	4.140	0.000	0.12	0.12	1.33	1.59	0.00	72	70	0	0.79	0.20	103	0.028	99	100	52.6	0.50	295	75	73	68	-0.061	0.02	13.30
35	4.314	4.262	0.000	0.12	0.12	1.33	1.60	0.00	72	70	0	0.79	0.20	103	0.028	99	99	52.2	0.40	300	75	73	68	-0.060	0.02	13.38
36	4.437	4.385	0.000	0.12	0.12	1.33	1.60	0.00	72	70	0	0.79	0.20	104	0.028	99	100	51.7	0.50	306	75	73	68	-0.060	0.02	13.38
37	4.561	4.507	0.000	0.12	0.12	1.33	1.60	0.00	71	70	0	0.79	0.20	105	0.028	100	100	51.1	0.60	309	75	73	68	-0.060	0.03	13.16
38	4.685	4.629	0.000	0.12	0.12	1.33	1.60	0.00	72	70	0	0.78	0.20	106	0.028	100	100	50.6	0.50	317	75	73	68	-0.063	0.02	13.60
39	4.809	4.752	0.000	0.12	0.12	1.33	1.60	0.00	72	71	0	0.79	0.20	107	0.028	100	100	50.1	0.50	321	75	74	68	-0.063	0.03	13.92
40	4.934	4.875	0.000	0.13	0.12	1.33	1.61	0.00	72	71	0	0.78	0.20	108	0.028	101	100	49.5	0.60	321	75	74	68	-0.064	0.03	13.22
41	5.057	4.998	0.000	0.12	0.12	1.33	1.60	0.00	72	71	0	0.78	0.20	109	0.028	99	101	49.0	0.50	328	76	74	68	-0.065	0.02	13.75
42	5.181	5.120	0.000	0.12	0.12	1.33	1.61	0.00	72	71	0	0.78	0.20	110	0.028	100	100	48.4	0.60	329	76	74	68	-0.064	0.01	13.74
43	5.305	5.243	0.000	0.12	0.12	1.32	1.59	0.00	72	71	0	0.78	0.20	110	0.028	100	101	47.8	0.60	331	76	74	68	-0.066	0.01	13.73
44	5.428	5.366	0.000	0.12	0.12	1.33	1.60	0.00	72	71	0	0.78	0.20	111	0.028	99	101	47.2	0.60	333	76	74	68	-0.066	0.01	13.77
45	5.553	5.489	0.000	0.13	0.12	1.33	1.60	0.00	72	71	0	0.78	0.20	111	0.028	101	101	46.6	0.60	332	76	74	68	-0.065	0.01	13.42
46	5.677	5.612	0.000	0.12	0.12	1.33	1.60	0.00	72	71	0	0.78	0.20	111	0.028	100	101	46.1	0.50	331	76	74	68	-0.066	0.01	12.95
47	5.800	5.735	0.000	0.12	0.12	1.33	1.60	0.00	72	71	0	0.78	0.20	111	0.028	99	101	45.6	0.50	330	76	74	68	-0.066	0.01	12.54
48	5.924	5.858	0.000	0.12	0.12	1.32	1.60	0.00	72	71	0	0.78	0.20	111	0.028	100	101	45.0	0.60	329	76	74	68	-0.066	0.01	12.08
49	6.048	5.981	0.000	0.12	0.12	1.32	1.60	0.00	72	71	0	0.78	0.20	111	0.028	100	101	44.4	0.60	327	76	74	68	-0.066	0.02	11.70
50	6.171	6.104	0.000	0.12	0.12	1.33	1.60	0.00	72	71	0	0.78	0.20	111	0.028	99	101	44.0	0.40	325	76	74	68	-0.065	0.02	11.52
51	6.296	6.227	0.000	0.13	0.12	1.33	1.60	0.00	72	71	0	0.78	0.20	111	0.028	101	101	43.4	0.60	324	76	74	68	-0.065	0.03	11.26
52	6.420	6.350	0.000	0.12	0.12	1.32	1.60	0.00	72	71	0	0.78	0.20	111	0.028	100	101	42.9	0.50	323	76	74	68	-0.066	0.02	11.38
53	6.543	6.472	0.000	0.12	0.12	1.32	1.60	0.00	72	71	0	0.78	0.20	111	0.028	99	100	42.2	0.70	326	77	75	68	-0.064	0.01	13.27
54	6.667	6.595	0.000	0.12	0.12	1.33	1.60	0.00	72	71	0	0.77	0.20	111	0.028	100	101	41.6	0.60	328	77	75	68	-0.066	0.00	14.00
55	6.790	6.718	0.000	0.12	0.12	1.32	1.60	0.00	72	71	0	0.77	0.20	111	0.028	99	101	41.0	0.60	329	77	75	68	-0.067	0.00	13.85
56	6.914	6.841	0.000	0.12	0.12	1.33	1.60	0.00	72	71	0	0.77	0.20	111	0.028	100	101	40.3	0.70	330	77	75	68	-0.065	0.00	13.57
57	7.038	6.963	0.000	0.12	0.12	1.32	1.59	0.00	72	71	0	0.77	0.20	111	0.028	100	100	39.8	0.50	329	77	75	68	-0.066	0.01	13.28
58	7.162	7.086	0.000	0.12	0.12	1.32	1.60	0.00	72	71	0	0.77	0.20	111	0.028	100	101	39.2	0.60	329	77	75	68	-0.066	0.01	12.99
59	7.286	7.208	0.000	0.12	0.12	1.33	1.59	0.00	72	71	0	0.77	0.20	111	0.028	100	100	38.6	0.60	330	77	75	68	-0.066	0.01	12.97
60	7.409	7.330	0.000	0.12	0.12	1.32	1.59	0.00	72	71	0	0.77	0.20	111	0.028	99	100	38.0	0.60	330	77	75	68	-0.066	0.01	13.44
61	7.536	7.453	0.000	0.13	0.12	1.40	1.59	0.00	72	72	0	0.82	0.20	111	0.028	102	101	37.4	0.60	330	76	75	68	-0.065	0.01	13.50
62	7.660	7.575	0.000	0.12	0.12	1.34	1.59	0.00	72	71	0	0.79	0.20	111	0.028	100	100	36.7	0.70	330	76	75	68	-0.065	0.00	13.12

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
63	7.785	7.698	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.79	0.20	112	0.028	101	101	36.2	0.50	330	76	75	68	-0.065	0.01	12.78
64	7.910	7.820	0.000	0.13	0.12	1.35	1.60	0.00	72	72	0	0.79	0.20	112	0.028	101	100	35.7	0.50	330	76	75	68	-0.065	0.01	12.46
65	8.034	7.943	0.000	0.12	0.12	1.34	1.60	0.00	72	72	0	0.79	0.20	111	0.028	100	101	35.1	0.60	329	77	75	68	-0.065	0.02	12.26
66	8.159	8.065	0.000	0.13	0.12	1.33	1.60	0.00	72	72	0	0.79	0.20	112	0.028	101	100	34.5	0.60	329	76	75	68	-0.066	0.03	12.15
67	8.283	8.188	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	112	0.028	100	101	33.8	0.70	334	77	75	68	-0.067	0.02	13.52
68	8.408	8.310	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	112	0.028	101	100	33.2	0.60	337	76	75	68	-0.067	0.00	14.05
69	8.533	8.433	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	112	0.028	101	101	32.7	0.50	336	76	75	68	-0.067	0.00	13.22
70	8.657	8.556	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	112	0.028	100	101	32.1	0.60	336	76	75	68	-0.066	0.01	12.88
71	8.782	8.679	0.000	0.13	0.12	1.33	1.60	0.00	72	72	0	0.78	0.20	112	0.028	101	101	31.6	0.50	335	76	75	68	-0.066	0.01	12.45
72	8.906	8.801	0.000	0.12	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	113	0.028	100	100	31.0	0.60	336	76	75	68	-0.067	0.00	12.35
73	9.031	8.924	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	113	0.028	101	101	30.5	0.50	336	76	75	68	-0.067	0.00	12.04
74	9.156	9.046	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.79	0.20	113	0.028	101	100	29.9	0.60	336	76	75	68	-0.067	0.01	11.70
75	9.281	9.169	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	114	0.028	101	101	29.4	0.50	337	76	75	68	-0.067	0.01	11.54
76	9.405	9.291	0.000	0.12	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	114	0.028	100	100	28.8	0.60	337	76	75	68	-0.068	0.01	11.37
77	9.529	9.414	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	115	0.028	100	101	28.3	0.50	338	76	75	68	-0.069	0.02	11.31
78	9.654	9.537	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	115	0.028	101	101	27.7	0.60	337	76	75	68	-0.068	0.04	11.24
79	9.779	9.659	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	116	0.028	101	100	27.1	0.60	339	76	75	68	-0.067	0.03	11.66
80	9.903	9.782	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	116	0.028	100	101	26.5	0.60	340	76	75	68	-0.070	0.02	11.74
81	10.028	9.904	0.000	0.13	0.12	1.33	1.59	0.00	72	72	0	0.78	0.20	117	0.028	101	100	25.9	0.60	341	76	75	68	-0.069	0.02	11.97
82	10.152	10.026	0.000	0.12	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	117	0.028	100	100	25.3	0.60	342	76	75	68	-0.069	0.03	11.91
83	10.277	10.149	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	117	0.028	101	101	24.7	0.60	342	76	75	68	-0.069	0.05	11.74
84	10.402	10.271	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	117	0.028	101	100	24.1	0.60	342	76	75	68	-0.069	0.04	11.62
85	10.526	10.394	0.000	0.12	0.12	1.33	1.59	0.00	72	72	0	0.78	0.20	117	0.028	100	101	23.6	0.50	341	77	75	68	-0.070	0.05	11.51
86	10.651	10.516	0.000	0.13	0.12	1.33	1.59	0.00	72	72	0	0.78	0.20	117	0.028	101	100	23.0	0.60	342	76	75	68	-0.068	0.03	11.78
87	10.775	10.638	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	117	0.028	100	100	22.4	0.60	343	77	75	68	-0.069	0.00	12.36
88	10.900	10.760	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	117	0.028	101	100	21.9	0.50	342	76	75	68	-0.068	0.01	12.14
89	11.025	10.883	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	117	0.028	101	101	21.2	0.70	342	76	76	68	-0.071	0.03	11.77
90	11.148	11.005	0.000	0.12	0.12	1.33	1.59	0.00	72	72	0	0.78	0.20	117	0.028	100	100	20.8	0.40	343	77	75	68	-0.070	0.04	11.64
91	11.272	11.127	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	117	0.028	100	100	20.2	0.60	343	77	75	68	-0.069	0.04	11.40
92	11.397	11.249	0.000	0.13	0.12	1.34	1.58	0.00	72	72	0	0.78	0.20	116	0.028	101	100	19.7	0.50	342	77	75	68	-0.068	0.04	11.17
93	11.522	11.371	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	116	0.028	101	100	19.1	0.60	341	77	75	68	-0.068	0.02	11.47
94	11.647	11.493	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	116	0.028	101	100	18.6	0.50	340	76	75	68	-0.068	0.03	11.33
95	11.770	11.616	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.77	0.20	116	0.028	100	101	18.1	0.50	338	77	75	68	-0.068	0.04	11.12
96	11.895	11.738	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	115	0.028	101	100	17.6	0.50	337	77	75	68	-0.068	0.07	11.10
97	12.019	11.861	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	115	0.028	100	101	17.0	0.60	335	76	75	68	-0.068	0.15	10.64
98	12.144	11.983	0.000	0.13	0.12	1.33	1.59	0.00	72	72	0	0.78	0.20	114	0.028	101	100	16.6	0.40	333	76	75	68	-0.066	0.09	11.20
99	12.270	12.105	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.77	0.20	114	0.028	102	100	15.9	0.70	334	76	75	68	-0.067	0.01	12.22
100	12.393	12.228	0.000	0.12	0.12	1.34	1.58	0.00	72	72	0	0.78	0.20	113	0.028	99	101	15.4	0.50	333	77	75	68	-0.066	0.03	11.71
101	12.518	12.350	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	113	0.028	101	100	14.9	0.50	333	76	75	68	-0.066	0.04	11.59
102	12.643	12.472	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.77	0.20	113	0.028	101	100	14.4	0.50	334	76	75	68	-0.067	0.03	11.89

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
103	12.767	12.595	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	112	0.028	100	101	14.0	0.40	333	76	75	68	-0.065	0.04	11.39
104	12.892	12.717	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	112	0.028	101	100	13.5	0.50	330	76	75	68	-0.065	0.09	10.96
105	13.016	12.840	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	112	0.028	100	101	13.1	0.40	326	76	75	68	-0.065	0.16	10.66
106	13.141	12.962	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	111	0.028	101	100	12.7	0.40	321	76	75	68	-0.065	0.26	10.66
107	13.265	13.084	0.000	0.12	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	109	0.028	100	100	12.1	0.60	316	76	75	67	-0.062	0.26	10.93
108	13.390	13.207	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	108	0.028	101	100	11.7	0.40	309	76	75	67	-0.062	0.23	11.09
109	13.516	13.330	0.000	0.13	0.12	1.34	1.60	0.00	72	72	0	0.78	0.20	106	0.028	101	100	11.2	0.50	304	76	74	67	-0.063	0.19	11.00
110	13.640	13.452	0.000	0.12	0.12	1.34	1.59	0.00	71	72	0	0.78	0.20	105	0.028	100	99	10.8	0.40	301	75	74	67	-0.063	0.21	10.77
111	13.765	13.575	0.000	0.13	0.12	1.35	1.60	0.00	72	72	0	0.78	0.20	105	0.028	100	100	10.4	0.40	298	75	74	67	-0.062	0.29	10.43
112	13.890	13.697	0.000	0.13	0.12	1.35	1.60	0.00	71	72	0	0.78	0.20	104	0.028	100	99	9.9	0.50	295	75	74	67	-0.062	0.34	10.21
113	14.015	13.820	0.000	0.13	0.12	1.34	1.59	0.00	72	72	0	0.78	0.20	103	0.028	100	100	9.5	0.40	293	75	74	67	-0.062	0.34	10.08
114	14.141	13.943	0.000	0.13	0.12	1.35	1.59	0.00	72	72	0	0.78	0.20	103	0.028	101	100	9.2	0.30	291	75	74	67	-0.062	0.38	9.90
115	14.264	14.066	0.000	0.12	0.12	1.34	1.60	0.00	71	72	0	0.78	0.20	103	0.028	99	100	8.7	0.50	289	75	74	67	-0.062	0.30	9.99
116	14.390	14.189	0.000	0.13	0.12	1.34	1.59	0.00	71	72	0	0.78	0.20	102	0.028	101	100	8.3	0.40	288	74	74	67	-0.062	0.34	9.88
117	14.514	14.312	0.000	0.12	0.12	1.35	1.60	0.00	72	72	0	0.79	0.20	102	0.028	99	100	7.8	0.50	287	74	73	67	-0.062	0.31	9.90
118	14.640	14.435	0.000	0.13	0.12	1.35	1.60	0.00	71	72	0	0.78	0.20	102	0.028	101	100	7.4	0.40	287	74	73	67	-0.061	0.12	11.37
119	14.765	14.557	0.000	0.13	0.12	1.35	1.60	0.00	72	72	0	0.79	0.20	101	0.028	100	99	7.0	0.40	287	74	73	66	-0.062	0.12	11.24
120	14.890	14.680	0.000	0.13	0.12	1.35	1.60	0.00	71	72	0	0.78	0.20	101	0.028	100	100	6.6	0.40	286	74	73	66	-0.062	0.18	10.80
121	15.015	14.802	0.000	0.13	0.12	1.34	1.60	0.00	71	72	0	0.78	0.20	101	0.028	100	99	6.2	0.40	285	74	73	66	-0.061	0.18	10.45
122	15.140	14.925	0.000	0.13	0.12	1.35	1.60	0.00	71	72	0	0.78	0.20	100	0.028	100	100	5.8	0.40	284	74	73	67	-0.062	0.20	10.08
123	15.266	15.048	0.000	0.13	0.12	1.35	1.60	0.00	72	72	0	0.79	0.20	100	0.028	101	100	5.4	0.40	283	74	73	66	-0.061	0.24	9.86
124	15.390	15.171	0.000	0.12	0.12	1.34	1.61	0.00	71	72	0	0.78	0.20	100	0.028	99	100	5.1	0.30	281	74	73	66	-0.061	0.23	9.74
125	15.516	15.294	0.000	0.13	0.12	1.35	1.60	0.00	72	71	0	0.78	0.20	100	0.028	101	100	4.7	0.40	281	73	73	66	-0.060	0.23	9.49
126	15.640	15.417	0.000	0.12	0.12	1.35	1.60	0.00	71	71	0	0.78	0.20	99	0.028	99	100	4.3	0.40	280	73	73	66	-0.061	0.26	9.24
127	15.766	15.540	0.000	0.13	0.12	1.35	1.59	0.00	71	71	0	0.79	0.20	99	0.028	101	100	4.0	0.30	278	73	73	66	-0.060	0.29	9.28
128	15.891	15.663	0.000	0.13	0.12	1.35	1.60	0.00	71	71	0	0.78	0.20	99	0.028	100	100	3.7	0.30	278	73	73	66	-0.061	0.28	9.31
129	16.016	15.786	0.000	0.12	0.12	1.34	1.60	0.00	71	71	0	0.79	0.20	99	0.028	100	100	3.3	0.40	277	73	72	66	-0.061	0.26	9.48
130	16.141	15.909	0.000	0.13	0.12	1.35	1.60	0.00	71	71	0	0.79	0.20	99	0.028	100	100	3.0	0.30	278	73	72	66	-0.060	0.27	9.40
131	16.266	16.032	0.000	0.13	0.12	1.35	1.60	0.00	71	71	0	0.78	0.20	99	0.028	100	100	2.6	0.40	277	73	72	66	-0.060	0.35	9.19
132	16.392	16.155	0.000	0.13	0.12	1.35	1.60	0.00	71	71	0	0.79	0.20	99	0.028	101	100	2.3	0.30	277	73	72	66	-0.060	0.42	9.08
133	16.517	16.278	0.000	0.13	0.12	1.35	1.60	0.00	71	71	0	0.79	0.20	98	0.028	100	100	2.0	0.30	276	73	72	66	-0.061	0.41	8.95
134	16.642	16.401	0.000	0.13	0.12	1.35	1.60	0.00	71	71	0	0.78	0.20	98	0.028	100	100	1.6	0.40	276	73	72	66	-0.060	0.39	8.89
135	16.767	16.524	0.000	0.13	0.12	1.35	1.60	0.00	71	71	0	0.79	0.20	98	0.028	100	100	1.3	0.30	275	73	72	66	-0.060	0.39	8.97
136	16.893	16.647	0.000	0.13	0.12	1.35	1.61	0.00	71	71	0	0.78	0.20	98	0.028	101	100	1.0	0.30	275	73	72	66	-0.060	0.39	9.08
137	17.018	16.771	0.000	0.13	0.12	1.35	1.60	0.00	71	71	0	0.79	0.20	98	0.028	100	100	0.7	0.30	276	73	72	66	-0.061	0.41	8.91
138	17.143	16.893	0.000	0.13	0.12	1.35	1.61	0.00	71	71	0	0.79	0.20	98	0.028	100	99	0.0	0.70	276	73	72	66	-0.060	0.40	8.80
	17.143	16.893	0.000			1.33	1.58	0.00	71	71	0			108	0.028						74.88	73.56		-0.064	0.09	11.66

Hydronic Heating Appliances - Test Method ASTM E2618-13 Annex A2
Water Test Data

Run: 1

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Test Date: 42436

Technician: AK/SB
Beginning Clock Time: 11:53
Recording Interval: 1 min.
Total Sampling Time: 138 min.

Boiler Dry Weight (lbs): 1814
Boiler Water Weight (lbs): 425
Tank Weight (lbs): 984
Tank Water Weight (lbs): 4678

Initial Average Tank Temp (°F): 126.0
Final Average Tank Temp (°F): 128.5

Elapsed Time	Flow, gpm		Water Temperature Data, oF																	
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
0	5.50	n/a	64.1	180	134	96	122	124	88	51	114	126	126	125	126	126	124	1.001	45.870	
1	5.55	n/a	64.2	180	134	98	122	124	88	51	115	126	126	125	126	126	124	1.001	46.287	2977
2	5.18	n/a	67.5	180	135	98	124	124	90	51	117	126	126	124	126	126	123	1.001	43.201	2918
3	4.84	n/a	69.2	180	136	100	125	126	93	51	120	126	126	124	126	126	124	1.001	40.365	2799
4	4.76	n/a	69.0	180	136	101	126	127	94	51	121	126	126	125	126	126	124	1.001	39.698	2741
5	4.90	n/a	69.2	180	136	100	126	127	93	51	121	127	126	125	126	126	124	1.001	40.866	2833
6	4.91	n/a	68.9	181	136	100	126	127	93	51	121	126	126	125	126	126	124	1.001	40.949	2826
7	4.87	n/a	69.4	181	136	101	126	127	93	51	121	126	126	124	126	126	124	1.001	40.616	2822
8	4.90	n/a	69.3	181	137	100	126	128	93	51	121	126	126	125	127	126	124	1.001	40.866	2836
9	4.90	n/a	69.4	182	137	101	126	128	93	51	121	126	126	125	126	126	124	1.001	40.866	2841
10	4.88	n/a	70.0	182	137	101	127	128	94	51	121	127	126	125	127	126	123	1.001	40.699	2851
11	4.89	n/a	70.0	182	137	101	126	128	94	51	121	126	126	125	127	126	124	1.001	40.782	2859
12	4.92	n/a	69.4	182	136	102	126	128	93	51	121	126	126	125	127	126	124	1.001	41.032	2853
13	4.91	n/a	69.8	182	137	101	126	128	94	51	121	126	126	125	127	126	124	1.001	40.949	2861
14	4.91	n/a	69.2	181	136	101	126	128	94	51	121	126	126	125	126	126	123	1.001	40.949	2838
15	4.89	n/a	69.3	181	137	100	126	128	93	51	121	126	126	125	127	126	124	1.001	40.782	2831
16	4.89	n/a	69.3	181	136	100	126	127	93	51	121	126	126	125	126	126	124	1.001	40.782	2829
17	4.91	n/a	69.0	181	136	100	125	127	93	51	121	126	126	125	126	126	124	1.001	40.949	2829
18	4.90	n/a	69.0	181	136	101	126	127	93	51	121	126	126	125	126	126	124	1.001	40.866	2823
19	4.90	n/a	69.1	181	136	101	126	127	93	51	121	126	126	125	126	126	124	1.001	40.866	2828
20	4.85	n/a	69.9	181	137	101	126	127	94	51	121	126	126	125	126	126	124	1.001	40.449	2830
21	4.89	n/a	69.0	181	137	100	126	128	93	51	121	126	126	125	126	126	124	1.001	40.782	2818
22	4.81	n/a	69.7	181	137	103	126	128	93	51	121	126	126	125	126	126	124	1.001	40.115	2800
23	4.86	n/a	68.8	181	137	101	126	128	93	51	121	126	126	125	127	126	124	1.001	40.532	2791
24	5.02	n/a	68.6	182	136	101	126	127	92	51	120	126	126	125	126	126	124	1.001	41.866	2877
25	4.87	n/a	69.5	181	137	102	126	128	92	51	120	126	126	125	127	126	124	1.001	40.616	2828
26	4.86	n/a	69.7	181	137	101	126	128	93	51	121	126	126	125	127	126	124	1.001	40.532	2828
27	4.96	n/a	68.4	181	136	101	126	128	92	51	120	126	126	125	126	126	124	1.001	41.366	2831
28	5.01	n/a	67.7	180	136	100	126	127	92	51	120	126	126	125	126	126	124	1.001	41.783	2830
29	4.96	n/a	67.7	180	136	100	125	127	92	51	120	126	126	125	126	126	124	1.001	41.367	2804
30	5.00	n/a	67.6	179	136	100	125	126	92	51	119	126	126	125	126	126	124	1.001	41.700	2824
31	5.02	n/a	67.0	179	135	100	124	126	91	51	119	126	126	125	126	126	124	1.001	41.867	2810
32	4.99	n/a	67.0	178	135	99	124	126	90	51	118	126	126	125	126	126	124	1.001	41.617	2791
33	5.01	n/a	66.7	179	135	100	124	125	91	51	118	126	126	125	126	126	124	1.001	41.784	2792
34	4.99	n/a	66.5	178	135	100	124	125	91	51	118	126	126	125	126	126	124	1.001	41.617	2773
35	4.99	n/a	66.6	178	135	100	123	125	90	51	118	126	126	125	126	126	124	1.001	41.617	2774
36	5.02	n/a	66.4	178	135	100	124	125	91	51	118	126	126	125	126	126	124	1.001	41.867	2784
37	4.98	n/a	67.1	179	135	99	124	125	91	51	118	126	126	125	126	126	123	1.001	41.534	2790
38	5.01	n/a	67.0	179	135	99	124	125	91	51	118	126	126	125	126	126	124	1.001	41.784	2801
39	4.89	n/a	67.8	180	136	101	125	126	91	51	119	126	126	125	126	126	123	1.001	40.783	2769
40	4.99	n/a	68.3	180	136	101	125	126	91	51	119	126	126	125	126	126	124	1.001	41.617	2844
41	4.99	n/a	68.4	181	136	101	125	126	91	51	119	126	126	125	126	126	124	1.001	41.617	2848
42	4.95	n/a	69.1	181	136	101	125	127	92	51	120	126	126	125	126	126	124	1.001	41.283	2857
43	4.82	n/a	69.3	182	137	102	127	128	93	51	121	126	126	125	126	126	124	1.001	40.199	2788
44	5.00	n/a	69.8	182	137	102	127	128	92	51	120	126	126	125	126	126	124	1.001	41.700	2914
45	4.81	n/a	72.1	183	137	103	128	128	93	51	122	126	126	125	126	126	124	1.001	40.116	2895
46	4.80	n/a	72.9	184	137	103	129	130	95	51	124	126	126	125	127	126	124	1.001	40.033	2921
47	4.99	n/a	73.0	184	136	101	130	131	94	51	124	127	126	125	127	126	124	1.001	41.617	3041
48	4.98	n/a	73.9	184	136	102	131	132	94	51	124	127	126	125	127	126	124	1.001	41.534	3075
49	4.83	n/a	76.3	184	136	102	131	133	95	51	125	128	126	125	128	126	124	1.001	40.283	3076
50	4.30	n/a	79.7	183	136	106	135	134	100	51	128	128	126	125	127	126	124	1.001	35.862	2861
51	4.30	n/a	80.4	182	137	107	136	137	101	51	131	128	126	125	128	126	124	1.001	35.862	2887
52	4.28	n/a	80.6	182	137	107	135	137	101	51	132	129	126	125	129	126	124	1.001	35.695	2879
53	4.28	n/a	79.4	181	136	107	134	136	101	51	131	130	126	125	129	126	124	1.001	35.695	2837
54	4.28	n/a	78.4	180	136	106	133	135	100	51	130	130	126	125	130	126	124	1.001	35.695	2803
55	4.28	n/a	78.5	180	136	106	132	134	100	51	129	130	126	125	130	126	124	1.001	35.695	2805
56	4.20	n/a	77.3	180	137	106	133	134	100	51	129	130	126	125	130	126	124	1.001	35.028	2712
57	4.25	n/a	77.2	180	137	105	132	134	100	51	128	130	126	125	131	126	124	1.001	35.445	2740
58	4.21	n/a	77.7	181	136	106	133	134	100	51	129	130	126	125	131	126	124	1.001	35.111	2732
59	4.32	n/a	78.2	181	137	107	133	134	100	51	129	130	126	125	131	126	124	1.001	36.029	2822
60	4.32	n/a	78.7	181	136	106	133	135	100	51	129	131	126	125	131	126	124	1.001	36.029	2839
61	4.29	n/a	79.3	182	137	106	134	136	100	51	130	131	126	125	131	126	124	1.001	35.779	2840
62	4.23	n/a	80.3	182	137	108	135	136	101	51	131	131	126	125	131	126	124	1.001	35.278	2836
63	4.34	n/a	79.7	182	136	107	135	137	101	51	131	131	126	125	131	126	124	1.001	36.196	2889
64	4.34	n/a	80.1	182	137	107	136	137	101	51	131	131	126	125	132	126	124	1.001	36.195	2904
65	4.32	n/a	79.9	182	136	108	135	136	101	51	131	132	126	125	132	126	124	1.001	36.029	2883
66	4.30	n/a	79.7	181	136	107	134	136	101	51	131	132	126	125	132	126	124	1.001	35.862	2860

Elapsed Time	Flow, gpm		Water Temperature Data, oF																	
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
67	4.31	n/a	78.5	181	136	107	134	136	100	51	130	132	126	125	132	126	124	1.001	35.945	2824
68	4.32	n/a	78.7	181	136	107	134	135	100	51	130	132	126	125	132	126	124	1.001	36.029	2838
69	4.27	n/a	79.0	181	136	106	134	135	100	51	130	132	126	125	132	126	124	1.001	35.612	2816
70	4.33	n/a	78.4	181	136	106	134	136	100	51	130	132	126	125	132	126	124	1.001	36.112	2834
71	4.32	n/a	79.6	182	136	106	134	136	100	51	130	132	126	125	132	126	124	1.001	36.029	2870
72	4.18	n/a	80.4	182	137	108	135	136	101	51	131	132	126	125	132	126	124	1.001	34.861	2806
73	4.34	n/a	79.8	182	136	107	135	136	101	51	131	132	126	125	133	126	124	1.001	36.195	2891
74	4.34	n/a	79.4	181	136	106	135	136	101	51	131	133	126	125	133	126	124	1.001	36.196	2878
75	4.32	n/a	79.8	181	136	107	134	136	101	51	131	133	126	125	133	126	124	1.001	36.029	2877
76	4.31	n/a	79.2	181	136	107	135	136	101	51	131	133	126	125	133	126	124	1.001	35.945	2850
77	4.30	n/a	79.5	181	136	107	135	136	100	51	130	133	126	125	133	126	124	1.001	35.862	2853
78	4.33	n/a	79.2	181	136	107	135	136	100	51	130	133	126	125	133	126	124	1.001	36.112	2863
79	4.31	n/a	79.2	181	136	106	135	136	101	51	130	133	126	125	133	126	124	1.001	35.945	2851
80	4.31	n/a	79.3	182	137	106	134	136	101	51	130	133	126	125	133	126	124	1.001	35.945	2854
81	4.32	n/a	79.3	182	136	107	135	136	100	51	130	133	126	125	133	126	124	1.001	36.029	2861
82	4.32	n/a	79.5	181	137	106	134	136	101	51	131	133	126	125	133	126	124	1.001	36.029	2866
83	4.30	n/a	79.5	182	137	107	134	136	101	51	130	133	126	125	133	126	124	1.001	35.862	2855
84	4.29	n/a	79.5	182	137	107	134	136	100	51	130	133	126	125	133	126	124	1.001	35.778	2847
85	4.31	n/a	79.8	182	137	107	135	136	100	51	131	133	126	125	133	127	124	1.001	35.945	2870
86	4.29	n/a	79.4	182	137	107	135	136	101	51	131	133	127	125	133	127	124	1.001	35.778	2844
87	4.30	n/a	79.9	182	136	108	135	136	100	51	131	133	127	125	133	127	124	1.001	35.862	2867
88	4.30	n/a	80.2	182	137	107	135	137	100	51	131	133	127	125	134	127	124	1.001	35.862	2879
89	4.31	n/a	80.1	182	137	106	135	137	101	51	131	133	127	125	134	128	124	1.001	35.945	2882
90	4.30	n/a	79.8	182	137	106	135	136	101	51	131	133	128	125	134	128	124	1.001	35.862	2865
91	4.31	n/a	79.9	182	137	108	135	137	101	51	131	134	128	125	134	129	124	1.001	35.945	2876
92	4.31	n/a	79.9	182	137	107	135	137	101	51	131	133	128	125	134	129	124	1.001	35.945	2875
93	4.33	n/a	79.9	182	137	107	135	137	101	51	131	134	129	125	134	129	124	1.001	36.112	2888
94	4.30	n/a	79.8	182	136	107	135	136	101	51	131	134	129	125	134	130	124	1.001	35.862	2865
95	4.30	n/a	79.0	181	137	107	134	136	101	51	131	134	129	125	134	130	124	1.001	35.862	2837
96	4.31	n/a	79.1	181	136	106	134	136	100	51	130	134	130	125	134	130	124	1.001	35.945	2845
97	4.32	n/a	79.0	181	136	105	134	135	100	51	130	134	130	125	134	131	124	1.001	36.029	2849
98	4.30	n/a	78.5	181	136	107	133	135	101	51	130	134	130	125	134	131	124	1.001	35.862	2820
99	4.30	n/a	78.4	181	136	107	134	135	100	51	130	134	130	125	134	131	124	1.001	35.862	2814
100	4.32	n/a	77.8	180	136	106	133	135	100	51	129	134	131	125	134	131	124	1.001	36.029	2807
101	4.31	n/a	77.2	180	137	106	131	134	99	51	129	133	131	125	134	131	124	1.001	35.945	2778
102	4.34	n/a	76.9	180	137	107	131	133	99	51	128	133	131	125	133	132	124	1.001	36.195	2786
103	4.32	n/a	76.9	180	137	106	132	134	100	51	128	133	131	125	134	132	124	1.001	36.029	2774
104	4.30	n/a	76.5	180	136	106	132	134	99	51	128	133	131	125	133	132	124	1.001	35.862	2748
105	4.17	n/a	77.9	180	136	108	132	133	99	51	128	133	132	125	133	132	124	1.001	34.778	2714
106	4.30	n/a	75.8	180	137	105	131	134	99	51	128	133	132	125	133	132	124	1.001	35.862	2723
107	4.30	n/a	76.5	179	136	105	131	133	99	51	127	133	132	125	133	132	124	1.001	35.862	2748
108	4.31	n/a	74.5	179	137	105	129	132	98	51	127	133	132	125	133	133	124	1.001	35.946	2680
109	4.29	n/a	73.4	179	137	104	128	130	97	51	125	133	132	125	133	133	124	1.001	35.779	2629
110	4.26	n/a	73.0	178	137	104	128	130	98	51	124	133	132	125	133	133	124	1.001	35.529	2596
111	4.29	n/a	72.2	178	137	103	127	129	97	51	124	133	132	125	133	132	124	1.001	35.779	2588
112	4.30	n/a	71.7	177	137	103	127	128	96	51	123	133	132	125	133	132	124	1.001	35.862	2575
113	4.32	n/a	71.7	177	137	103	127	128	97	51	123	133	132	125	133	132	124	1.001	36.029	2588
114	4.28	n/a	71.5	176	136	103	126	128	96	51	123	133	132	125	132	132	124	1.001	35.695	2556
115	4.32	n/a	71.3	177	136	103	126	128	96	51	122	133	132	125	132	132	124	1.001	36.029	2571
116	4.31	n/a	70.6	176	136	103	125	127	96	51	122	133	132	125	132	132	124	1.001	35.945	2541
117	4.31	n/a	70.7	176	136	102	126	127	95	51	122	133	132	125	132	132	124	1.001	35.945	2545
118	4.29	n/a	70.5	176	136	103	126	127	95	51	122	133	132	125	132	132	124	1.001	35.779	2527
119	4.30	n/a	70.1	176	136	102	125	127	96	51	122	132	132	125	132	132	124	1.001	35.862	2518
120	4.32	n/a	70.2	175	135	103	125	127	96	51	122	133	132	125	132	131	124	1.001	36.029	2532
121	4.31	n/a	70.3	175	135	104	125	127	95	51	122	132	132	125	132	131	124	1.001	35.945	2531
122	4.22	n/a	70.6	175	135	103	125	127	96	51	122	132	132	125	131	131	124	1.001	35.195	2488
123	4.27	n/a	69.8	175	135	103	125	127	96	51	122	132	131	125	132	131	124	1.001	35.612	2488
124	4.32	n/a	69.4	175	135	103	125	126	95	51	121	132	131	125	132	131	124	1.001	36.029	2503
125	4.59	n/a	67.3	174	134	102	123	125	94	51	120	132	131	125	132	131	124	1.001	38.281	2579
126	4.59	n/a	67.0	174	134	100	123	124	93	51	119	132	131	125	131	131	124	1.001	38.281	2568
127	4.57	n/a	66.5	174	134	100	122	124	92	51	118	132	131	125	131	131	124	1.001	38.114	2539
128	4.59	n/a	66.8	173	134	100	122	124	92	51	118	132	131	125	131	131	124	1.001	38.281	2562
129	4.58	n/a	66.4	173	134	100	121	124	92	51	118	132	131	125	131	130	124	1.001	38.198	2540
130	4.59	n/a	66.1	173	134	100	121	123	92	51	117	131	131	125	131	130	125	1.001	38.281	2535
131	4.60	n/a	65.3	172	134	100	121	123	92	51	117	131	130	125	131	130	124	1.001	38.365	2507
132	4.56	n/a	65.2	172	133	99	121	122	92	51	117	131	130	125	131	130	124	1.001	38.031	2484
133	4.72	n/a	63.7	172	133	100	120	122	91	51	116	131	130	125	131	130	124	1.001	39.365	2510
134	4.71	n/a	62.3	171	134	98	118	121	90	51	114	131	130	125	131	130	124	1.001	39.282	2451
135	4.73	n/a	61.8	171	134	99	117	119	89	51	113	131	130	125	130	130	125	1.001	39.449	2439
136	4.71	n/a	61.8	171	134	99	117	119	88	51	113	131	130	125	130	129	124	1.001	39.282	2432
137	4.68	n/a	61.5	171	134	98	118	119	88	51	113	131	130	125	130	129	125	1.001	39.032	2403
138	4.70	n/a	61.6	171	134	97	117	119	89	51	113	131	130	125	130	129	124	1.001	39.199	2418
	4.57	#DIV/0!	73.0	179.6	136.0	103.3	128.7	130.2	96.0	51.3	124.2	130.0	127.7	125.0	130.0	127.8	124.0			2770
																			Total Heat Output	382247

Run 2

Hydronic Heating Appliances - Test Methods ASTM E2515-11 & E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Run: 2
Test Date: March 8, 2016

Burn Rate	**9.10 kg/hr dry**
Average Tunnel Temperature	97 degrees F
Average Gas Velocity in Dilution Tunnel - vs	9.5 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	25046 dscf/hour
Average Delta p	0.028 inches H20
Average Delta H	1.33 inches H20
Total Time of Test	175 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**12.22** g/hr
	1.11 g/kg
Complete Run:	**7.53** g/hr
	0.83 g/kg
	0.14 lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	21.83 cubic feet	21.60 cubic feet	0.00 cubic feet
Average Gas Meter Temperature	73 degrees F	72 degrees F	0 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	21.7 dscf	21.3 dscf	0.0 dscf
Total Particulates - mn	6.9 mg	6 mg	0 mg
Particulate Concentration (dry-standard)	0.000319 grams/dscf	0.000282 grams/dscf	0.000000 grams/dscf
Particulate Emissions	23.28 grams	20.62 grams	
Difference from Average	1.33 grams	1.33 grams	

Results Are Acceptable

	AVERAGE
Total Sample Volume - Vm	21.72 cubic feet
Average Gas Meter Temperature	73 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	21.5 dscf
Particulate Concentration (dry-standard)	0.00030 grams/dscf
Particulate Emissions	21.95 grams
7.5% of the average particulate emissions	1.65 grams

ADDITIONAL ACCEPTANCE CRITERIA

Boiler Water Return Temperature >120 °F	**N/A - Cold Start**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	7.44 cubic feet
Average Gas Meter Temperature	72 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	7.38 dscf
Total Particulates - mn	3.6 mg
Particulate Concentration (dry-standard)	0.00049 grams/dscf
Particulate Emissions	12.22 grams
Burn Rate	11.01 (dry kg/hr)

ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2152
Project No.:	0456WB005E
Technician:	AK/SB
Comments:	

Parameters:

Run Number:	2
Test Date:	3/8/16
Total Fuel Weight (lb):	71.3
Average Moisture of Fuel (% dry):	21.9
Average Moisture of Fuel (% wet):	17.97
Average Temperature of Appliance Water at Start of Test (°F):	102.5
Average Temperature of Appliance Water at End of Test (°F):	181.5
Average Thermopile Reading (°F):	90.9
Average Load Side Liquid Flow Rate (gal/min):	0.5
Time Interval (min):	175
Burn Rate (kg/hr):	9.10
Emissions (g):	22.0
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

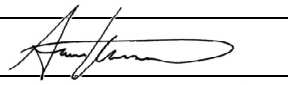
Calculations:

HHV Heat Input (Btu):	502997
Net HHV Heat Input (Btu):	495797
Net HHV Heat Input Rate (Btu/hr):	169988
LHV Heat Input (Btu):	467203
Net LHV Heat Input (Btu):	460003
Net LHV Heat Input Rate (Btu/hr):	157715
Appliance Water Specific Heat (Btu/lb^{o}F):	1.001
Tank Water Specific Heat (Btu/lb^{o}F):	1.001
Q_{unit} (Btu):	47936
Q_{Load} (Btu):	66739
$Q_{Storage}$ (Btu):	226117
Total Heat Output (Btu):	340792
Total Heat Output Rate (Btu/hr):	116843
Load Output Rate (Btu/hr):	22882
Emissions Factor(g/kg):	0.83
Total Particulate Emissions Rate (g/MJ):	0.061
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.142**
Total Particulate Emissions (g/hr):	7.53
Delivered Efficiency, HHV (%):	67.8
First Hour Emissions Factor (g/kg):	1.11
First Hour Emissions Rate (g/hr):	12.22

OMNI-Test Laboratories, Inc.

Manufacturer:	Froling
Model:	S3 Large
Date:	03/08/16
Run:	2
Control #:	2152
Test Duration:	175
Output Category:	I

Technicians: A. Kravitz



Test Results in Accordance with CSA B415.1-09

	HHV Basis	LHV Basis
Overall Efficiency	80.7%	86.9%
Combustion Efficiency	98.3%	98.3%
Heat Transfer Efficiency	82%	88.3%

Output Rate (kJ/h)	145,624	138,140	**(Btu/h)**
Burn Rate (kg/h)	9.02	19.88	**(lb/h)**
Input (kJ/h)	180,463	171,189	**(Btu/h)**

Test Load Weight (dry kg)	26.31	58.00	**dry lb**
MC wet (%)	17.97		
MC dry (%)	21.91		
Particulate (g)	0		
CO (g)	716		
Test Duration (h)	2.92		

Emissions	Particulate	CO
g/MJ Output	0.00	1.69
g/kg Dry Fuel	0.00	27.23
g/h	0.00	245.62
lb/MM Btu Output	0.00	3.92

Air/Fuel Ratio (A/F)	12.04

VERSION: **2.3** **3/23/2010**

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 2
Model: S3 Tracking Number: 2152 Date: 3/8/16
Test Crew: A. Kravitz, S. Button
OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Run Notes

Preburn Settings – N/A – COLD START

Target Output (%): _____
Target Output (BTU/hr):

Preburn Notes

TIME	NOTES

Test Settings

Target Output (%): 13%
Target Output (BTU/hr): 23,000

Start-Up Timeline

Ignition Complete by: 3:00
Door Closed at: 4:30
Notes: Cold start test with propane torch – kindling, newspaper, startup fuel and test fuel all loaded at once prior to test start.

Test Notes

TIME	NOTES
N/A	None

Technician Signature: _____ Date: 3/8/16

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 2
Model: S3 Tracking Number: 2152 Date: 3/8/16
Test Crew: A. Kravitz, S. Button
OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Supplemental Data

Start Time: 10:35 Booth #: E3
Stop Time: 13:30

Stack Gas Leak Check:
Initial: 0 Final: 0

Sample Train Leak Check:
A: 0.000 @ -4 "Hg
B: 0.000 @ -4 "Hg

Calibrations: Span Gas CO_2: 16.89 CO: 4.293

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	10:08	10:11	13:36	13:39
CO_2	0.003	16.91	0.05	16.85
CO	-0.005	4.292	-0.003	4.285

Air Velocity (ft/min): Initial: <50 Final: <50
Scale Audit (lbs): Initial: 10 Final: 10
Pitot Tube Leak Test: Initial: 0 Final: 0
Stack Diameter (in): 6
Induced Draft: 0
% Smoke Capture: 100%
Flue Pipe Cleaned Prior to First Test in Series:
Date: 3/4/16 Initials: SB

	Initial	Middle	Ending
P_b (in/Hg)	30.00	30.02	30.03
Ambient (°F)	68	68	69

Background Filter Volume (ft^3): N/A

Tunnel Traverse	
dP (in H_2O)	T(°F)
0.020	80
0.020	80
0.024	80
0.028	80
0.026	80
0.006	80
0.008	80
0.018	80
0.026	80
0.026	80
0.022	80
0.020	80
Static P:	-0.25

Center: 0.028/80

Technician Signature: Date: 3/8/16

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 2

Model: S3 Tracking Number: 2152 Date: 3/8/16

Test Crew: A. Kravitz, S. Button

OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Fuel Data

Fuel Load Prepared by: A. Kravitz

Fuel: Cordwood meeting ASTM 2618 Requirements, Oak, Ash, Alder, & Maple

Firebox Volume (ft^3): 6.78 Test Fuel Piece Length (in): Varies

Pre-test fuel total weight: N/A

Test Fuel

CALIBRATION: Cal Value (1) = 12% Actual Reading: 12.0

Cal Value (2) = 22% Actual Reading: 22.0

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Kindling Aggregate	4.5	19	19.6	18.5	25.9	25.8
Start-up Fuel	1.6	18.1	18.8	18.5	21.9	19.3
Start-up Fuel	1.6	20.1	20.4	18.6	18.3	19.9
Start-up Fuel	1.7	21.4	21.8	19.5	19.9	21.7
Start-up Fuel	1.7	19.6	18.1	22.6	22.1	18
Main Test Fuel	7.1	25.8	25.3	22.8	22	22.5
Main Test Fuel	6.6	24.6	25.8	23.2	23.2	22.5
Main Test Fuel	4.5	20	18.2	18.3	20.4	19
Main Test Fuel	7.1	27.3	24.1	26.1	26.2	19.2
Main Test Fuel	6.8	19	22.2	18.5	21.3	24.8
Main Test Fuel	8.4	18.8	18.4	25.9	23.2	23.2
Main Test Fuel	6.6	21.7	18.7	23.2	22.1	21.9
Main Test Fuel	7.2	18	20.9	23.5	23.2	19.1
Main Test Fuel	5.9	23.3	18.1	19	19.9	25.8

Total Wet Weight: 71.3

TIME (CLOCK): 9:15 TEMPERATURE (F): 67 INITIALS: [signature]

Technician Signature: [signature] Date: 3/8/16

Hydronic Heating Appliances - Test Method ASTM E2618-13
Fuel Moisture

Manufacturer:	Froling
Model:	S3
Tracking No.:	2152
Project No.:	0456WB005E
Technician:	AK/SB
Run #:	2
Test Date:	March 8, 2016

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Kindling Aggregate	4.5	19	19.6	18.5	25.9	25.8
Start-up Fuel	1.6	18.1	18.8	18.5	21.9	19.3
Start-up Fuel	1.6	20.1	20.4	18.6	18.3	19.9
Start-up Fuel	1.7	21.4	21.8	19.5	19.9	21.7
Start-up Fuel	1.7	19.6	18.1	22.6	22.1	18
Main Test Fuel	7.1	25.8	25.3	22.8	22	22.5
Main Test Fuel	6.6	24.6	25.8	23.2	23.2	22.5
Main Test Fuel	4.5	20	18.2	18.3	20.4	19
Main Test Fuel	7.1	27.3	24.1	26.1	26.2	19.2
Main Test Fuel	6.8	19	22.2	18.5	21.3	24.8
Main Test Fuel	8.4	18.8	18.4	25.9	23.2	23.2
Main Test Fuel	6.6	21.7	18.7	23.2	22.1	21.9
Main Test Fuel	7.2	18	20.9	23.5	23.2	19.1
Main Test Fuel	5.9	23.3	18.1	19	19.9	25.8

Total Weight of Load (lb):	71.3
Total Moisture of Load (%):	21.91

Equipment Numbers:
340, 353, 431

Hydronic Heating Appliances - Test Method ASTM E2515-11

Emissions Sampling Data

Run: 2

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Test Date: March 8, 2016
Technician: AK/SB
Beginning Clock Time: 10:35
Recording Interval: 1 min.
Total Sampling Time: 175 min.

Velocity Traverse Data	Pt.1	Pt.2	Pt.3	Pt.4	Pt.5	Pt.6	Pt.7	Pt.8	Pt.9	Pt.10	Pt.11	Pt.12	Center	
Initial dP	0.020	0.020	0.024	0.028	0.026	0.006	0.008	0.018	0.026	0.026	0.022	0.020	0.028	"H2O
Initial Temp.	80	80	80	80	80	80	80	80	80	80	80	80	80	oF

Air Velocity: Initial: <50 Final: <50
Scale Audit: Pre: 10.0 Post: 10.0
Pitot Tube Leak Test: Pre: 0 Post: 0
Flue Pipe Cleaned Prior to First Test in Series: Date: 3/4/2016

Induced Draft: 0
% Smoke Capture: 100

V_{strav} 9.37 ft/sec
V_{scent} 11.20 ft/sec
F_p 0.836

	(1)	(2)	(amb)	
Meter Box Y Factor:	0.995	0.985	1	
Barometric Pressure:	Begin	Middle	End	Average
	30.00	30.02	30.03	30.02 "Hg

PM Control Module: 428A/B
Dilution Tunnel MW(dry): 29.00 lb/lb-mole
Dilution Tunnel MW(wet): 28.78 lb/lb-mole
Dilution Tunnel H2O: 2.00 percent
Dilution Tunnel Static: -0.250 "H2O
Pitot Tube Cp: 0.99

Tunnel Velocity: 9.52 ft/sec.
Intial Tunnel Flow: 423.9 scfm
Average Tunnel Flow: 417.4 scfm
Tunnel Area: 0.785 ft2

Post-Test Leak Check (1): 0.000 cfm @ -4 in. Hg
Post-Test Leak Check (2): 0.000 cfm @ -4 in. Hg
Fuel Moisture (dry basis %): 21.9
Total Particulate (1): 6.9
Total Particulate (2): 6.0

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
0	0.000	0.000	0.000			-0.01	0.01	0.00	68	67	0	1.60	1.00	80	0.028			71.3		105	69	67	68	-0.046	0.00	0.09
1	0.118	0.116	0.000	0.12	0.12	1.35	1.59	0.00	68	68	0	0.80	0.20	84	0.028	94	94	71.8	-0.50	128	69	67	68	-0.053	0.10	1.11
2	0.243	0.238	0.000	0.13	0.12	1.36	1.59	0.00	69	68	0	0.79	0.20	88	0.028	100	99	71.0	0.80	147	70	67	68	-0.069	0.24	1.71
3	0.368	0.361	0.000	0.13	0.12	1.37	1.60	0.00	69	68	0	0.79	0.20	94	0.028	101	100	70.2	0.80	179	70	67	68	-0.066	0.30	2.96
4	0.494	0.483	0.000	0.13	0.12	1.37	1.60	0.00	70	68	0	0.79	0.20	100	0.028	102	100	69.6	0.60	226	72	67	68	-0.062	0.25	7.46
5	0.619	0.606	0.000	0.13	0.12	1.37	1.60	0.00	70	68	0	0.79	0.20	101	0.028	101	101	68.8	0.80	242	72	67	69	-0.059	0.24	8.08
6	0.744	0.729	0.000	0.13	0.12	1.36	1.61	0.00	70	68	0	0.79	0.20	100	0.028	101	101	68.2	0.60	230	71	67	68	-0.053	0.38	6.79
7	0.868	0.852	0.000	0.12	0.12	1.36	1.61	0.00	71	68	0	0.79	0.20	100	0.028	100	101	67.5	0.70	229	72	67	68	-0.052	0.44	6.45
8	0.993	0.975	0.000	0.13	0.12	1.35	1.60	0.00	71	68	0	0.79	0.20	100	0.028	101	101	67.0	0.50	232	72	68	69	-0.051	0.38	7.59
9	1.118	1.098	0.000	0.13	0.12	1.35	1.61	0.00	71	68	0	0.79	0.20	99	0.028	101	101	66.4	0.60	235	72	68	69	-0.052	0.29	8.71
10	1.242	1.221	0.000	0.12	0.12	1.35	1.61	0.00	71	68	0	0.79	0.20	99	0.028	100	101	65.8	0.60	240	73	68	69	-0.052	0.12	9.88
11	1.366	1.344	0.000	0.12	0.12	1.35	1.60	0.00	71	68	0	0.78	0.20	99	0.028	100	101	65.2	0.60	243	73	68	69	-0.054	0.15	9.73
12	1.490	1.466	0.000	0.12	0.12	1.34	1.60	0.00	72	69	0	0.78	0.20	98	0.028	100	100	64.6	0.60	244	73	68	69	-0.053	0.17	9.65
13	1.614	1.589	0.000	0.12	0.12	1.34	1.61	0.00	72	69	0	0.78	0.20	99	0.028	100	100	64.0	0.60	248	73	68	69	-0.054	0.14	9.75
14	1.738	1.712	0.000	0.12	0.12	1.34	1.61	0.00	72	69	0	0.78	0.20	99	0.028	100	100	63.3	0.70	253	74	68	69	-0.054	0.09	10.39
15	1.863	1.835	0.000	0.13	0.12	1.33	1.60	0.00	72	69	0	0.78	0.20	100	0.028	101	101	62.7	0.60	260	74	68	69	-0.056	0.03	11.60
16	1.986	1.957	0.000	0.12	0.12	1.33	1.61	0.00	72	69	0	0.78	0.20	100	0.028	99	100	62.1	0.60	267	74	68	69	-0.056	0.02	12.35
17	2.109	2.080	0.000	0.12	0.12	1.34	1.60	0.00	72	69	0	0.77	0.20	101	0.028	99	101	61.5	0.60	274	75	68	69	-0.058	0.01	13.25
18	2.232	2.202	0.000	0.12	0.12	1.33	1.60	0.00	72	69	0	0.78	0.20	102	0.028	99	100	60.7	0.80	279	75	68	69	-0.058	0.01	13.45
19	2.356	2.325	0.000	0.12	0.12	1.33	1.59	0.00	72	69	0	0.77	0.20	102	0.028	100	101	60.0	0.70	282	75	68	69	-0.058	0.01	13.63
20	2.479	2.448	0.000	0.12	0.12	1.32	1.59	0.00	72	70	0	0.77	0.20	103	0.028	99	101	59.2	0.80	283	75	68	69	-0.059	0.01	12.76
21	2.603	2.570	0.000	0.12	0.12	1.32	1.60	0.00	72	70	0	0.77	0.20	103	0.028	100	100	58.6	0.60	283	75	68	69	-0.058	0.01	12.17
22	2.726	2.693	0.000	0.12	0.12	1.32	1.60	0.00	72	70	0	0.77	0.20	103	0.028	99	101	58.1	0.50	283	74	68	69	-0.058	0.01	11.71

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
23	2.849	2.815	0.000	0.12	0.12	1.32	1.60	0.00	73	70	0	0.77	0.20	103	0.028	99	100	57.5	0.60	283	74	68	69	-0.058	0.01	11.40
24	2.972	2.938	0.000	0.12	0.12	1.32	1.60	0.00	73	70	0	0.77	0.20	103	0.028	99	101	57.0	0.50	281	74	68	69	-0.057	0.01	11.29
25	3.095	3.060	0.000	0.12	0.12	1.32	1.60	0.00	73	70	0	0.77	0.20	102	0.028	99	100	56.5	0.50	281	74	68	69	-0.057	0.01	11.10
26	3.218	3.183	0.000	0.12	0.12	1.32	1.60	0.00	72	70	0	0.77	0.20	102	0.028	99	101	56.2	0.30	281	74	68	69	-0.058	0.02	10.77
27	3.342	3.305	0.000	0.12	0.12	1.32	1.60	0.00	73	70	0	0.77	0.20	103	0.028	100	100	55.7	0.50	282	75	68	69	-0.058	0.02	10.95
28	3.466	3.428	0.000	0.12	0.12	1.32	1.60	0.00	73	71	0	0.77	0.20	102	0.028	100	100	55.1	0.60	281	75	68	69	-0.058	0.02	11.31
29	3.590	3.550	0.000	0.12	0.12	1.32	1.59	0.00	73	71	0	0.77	0.20	102	0.028	100	100	54.7	0.40	280	75	68	69	-0.058	0.02	11.39
30	3.712	3.673	0.000	0.12	0.12	1.32	1.60	0.00	73	71	0	0.77	0.20	102	0.028	98	100	54.1	0.60	278	75	68	69	-0.058	0.02	10.83
31	3.836	3.795	0.000	0.12	0.12	1.32	1.60	0.00	73	71	0	0.77	0.20	101	0.028	100	99	53.7	0.40	276	75	68	69	-0.058	0.03	10.72
32	3.959	3.919	0.000	0.12	0.12	1.32	1.61	0.00	73	71	0	0.78	0.20	101	0.028	99	101	53.2	0.50	272	75	68	69	-0.059	0.01	12.40
33	4.082	4.042	0.000	0.12	0.12	1.32	1.61	0.00	73	71	0	0.77	0.20	100	0.028	99	100	52.7	0.50	269	74	68	69	-0.058	0.01	12.20
34	4.206	4.165	0.000	0.12	0.12	1.32	1.61	0.00	73	71	0	0.77	0.20	99	0.028	100	100	52.2	0.50	267	74	68	69	-0.057	0.01	11.89
35	4.330	4.287	0.000	0.12	0.12	1.32	1.60	0.00	73	71	0	0.77	0.20	98	0.028	99	99	51.7	0.50	266	74	68	69	-0.057	0.03	11.89
36	4.454	4.410	0.000	0.12	0.12	1.33	1.60	0.00	73	71	0	0.78	0.20	98	0.028	99	100	51.3	0.40	265	74	68	69	-0.058	0.04	11.98
37	4.577	4.534	0.000	0.12	0.12	1.32	1.61	0.00	73	71	0	0.78	0.20	98	0.028	99	101	50.8	0.50	266	74	68	69	-0.058	0.06	11.98
38	4.701	4.657	0.000	0.12	0.12	1.32	1.61	0.00	73	71	0	0.78	0.20	99	0.028	100	100	50.5	0.30	270	74	68	69	-0.059	0.07	11.24
39	4.825	4.780	0.000	0.12	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	100	0.028	100	100	50.0	0.50	276	74	68	69	-0.058	0.14	10.48
40	4.949	4.903	0.000	0.12	0.12	1.32	1.61	0.00	73	72	0	0.78	0.20	100	0.028	100	100	49.5	0.50	274	74	68	69	-0.059	0.13	10.11
41	5.073	5.027	0.000	0.12	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	100	0.028	100	101	49.1	0.40	272	74	68	69	-0.059	0.21	9.39
42	5.197	5.150	0.000	0.12	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	100	0.028	100	100	48.8	0.30	270	74	68	69	-0.058	0.32	8.90
43	5.321	5.273	0.000	0.12	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	100	0.028	100	100	48.4	0.40	271	74	68	69	-0.057	0.38	8.20
44	5.445	5.397	0.000	0.12	0.12	1.32	1.62	0.00	73	72	0	0.78	0.20	101	0.028	100	101	48.0	0.40	271	74	68	69	-0.058	0.44	7.72
45	5.569	5.520	0.000	0.12	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	101	0.028	100	100	47.6	0.40	269	73	68	69	-0.058	0.48	7.57
46	5.693	5.643	0.000	0.12	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	101	0.028	100	100	47.2	0.40	269	74	68	69	-0.057	0.48	7.95
47	5.818	5.766	0.000	0.13	0.12	1.33	1.62	0.00	73	72	0	0.78	0.20	101	0.028	101	100	46.8	0.40	269	74	68	69	-0.058	0.48	7.67
48	5.942	5.890	0.000	0.12	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	101	0.028	100	101	46.4	0.40	267	74	68	69	-0.057	0.54	7.29
49	6.066	6.013	0.000	0.12	0.12	1.33	1.62	0.00	73	72	0	0.79	0.20	101	0.028	100	100	46.1	0.30	265	74	68	69	-0.056	0.56	7.05
50	6.191	6.137	0.000	0.13	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	101	0.028	101	101	45.7	0.40	265	74	68	69	-0.057	0.60	6.74
51	6.315	6.261	0.000	0.12	0.12	1.33	1.61	0.00	74	72	0	0.79	0.20	101	0.028	100	101	45.3	0.40	265	74	68	69	-0.058	0.57	6.77
52	6.440	6.385	0.000	0.13	0.12	1.33	1.62	0.00	73	72	0	0.78	0.20	101	0.028	101	101	44.9	0.40	262	74	68	69	-0.057	0.60	6.42
53	6.564	6.509	0.000	0.12	0.12	1.33	1.61	0.00	73	72	0	0.79	0.20	101	0.028	100	101	44.6	0.30	259	74	68	69	-0.056	0.62	6.08
54	6.688	6.633	0.000	0.12	0.12	1.33	1.62	0.00	73	72	0	0.78	0.20	100	0.028	100	101	44.1	0.50	257	74	68	69	-0.057	0.62	5.99
55	6.813	6.756	0.000	0.13	0.12	1.33	1.62	0.00	73	72	0	0.79	0.20	100	0.028	100	100	43.7	0.40	258	74	68	69	-0.056	0.58	6.32
56	6.937	6.880	0.000	0.12	0.12	1.33	1.61	0.00	73	73	0	0.78	0.20	100	0.028	100	101	43.3	0.40	256	74	68	69	-0.056	0.56	6.09
57	7.062	7.004	0.000	0.13	0.12	1.34	1.61	0.00	73	72	0	0.78	0.20	100	0.028	100	101	42.9	0.40	255	74	68	69	-0.057	0.56	5.92
58	7.187	7.127	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	99	0.028	100	100	42.6	0.30	254	74	68	69	-0.056	0.56	5.85
59	7.311	7.251	0.000	0.12	0.12	1.33	1.62	0.00	73	73	0	0.79	0.20	100	0.028	100	101	42.2	0.40	255	74	68	69	-0.056	0.53	6.22
60	7.436	7.375	0.000	0.13	0.12	1.33	1.62	0.00	73	73	0	0.79	0.20	100	0.028	100	101	41.7	0.50	260	74	68	69	-0.057	0.49	7.52
61	7.562	7.498	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	100	0.028	101	100	41.2	0.50	262	74	68	68	-0.055	0.72	7.46
62	7.687	7.622	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	101	0.028	101	101	40.6	0.60	266	74	68	69	-0.058	0.47	8.22

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
63	7.812	7.746	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	101	0.028	101	101	40.1	0.50	270	74	68	68	-0.058	0.27	8.91
64	7.936	7.869	0.000	0.12	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	102	0.028	100	100	39.7	0.40	271	74	68	69	-0.058	0.46	8.44
65	8.061	7.993	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	102	0.028	101	101	39.1	0.60	271	74	68	69	-0.058	0.67	8.10
66	8.186	8.117	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	102	0.028	101	101	38.7	0.40	271	74	68	69	-0.057	0.75	7.99
67	8.312	8.241	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.80	0.20	102	0.028	101	101	38.1	0.60	271	74	68	69	-0.058	0.66	7.80
68	8.436	8.365	0.000	0.12	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	102	0.028	100	101	37.7	0.40	270	74	68	68	-0.058	0.67	7.54
69	8.561	8.488	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	102	0.028	101	100	37.2	0.50	270	74	68	68	-0.058	0.58	7.64
70	8.686	8.611	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	102	0.028	101	100	36.7	0.50	273	74	68	68	-0.059	0.45	8.58
71	8.812	8.734	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	102	0.028	101	100	36.2	0.50	271	74	68	68	-0.059	0.63	7.63
72	8.937	8.858	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	102	0.028	101	101	35.7	0.50	274	74	68	68	-0.058	0.20	9.41
73	9.062	8.982	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	102	0.028	101	101	35.1	0.60	280	75	68	68	-0.058	0.08	10.66
74	9.187	9.106	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	103	0.028	101	101	34.5	0.60	282	75	68	68	-0.060	0.07	10.69
75	9.312	9.230	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	105	0.028	101	101	33.9	0.60	291	75	68	68	-0.062	0.10	9.88
76	9.438	9.354	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	106	0.028	102	101	33.4	0.50	296	75	68	68	-0.063	0.19	9.06
77	9.562	9.477	0.000	0.12	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	107	0.028	100	100	32.9	0.50	297	75	68	68	-0.064	0.23	8.73
78	9.687	9.600	0.000	0.13	0.12	1.34	1.60	0.00	73	73	0	0.79	0.20	108	0.028	101	100	32.3	0.60	302	75	68	68	-0.064	0.09	10.44
79	9.811	9.724	0.000	0.12	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	109	0.028	100	101	31.6	0.70	305	75	68	68	-0.064	0.04	10.89
80	9.937	9.848	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	109	0.028	102	101	31.0	0.60	305	75	68	68	-0.064	0.04	11.00
81	10.062	9.972	0.000	0.13	0.12	1.34	1.60	0.00	73	73	0	0.78	0.20	108	0.028	101	101	30.4	0.60	303	75	68	68	-0.062	0.05	11.08
82	10.186	10.095	0.000	0.12	0.12	1.34	1.61	0.00	73	73	0	0.78	0.20	108	0.028	100	100	29.8	0.60	302	75	68	68	-0.062	0.05	11.53
83	10.311	10.218	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.78	0.20	107	0.028	101	100	29.2	0.60	302	75	68	68	-0.061	0.04	12.41
84	10.435	10.341	0.000	0.12	0.12	1.34	1.60	0.00	73	73	0	0.78	0.20	107	0.028	100	100	28.6	0.60	302	75	68	69	-0.061	0.05	12.15
85	10.561	10.464	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.78	0.20	107	0.028	102	100	28.0	0.60	302	75	68	69	-0.061	0.07	11.86
86	10.686	10.587	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.78	0.20	107	0.028	101	100	27.4	0.60	302	75	68	69	-0.061	0.05	11.86
87	10.810	10.711	0.000	0.12	0.12	1.33	1.61	0.00	73	73	0	0.78	0.20	104	0.028	100	101	26.7	0.70	291	75	68	68	-0.060	0.05	12.66
88	10.935	10.834	0.000	0.13	0.12	1.33	1.60	0.00	73	73	0	0.78	0.20	102	0.028	101	100	26.3	0.40	279	75	68	68	-0.061	0.01	13.66
89	11.059	10.958	0.000	0.12	0.12	1.34	1.61	0.00	73	73	0	0.78	0.20	101	0.028	100	101	25.7	0.60	278	75	68	68	-0.062	0.02	12.15
90	11.184	11.082	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.78	0.20	101	0.028	101	101	25.2	0.50	278	75	68	69	-0.060	0.04	11.36
91	11.309	11.205	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.78	0.20	100	0.028	100	100	24.7	0.50	278	75	68	68	-0.061	0.06	11.16
92	11.433	11.329	0.000	0.12	0.12	1.33	1.61	0.00	74	73	0	0.78	0.20	100	0.028	99	101	24.3	0.40	277	75	68	68	-0.060	0.04	11.39
93	11.558	11.452	0.000	0.13	0.12	1.33	1.60	0.00	73	73	0	0.78	0.20	99	0.028	100	100	23.7	0.60	274	75	68	68	-0.060	0.03	11.71
94	11.683	11.575	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	99	0.028	100	100	23.3	0.40	270	74	68	68	-0.059	0.01	12.07
95	11.809	11.699	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	98	0.028	101	100	22.8	0.50	269	74	68	68	-0.059	0.01	11.62
96	11.934	11.822	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.78	0.20	97	0.028	100	99	22.3	0.50	268	74	68	68	-0.059	0.01	11.42
97	12.058	11.945	0.000	0.12	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	96	0.028	99	99	21.9	0.40	265	74	68	68	-0.058	0.02	11.19
98	12.183	12.069	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	95	0.028	100	100	21.6	0.30	259	74	68	68	-0.057	0.05	10.90
99	12.308	12.193	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	95	0.028	100	100	21.2	0.40	256	74	68	68	-0.058	0.10	10.71
100	12.434	12.316	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	94	0.028	101	99	20.7	0.50	254	74	68	68	-0.057	0.08	10.79
101	12.558	12.440	0.000	0.12	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	94	0.028	99	100	20.3	0.40	254	74	68	68	-0.057	0.06	10.67
102	12.684	12.564	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	94	0.028	101	100	20.0	0.30	253	74	68	68	-0.057	0.10	10.67

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
103	12.809	12.688	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	94	0.028	100	100	19.6	0.40	259	74	68	68	-0.057	0.08	10.90
104	12.935	12.811	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	95	0.028	101	99	19.1	0.50	262	74	68	68	-0.058	0.03	11.26
105	13.060	12.935	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	96	0.028	100	100	18.7	0.40	265	74	68	68	-0.058	0.04	11.32
106	13.185	13.059	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	96	0.028	100	100	18.2	0.50	267	74	68	68	-0.058	0.02	11.81
107	13.310	13.183	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	96	0.028	100	100	17.8	0.40	269	74	68	68	-0.058	0.02	12.43
108	13.435	13.307	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	97	0.028	100	100	17.2	0.60	273	74	68	68	-0.059	0.01	12.97
109	13.561	13.430	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	97	0.028	101	99	16.8	0.40	274	74	68	68	-0.058	0.01	12.95
110	13.685	13.554	0.000	0.12	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	98	0.028	99	100	16.3	0.50	276	74	68	68	-0.059	0.01	12.59
111	13.811	13.678	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	98	0.028	101	100	15.8	0.50	277	74	68	68	-0.059	0.01	12.35
112	13.936	13.801	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	98	0.028	100	100	15.4	0.40	278	74	68	68	-0.059	0.01	11.87
113	14.062	13.925	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	98	0.028	101	100	15.0	0.40	279	74	68	68	-0.060	0.01	11.55
114	14.187	14.049	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	98	0.028	100	100	14.5	0.50	279	74	68	68	-0.060	0.02	11.36
115	14.312	14.173	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	99	0.028	100	100	14.1	0.40	280	74	68	68	-0.060	0.03	11.13
116	14.437	14.297	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	99	0.028	100	100	13.7	0.40	280	74	68	68	-0.059	0.04	11.15
117	14.562	14.421	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	99	0.028	100	100	13.4	0.30	280	74	68	68	-0.059	0.05	11.09
118	14.688	14.545	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	98	0.028	101	100	13.0	0.40	277	74	68	68	-0.059	0.06	11.35
119	14.813	14.669	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	98	0.028	100	100	12.7	0.30	277	74	68	68	-0.059	0.02	11.38
120	14.938	14.792	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	98	0.028	100	100	12.2	0.50	278	74	68	68	-0.059	0.02	11.12
121	15.063	14.915	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	98	0.028	100	100	11.9	0.30	278	74	68	68	-0.059	0.02	11.01
122	15.189	15.039	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	98	0.028	101	100	11.5	0.40	281	74	68	68	-0.060	0.03	11.17
123	15.314	15.163	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	99	0.028	100	100	11.1	0.40	284	74	68	68	-0.060	0.03	11.13
124	15.439	15.286	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	99	0.028	100	100	10.7	0.40	285	74	68	68	-0.059	0.04	10.79
125	15.564	15.410	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	99	0.028	100	100	10.4	0.30	284	74	68	68	-0.058	0.06	10.68
126	15.690	15.534	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	98	0.028	101	100	10.0	0.40	282	74	68	68	-0.059	0.04	11.92
127	15.816	15.658	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	98	0.028	101	100	9.7	0.30	283	74	68	68	-0.059	0.05	12.21
128	15.941	15.782	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	99	0.028	100	100	9.3	0.40	291	74	68	68	-0.060	0.04	12.35
129	16.066	15.905	0.000	0.12	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	100	0.028	100	100	8.8	0.50	295	74	68	68	-0.060	0.02	13.44
130	16.191	16.029	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	100	0.028	100	101	8.5	0.30	294	74	68	68	-0.059	0.02	13.20
131	16.317	16.153	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	99	0.028	101	100	8.1	0.40	293	74	68	68	-0.059	0.03	12.84
132	16.442	16.276	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	99	0.028	100	100	7.8	0.30	291	74	68	68	-0.059	0.04	13.02
133	16.567	16.399	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	98	0.028	100	100	7.4	0.40	289	74	68	68	-0.058	0.06	12.49
134	16.692	16.523	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	98	0.028	100	100	7.2	0.20	286	74	68	68	-0.058	0.07	11.99
135	16.818	16.647	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	93	0.028	101	100	6.9	0.30	273	74	68	69	-0.052	0.07	12.94
136	16.943	16.771	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	87	0.028	99	99	6.7	0.20	246	73	68	68	-0.048	0.53	15.28
137	17.068	16.894	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	83	0.028	99	98	6.6	0.10	231	73	68	68	-0.047	0.02	13.51
138	17.194	17.018	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	81	0.028	99	99	6.5	0.10	219	73	68	69	-0.046	0.00	11.99
139	17.319	17.142	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	79	0.028	99	99	6.4	0.10	211	73	68	68	-0.045	0.00	10.94
140	17.445	17.266	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.80	0.20	78	0.028	99	99	6.3	0.10	204	73	68	68	-0.044	0.00	10.20
141	17.570	17.390	0.000	0.13	0.12	1.34	1.61	0.00	73	73	0	0.79	0.20	77	0.028	98	98	6.3	0.00	198	72	68	68	-0.043	0.00	9.93
142	17.695	17.514	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.80	0.20	77	0.028	98	98	6.2	0.10	192	72	68	69	-0.041	0.00	10.01

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
143	17.821	17.638	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.80	0.20	76	0.028	99	98	6.5	-0.30	186	72	68	69	-0.040	0.00	10.50
144	17.947	17.761	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	81	0.028	99	98	6.3	0.20	202	72	68	69	-0.050	0.78	9.28
145	18.071	17.884	0.000	0.12	0.12	1.35	1.61	0.00	74	73	0	0.79	0.20	85	0.028	98	98	6.0	0.30	231	72	68	68	-0.051	0.98	10.09
146	18.197	18.008	0.000	0.13	0.12	1.35	1.61	0.00	74	73	0	0.79	0.20	88	0.028	100	99	5.8	0.20	244	73	68	69	-0.052	0.13	12.65
147	18.322	18.132	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	89	0.028	99	100	5.4	0.40	250	73	68	69	-0.053	0.04	13.23
148	18.448	18.256	0.000	0.13	0.12	1.36	1.62	0.00	74	73	0	0.79	0.20	90	0.028	100	100	5.1	0.30	254	73	68	69	-0.052	0.03	13.20
149	18.573	18.380	0.000	0.13	0.12	1.35	1.61	0.00	74	73	0	0.79	0.20	90	0.028	99	100	4.9	0.20	256	73	68	69	-0.053	0.06	12.81
150	18.699	18.503	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	91	0.028	100	99	4.6	0.30	259	73	68	69	-0.053	0.11	11.69
151	18.824	18.627	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	91	0.028	99	100	4.4	0.20	260	73	68	68	-0.054	0.20	11.33
152	18.949	18.751	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	91	0.028	99	100	4.2	0.20	261	73	68	69	-0.054	0.33	10.64
153	19.075	18.875	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	92	0.028	100	100	3.9	0.30	261	73	68	69	-0.054	0.46	9.68
154	19.199	18.999	0.000	0.12	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	92	0.028	99	100	3.8	0.10	260	73	68	69	-0.054	0.38	9.80
155	19.325	19.123	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	92	0.028	100	100	3.5	0.30	260	73	68	69	-0.054	0.25	10.12
156	19.450	19.246	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	92	0.028	100	99	3.4	0.10	260	73	68	69	-0.054	0.35	9.61
157	19.576	19.370	0.000	0.13	0.12	1.35	1.61	0.00	73	73	0	0.79	0.20	92	0.028	101	100	3.2	0.20	260	73	68	69	-0.054	0.52	8.33
158	19.701	19.494	0.000	0.13	0.12	1.35	1.62	0.00	74	73	0	0.79	0.20	91	0.028	99	100	3.0	0.20	257	73	68	69	-0.053	0.72	7.61
159	19.827	19.618	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	91	0.028	100	100	2.8	0.20	254	73	68	69	-0.053	0.74	7.37
160	19.952	19.742	0.000	0.13	0.12	1.35	1.61	0.00	74	73	0	0.79	0.20	91	0.028	99	100	2.6	0.20	253	73	68	69	-0.053	0.81	7.18
161	20.077	19.866	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	91	0.028	99	100	2.6	0.00	251	73	68	69	-0.052	0.79	7.14
162	20.203	19.989	0.000	0.13	0.12	1.35	1.61	0.00	74	73	0	0.79	0.20	90	0.028	100	99	2.4	0.20	250	73	68	69	-0.052	0.80	6.99
163	20.328	20.113	0.000	0.13	0.12	1.35	1.61	0.00	74	73	0	0.79	0.20	90	0.028	99	100	2.2	0.20	248	73	68	69	-0.052	0.83	6.73
164	20.453	20.237	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	90	0.028	99	100	2.0	0.20	247	73	68	69	-0.052	1.05	7.58
165	20.579	20.361	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	89	0.028	100	100	1.8	0.20	246	73	68	69	-0.052	0.74	8.43
166	20.705	20.485	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	89	0.028	100	100	1.6	0.20	245	73	68	69	-0.051	0.56	8.42
167	20.829	20.608	0.000	0.12	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	88	0.028	98	99	1.4	0.20	244	73	68	69	-0.051	0.60	8.80
168	20.955	20.731	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	88	0.028	100	99	1.4	0.00	242	73	68	69	-0.051	0.54	8.51
169	21.080	20.854	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	87	0.028	99	99	1.1	0.30	240	73	68	69	-0.050	0.62	7.86
170	21.206	20.978	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	87	0.028	100	99	1.0	0.10	237	72	68	69	-0.050	0.65	7.39
171	21.331	21.102	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	86	0.028	99	99	1.0	0.00	234	72	68	69	-0.049	0.64	6.74
172	21.456	21.226	0.000	0.13	0.12	1.35	1.61	0.00	74	73	0	0.79	0.20	86	0.028	99	99	0.8	0.20	231	72	68	69	-0.049	0.67	6.08
173	21.581	21.350	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	85	0.028	99	99	0.8	0.00	228	72	68	69	-0.049	0.68	5.68
174	21.707	21.474	0.000	0.13	0.12	1.34	1.62	0.00	74	73	0	0.79	0.20	85	0.028	100	99	0.7	0.10	226	72	68	69	-0.048	0.66	5.37
175	21.833	21.598	0.000	0.13	0.12	1.34	1.61	0.00	74	73	0	0.79	0.20	85	0.028	100	99	0.6	0.10	224	72	68	69	-0.048	0.64	5.17
	21.833	21.598	0.000			1.33	1.60	0.00	73	72	0			97	0.028						73.69	67.95		-0.056	0.24	9.92

Hydronic Heating Appliances - Test Method ASTM E2618-13 Annex A2
Water Test Data

Run: 2

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Test Date: 42437
Technician: AK/SB
Beginning Clock Time: 10:35
Recording Interval: 1 min.
Total Sampling Time: 175 min.

Boiler Dry Weight (lbs): 1814
Boiler Water Weight (lbs): 425
Tank Weight (lbs): 984
Tank Water Weight (lbs): 4678

Initial Average Tank Temp (°F): 127.0
Final Average Tank Temp (°F): 174.3

Elapsed Time	Flow, gpm		Water Temperature Data, oF																		
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
0	0.76	n/a	60.5	107	98	115	114	116	110	55	116	128	126	126	128	126	127	1.001	6.335	
1	0.79	n/a	60.7	107	98	114	115	116	111	56	116	127	126	126	126	127	127	1.001	6.585	400
2	0.78	n/a	60.5	108	98	114	115	116	111	56	116	127	126	126	127	126	127	1.001	6.502	394
3	0.80	n/a	60.3	108	99	114	115	116	111	56	116	127	126	126	127	126	126	1.001	6.669	403
4	0.77	n/a	60.2	108	99	114	115	116	111	56	116	127	126	126	127	126	126	1.001	6.419	387
5	0.78	n/a	60.2	107	101	114	114	116	110	56	116	126	126	126	127	126	126	1.001	6.502	392
6	0.79	n/a	60.0	107	104	114	114	116	110	55	116	126	126	126	127	126	126	1.001	6.586	395
7	0.80	n/a	60.3	107	108	114	114	116	110	55	116	126	126	126	127	126	126	1.001	6.669	403
8	0.81	n/a	60.3	107	110	114	114	116	110	55	116	126	125	125	126	126	126	1.001	6.753	407
9	0.79	n/a	60.4	107	113	114	114	115	110	55	115	126	125	125	126	125	126	1.001	6.586	398
10	0.78	n/a	60.0	108	116	113	114	115	110	55	115	126	125	125	126	125	126	1.001	6.502	391
11	0.77	n/a	60.3	106	119	114	114	115	110	55	115	126	125	125	126	125	126	1.001	6.419	387
12	0.80	n/a	59.8	106	120	114	114	115	110	55	115	126	125	125	126	125	126	1.001	6.669	399
13	0.80	n/a	60.3	106	123	113	114	115	110	55	115	126	125	125	126	125	126	1.001	6.669	402
14	0.81	n/a	60.1	106	125	114	114	115	110	55	115	126	125	125	126	125	125	1.001	6.753	406
15	0.79	n/a	59.8	107	128	113	114	115	109	55	115	126	125	125	125	125	125	1.001	6.586	394
16	0.79	n/a	59.9	107	131	113	113	115	110	55	115	125	125	125	126	125	125	1.001	6.586	395
17	0.78	n/a	59.9	154	139	116	121	118	111	55	116	125	125	125	124	125	125	1.001	6.503	390
18	0.78	n/a	62.5	157	140	121	128	126	119	55	123	125	125	125	125	125	125	1.001	6.503	407
19	0.56	n/a	71.2	159	140	127	137	133	127	55	130	127	125	125	126	125	125	1.001	4.669	333
20	0.49	n/a	77.3	161	140	126	142	141	132	55	137	128	125	125	129	125	125	1.001	4.085	316
21	0.49	n/a	85.6	163	139	124	141	144	126	55	142	128	125	125	131	125	125	1.001	4.085	350
22	0.58	n/a	88.5	164	140	125	143	144	123	55	143	130	125	125	133	125	125	1.001	4.835	428
23	0.56	n/a	88.3	165	140	125	144	144	122	55	133	130	125	125	133	125	125	1.001	4.668	413
24	0.54	n/a	65.6	166	140	125	145	144	121	55	104	132	125	125	133	125	125	1.001	4.502	296
25	0.73	n/a	33.1	166	140	124	144	148	74	56	93	132	125	125	133	125	125	1.001	6.085	202
26	0.78	n/a	40.1	166	138	119	140	150	86	56	130	133	125	125	134	125	125	1.001	6.502	261
27	0.53	n/a	85.8	167	139	121	141	145	106	55	140	132	125	125	134	125	125	1.001	4.418	380
28	0.53	n/a	85.5	166	140	122	142	145	114	56	141	134	125	125	135	125	125	1.001	4.418	378
29	0.53	n/a	86.8	167	140	123	143	146	116	56	143	134	125	125	135	125	125	1.001	4.418	384
30	0.54	n/a	87.8	167	140	123	144	147	113	56	144	134	125	125	136	125	125	1.001	4.501	396
31	0.52	n/a	88.5	167	140	123	143	148	110	56	143	135	125	125	137	126	125	1.001	4.335	384
32	0.51	n/a	88.0	167	140	123	143	148	110	56	143	135	127	125	137	127	125	1.001	4.251	375
33	0.53	n/a	87.1	167	140	123	143	148	109	56	143	135	128	125	138	129	125	1.001	4.418	385
34	0.52	n/a	87.0	167	140	123	143	148	109	56	142	135	130	125	137	131	125	1.001	4.335	377
35	0.51	n/a	86.0	167	140	123	143	148	109	56	142	136	131	125	138	132	125	1.001	4.251	366
36	0.51	n/a	85.9	167	140	123	143	148	109	56	142	136	132	125	138	133	125	1.001	4.251	365
37	0.53	n/a	86.9	167	140	123	143	148	109	56	142	136	133	125	139	133	125	1.001	4.418	384
38	0.52	n/a	86.5	167	140	123	143	148	109	56	142	136	134	125	139	134	125	1.001	4.334	375
39	0.51	n/a	86.3	167	140	123	143	148	108	56	142	137	135	125	139	134	125	1.001	4.251	367
40	0.51	n/a	85.5	167	140	123	143	148	110	56	142	137	136	125	139	135	125	1.001	4.251	364
41	0.51	n/a	86.8	167	140	122	143	148	110	56	142	137	136	125	139	135	125	1.001	4.251	369
42	0.49	n/a	87.2	167	140	123	143	148	113	56	143	137	136	125	139	136	125	1.001	4.084	357
43	0.52	n/a	87.1	167	140	123	143	148	113	56	143	137	137	125	140	137	125	1.001	4.334	378
44	0.51	n/a	87.7	167	140	123	143	148	113	56	144	138	137	125	140	137	125	1.001	4.251	373
45	0.52	n/a	87.8	167	140	123	143	148	112	56	144	138	138	125	140	138	125	1.001	4.334	381
46	0.51	n/a	88.2	166	140	123	143	147	113	56	144	138	138	125	140	138	125	1.001	4.251	375
47	0.53	n/a	87.8	166	139	123	143	147	114	56	144	138	138	125	140	138	125	1.001	4.418	388
48	0.50	n/a	87.6	165	139	123	142	147	112	56	143	138	138	125	140	138	125	1.001	4.168	365
49	0.52	n/a	87.6	165	139	123	142	147	112	56	143	139	138	125	140	139	125	1.001	4.334	380
50	0.51	n/a	87.3	165	139	123	142	147	112	56	143	139	139	125	140	139	125	1.001	4.251	372
51	0.51	n/a	87.3	164	139	123	142	146	112	56	143	139	139	125	140	139	125	1.001	4.251	372
52	0.50	n/a	86.9	164	139	123	142	146	113	56	143	139	139	125	140	139	125	1.001	4.168	362
53	0.51	n/a	86.3	163	139	124	142	146	113	56	143	139	139	126	140	139	125	1.001	4.251	367
54	0.51	n/a	86.6	163	139	124	142	146	112	56	143	139	139	126	140	139	125	1.001	4.251	369
55	0.51	n/a	86.9	163	139	125	142	146	112	56	143	139	139	128	140	139	127	1.001	4.251	370
56	0.52	n/a	86.9	162	140	126	142	146	111	56	143	139	139	129	140	139	127	1.001	4.334	377
57	0.51	n/a	86.7	162	140	127	143	147	112	56	143	139	139	130	141	140	129	1.001	4.251	369
58	0.51	n/a	86.8	162	140	128	143	147	113	56	143	139	139	131	141	140	130	1.001	4.251	370
59	0.50	n/a	87.3	161	141	128	144	147	113	56	143	139	139	133	141	140	131	1.001	4.168	364
60	0.51	n/a	87.9	162	141	129	144	148	114	56	144	139	139	133	141	140	132	1.001	4.251	374
61	0.51	n/a	87.5	162	141	130	145	148	114	56	144	140	140	134	141	140	132	1.001	4.251	372
62	0.50	n/a	88.2	162	142	131	146	149	114	56	144	140	140	135	142	140	133	1.001	4.168	368
63	0.52	n/a	89.0	163	142	131	147	150	115	56	145	140	140	135	142	140	133	1.001	4.334	386
64	0.52	n/a	89.2	163	142	132	148	151	114	56	146	140	140	136	142	140	134	1.001	4.334	387
65	0.52	n/a	89.8	164	143	132	149	151	116	56	146	140	140	136	142	140	134	1.001	4.334	390
66	0.52	n/a	90.6	165	143	133	150	152	116	56	147	141	140	137	144	140	135	1.001	4.334	393

Elapsed Time	Flow, gpm		Water Temperature Data, oF																	
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
67	0.53	n/a	91.0	165	144	133	150	153	117	56	148	141	140	137	144	140	136	1.001	4.418	402
68	0.52	n/a	91.7	166	144	134	151	154	116	56	148	142	140	138	144	140	137	1.001	4.334	398
69	0.51	n/a	92.7	166	144	134	151	155	119	56	149	144	140	138	145	141	137	1.001	4.251	394
70	0.49	n/a	93.5	167	145	134	152	155	120	56	149	144	141	138	145	141	138	1.001	4.084	382
71	0.53	n/a	93.9	167	145	135	152	156	119	56	150	144	141	138	146	141	138	1.001	4.418	415
72	0.51	n/a	94.7	168	145	135	153	156	119	56	151	144	141	139	147	141	138	1.001	4.251	403
73	0.49	n/a	95.2	168	146	135	153	157	121	56	151	145	141	139	147	141	139	1.001	4.084	389
74	0.48	n/a	94.9	169	146	135	154	157	123	56	151	146	142	139	147	142	139	1.001	4.001	380
75	0.48	n/a	95.4	170	146	136	155	158	123	56	152	146	142	139	148	142	139	1.001	4.001	382
76	0.47	n/a	96.8	171	147	136	156	159	123	56	152	146	142	139	148	142	139	1.001	3.918	380
77	0.47	n/a	97.0	172	147	136	156	159	125	56	153	146	142	139	148	143	139	1.001	3.918	381
78	0.48	n/a	97.2	173	147	136	157	160	126	56	154	148	142	139	149	143	139	1.001	4.001	389
79	0.48	n/a	98.3	174	148	136	158	161	126	56	154	148	143	139	150	144	139	1.001	4.001	394
80	0.46	n/a	98.8	175	148	136	158	161	128	56	155	148	143	139	150	144	139	1.001	3.834	379
81	0.47	n/a	99.4	175	149	136	159	162	129	56	156	149	144	139	150	144	139	1.001	3.918	390
82	0.48	n/a	100.0	176	149	137	159	163	128	56	156	150	144	139	151	145	139	1.001	4.001	401
83	0.46	n/a	100.2	177	149	137	160	163	129	56	157	150	145	139	152	145	139	1.001	3.834	384
84	0.49	n/a	101.0	178	150	137	161	164	129	56	157	150	145	139	153	146	140	1.001	4.084	413
85	0.49	n/a	102.0	178	150	137	161	164	130	56	157	152	145	139	153	146	139	1.001	4.084	417
86	0.46	n/a	101.7	179	150	137	162	165	131	56	158	152	146	139	153	146	140	1.001	3.834	390
87	0.48	n/a	102.6	180	151	138	163	165	130	56	158	153	146	140	154	147	140	1.001	4.001	411
88	0.46	n/a	102.4	180	151	138	163	166	123	57	156	153	147	140	155	147	140	1.001	3.834	393
89	0.47	n/a	96.6	180	151	138	163	168	118	57	152	154	147	140	154	148	140	1.001	3.917	379
90	0.48	n/a	93.7	180	151	137	163	168	117	57	151	155	148	140	155	148	140	1.001	4.001	376
91	0.46	n/a	93.7	180	151	137	163	168	118	57	151	154	148	140	156	149	140	1.001	3.834	360
92	0.46	n/a	94.3	180	151	138	163	168	117	57	152	156	149	140	156	149	140	1.001	3.834	362
93	0.45	n/a	94.5	180	151	138	163	168	118	57	152	155	150	140	156	150	140	1.001	3.751	355
94	0.47	n/a	94.9	180	151	138	163	168	118	57	152	156	150	140	156	150	140	1.001	3.917	372
95	0.46	n/a	93.8	180	151	138	163	168	118	57	152	155	150	141	157	151	141	1.001	3.834	360
96	0.47	n/a	95.2	180	151	138	163	168	119	57	152	156	151	141	157	151	141	1.001	3.917	373
97	0.47	n/a	95.4	180	151	138	163	168	118	57	152	157	152	141	158	152	141	1.001	3.917	374
98	0.47	n/a	94.6	179	151	139	163	168	119	57	152	157	152	141	159	153	141	1.001	3.917	371
99	0.48	n/a	95.3	179	152	139	163	168	119	57	152	157	153	142	158	153	142	1.001	4.001	382
100	0.46	n/a	95.2	179	151	139	163	168	119	57	151	157	154	142	158	153	142	1.001	3.834	366
101	0.47	n/a	94.9	178	152	140	163	168	119	57	151	157	155	142	158	154	142	1.001	3.917	372
102	0.45	n/a	94.0	178	152	140	162	168	119	57	151	157	156	142	158	155	142	1.001	3.751	353
103	0.48	n/a	95.5	178	152	140	163	168	118	57	151	157	156	143	159	155	143	1.001	4.001	383
104	0.48	n/a	94.7	178	152	140	163	168	118	57	151	157	157	144	159	156	143	1.001	4.001	379
105	0.47	n/a	94.3	178	152	141	163	168	119	57	151	158	157	144	159	156	144	1.001	3.917	370
106	0.47	n/a	94.0	178	153	141	163	168	118	57	151	158	158	144	159	157	144	1.001	3.917	369
107	0.46	n/a	94.7	179	153	142	164	168	117	57	151	158	158	145	160	157	145	1.001	3.834	364
108	0.46	n/a	94.2	180	153	142	164	169	119	57	152	159	158	145	160	157	145	1.001	3.834	362
109	0.47	n/a	94.2	181	154	143	165	169	118	57	152	158	158	146	160	158	145	1.001	3.917	370
110	0.47	n/a	95.7	181	155	143	166	170	119	57	152	159	158	146	160	158	146	1.001	3.917	375
111	0.47	n/a	95.6	182	155	143	166	170	119	57	152	159	159	146	161	158	146	1.001	3.917	375
112	0.47	n/a	95.8	183	156	144	167	171	120	57	153	159	159	147	162	158	147	1.001	3.917	376
113	0.47	n/a	96.4	183	156	144	167	171	119	57	153	160	159	148	162	159	147	1.001	3.917	378
114	0.46	n/a	95.5	184	157	145	168	172	121	57	154	160	159	148	162	159	148	1.001	3.834	366
115	0.47	n/a	97.1	185	157	145	169	173	122	57	154	161	159	148	163	159	149	1.001	3.917	381
116	0.46	n/a	97.6	185	157	146	169	173	122	57	154	163	160	149	164	159	149	1.001	3.834	375
117	0.47	n/a	97.3	186	158	146	170	174	122	57	155	162	160	150	164	159	149	1.001	3.917	382
118	0.46	n/a	98.1	186	158	147	170	174	123	57	155	162	160	150	164	159	150	1.001	3.834	377
119	0.47	n/a	98.4	186	159	147	170	175	123	57	155	162	160	151	165	160	150	1.001	3.917	386
120	0.46	n/a	98.6	187	159	148	171	175	124	57	156	162	160	152	165	160	150	1.001	3.834	379
121	0.46	n/a	98.7	187	160	149	171	175	124	57	156	163	160	152	165	160	151	1.001	3.834	379
122	0.45	n/a	98.9	188	160	149	172	176	125	57	156	164	161	153	166	161	151	1.001	3.751	371
123	0.45	n/a	99.0	188	161	149	172	176	125	57	156	164	161	153	166	161	152	1.001	3.751	372
124	0.47	n/a	99.6	189	161	150	173	177	126	57	157	164	161	155	167	162	152	1.001	3.917	391
125	0.46	n/a	99.8	189	162	151	174	177	126	57	157	165	162	155	167	162	154	1.001	3.834	383
126	0.46	n/a	99.7	190	162	151	174	178	126	57	157	165	162	156	168	162	154	1.001	3.834	383
127	0.48	n/a	100.8	191	163	152	175	179	125	57	158	165	162	156	169	163	155	1.001	4.001	404
128	0.46	n/a	100.3	191	163	152	175	179	127	57	158	166	163	157	168	163	155	1.001	3.834	385
129	0.47	n/a	100.6	192	164	153	176	180	126	57	158	166	163	157	169	164	155	1.001	3.917	395
130	0.46	n/a	101.3	193	164	153	177	180	127	57	158	167	163	157	169	164	156	1.001	3.834	389
131	0.47	n/a	101.8	194	165	153	177	181	128	57	159	168	164	157	170	164	156	1.001	3.917	399
132	0.46	n/a	101.8	195	165	154	178	181	129	57	159	168	164	157	171	165	156	1.001	3.834	391
133	0.46	n/a	101.8	195	166	154	178	182	129	57	159	168	164	157	171	165	156	1.001	3.834	391
134	0.45	n/a	102.7	196	166	154	179	183	129	57	160	169	165	158	170	165	157	1.001	3.751	386
135	0.46	n/a	102.4	196	166	154	179	183	128	57	160	170	165	158	172	165	157	1.001	3.834	393
136	0.45	n/a	103.1	195	166	154	179	183	131	57	161	171	166	158	173	166	158	1.001	3.751	387
137	0.46	n/a	102.8	194	166	155	178	184	132	57	161	171	166	158	172	166	158	1.001	3.834	394
138	0.46	n/a	103.4	193	166	155	178	183	130	57	161	171	166	158	172	167	158	1.001	3.834	397
139	0.45	n/a	103.3	191	165	155	176	183	129	57	161	171	167	159	172	167	158	1.001	3.751	388
140	0.46	n/a	103.4	189	165	155	175	182	129	57	160	171	167	159	172	167	158	1.001	3.834	397
141	0.46	n/a	102.3	187	164	155	174	181	129	57	160	171	168	159	172	168	158	1.001	3.834	393
142	0.46	n/a	102.4	185	164	156	173	180	129	57	159	171	168	159	172	168	159	1.001	3.834	393
143	0.47	n/a	100.4	183	163	156	172	179	128	57	158	171	168	159	172	169	159	1.001	3.917	394
144	0.47	n/a	101.2	182	163	156	171	178	126	57	158	171	170	160	172	169	159	1.001	3.917	397
145	0.46	n/a	99.8	182	163	156	171	177	125	57	157	171	171	160	172	170	160	1.001	3.834	383

Elapsed Time	Flow, gpm		Water Temperature Data, oF																	
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
146	0.47	n/a	100.3	183	163	157	172	177	126	57	157	171	171	160	172	171	160	1.001	3.917	393
147	0.47	n/a	99.9	184	164	157	173	177	125	57	157	171	171	160	172	171	160	1.001	3.917	392
148	0.45	n/a	99.2	185	164	157	174	177	125	57	157	171	171	161	172	171	161	1.001	3.751	373
149	0.45	n/a	99.0	186	165	158	174	178	126	57	157	171	171	161	172	171	161	1.001	3.751	372
150	0.45	n/a	100.1	188	166	158	175	179	125	57	158	171	171	161	172	171	161	1.001	3.751	376
151	0.46	n/a	101.0	189	166	158	176	179	127	57	158	171	171	162	172	171	162	1.001	3.834	388
152	0.45	n/a	101.0	189	167	159	177	180	126	57	158	171	171	162	172	171	162	1.001	3.751	379
153	0.44	n/a	101.1	190	167	159	177	181	128	57	159	171	172	162	173	171	163	1.001	3.667	371
154	0.46	n/a	101.3	191	168	159	178	181	129	57	159	171	172	163	173	171	163	1.001	3.834	389
155	0.45	n/a	101.8	191	168	160	178	182	130	57	159	171	172	163	173	171	163	1.001	3.751	382
156	0.46	n/a	102.1	192	168	160	179	182	129	57	160	172	172	164	174	171	164	1.001	3.834	392
157	0.46	n/a	103.1	192	169	161	179	183	129	57	160	172	172	164	174	172	164	1.001	3.834	396
158	0.45	n/a	102.4	192	169	161	179	183	130	57	161	172	172	164	174	172	164	1.001	3.751	385
159	0.45	n/a	103.1	192	169	161	179	184	131	57	161	172	172	165	175	172	165	1.001	3.751	387
160	0.45	n/a	103.7	192	170	162	179	184	130	57	161	173	172	166	175	172	165	1.001	3.751	389
161	0.46	n/a	104.1	192	170	162	179	184	131	57	161	173	173	166	175	172	166	1.001	3.834	400
162	0.45	n/a	103.2	192	170	163	180	184	132	57	161	174	173	166	175	173	166	1.001	3.751	388
163	0.45	n/a	104.2	191	170	164	180	184	131	57	161	174	173	167	176	173	166	1.001	3.751	391
164	0.46	n/a	103.7	191	171	164	180	184	132	57	161	174	173	168	176	173	167	1.001	3.834	398
165	0.45	n/a	103.9	191	171	165	180	185	131	57	162	174	173	169	176	173	167	1.001	3.751	390
166	0.45	n/a	104.1	191	171	165	180	185	132	57	162	174	174	170	176	173	168	1.001	3.751	391
167	0.46	n/a	103.6	192	172	165	181	185	132	57	162	174	174	170	177	174	169	1.001	3.834	398
168	0.45	n/a	104.8	192	172	166	181	185	134	57	162	175	174	170	177	174	169	1.001	3.751	393
169	0.46	n/a	104.4	192	172	165	181	185	133	57	162	175	175	170	177	174	170	1.001	3.834	401
170	0.44	n/a	104.7	192	172	166	181	185	132	57	162	175	175	170	177	174	170	1.001	3.667	384
171	0.44	n/a	104.5	192	172	166	181	186	132	57	162	175	175	170	177	175	170	1.001	3.667	384
172	0.45	n/a	104.6	192	172	166	181	186	134	57	163	175	175	170	177	175	170	1.001	3.751	393
173	0.45	n/a	105.8	192	172	166	181	186	132	57	163	176	175	171	177	175	170	1.001	3.751	397
174	0.46	n/a	105.3	192	172	166	181	186	134	57	162	176	176	171	178	175	170	1.001	3.834	404
175	0.46	n/a	104.5	191	172	166	181	186	133	57	163	176	176	171	178	175	170	1.001	3.834	401
	0.52	#DIV/0!	90.9	171.0	148.9	138.4	156.4	160.1	120.0	56.4	147.5	151.3	148.9	142.4	152.9	149.0	142.1			381
																			Total Heat Output	66739

Run 3

Hydronic Heating Appliances - Test Methods ASTM E2515-11 & E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Run: 3
Test Date: March 9, 2016

Burn Rate	**9.36 kg/hr dry**
Average Tunnel Temperature	98 degrees F
Average Gas Velocity in Dilution Tunnel - vs	10.1 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	26316 dscf/hour
Average Delta p	0.026 inches H20
Average Delta H	1.30 inches H20
Total Time of Test	175 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**6.81** g/hr **0.54** g/kg
Complete Run:	**6.49** g/hr **0.69** g/kg **0.12** lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	21.64 cubic feet	21.58 cubic feet	0.00 cubic feet
Average Gas Meter Temperature	71 degrees F	71 degrees F	0 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	21.4 dscf	21.2 dscf	0.0 dscf
Total Particulates - mn	5.3 mg	5.2 mg	0 mg
Particulate Concentration (dry-standard)	0.000248 grams/dscf	0.000246 grams/dscf	0.000000 grams/dscf
Particulate Emissions	19.02 grams	18.86 grams	
Difference from Average	0.08 grams	0.08 grams	

Results Are Acceptable

	AVERAGE
Total Sample Volume - Vm	21.61 cubic feet
Average Gas Meter Temperature	71 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	21.3 dscf
Particulate Concentration (dry-standard)	0.00025 grams/dscf
Particulate Emissions	18.94 grams
7.5% of the average particulate emissions	1.42 grams

ADDITIONAL ACCEPTANCE CRITERIA

Boiler Water Return Temperature >120 °F	**N/A - Cold Start**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	7.43 cubic feet
Average Gas Meter Temperature	71 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	7.34 dscf
Total Particulates - mn	1.9 mg
Particulate Concentration (dry-standard)	0.00026 grams/dscf
Particulate Emissions	6.81 grams
Burn Rate	12.64 (dry kg/hr)

ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2152
Project No.:	0456WB005E
Technician:	AK/SB
Comments:	

Parameters:

Run Number:	3
Test Date:	3/9/16
Total Fuel Weight (lb):	73.7
Average Moisture of Fuel (% dry):	22.4
Average Moisture of Fuel (% wet):	18.30
Average Temperature of Appliance Water at Start of Test (°F):	89.0
Average Temperature of Appliance Water at End of Test (°F):	173.0
Average Thermopile Reading (°F):	99.9
Average Load Side Liquid Flow Rate (gal/min):	0.8
Time Interval (min):	175
Burn Rate (kg/hr):	9.36
Emissions (g):	18.9
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

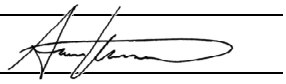
Calculations:

HHV Heat Input (Btu):	517801
Net HHV Heat Input (Btu):	517801
Net HHV Heat Input Rate (Btu/hr):	177532
LHV Heat Input (Btu):	480953
Net LHV Heat Input (Btu):	480953
Net LHV Heat Input Rate (Btu/hr):	164898
Appliance Water Specific Heat (Btu/lb^{o}F):	1.001
Tank Water Specific Heat (Btu/lb^{o}F):	1.001
Q_{unit} (Btu):	50971
Q_{Load} (Btu):	106987
$Q_{Storage}$ (Btu):	193613
Total Heat Output (Btu):	351571
Total Heat Output Rate (Btu/hr):	120539
Load Output Rate (Btu/hr):	36681
Emissions Factor(g/kg):	0.69
Total Particulate Emissions Rate (g/MJ):	0.051
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.119**
Total Particulate Emissions (g/hr):	6.49
Delivered Efficiency, HHV (%):	67.9
First Hour Emissions Factor (g/kg):	0.54
First Hour Emissions Rate (g/hr):	6.81

OMNI-Test Laboratories, Inc.

Manufacturer:	Froling
Model:	S3 Large
Date:	03/09/16
Run:	3
Control #:	2152
Test Duration:	175
Output Category:	II

Technicians: A. Kravitz



Test Results in Accordance with CSA B415.1-09

	HHV Basis	LHV Basis
Overall Efficiency	79.0%	85.0%
Combustion Efficiency	97.7%	97.7%
Heat Transfer Efficiency	81%	87.0%

Output Rate (kJ/h)	147,993	140,387	**(Btu/h)**
Burn Rate (kg/h)	9.37	20.65	**(lb/h)**
Input (kJ/h)	187,387	177,757	**(Btu/h)**

Test Load Weight (dry kg)	27.32	60.22	**dry lb**
MC wet (%)	18.29		
MC dry (%)	22.38		
Particulate (g)	0		
CO (g)	1,005		
Test Duration (h)	2.92		

Emissions	Particulate	CO
g/MJ Output	0.00	2.33
g/kg Dry Fuel	0.00	36.78
g/h	0.00	344.57
lb/MM Btu Output	0.00	5.41

Air/Fuel Ratio (A/F)	13.30

VERSION: **2.3** **3/23/2010**

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 3
Model: S3 Tracking Number: 2152 Date: 3/9/16
Test Crew: A. Kravitz, S. Button
OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Run Notes

Preburn Settings – N/A – COLD START

Target Output (%): _____
Target Output (BTU/hr):

Preburn Notes

TIME	NOTES

Test Settings

Target Output (%): 21%
Target Output (BTU/hr): 35,000

Start-Up Timeline

Ignition Complete by: 2:00
Door Closed at: 3:20
Notes: Cold start test with propane torch – kindling, newspaper, startup fuel and test fuel all loaded at once prior to test start.

Test Notes

TIME	NOTES
N/A	None

Technician Signature: _____ Date: 3/9/16

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 3

Model: S3 Tracking Number: 2152 Date: 3/9/16

Test Crew: A. Kravitz, S. Button

OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Supplemental Data

Start Time: 9:54 Booth #: E3

Stop Time: 12:49

Stack Gas Leak Check:

Initial: 0 Final: 0

Sample Train Leak Check:

A: 0.001 @ -4 "Hg

B: 0.001 @ -4 "Hg

Calibrations: Span Gas CO_2: 16.89 CO: 4.293

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	9:29	9:30	12:57	13:03
CO_2	0.00	16.89	0.04	16.85
CO	0.000	4.294	0.005	4.285

Air Velocity (ft/min): Initial: <50 Final: <50

Scale Audit (lbs): Initial: 10 Final: 10

Pitot Tube Leak Test: Initial: 0 Final: 0

Stack Diameter (in): 6

Induced Draft: 0

% Smoke Capture: 100%

Flue Pipe Cleaned Prior to First Test in Series:

Date: 3/4/16 Initials: SB

	Initial	Middle	Ending
P_b (in/Hg)	29.80	20.82	20.84
Ambient (°F)	66	66	69

Background Filter Volume (ft^3): N/A

Tunnel Traverse	
dP (in H_2O)	T(°F)
0.018	78
0.024	78
0.022	78
0.026	78
0.026	78
0.022	78
0.020	78
0.022	78
0.026	78
0.024	78
0.022	78
0.012	78
Static P:	-0.27

Center: 0.026 / 78

Technician Signature: Date: 3/9/16

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 3

Model: S3 Tracking Number: 2152 Date: 3/9/16

Test Crew: A. Kravitz, S. Button

OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Fuel Data

Fuel Load Prepared by: A. Kravitz

Fuel: Cordwood meeting ASTM 2618 Requirements, Oak, Ash, Alder, & Maple

Firebox Volume (ft^3): 6.78 Test Fuel Piece Length (in): Varies

Pre-test fuel total weight: N/A

Test Fuel

CALIBRATION: Cal Value (1) = 12% Actual Reading: 12.0

Cal Value (2) = 22% Actual Reading: 22.0

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Kindling Aggregate	5.7	20	18.6	13.5	20.2	21.7
Start-up Fuel	2.2	20.5	19.6	25.1	26.1	22.3
Start-up Fuel	1.5	18	18.5	18.6	23.2	21.9
Start-up Fuel	1.9	21	20.2	18.4	19.3	19.3
Start-up Fuel	1.1	18.6	18.2	23.3	22.9	22.2
Main Test Fuel	6.6	22	24.4	26.1	27.5	23.6
Main Test Fuel	7.9	27.2	25.3	23.2	26.1	23
Main Test Fuel	8.8	20.4	21.3	25.3	24.2	24.4
Main Test Fuel	7	25.5	19.2	21.8	22.5	26.3
Main Test Fuel	7.1	18.8	18.7	20.8	19.5	20.5
Main Test Fuel	6.6	18.7	19.8	23.7	24.1	24.2
Main Test Fuel	5.2	20.2	19.6	19.5	18.8	18.1
Main Test Fuel	5.7	25.2	27.3	20.8	21.5	27
Main Test Fuel	6.4	18.5	23.7	25.8	26.9	25.5

Total Wet Weight: 73.7

TIME (CLOCK): 9:00 TEMPERATURE (F): 65 INITIALS: [signature]

Technician Signature: [signature] Date: 3/9/16

Hydronic Heating Appliances - Test Method ASTM E2618-13
Fuel Moisture

Manufacturer:	Froling
Model:	S3
Tracking No.:	2152
Project No.:	0456WB005E
Technician:	AK/SB
Run #:	3
Test Date:	March 9, 2016

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Kindling Aggregate	5.7	20	18.6	13.5	20.2	21.7
Start-up Fuel	2.2	20.5	19.6	25.1	26.1	22.3
Start-up Fuel	1.5	18	18.5	18.6	23.2	21.9
Start-up Fuel	1.9	21	20.2	18.4	19.3	19.3
Start-up Fuel	1.1	18.6	18.2	23.3	22.9	22.2
Main Test Fuel	6.6	22	24.4	26.1	27.5	23.6
Main Test Fuel	7.9	27.2	25.3	23.2	26.1	23
Main Test Fuel	8.8	20.4	21.3	25.3	24.2	24.4
Main Test Fuel	7	25.5	19.2	21.8	22.5	26.3
Main Test Fuel	7.1	18.8	18.7	20.8	19.5	20.5
Main Test Fuel	6.6	18.7	19.8	23.7	24.1	24.2
Main Test Fuel	5.2	20.2	19.6	19.5	18.8	18.1
Main Test Fuel	5.7	25.2	27.3	20.8	21.5	27
Main Test Fuel	6.4	18.5	23.7	25.8	26.9	25.5

Total Weight of Load (lb):	73.7
Total Moisture of Load (%):	22.41

Equipment Numbers:
240, 353, 431

Hydronic Heating Appliances - Test Method ASTM E2515-11

Emissions Sampling Data

Run: 3

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Test Date: March 9, 2016
Technician: AK/SB
Beginning Clock Time: 09:54
Recording Interval: 1 min.
Total Sampling Time: 175 min.

Velocity Traverse Data	Pt.1	Pt.2	Pt.3	Pt.4	Pt.5	Pt.6	Pt.7	Pt.8	Pt.9	Pt.10	Pt.11	Pt.12	Center	
Initial dP	0.018	0.024	0.022	0.026	0.026	0.022	0.020	0.022	0.026	0.024	0.022	0.012	0.026	"H2O
Initial Temp.	78	78	78	78	78	78	78	78	78	78	78	78	78	oF

Air Velocity: Initial: <50 Final: <50
Scale Audit: Pre: 10.0 Post: 10.0
Pitot Tube Leak Test: Pre: 0 Post: 0
Induced Draft: 0
% Smoke Capture: 100
Flue Pipe Cleaned Prior to First Test in Series: Date: 3/4/2016

V_{strav} 9.90 ft/sec
V_{scent} 10.81 ft/sec
F_p 0.916

	(1)	(2)	(amb)	
Meter Box Y Factor:	0.995	0.985	1	
Barometric Pressure:	Begin	Middle	End	Average
	29.80	29.82	29.84	29.82 "Hg

PM Control Module: 428A/B
Dilution Tunnel MW(dry): 29.00 lb/lb-mole
Dilution Tunnel MW(wet): 28.78 lb/lb-mole
Dilution Tunnel H2O: 2.00 percent
Dilution Tunnel Static: -0.270 "H2O
Pitot Tube Cp: 0.99

Tunnel Velocity: 10.08 ft/sec.
Intial Tunnel Flow: 446.6 scfm
Average Tunnel Flow: 438.6 scfm
Tunnel Area: 0.785 ft2

Post-Test Leak Check (1): 0.001 cfm @ -4 in. Hg
Post-Test Leak Check (2): 0.001 cfm @ -4 in. Hg
Fuel Moisture (dry basis %): 22.4
Total Particulate (1): 4.8
Total Particulate (2): 5.2

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
0	0.000	0.000	0.000			-0.01	0.01	0.00	67	67	0	1.60	1.00	78	0.026			73.7		116	69	69	66	-0.032	-0.01	0.06
1	0.115	0.107	0.000	0.12	0.11	1.34	1.56	0.00	67	67	0	0.81	0.20	82	0.026	92	86	72.7	1.00	160	69	69	66	-0.061	0.13	2.42
2	0.241	0.229	0.000	0.13	0.12	1.36	1.57	0.00	68	67	0	0.80	0.20	92	0.026	102	99	71.7	1.00	221	70	71	66	-0.072	0.26	6.02
3	0.366	0.351	0.000	0.13	0.12	1.36	1.58	0.00	68	68	0	0.80	0.20	98	0.026	102	99	71.4	0.30	241	71	71	66	-0.071	0.27	5.57
4	0.492	0.474	0.000	0.13	0.12	1.37	1.59	0.00	68	68	0	0.80	0.20	98	0.026	103	100	70.6	0.80	239	70	71	66	-0.057	0.21	6.31
5	0.617	0.596	0.000	0.13	0.12	1.37	1.59	0.00	68	68	0	0.80	0.20	96	0.026	102	99	70.2	0.40	225	70	71	66	-0.051	0.17	5.22
6	0.742	0.719	0.000	0.13	0.12	1.36	1.58	0.00	69	68	0	0.80	0.20	95	0.026	101	100	69.7	0.50	224	70	71	66	-0.049	0.17	5.83
7	0.867	0.842	0.000	0.13	0.12	1.35	1.59	0.00	69	68	0	0.80	0.20	94	0.026	101	100	69.2	0.50	226	70	71	66	-0.052	0.14	8.00
8	0.992	0.965	0.000	0.13	0.12	1.35	1.58	0.00	69	68	0	0.80	0.20	93	0.026	101	100	68.7	0.50	229	70	71	66	-0.052	0.13	8.41
9	1.117	1.088	0.000	0.13	0.12	1.35	1.59	0.00	69	68	0	0.80	0.20	93	0.026	101	100	68.1	0.60	233	70	71	66	-0.053	0.14	8.37
10	1.241	1.210	0.000	0.12	0.12	1.34	1.59	0.00	70	68	0	0.80	0.20	94	0.026	100	99	67.6	0.50	238	71	71	66	-0.053	0.09	9.13
11	1.366	1.333	0.000	0.13	0.12	1.34	1.59	0.00	69	68	0	0.80	0.20	94	0.026	101	100	67.0	0.60	244	71	71	66	-0.055	0.07	9.74
12	1.491	1.456	0.000	0.13	0.12	1.35	1.60	0.00	70	68	0	0.80	0.20	95	0.026	101	100	66.4	0.60	250	71	71	66	-0.055	0.03	10.92
13	1.615	1.579	0.000	0.12	0.12	1.34	1.59	0.00	70	68	0	0.80	0.20	95	0.026	100	100	65.8	0.60	252	71	71	66	-0.055	0.04	10.65
14	1.741	1.702	0.000	0.13	0.12	1.34	1.59	0.00	70	68	0	0.80	0.20	96	0.026	102	100	65.2	0.60	256	71	72	66	-0.055	0.03	10.79
15	1.864	1.824	0.000	0.12	0.12	1.34	1.58	0.00	70	68	0	0.79	0.20	97	0.026	100	99	64.6	0.60	265	72	72	66	-0.057	0.01	13.44
16	1.988	1.946	0.000	0.12	0.12	1.34	1.59	0.00	70	68	0	0.79	0.20	98	0.026	101	99	63.9	0.70	271	72	72	66	-0.058	0.01	14.25
17	2.112	2.069	0.000	0.12	0.12	1.33	1.59	0.00	70	68	0	0.79	0.20	99	0.026	101	100	63.3	0.60	280	72	72	66	-0.058	0.01	13.37
18	2.236	2.191	0.000	0.12	0.12	1.33	1.58	0.00	70	68	0	0.79	0.20	99	0.026	101	100	62.8	0.50	282	72	72	66	-0.057	0.02	12.19
19	2.361	2.314	0.000	0.13	0.12	1.33	1.58	0.00	71	68	0	0.79	0.20	100	0.026	101	100	62.3	0.50	283	72	72	66	-0.057	0.02	11.66
20	2.485	2.436	0.000	0.12	0.12	1.33	1.59	0.00	71	69	0	0.79	0.20	100	0.026	101	99	61.8	0.50	283	72	72	66	-0.057	0.02	11.53
21	2.608	2.559	0.000	0.12	0.12	1.32	1.59	0.00	71	69	0	0.78	0.20	100	0.026	100	100	61.2	0.60	279	72	72	66	-0.056	0.02	11.32
22	2.732	2.681	0.000	0.12	0.12	1.32	1.58	0.00	71	69	0	0.79	0.20	99	0.026	100	99	60.5	0.70	274	72	72	67	-0.057	0.02	11.42

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
23	2.856	2.804	0.000	0.12	0.12	1.32	1.59	0.00	71	69	0	0.79	0.20	99	0.026	100	100	59.9	0.60	271	72	72	67	-0.056	0.01	11.55
24	2.979	2.926	0.000	0.12	0.12	1.32	1.58	0.00	71	69	0	0.79	0.20	98	0.026	100	99	59.5	0.40	269	72	72	67	-0.057	0.02	11.30
25	3.103	3.049	0.000	0.12	0.12	1.32	1.59	0.00	71	69	0	0.79	0.20	97	0.026	100	100	59.0	0.50	265	72	71	67	-0.056	0.05	11.21
26	3.228	3.171	0.000	0.13	0.12	1.32	1.58	0.00	72	69	0	0.79	0.20	97	0.026	101	99	58.5	0.50	264	71	71	67	-0.056	0.17	10.15
27	3.350	3.294	0.000	0.12	0.12	1.31	1.58	0.00	72	69	0	0.79	0.20	97	0.026	98	100	57.9	0.60	263	71	71	67	-0.057	0.25	9.59
28	3.474	3.417	0.000	0.12	0.12	1.32	1.59	0.00	71	69	0	0.79	0.20	98	0.026	100	100	57.3	0.60	264	72	72	67	-0.057	0.15	11.02
29	3.598	3.540	0.000	0.12	0.12	1.31	1.59	0.00	71	69	0	0.79	0.20	99	0.026	100	100	56.8	0.50	271	72	72	67	-0.056	0.06	11.87
30	3.721	3.662	0.000	0.12	0.12	1.32	1.59	0.00	72	69	0	0.78	0.20	99	0.026	99	99	56.3	0.50	274	72	72	67	-0.058	0.07	11.40
31	3.846	3.785	0.000	0.13	0.12	1.32	1.59	0.00	72	70	0	0.79	0.20	100	0.026	101	100	55.7	0.60	275	72	72	67	-0.058	0.07	11.20
32	3.970	3.908	0.000	0.12	0.12	1.31	1.59	0.00	72	70	0	0.79	0.20	100	0.026	100	100	55.2	0.50	277	72	72	67	-0.057	0.11	10.77
33	4.093	4.031	0.000	0.12	0.12	1.31	1.59	0.00	72	70	0	0.79	0.20	101	0.026	100	100	54.7	0.50	276	72	72	67	-0.055	0.19	10.23
34	4.216	4.153	0.000	0.12	0.12	1.32	1.59	0.00	72	70	0	0.79	0.20	101	0.026	100	99	54.2	0.50	276	72	72	67	-0.057	0.29	9.56
35	4.340	4.276	0.000	0.12	0.12	1.32	1.59	0.00	72	70	0	0.79	0.20	101	0.026	100	100	53.6	0.60	278	72	72	68	-0.058	0.31	9.63
36	4.463	4.398	0.000	0.12	0.12	1.32	1.59	0.00	72	70	0	0.78	0.20	103	0.026	100	99	52.8	0.80	285	73	73	68	-0.059	0.28	12.69
37	4.587	4.521	0.000	0.12	0.12	1.31	1.58	0.00	72	70	0	0.78	0.20	104	0.026	101	100	52.1	0.70	297	74	74	68	-0.062	0.06	15.37
38	4.711	4.643	0.000	0.12	0.12	1.31	1.59	0.00	72	70	0	0.78	0.20	105	0.026	101	100	51.5	0.60	302	74	74	68	-0.061	0.05	13.49
39	4.835	4.766	0.000	0.12	0.12	1.31	1.59	0.00	72	70	0	0.77	0.20	105	0.026	101	100	50.7	0.80	303	74	74	68	-0.062	0.08	12.48
40	4.957	4.888	0.000	0.12	0.12	1.30	1.59	0.00	72	70	0	0.77	0.20	106	0.026	99	100	50.1	0.60	302	74	74	68	-0.062	0.10	11.82
41	5.081	5.011	0.000	0.12	0.12	1.31	1.58	0.00	72	70	0	0.77	0.20	106	0.026	101	101	49.5	0.60	302	74	74	67	-0.061	0.08	11.43
42	5.204	5.133	0.000	0.12	0.12	1.30	1.58	0.00	72	71	0	0.77	0.20	106	0.026	100	100	48.9	0.60	300	74	74	67	-0.061	0.11	10.93
43	5.327	5.255	0.000	0.12	0.12	1.31	1.57	0.00	72	71	0	0.77	0.20	105	0.026	100	99	48.3	0.60	297	74	74	67	-0.059	0.10	11.05
44	5.451	5.378	0.000	0.12	0.12	1.30	1.59	0.00	72	71	0	0.77	0.20	105	0.026	101	100	47.7	0.60	294	74	74	67	-0.059	0.16	11.11
45	5.575	5.500	0.000	0.12	0.12	1.30	1.58	0.00	72	71	0	0.77	0.20	104	0.026	101	99	47.1	0.60	289	74	74	67	-0.060	0.15	11.16
46	5.698	5.622	0.000	0.12	0.12	1.31	1.57	0.00	72	71	0	0.77	0.20	102	0.026	100	99	46.6	0.50	281	73	73	67	-0.059	0.26	10.88
47	5.821	5.744	0.000	0.12	0.12	1.30	1.58	0.00	72	71	0	0.77	0.20	101	0.026	100	99	46.1	0.50	277	73	73	67	-0.060	0.52	9.97
48	5.945	5.867	0.000	0.12	0.12	1.30	1.58	0.00	72	71	0	0.77	0.20	101	0.026	100	100	45.5	0.60	277	73	73	67	-0.059	0.19	11.99
49	6.068	5.989	0.000	0.12	0.12	1.30	1.59	0.00	72	71	0	0.77	0.20	100	0.026	100	99	45.0	0.50	278	73	73	67	-0.060	0.04	12.35
50	6.192	6.112	0.000	0.12	0.12	1.31	1.59	0.00	72	71	0	0.77	0.20	100	0.026	100	100	44.5	0.50	278	73	73	67	-0.060	0.07	11.63
51	6.316	6.234	0.000	0.12	0.12	1.30	1.58	0.00	72	71	0	0.77	0.20	99	0.026	100	99	44.0	0.50	277	73	73	67	-0.059	0.14	10.85
52	6.440	6.357	0.000	0.12	0.12	1.30	1.59	0.00	72	71	0	0.77	0.20	99	0.026	100	100	43.4	0.60	276	73	72	67	-0.060	0.21	10.24
53	6.562	6.479	0.000	0.12	0.12	1.30	1.57	0.00	72	71	0	0.77	0.20	99	0.026	99	99	43.0	0.40	275	72	72	67	-0.059	0.31	9.85
54	6.686	6.602	0.000	0.12	0.12	1.30	1.59	0.00	72	71	0	0.77	0.20	99	0.026	100	100	42.6	0.40	274	72	72	66	-0.059	0.42	9.56
55	6.809	6.725	0.000	0.12	0.12	1.30	1.59	0.00	71	71	0	0.77	0.20	99	0.026	100	100	42.1	0.50	274	72	72	66	-0.059	0.42	9.41
56	6.933	6.848	0.000	0.12	0.12	1.31	1.58	0.00	72	71	0	0.77	0.20	99	0.026	100	100	41.6	0.50	274	72	72	66	-0.060	0.19	10.12
57	7.057	6.971	0.000	0.12	0.12	1.30	1.58	0.00	72	71	0	0.78	0.20	99	0.026	100	100	41.0	0.60	275	72	72	66	-0.060	0.16	10.00
58	7.180	7.093	0.000	0.12	0.12	1.30	1.58	0.00	71	71	0	0.77	0.20	99	0.026	100	99	40.5	0.50	275	72	72	66	-0.059	0.20	9.60
59	7.304	7.216	0.000	0.12	0.12	1.31	1.58	0.00	71	71	0	0.77	0.20	99	0.026	100	100	40.1	0.40	275	72	72	66	-0.059	0.19	9.33
60	7.427	7.338	0.000	0.12	0.12	1.30	1.59	0.00	72	71	0	0.77	0.20	99	0.026	99	99	39.6	0.50	274	72	72	66	-0.060	0.27	9.08
61	7.553	7.461	0.000	0.13	0.12	1.31	1.57	0.00	71	71	0	0.77	0.20	99	0.026	102	100	39.1	0.50	273	72	72	66	-0.059	0.49	8.73
62	7.676	7.584	0.000	0.12	0.12	1.30	1.59	0.00	71	71	0	0.76	0.20	99	0.026	100	100	38.6	0.50	273	72	72	66	-0.058	0.50	8.75

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
63	7.799	7.707	0.000	0.12	0.12	1.29	1.59	0.00	71	71	0	0.77	0.20	99	0.026	100	100	38.1	0.50	273	72	72	66	-0.059	0.46	9.09
64	7.923	7.830	0.000	0.12	0.12	1.30	1.58	0.00	71	71	0	0.76	0.20	99	0.026	100	100	37.6	0.50	276	72	72	66	-0.059	0.34	9.83
65	8.047	7.952	0.000	0.12	0.12	1.30	1.58	0.00	71	71	0	0.76	0.20	99	0.026	100	99	37.0	0.60	278	72	72	66	-0.059	0.26	10.20
66	8.169	8.076	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	100	0.026	99	101	36.5	0.50	281	72	72	66	-0.060	0.10	10.52
67	8.292	8.200	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	99	0.026	100	101	35.9	0.60	281	72	72	66	-0.059	0.11	10.26
68	8.415	8.323	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	99	0.026	100	100	35.2	0.70	277	72	72	66	-0.061	0.05	12.28
69	8.538	8.446	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	98	0.026	100	100	34.6	0.60	276	72	72	66	-0.060	0.02	12.76
70	8.662	8.569	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	98	0.026	100	100	34.0	0.60	275	72	72	66	-0.059	0.02	12.67
71	8.785	8.693	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	97	0.026	99	100	33.5	0.50	272	72	71	66	-0.059	0.02	12.64
72	8.909	8.816	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.75	0.20	96	0.026	100	99	32.9	0.60	272	72	71	66	-0.059	0.02	11.78
73	9.032	8.940	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	96	0.026	99	100	32.4	0.50	271	71	71	66	-0.059	0.02	11.40
74	9.155	9.064	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.75	0.20	96	0.026	99	100	32.0	0.40	271	71	71	66	-0.060	0.04	10.98
75	9.278	9.188	0.000	0.12	0.12	1.29	1.61	0.00	71	71	0	0.76	0.20	95	0.026	99	100	31.5	0.50	271	71	71	66	-0.059	0.05	10.59
76	9.401	9.311	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	95	0.026	99	99	31.0	0.50	270	71	71	66	-0.058	0.07	10.09
77	9.525	9.435	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	95	0.026	100	100	30.6	0.40	270	71	70	66	-0.059	0.04	10.29
78	9.648	9.558	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	96	0.026	99	99	30.0	0.60	275	71	70	65	-0.060	0.04	10.24
79	9.772	9.682	0.000	0.12	0.12	1.29	1.61	0.00	71	71	0	0.75	0.20	98	0.026	100	100	29.6	0.40	283	71	71	65	-0.059	0.03	10.71
80	9.894	9.806	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	98	0.026	99	100	29.0	0.60	288	71	71	65	-0.060	0.03	10.43
81	10.017	9.929	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	99	0.026	100	100	28.6	0.40	289	71	71	65	-0.060	0.05	9.92
82	10.140	10.052	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	99	0.026	100	100	28.1	0.50	288	71	70	65	-0.060	0.06	9.54
83	10.264	10.176	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	99	0.026	100	101	27.6	0.50	288	71	70	65	-0.059	0.06	9.23
84	10.386	10.299	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	99	0.026	99	100	27.2	0.40	287	71	70	65	-0.059	0.11	8.97
85	10.510	10.423	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	99	0.026	100	101	26.8	0.40	287	71	70	65	-0.059	0.22	8.60
86	10.633	10.546	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	99	0.026	100	100	26.3	0.50	286	71	70	65	-0.060	0.35	8.12
87	10.756	10.670	0.000	0.12	0.12	1.30	1.59	0.00	71	71	0	0.75	0.20	99	0.026	100	101	25.9	0.40	284	71	70	65	-0.059	0.39	7.95
88	10.879	10.794	0.000	0.12	0.12	1.29	1.61	0.00	71	71	0	0.76	0.20	99	0.026	100	101	25.5	0.40	283	71	70	65	-0.059	0.44	7.74
89	11.002	10.918	0.000	0.12	0.12	1.29	1.59	0.00	71	71	0	0.75	0.20	99	0.026	100	101	25.1	0.40	281	71	70	65	-0.058	0.54	7.45
90	11.126	11.041	0.000	0.12	0.12	1.28	1.60	0.00	71	71	0	0.75	0.20	99	0.026	100	100	24.8	0.30	280	71	70	65	-0.059	0.61	7.30
91	11.248	11.165	0.000	0.12	0.12	1.28	1.60	0.00	71	71	0	0.75	0.20	99	0.026	99	101	24.4	0.40	279	71	70	65	-0.058	0.62	7.15
92	11.371	11.288	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	99	0.026	100	100	24.0	0.40	278	71	70	65	-0.059	0.59	7.05
93	11.495	11.412	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	99	0.026	100	101	23.5	0.50	277	70	70	65	-0.059	0.47	7.19
94	11.618	11.535	0.000	0.12	0.12	1.29	1.59	0.00	71	71	0	0.76	0.20	99	0.026	100	100	23.2	0.30	276	70	70	65	-0.058	0.46	7.29
95	11.741	11.658	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	98	0.026	100	100	22.7	0.50	275	70	70	65	-0.060	0.52	7.42
96	11.864	11.781	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	98	0.026	100	100	22.4	0.30	274	70	70	65	-0.059	0.52	7.41
97	11.987	11.905	0.000	0.12	0.12	1.29	1.59	0.00	71	71	0	0.75	0.20	98	0.026	100	100	22.0	0.40	274	70	70	65	-0.060	0.52	7.40
98	12.110	12.028	0.000	0.12	0.12	1.29	1.59	0.00	71	71	0	0.75	0.20	98	0.026	100	100	21.6	0.40	273	70	70	65	-0.059	0.51	7.36
99	12.233	12.151	0.000	0.12	0.12	1.29	1.59	0.00	71	71	0	0.76	0.20	98	0.026	100	100	21.2	0.40	273	70	70	65	-0.059	0.50	7.40
100	12.357	12.275	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.75	0.20	98	0.026	100	100	20.9	0.30	273	70	70	65	-0.059	0.49	7.51
101	12.481	12.399	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	98	0.026	100	100	20.4	0.50	274	70	70	65	-0.058	0.46	7.63
102	12.603	12.522	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	98	0.026	99	100	20.0	0.40	274	70	70	65	-0.059	0.46	7.73

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
103	12.727	12.646	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.75	0.20	98	0.026	100	100	19.6	0.40	274	70	69	65	-0.059	0.46	7.77
104	12.850	12.770	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	98	0.026	100	100	19.2	0.40	274	70	70	65	-0.059	0.44	7.79
105	12.973	12.894	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.75	0.20	98	0.026	100	100	18.9	0.30	275	70	69	65	-0.058	0.44	7.85
106	13.096	13.017	0.000	0.12	0.12	1.29	1.61	0.00	71	71	0	0.75	0.20	98	0.026	100	100	18.5	0.40	274	70	69	65	-0.058	0.43	7.83
107	13.220	13.140	0.000	0.12	0.12	1.30	1.59	0.00	71	71	0	0.76	0.20	98	0.026	100	100	18.1	0.40	274	70	69	65	-0.059	0.40	7.71
108	13.343	13.264	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	98	0.026	100	100	17.8	0.30	273	70	69	65	-0.059	0.43	7.63
109	13.466	13.387	0.000	0.12	0.12	1.29	1.61	0.00	71	71	0	0.76	0.20	98	0.026	100	100	17.4	0.40	273	70	69	65	-0.057	0.44	7.60
110	13.589	13.511	0.000	0.12	0.12	1.30	1.61	0.00	71	71	0	0.75	0.20	98	0.026	100	100	17.0	0.40	273	70	69	65	-0.057	0.44	7.60
111	13.712	13.635	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	98	0.026	100	100	16.6	0.40	272	70	69	65	-0.058	0.46	7.83
112	13.835	13.759	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	98	0.026	100	100	16.2	0.40	271	70	69	65	-0.059	0.42	9.02
113	13.959	13.882	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	97	0.026	100	100	15.8	0.40	272	70	69	65	-0.059	0.35	9.19
114	14.082	14.006	0.000	0.12	0.12	1.29	1.61	0.00	71	71	0	0.76	0.20	97	0.026	99	100	15.4	0.40	273	70	69	65	-0.060	0.34	9.07
115	14.206	14.129	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	97	0.026	100	100	15.1	0.30	273	70	69	65	-0.058	0.32	8.94
116	14.329	14.253	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	98	0.026	100	100	14.7	0.40	281	70	69	65	-0.059	0.39	8.10
117	14.452	14.377	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.75	0.20	100	0.026	100	101	14.3	0.40	289	70	69	65	-0.059	0.42	6.91
118	14.575	14.501	0.000	0.12	0.12	1.29	1.61	0.00	71	71	0	0.76	0.20	101	0.026	100	101	14.0	0.30	290	70	69	65	-0.059	0.46	7.09
119	14.698	14.625	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	101	0.026	100	101	13.6	0.40	286	70	69	65	-0.059	0.47	7.53
120	14.821	14.748	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	99	0.026	100	100	13.3	0.30	278	70	69	65	-0.060	0.44	8.50
121	14.945	14.871	0.000	0.12	0.12	1.29	1.60	0.00	71	71	0	0.76	0.20	99	0.026	100	100	12.9	0.40	276	69	69	65	-0.058	0.40	8.68
122	15.069	14.995	0.000	0.12	0.12	1.30	1.61	0.00	71	71	0	0.76	0.20	98	0.026	100	100	12.6	0.30	276	69	69	65	-0.059	0.40	8.89
123	15.191	15.119	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	97	0.026	99	100	12.2	0.40	274	69	69	65	-0.059	0.32	9.66
124	15.314	15.243	0.000	0.12	0.12	1.29	1.60	0.00	70	71	0	0.76	0.20	96	0.026	100	100	11.8	0.40	275	69	69	65	-0.059	0.23	9.72
125	15.438	15.367	0.000	0.12	0.12	1.30	1.61	0.00	71	71	0	0.76	0.20	96	0.026	100	100	11.4	0.40	276	69	69	65	-0.058	0.21	9.73
126	15.561	15.491	0.000	0.12	0.12	1.29	1.61	0.00	71	71	0	0.76	0.20	95	0.026	99	100	11.2	0.20	275	69	69	65	-0.059	0.22	9.59
127	15.684	15.615	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	95	0.026	99	100	10.7	0.50	275	69	69	65	-0.058	0.30	9.21
128	15.808	15.739	0.000	0.12	0.12	1.30	1.61	0.00	70	71	0	0.76	0.20	95	0.026	100	100	10.4	0.30	275	69	69	65	-0.059	0.31	8.94
129	15.932	15.862	0.000	0.12	0.12	1.30	1.60	0.00	70	71	0	0.76	0.20	95	0.026	100	99	10.1	0.30	274	69	69	65	-0.058	0.38	8.44
130	16.055	15.986	0.000	0.12	0.12	1.30	1.61	0.00	70	71	0	0.76	0.20	95	0.026	99	100	9.8	0.30	273	69	69	65	-0.059	0.36	8.10
131	16.179	16.110	0.000	0.12	0.12	1.30	1.61	0.00	71	71	0	0.76	0.20	94	0.026	100	100	9.6	0.20	272	69	69	65	-0.059	0.33	8.10
132	16.302	16.233	0.000	0.12	0.12	1.30	1.60	0.00	71	71	0	0.76	0.20	94	0.026	99	99	9.3	0.30	271	69	69	65	-0.059	0.33	7.83
133	16.425	16.357	0.000	0.12	0.12	1.30	1.61	0.00	70	71	0	0.77	0.20	94	0.026	99	100	9.1	0.20	271	69	69	65	-0.059	0.31	7.65
134	16.549	16.482	0.000	0.12	0.13	1.30	1.62	0.00	71	71	0	0.77	0.20	95	0.026	100	101	8.7	0.40	272	69	69	65	-0.059	0.32	7.61
135	16.673	16.606	0.000	0.12	0.12	1.30	1.61	0.00	71	71	0	0.77	0.20	95	0.026	100	100	8.5	0.20	273	69	69	65	-0.058	0.32	7.52
136	16.797	16.730	0.000	0.12	0.12	1.30	1.61	0.00	71	71	0	0.77	0.20	95	0.026	100	100	8.2	0.30	272	69	69	65	-0.058	0.32	7.37
137	16.919	16.854	0.000	0.12	0.12	1.30	1.61	0.00	71	71	0	0.77	0.20	95	0.026	98	100	7.9	0.30	273	69	69	65	-0.058	0.30	7.24
138	17.044	16.978	0.000	0.13	0.12	1.30	1.61	0.00	71	71	0	0.77	0.20	95	0.026	101	100	7.7	0.20	273	69	69	65	-0.059	0.36	7.24
139	17.168	17.102	0.000	0.12	0.12	1.31	1.61	0.00	71	71	0	0.78	0.20	95	0.026	100	100	7.4	0.30	273	69	69	65	-0.058	0.39	7.29
140	17.291	17.226	0.000	0.12	0.12	1.30	1.62	0.00	70	71	0	0.77	0.20	95	0.026	99	100	7.1	0.30	274	70	69	65	-0.058	0.42	7.49
141	17.416	17.351	0.000	0.13	0.13	1.31	1.60	0.00	70	71	0	0.77	0.20	95	0.026	101	101	6.9	0.20	271	70	69	66	-0.056	0.34	8.66
142	17.540	17.474	0.000	0.12	0.12	1.31	1.61	0.00	71	71	0	0.78	0.20	95	0.026	100	99	6.7	0.20	271	70	69	65	-0.056	0.26	9.31

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
143	17.663	17.598	0.000	0.12	0.12	1.31	1.61	0.00	71	71	0	0.77	0.20	95	0.026	99	100	6.4	0.30	274	70	69	65	-0.058	0.48	8.54
144	17.787	17.723	0.000	0.12	0.13	1.31	1.62	0.00	71	71	0	0.78	0.20	97	0.026	100	101	6.1	0.30	284	70	69	65	-0.059	0.64	7.60
145	17.911	17.847	0.000	0.12	0.12	1.31	1.61	0.00	71	71	0	0.78	0.20	99	0.026	100	101	5.9	0.20	293	70	69	65	-0.059	0.67	6.30
146	18.035	17.971	0.000	0.12	0.12	1.31	1.61	0.00	71	71	0	0.78	0.20	100	0.026	101	101	5.6	0.30	294	70	69	65	-0.058	0.65	6.33
147	18.160	18.096	0.000	0.13	0.13	1.32	1.62	0.00	71	71	0	0.78	0.20	99	0.026	101	101	5.4	0.20	286	70	70	66	-0.058	0.62	7.41
148	18.284	18.220	0.000	0.12	0.12	1.32	1.61	0.00	71	71	0	0.78	0.20	98	0.026	100	100	5.1	0.30	284	70	70	66	-0.057	0.13	10.62
149	18.408	18.345	0.000	0.12	0.13	1.31	1.62	0.00	71	71	0	0.78	0.20	98	0.026	100	101	4.7	0.40	285	70	70	66	-0.058	0.06	11.14
150	18.532	18.470	0.000	0.12	0.13	1.31	1.62	0.00	72	71	0	0.78	0.20	97	0.026	100	101	4.5	0.20	286	70	70	66	-0.058	0.09	10.93
151	18.656	18.593	0.000	0.12	0.12	1.32	1.62	0.00	72	71	0	0.78	0.20	97	0.026	100	100	4.2	0.30	286	70	70	66	-0.057	0.11	10.67
152	18.780	18.717	0.000	0.12	0.12	1.32	1.62	0.00	72	71	0	0.78	0.20	97	0.026	100	100	4.0	0.20	285	71	70	66	-0.058	0.17	10.23
153	18.905	18.842	0.000	0.13	0.13	1.32	1.62	0.00	72	71	0	0.78	0.20	97	0.026	101	101	3.7	0.30	284	71	70	66	-0.057	0.21	9.97
154	19.028	18.966	0.000	0.12	0.12	1.31	1.61	0.00	72	71	0	0.78	0.20	96	0.026	99	100	3.5	0.20	282	71	70	67	-0.057	0.23	9.40
155	19.153	19.091	0.000	0.13	0.13	1.31	1.62	0.00	72	71	0	0.78	0.20	96	0.026	101	101	3.2	0.30	281	71	71	67	-0.058	0.24	8.78
156	19.277	19.215	0.000	0.12	0.12	1.32	1.62	0.00	72	71	0	0.79	0.20	96	0.026	100	100	3.1	0.10	279	71	71	67	-0.057	0.25	8.27
157	19.401	19.340	0.000	0.12	0.13	1.31	1.62	0.00	72	71	0	0.78	0.20	96	0.026	100	101	2.9	0.20	280	71	71	67	-0.057	0.36	7.71
158	19.525	19.465	0.000	0.12	0.13	1.32	1.62	0.00	72	71	0	0.78	0.20	97	0.026	100	101	2.7	0.20	279	71	71	67	-0.057	0.43	7.20
159	19.650	19.589	0.000	0.13	0.12	1.32	1.61	0.00	72	71	0	0.79	0.20	97	0.026	101	100	2.5	0.20	277	71	71	67	-0.057	0.44	6.88
160	19.773	19.713	0.000	0.12	0.12	1.31	1.61	0.00	72	71	0	0.78	0.20	97	0.026	99	100	2.4	0.10	275	71	71	67	-0.056	0.40	6.56
161	19.897	19.837	0.000	0.12	0.12	1.31	1.62	0.00	72	71	0	0.78	0.20	97	0.026	100	100	2.2	0.20	274	72	71	67	-0.056	0.40	6.25
162	20.021	19.961	0.000	0.12	0.12	1.31	1.62	0.00	72	71	0	0.78	0.20	97	0.026	100	100	2.0	0.20	272	72	71	67	-0.056	0.48	5.84
163	20.146	20.086	0.000	0.13	0.13	1.31	1.62	0.00	72	71	0	0.78	0.20	97	0.026	101	101	1.9	0.10	270	72	71	68	-0.056	0.59	5.48
164	20.271	20.210	0.000	0.13	0.12	1.31	1.62	0.00	72	71	0	0.79	0.20	97	0.026	101	100	1.8	0.10	270	72	71	68	-0.057	0.59	5.49
165	20.394	20.335	0.000	0.12	0.13	1.31	1.61	0.00	73	71	0	0.79	0.20	98	0.026	99	101	1.6	0.20	269	72	72	68	-0.057	0.58	5.55
166	20.518	20.459	0.000	0.12	0.12	1.31	1.62	0.00	72	71	0	0.78	0.20	98	0.026	100	100	1.4	0.20	269	72	72	68	-0.056	0.57	5.43
167	20.642	20.584	0.000	0.12	0.13	1.31	1.62	0.00	73	72	0	0.79	0.20	98	0.026	100	101	1.3	0.10	268	72	72	68	-0.056	0.62	5.08
168	20.766	20.709	0.000	0.12	0.13	1.31	1.62	0.00	73	72	0	0.78	0.20	98	0.026	100	101	1.2	0.10	266	72	72	68	-0.056	0.63	4.85
169	20.891	20.832	0.000	0.13	0.12	1.31	1.61	0.00	73	72	0	0.79	0.20	98	0.026	101	99	1.1	0.10	264	72	72	68	-0.055	0.64	4.61
170	21.015	20.956	0.000	0.12	0.12	1.31	1.62	0.00	73	72	0	0.79	0.20	98	0.026	100	100	1.0	0.10	262	72	72	68	-0.055	0.62	4.37
171	21.138	21.081	0.000	0.12	0.13	1.30	1.62	0.00	73	72	0	0.78	0.20	98	0.026	99	101	0.9	0.10	261	72	72	68	-0.056	0.62	4.42
172	21.263	21.205	0.000	0.13	0.12	1.31	1.61	0.00	73	72	0	0.79	0.20	98	0.026	101	100	0.8	0.10	262	72	72	68	-0.056	0.66	4.94
173	21.387	21.330	0.000	0.12	0.13	1.31	1.62	0.00	73	72	0	0.79	0.20	98	0.026	100	101	0.7	0.10	262	73	72	68	-0.056	0.68	4.75
174	21.511	21.454	0.000	0.12	0.12	1.31	1.62	0.00	73	72	0	0.79	0.20	98	0.026	100	100	0.5	0.20	261	73	72	68	-0.055	0.69	4.50
175	21.636	21.579	0.000	0.13	0.13	1.31	1.61	0.00	73	72	0	0.79	0.20	99	0.026	101	101	0.0	0.50	260	73	72	69	-0.054	0.73	4.24
	21.636	21.579	0.000			1.30	1.59	0.00	71	71	0			98	0.026						71.06	70.82		-0.058	0.28	8.91

Hydronic Heating Appliances - Test Method ASTM E2618-13 Annex A2
Water Test Data

Run: 3

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Test Date: 42438

Technician: AK/SB
Beginning Clock Time: 09:54
Recording Interval: 1 min.
Total Sampling Time: 175 min.

Boiler Dry Weight (lbs): 1814
Boiler Water Weight (lbs): 425
Tank Weight (lbs): 984
Tank Water Weight (lbs): 4678

Initial Average Tank Temp (°F): 126.0
Final Average Tank Temp (°F): 166.5

Elapsed Time	Flow, gpm		Water Temperature Data, oF																		
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
0	1.04	n/a	70.7	80	98	112	114	111	104	54	120	125	125	125	127	127	127	1.001	8.671	
1	1.02	n/a	70.4	80	98	109	109	111	105	54	112	125	125	125	127	127	127	1.001	8.505	599
2	1.04	n/a	59.5	82	98	108	108	110	104	54	110	125	125	125	127	127	127	1.001	8.671	517
3	1.04	n/a	56.8	85	101	108	108	110	104	54	110	125	125	125	126	126	127	1.001	8.671	493
4	1.08	n/a	56.0	87	104	107	107	109	103	54	109	125	125	125	127	126	126	1.001	9.005	505
5	1.20	n/a	55.7	88	108	106	106	108	102	54	108	125	125	125	127	126	126	1.001	10.006	558
6	1.25	n/a	55.1	89	111	105	105	107	100	54	107	125	124	125	127	126	126	1.001	10.422	575
7	1.28	n/a	53.9	91	114	105	105	106	100	53	107	125	125	124	127	126	126	1.001	10.673	576
8	1.33	n/a	53.5	90	117	104	104	106	99	53	106	125	124	124	126	125	126	1.001	11.090	594
9	1.36	n/a	52.5	89	120	103	103	105	98	53	105	124	124	124	126	125	126	1.001	11.340	596
10	1.36	n/a	51.8	91	122	103	103	105	98	53	105	125	124	124	126	125	126	1.001	11.340	588
11	1.37	n/a	51.7	93	125	103	103	104	97	53	104	125	124	124	126	125	125	1.001	11.423	592
12	1.38	n/a	51.2	90	128	103	103	104	97	53	104	125	124	124	126	125	125	1.001	11.507	590
13	1.37	n/a	50.8	145	139	102	104	104	97	53	104	125	124	123	126	124	125	1.001	11.424	581
14	1.37	n/a	51.1	152	139	106	110	109	100	53	107	124	124	123	126	125	125	1.001	11.424	585
15	1.33	n/a	52.9	154	139	110	115	114	105	53	113	125	123	123	126	125	125	1.001	11.090	587
16	1.22	n/a	58.9	157	140	113	119	118	110	54	117	124	123	123	125	125	125	1.001	10.172	600
17	1.09	n/a	63.0	159	141	117	124	123	115	54	121	124	123	123	125	125	125	1.001	9.088	573
18	1.08	n/a	66.8	161	140	121	131	128	119	54	126	124	123	123	126	125	125	1.001	9.005	602
19	0.85	n/a	72.1	163	140	129	141	138	130	54	134	125	123	123	125	125	125	1.001	7.087	511
20	0.83	n/a	79.0	164	143	135	148	147	138	54	144	124	123	123	126	125	125	1.001	6.920	547
21	0.81	n/a	89.3	165	145	138	151	151	142	54	149	125	123	123	126	125	125	1.001	6.753	604
22	0.79	n/a	95.4	165	146	140	152	153	144	54	152	125	123	123	127	125	125	1.001	6.586	629
23	0.79	n/a	98.0	166	147	140	153	154	145	54	153	125	123	123	126	125	125	1.001	6.586	647
24	0.78	n/a	99.2	167	147	141	154	155	146	55	154	126	123	123	126	125	125	1.001	6.503	646
25	0.71	n/a	99.9	168	148	143	155	156	148	55	155	127	123	123	127	125	125	1.001	5.919	592
26	0.71	n/a	100.7	168	149	143	156	157	149	55	156	128	123	123	127	125	125	1.001	5.919	596
27	0.70	n/a	101.7	169	143	128	150	157	140	55	157	132	123	123	131	125	125	1.001	5.836	594
28	0.70	n/a	102.2	169	140	126	148	152	130	55	154	131	123	123	136	125	125	1.001	5.835	597
29	0.71	n/a	99.7	170	140	125	147	150	127	55	150	134	123	123	135	125	125	1.001	5.919	591
30	0.69	n/a	95.3	170	140	125	147	149	127	55	149	134	123	123	136	125	125	1.001	5.752	549
31	0.68	n/a	94.2	170	140	125	147	149	130	56	149	133	123	123	136	125	124	1.001	5.669	535
32	0.70	n/a	93.9	169	140	125	147	149	126	56	149	135	123	123	138	125	124	1.001	5.835	549
33	0.70	n/a	93.8	169	140	125	146	149	126	56	149	136	123	123	138	125	125	1.001	5.835	548
34	0.77	n/a	93.6	168	139	124	145	148	124	56	148	136	123	123	137	125	125	1.001	6.419	601
35	0.81	n/a	93.0	167	139	124	145	147	123	56	148	136	123	123	138	125	124	1.001	6.752	629
36	0.83	n/a	92.5	167	139	124	144	147	124	55	147	137	123	123	139	125	124	1.001	6.919	641
37	0.83	n/a	91.7	168	139	123	144	146	121	55	146	137	123	123	139	125	124	1.001	6.919	635
38	0.82	n/a	91.5	168	139	123	144	146	122	55	146	137	124	123	138	125	125	1.001	6.836	626
39	0.84	n/a	91.7	169	139	123	145	147	121	55	146	138	124	123	140	125	124	1.001	7.003	643
40	0.83	n/a	91.8	169	140	123	145	147	121	54	146	138	124	123	140	125	124	1.001	6.920	636
41	0.83	n/a	92.3	170	140	123	145	147	122	54	147	138	124	123	140	125	124	1.001	6.920	639
42	0.83	n/a	92.8	170	140	124	145	147	122	54	147	138	125	123	140	126	125	1.001	6.920	643
43	0.83	n/a	93.3	170	140	124	146	148	122	54	147	139	126	123	141	129	124	1.001	6.920	646
44	0.82	n/a	93.5	171	140	124	146	148	122	54	147	139	129	123	141	131	125	1.001	6.837	640
45	0.83	n/a	93.6	170	140	123	146	148	120	54	148	139	131	123	141	133	125	1.001	6.920	648
46	0.80	n/a	93.5	170	139	123	145	148	120	54	148	139	133	123	141	135	125	1.001	6.670	625
47	0.70	n/a	94.0	170	139	123	145	148	120	54	147	139	135	123	141	136	125	1.001	5.836	549
48	0.71	n/a	93.8	170	140	124	146	148	125	54	147	139	136	123	142	137	125	1.001	5.920	556
49	0.77	n/a	93.9	170	139	123	145	148	119	54	148	140	137	123	141	137	125	1.001	6.420	604
50	0.77	n/a	94.2	170	139	123	145	148	124	54	147	140	137	123	142	138	125	1.001	6.420	606
51	0.76	n/a	93.9	170	139	123	145	147	121	54	147	140	138	123	142	138	125	1.001	6.337	595
52	0.77	n/a	93.3	169	139	123	145	147	120	54	147	140	139	123	142	138	125	1.001	6.420	599
53	0.78	n/a	93.3	169	139	123	145	147	122	54	147	140	140	123	142	139	125	1.001	6.503	608
54	0.77	n/a	93.5	169	139	123	145	147	121	54	147	141	140	123	142	139	125	1.001	6.420	601
55	0.78	n/a	93.4	169	139	123	145	147	121	54	147	140	140	123	142	140	125	1.001	6.503	608
56	0.77	n/a	93.4	169	139	123	144	147	119	54	147	141	140	123	142	140	125	1.001	6.420	600
57	0.78	n/a	93.2	168	139	123	144	147	121	54	146	141	140	123	142	141	125	1.001	6.503	607
58	0.77	n/a	92.9	168	139	123	144	146	120	54	146	141	141	123	142	141	125	1.001	6.420	597
59	0.78	n/a	92.7	168	139	123	144	146	120	54	146	141	141	123	142	141	125	1.001	6.503	604
60	0.78	n/a	92.7	168	139	123	143	146	120	54	146	141	141	123	142	141	125	1.001	6.503	604
61	0.78	n/a	92.1	167	139	123	143	146	120	54	146	141	141	123	142	141	125	1.001	6.503	600
62	0.79	n/a	91.6	168	139	123	143	146	118	54	145	141	141	123	142	141	125	1.001	6.587	604
63	0.77	n/a	91.8	167	139	123	143	146	119	54	145	141	141	123	142	141	125	1.001	6.420	590
64	0.79	n/a	91.6	167	139	123	143	146	120	54	145	141	141	123	142	142	125	1.001	6.587	604
65	0.78	n/a	91.7	167	139	123	143	146	119	54	145	141	141	123	142	142	125	1.001	6.503	597
66	0.77	n/a	92.0	167	139	123	144	146	119	54	145	141	141	124	143	142	125	1.001	6.420	591

Elapsed Time	Flow, gpm		Water Temperature Data, oF																	
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
67	0.78	n/a	91.9	168	139	124	144	146	119	54	146	141	141	124	143	142	125	1.001	6.503	599
68	0.77	n/a	92.3	168	140	125	145	147	119	54	146	141	141	125	143	142	125	1.001	6.420	593
69	0.78	n/a	92.7	169	140	126	146	148	120	54	147	142	142	127	143	142	126	1.001	6.503	604
70	0.67	n/a	93.3	169	141	128	148	149	126	54	148	141	142	129	144	142	128	1.001	5.586	522
71	0.73	n/a	94.2	169	142	129	149	151	126	54	149	142	142	131	144	142	129	1.001	6.086	574
72	0.75	n/a	95.4	169	142	129	150	152	123	54	151	143	142	133	145	142	131	1.001	6.253	597
73	0.77	n/a	97.4	170	143	130	151	152	124	54	151	143	142	134	145	142	133	1.001	6.420	626
74	0.78	n/a	97.8	170	144	131	151	153	126	54	152	143	142	136	145	142	134	1.001	6.503	637
75	0.79	n/a	98.9	170	144	132	152	154	127	54	153	143	142	136	145	142	136	1.001	6.587	652
76	0.75	n/a	99.7	171	144	132	153	155	126	54	154	144	142	138	145	142	135	1.001	6.253	624
77	0.71	n/a	100.0	171	145	134	154	155	129	54	154	144	142	138	146	142	137	1.001	5.920	593
78	0.72	n/a	101.0	171	145	134	154	156	129	54	155	144	142	139	147	142	137	1.001	6.003	607
79	0.71	n/a	101.9	171	146	135	155	157	130	54	156	145	142	139	146	142	137	1.001	5.920	604
80	0.71	n/a	102.8	171	146	136	155	157	131	54	156	146	143	140	147	143	138	1.001	5.920	609
81	0.71	n/a	103.0	172	147	136	156	158	134	54	157	146	143	140	148	143	138	1.001	5.920	610
82	0.70	n/a	103.5	173	147	136	157	158	128	54	157	147	143	140	148	143	139	1.001	5.836	605
83	0.70	n/a	104.1	173	147	137	157	159	131	54	158	148	143	141	149	143	140	1.001	5.836	609
84	0.70	n/a	104.4	174	148	137	158	160	132	54	159	149	143	140	150	143	140	1.001	5.836	610
85	0.71	n/a	105.2	174	148	137	158	160	131	54	159	148	144	141	150	144	140	1.001	5.920	623
86	0.71	n/a	105.8	174	148	137	158	160	132	54	159	149	144	141	150	144	141	1.001	5.920	627
87	0.71	n/a	106.1	174	148	138	158	160	130	54	160	149	144	141	152	144	141	1.001	5.920	629
88	0.71	n/a	106.1	174	148	138	158	161	129	54	160	150	144	141	152	144	141	1.001	5.920	629
89	0.70	n/a	106.4	174	148	138	158	161	134	54	160	150	145	141	151	145	141	1.001	5.836	621
90	0.71	n/a	106.5	174	148	138	158	161	131	54	160	151	145	141	151	145	141	1.001	5.920	631
91	0.69	n/a	106.5	174	148	138	158	161	135	54	160	151	145	141	152	146	141	1.001	5.753	614
92	0.69	n/a	106.6	174	148	138	158	161	136	54	160	151	146	141	153	146	141	1.001	5.753	614
93	0.71	n/a	106.3	174	148	138	158	161	135	54	160	151	146	141	152	147	141	1.001	5.920	630
94	0.69	n/a	106.4	173	148	138	158	160	134	54	160	151	146	141	153	147	141	1.001	5.753	613
95	0.69	n/a	106.4	173	148	138	158	160	132	54	160	151	147	141	153	147	141	1.001	5.753	613
96	0.69	n/a	106.1	173	148	138	158	160	135	54	160	152	147	141	154	148	141	1.001	5.753	611
97	0.69	n/a	106.4	173	148	138	158	160	133	54	160	152	148	141	154	148	141	1.001	5.753	613
98	0.68	n/a	106.0	173	148	138	158	160	133	54	160	152	148	141	153	149	142	1.001	5.670	601
99	0.69	n/a	106.0	173	148	138	158	160	133	54	160	152	149	141	154	149	142	1.001	5.753	610
100	0.69	n/a	106.1	173	148	138	158	160	133	54	160	152	150	141	154	150	142	1.001	5.753	611
101	0.69	n/a	105.9	173	148	138	158	160	132	54	160	152	151	141	155	150	142	1.001	5.753	610
102	0.69	n/a	105.9	173	148	138	158	160	136	54	160	153	152	142	155	151	142	1.001	5.753	610
103	0.68	n/a	105.9	173	148	139	158	160	135	54	160	153	152	142	155	151	142	1.001	5.670	601
104	0.69	n/a	106.1	173	149	139	158	160	133	54	160	153	153	141	155	151	142	1.001	5.753	611
105	0.67	n/a	106.1	173	149	139	158	161	132	54	160	153	153	142	155	152	142	1.001	5.586	593
106	0.67	n/a	106.3	174	149	139	158	161	133	54	160	153	153	142	155	152	142	1.001	5.586	594
107	0.67	n/a	106.6	174	149	139	159	161	135	54	160	153	153	142	155	153	142	1.001	5.586	596
108	0.68	n/a	106.4	174	149	139	159	161	136	54	160	154	153	142	155	153	142	1.001	5.669	604
109	0.68	n/a	106.7	174	149	140	159	161	132	54	161	154	154	143	156	153	142	1.001	5.669	606
110	0.67	n/a	107.1	174	150	140	159	161	137	54	161	154	154	143	156	153	142	1.001	5.586	599
111	0.67	n/a	107.1	174	150	140	159	162	133	54	161	154	154	143	156	154	143	1.001	5.586	599
112	0.67	n/a	107.4	175	150	140	160	162	137	54	161	154	154	144	156	154	143	1.001	5.586	601
113	0.67	n/a	107.6	175	150	140	160	162	134	54	161	155	154	144	156	154	143	1.001	5.586	602
114	0.69	n/a	107.6	175	150	141	160	162	134	54	162	155	154	144	156	154	144	1.001	5.753	620
115	0.67	n/a	108.0	175	151	141	160	163	133	54	162	155	155	144	157	154	143	1.001	5.586	604
116	0.67	n/a	108.4	176	151	141	161	163	135	54	162	155	155	145	157	155	144	1.001	5.586	606
117	0.66	n/a	108.4	176	151	142	161	163	134	54	163	155	155	145	157	155	144	1.001	5.503	597
118	0.67	n/a	108.9	177	152	142	162	164	135	54	163	155	155	145	157	155	145	1.001	5.586	609
119	0.67	n/a	109.4	177	152	142	162	164	137	54	163	156	155	145	158	155	145	1.001	5.586	612
120	0.66	n/a	109.6	177	152	143	162	165	136	54	164	156	155	146	158	155	146	1.001	5.503	604
121	0.67	n/a	110.0	177	152	143	162	165	135	54	164	156	156	146	158	155	146	1.001	5.586	615
122	0.66	n/a	110.2	177	153	144	163	165	136	54	164	156	156	147	159	155	146	1.001	5.503	607
123	0.65	n/a	110.4	178	153	144	163	165	140	54	165	157	156	148	159	156	147	1.001	5.419	599
124	0.67	n/a	111.0	178	154	144	164	166	137	54	165	157	156	148	159	156	147	1.001	5.586	621
125	0.67	n/a	111.1	179	154	145	164	166	142	54	165	157	156	149	160	156	148	1.001	5.586	621
126	0.65	n/a	111.4	179	155	146	165	167	140	54	166	157	156	150	159	156	148	1.001	5.419	605
127	0.67	n/a	111.9	180	155	146	165	167	138	54	166	158	156	151	160	156	149	1.001	5.586	626
128	0.67	n/a	112.7	180	155	146	166	168	137	54	167	158	157	151	160	156	150	1.001	5.586	630
129	0.67	n/a	112.9	180	155	147	166	168	139	54	167	158	157	151	160	157	150	1.001	5.586	631
130	0.66	n/a	113.6	181	156	147	166	168	143	54	167	159	157	152	161	157	150	1.001	5.503	626
131	0.66	n/a	113.9	181	156	148	167	169	144	54	168	159	157	152	161	157	151	1.001	5.503	628
132	0.66	n/a	113.9	181	156	148	167	169	139	54	168	159	157	152	161	157	151	1.001	5.503	628
133	0.66	n/a	114.4	181	157	148	167	169	144	54	168	159	158	153	162	157	152	1.001	5.503	630
134	0.68	n/a	114.4	181	157	148	167	169	144	54	168	160	158	152	162	158	152	1.001	5.669	650
135	0.66	n/a	114.9	181	157	148	167	169	138	54	169	160	158	153	162	158	152	1.001	5.503	633
136	0.67	n/a	114.7	182	157	149	167	170	141	54	169	160	158	153	162	158	153	1.001	5.586	641
137	0.68	n/a	115.0	182	157	149	167	170	137	54	169	161	159	153	163	158	153	1.001	5.669	653
138	0.67	n/a	115.1	182	158	149	168	170	142	54	169	161	159	153	163	159	153	1.001	5.586	644
139	0.66	n/a	115.3	182	158	149	168	170	141	54	169	162	159	153	163	159	153	1.001	5.503	635
140	0.66	n/a	115.4	182	158	149	168	170	141	54	169	161	159	154	163	159	153	1.001	5.503	636
141	0.66	n/a	115.8	182	158	150	168	170	141	54	170	162	160	154	164	160	154	1.001	5.503	638
142	0.63	n/a	115.8	183	158	150	168	171	145	54	170	162	160	154	164	160	154	1.001	5.252	609
143	0.65	n/a	116.1	183	159	150	169	171	144	55	170	162	160	154	164	160	154	1.001	5.419	630
144	0.65	n/a	116.1	184	159	150	169	171	142	55	170	163	161	154	164	160	154	1.001	5.419	630
145	0.65	n/a	116.2	184	159	150	169	172	143	55	171	163	161	154	165	161	154	1.001	5.419	631

Elapsed Time	Flow, gpm		Water Temperature Data, oF																	
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
146	0.66	n/a	116.7	184	159	151	170	172	142	55	171	163	161	155	165	161	154	1.001	5.502	643
147	0.67	n/a	116.5	185	159	151	170	172	141	55	171	163	162	154	165	161	154	1.001	5.585	651
148	0.65	n/a	116.8	185	159	151	170	172	144	55	171	164	162	155	166	162	154	1.001	5.419	634
149	0.66	n/a	116.9	186	160	151	171	173	144	55	172	164	162	155	166	162	155	1.001	5.502	644
150	0.65	n/a	117.2	186	160	151	171	173	142	55	172	164	162	155	166	162	155	1.001	5.419	636
151	0.66	n/a	117.2	187	161	152	172	174	146	55	172	164	163	155	166	162	155	1.001	5.502	646
152	0.65	n/a	117.9	188	161	152	172	174	146	55	173	164	163	155	167	162	155	1.001	5.419	640
153	0.65	n/a	118.4	188	161	152	173	175	143	55	173	165	163	156	167	163	155	1.001	5.418	643
154	0.64	n/a	118.5	189	162	152	173	175	147	56	174	166	163	156	168	163	156	1.001	5.335	633
155	0.65	n/a	119.1	189	162	152	173	175	145	56	174	166	164	156	167	163	156	1.001	5.418	646
156	0.64	n/a	119.5	189	162	153	173	176	147	56	175	166	164	156	167	163	156	1.001	5.335	638
157	0.65	n/a	119.4	189	162	153	174	176	147	56	175	167	164	156	168	164	156	1.001	5.418	648
158	0.65	n/a	119.6	189	162	153	174	176	145	56	175	167	164	156	168	164	156	1.001	5.418	649
159	0.64	n/a	119.8	189	162	153	173	176	150	56	175	166	164	157	169	164	156	1.001	5.335	640
160	0.65	n/a	119.6	188	162	153	173	176	148	56	175	167	165	157	169	164	157	1.001	5.418	649
161	0.65	n/a	119.6	188	162	154	173	176	145	56	175	167	165	157	169	164	157	1.001	5.418	649
162	0.65	n/a	119.5	188	162	154	173	176	150	56	175	168	165	157	169	165	157	1.001	5.418	649
163	0.65	n/a	119.4	187	162	154	173	175	149	56	175	167	165	158	170	165	157	1.001	5.418	647
164	0.65	n/a	119.3	187	162	154	173	175	150	56	175	167	166	158	170	165	158	1.001	5.418	647
165	0.65	n/a	119.2	187	162	154	173	175	148	56	174	168	166	158	169	166	158	1.001	5.418	647
166	0.65	n/a	119.0	186	162	155	173	175	148	56	174	168	167	158	170	166	158	1.001	5.418	646
167	0.64	n/a	118.8	186	162	155	172	175	147	56	174	168	167	159	170	166	158	1.001	5.335	634
168	0.65	n/a	118.5	186	163	155	172	175	144	56	174	168	167	159	170	167	159	1.001	5.418	643
169	0.63	n/a	118.3	185	162	155	172	175	145	56	174	168	168	159	170	167	159	1.001	5.251	622
170	0.63	n/a	118.2	185	163	155	172	174	147	56	174	168	168	160	170	168	159	1.001	5.251	622
171	0.64	n/a	118.3	184	162	156	172	174	148	56	174	168	168	160	170	168	159	1.001	5.335	632
172	0.65	n/a	118.2	184	163	156	172	174	143	56	173	168	169	160	170	168	160	1.001	5.418	641
173	0.65	n/a	118.1	184	163	156	172	174	147	56	173	168	169	161	170	169	160	1.001	5.418	641
174	0.64	n/a	117.8	184	163	156	172	174	148	56	173	169	169	161	170	169	160	1.001	5.335	629
175	0.65	n/a	117.6	183	163	156	172	174	146	56	173	169	169	161	170	169	161	1.001	5.418	638
	0.76	#DIV/0!	99.9	168.2	146.2	135.1	152.7	154.7	130.6	54.4	154.1	147.6	144.9	138.2	149.3	145.2	138.6			611
																			Total Heat Output	106987

Run 4

Hydronic Heating Appliances - Test Methods ASTM E2515-11 & E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Run: 4
Test Date: March 10, 2016

Burn Rate	**10.23 kg/hr dry**
Average Tunnel Temperature	104 degrees F
Average Gas Velocity in Dilution Tunnel - vs	9.7 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	25273 dscf/hour
Average Delta p	0.024 inches H20
Average Delta H	1.33 inches H20
Total Time of Test	146 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**4.78** g/hr
	0.40 g/kg
Complete Run:	**5.93** g/hr
	0.58 g/kg
	0.08 lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	18.21 cubic feet	18.07 cubic feet	0.00 cubic feet
Average Gas Meter Temperature	72 degrees F	71 degrees F	0 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	18.0 dscf	17.8 dscf	0.0 dscf
Total Particulates - mn	4.3 mg	4.1 mg	0 mg
Particulate Concentration (dry-standard)	0.000238 grams/dscf	0.000231 grams/dscf	0.000000 grams/dscf
Particulate Emissions	14.65 grams	14.20 grams	
Difference from Average	0.23 grams	0.23 grams	

Results Are Acceptable

	AVERAGE
Total Sample Volume - Vm	18.14 cubic feet
Average Gas Meter Temperature	72 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	17.9 dscf
Particulate Concentration (dry-standard)	0.00023 grams/dscf
Particulate Emissions	14.42 grams
7.5% of the average particulate emissions	1.08 grams

ADDITIONAL ACCEPTANCE CRITERIA

Boiler Water Return Temperature >120 °F	**Acceptable**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	7.47 cubic feet
Average Gas Meter Temperature	71 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	7.41 dscf
Total Particulates - mn	1.4 mg
Particulate Concentration (dry-standard)	0.00019 grams/dscf
Particulate Emissions	4.78 grams
Burn Rate	11.97 (dry kg/hr)

ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2152
Project No.:	0456WB005E
Technician:	AK/SB
Comments:	

Parameters:

Run Number:	4
Test Date:	3/10/16
Total Fuel Weight (lb):	68.0
Average Moisture of Fuel (% dry):	23.9
Average Moisture of Fuel (% wet):	19.27
Average Temperature of Appliance Water at Start of Test (°F):	170.0
Average Temperature of Appliance Water at End of Test (°F):	176.0
Average Thermopile Reading (°F):	112.5
Average Load Side Liquid Flow Rate (gal/min):	1.4
Time Interval (min):	146
Burn Rate (kg/hr):	10.23
Emissions (g):	14.4
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

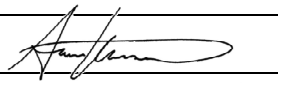
Calculations:

HHV Heat Input (Btu):	472094
Net HHV Heat Input (Btu):	472094
Net HHV Heat Input Rate (Btu/hr):	194011
LHV Heat Input (Btu):	438498
Net LHV Heat Input (Btu):	438498
Net LHV Heat Input Rate (Btu/hr):	180205
Appliance Water Specific Heat (Btu/lb^{o}F):	1.001
Tank Water Specific Heat (Btu/lb^{o}F):	1.001
Q_{unit} (Btu):	3640
Q_{Load} (Btu):	185705
$Q_{Storage}$ (Btu):	204752
Total Heat Output (Btu):	394097
Total Heat Output Rate (Btu/hr):	161958
Load Output Rate (Btu/hr):	76317
Emissions Factor(g/kg):	0.58
Total Particulate Emissions Rate (g/MJ):	0.035
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.081**
Total Particulate Emissions (g/hr):	5.93
Delivered Efficiency, HHV (%):	83.5
First Hour Emissions Factor (g/kg):	0.40
First Hour Emissions Rate (g/hr):	4.78

OMNI-Test Laboratories, Inc.

Manufacturer:	Froling
Model:	S3 Large
Date:	03/10/16
Run:	4
Control #:	2152
Test Duration:	146
Output Category:	III

Technicians: A. Kravitz



Test Results in Accordance with CSA B415.1-09

	HHV Basis	LHV Basis
Overall Efficiency	80.9%	87.1%
Combustion Efficiency	99.5%	99.5%
Heat Transfer Efficiency	81%	87.5%

Output Rate (kJ/h)	165,672	157,157	**(Btu/h)**
Burn Rate (kg/h)	10.24	22.56	**(lb/h)**
Input (kJ/h)	204,751	194,228	**(Btu/h)**

Test Load Weight (dry kg)	24.91	54.90	**dry lb**
MC wet (%)	19.27		
MC dry (%)	23.87		
Particulate (g)	0		
CO (g)	117		
Test Duration (h)	2.43		

Emissions	Particulate	CO
g/MJ Output	0.00	0.29
g/kg Dry Fuel	0.00	4.68
g/h	0.00	47.89
lb/MM Btu Output	0.00	0.67

Air/Fuel Ratio (A/F)	10.21

VERSION: **2.3** **3/23/2010**

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 4
Model: S3 Tracking Number: 2152 Date: 3/10/16
Test Crew: A. Kravitz, S. Button
OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Run Notes

Preburn Settings

Target Output (%): 47%
Target Output (BTU/hr): 80,000

Preburn Notes

TIME	NOTES
54 MIN	Added 14.5 lbs of wood

Test Settings

Target Output (%): 47%
Target Output (BTU/hr): 80,000

Start-Up Timeline

Fuel Loaded by: 40 sec
Door Closed at: 50 sec
Notes: N/A

Test Notes

TIME	NOTES
N/A	None

Technician Signature: _____ Date: 3/16/16

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 4

Model: S3 Tracking Number: 2152 Date: 3/10/16

Test Crew: A. Kravitz, S. Button

OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Supplemental Data

Start Time: 11:50 Booth #: E3

Stop Time: 14:16

Stack Gas Leak Check:

Initial: 0 Final: 0

Sample Train Leak Check:

A: 0.001 @ -4 "Hg

B: 0.000 @ -4 "Hg

Calibrations: Span Gas CO_2: 16.89 CO: 4.293

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	9:45	9:48	14:23	14:25
CO_2	0.00	16.90	0.05	16.97
CO	-0.002	4.293	-0.004	4.287

Air Velocity (ft/min): Initial: <50 Final: <50

Scale Audit (lbs): Initial: 10 Final: 10

Pitot Tube Leak Test: Initial: 0 Final: 0

Stack Diameter (in): 6

Induced Draft: 0

% Smoke Capture: 100%

Flue Pipe Cleaned Prior to First Test in Series:

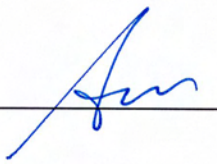
Date: 3/4/16 Initials: SB

	Initial	Middle	Ending
P_b (in/Hg)	29.94	29.96	29.98
Ambient (°F)	67	67	66

Background Filter Volume (ft^3): N/A

Tunnel Traverse	
dP (in H_2O)	T(°F)
0.022	104
0.022	104
0.026	104
0.028	104
0.020	104
0.008	104
0.016	104
0.022	104
0.026	104
0.024	104
0.020	104
0.014	104
Static P:	-0.27

Center: 0.024 / 104

Technician Signature: 

Date: 3/10/16

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 4
Model: S3 Tracking Number: 2152 Date: 3/10/16
Test Crew: A. Kravitz, S. Button
OMNI Equipment ID numbers: 23, 131, 132, 209, 283A, 296-T55, 340, 353, 356, 371, 372, 410, 419, 428A, 428B, 431, 513, 533, 559, 592

WHH Fuel Data

Fuel Load Prepared by: A. Kravitz

Fuel: Cordwood meeting ASTM 2618 Requirements, Oak, Ash, Alder, & Maple

Firebox Volume (ft^3): 6.78 Test Fuel Piece Length (in): Varies

Pre-test fuel total weight: 78 lb

Test Fuel

CALIBRATION: Cal Value (1) = 12% Actual Reading: 12.0
Cal Value (2) = 22% Actual Reading: 22.0

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Main Test Fuel	7.2	27.6	21.5	20.2	19.6	25.5
Main Test Fuel	6.9	23.8	24.0	23.9	19.9	20.4
Main Test Fuel	7.6	25.7	22.0	26.4	26.3	24.1
Main Test Fuel	10.6	26.7	27.1	26.3	21.5	22.1
Main Test Fuel	7.7	20.1	22.9	23.4	23.9	24.0
Main Test Fuel	5.5	23.4	27.3	24.6	22.1	20.4
Main Test Fuel	9.1	24.6	19.1	27.6	26.3	23.7
Main Test Fuel	8.0	27.6	25.7	23.8	21.9	25.4
Main Test Fuel	5.4	23.3	26.1	20.9	19.9	27.6

Total Wet Weight: 68.0

TIME (CLOCK): 10:00 TEMPERATURE (F): 69 INITIALS: A

Technician Signature: Date: 3/10/16

Hydronic Heating Appliances - Test Method ASTM E2618-13
Fuel Moisture

Manufacturer:	Froling
Model:	S3
Tracking No.:	2152
Project No.:	0456WB005E
Technician:	AK/SB
Run #:	4
Test Date:	March 10, 2016

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Main Test Fuel	7.2	27.6	21.5	20.2	19.6	25.5
Main Test Fuel	6.9	23.8	24.0	23.9	19.9	20.4
Main Test Fuel	7.6	25.7	22.0	26.4	26.3	24.1
Main Test Fuel	10.6	26.7	27.1	26.3	21.5	22.1
Main Test Fuel	7.7	20.1	22.9	23.4	23.9	24.0
Main Test Fuel	5.5	23.4	27.3	24.6	22.1	20.4
Main Test Fuel	9.1	24.6	19.1	27.6	26.3	23.7
Main Test Fuel	8.0	27.6	25.7	23.8	21.9	25.4
Main Test Fuel	5.4	23.3	26.1	20.9	19.9	27.6

Total Weight of Load (lb):	68
Total Moisture of Load (%):	23.87

Equipment Numbers:
340, 353, 431

Hydronic Heating Appliances - Test Method ASTM E2515-11

Emissions Sampling Data

Run: 4

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Test Date: March 10, 2016
Technician: AK/SB
Beginning Clock Time: 11:50
Recording Interval: 1 min.
Total Sampling Time: 146 min.

Velocity Traverse Data													
	Pt.1	Pt.2	Pt.3	Pt.4	Pt.5	Pt.6	Pt.7	Pt.8	Pt.9	Pt.10	Pt.11	Pt.12	Center
Initial dP	0.022	0.022	0.026	0.028	0.020	0.008	0.016	0.022	0.026	0.024	0.020	0.014	0.024
Initial Temp.	104	104	104	104	104	104	104	104	104	104	104	104	104

"H2O
oF

Air Velocity: Initial: <50 Final: <50
Scale Audit: Pre: 10.0 Post: 10.0
Pitot Tube Leak Test: Pre: 0 Post: 0
Induced Draft: 0
% Smoke Capture: 100
Flue Pipe Cleaned Prior to First Test in Series: Date: 3/4/2016

V_{strav} 9.74 ft/sec
V_{scent} 10.61 ft/sec
F_p 0.918

	(1)	(2)	(amb)	
Meter Box Y Factor:	0.995	0.985	1	
Barometric Pressure:	Begin	Middle	End	Average
	29.94	29.95	29.97	29.95 "Hg

PM Control Module: 428A/B
Dilution Tunnel MW(dry): 29.00 lb/lb-mole
Dilution Tunnel MW(wet): 28.78 lb/lb-mole
Dilution Tunnel H2O: 2.00 percent
Dilution Tunnel Static: -0.270 "H2O
Pitot Tube Cp: 0.99

Tunnel Velocity: 9.74 ft/sec.
Intial Tunnel Flow: 421.1 scfm
Average Tunnel Flow: 421.2 scfm
Tunnel Area: 0.785 ft2

Post-Test Leak Check (1): 0.001 cfm @ -4 in. Hg
Post-Test Leak Check (2): 0.001 cfm @ -4 in. Hg
Fuel Moisture (dry basis %): 23.9
Total Particulate (1): 4.1
Total Particulate (2): 4.4

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
0	0.000	0.000	0.000			-0.01	0.01	0.00	68	68	0	1.60	1.00	104	0.024			68.0		333	67	67	67	-0.061	0.12	9.30
1	0.120	0.108	0.000	0.12	0.11	1.35	1.58	0.00	68	68	0	0.80	0.20	124	0.024	99	89	67.4	0.60	302	69	69	67	-0.074	0.09	8.07
2	0.246	0.231	0.000	0.13	0.12	1.37	1.61	0.00	68	68	0	0.80	0.20	113	0.024	103	101	66.9	0.50	306	69	70	67	-0.059	0.02	13.52
3	0.371	0.353	0.000	0.13	0.12	1.37	1.61	0.00	69	68	0	0.80	0.20	108	0.024	101	100	66.4	0.50	310	70	70	67	-0.058	0.02	12.93
4	0.496	0.476	0.000	0.13	0.12	1.37	1.61	0.00	69	68	0	0.80	0.20	105	0.024	101	100	65.9	0.50	309	70	70	67	-0.058	0.02	12.44
5	0.621	0.600	0.000	0.13	0.12	1.37	1.61	0.00	69	68	0	0.80	0.20	104	0.024	101	101	65.5	0.40	308	70	70	68	-0.058	0.02	12.02
6	0.747	0.723	0.000	0.13	0.12	1.37	1.62	0.00	70	68	0	0.80	0.20	103	0.024	101	100	65.0	0.50	306	70	70	67	-0.058	0.02	11.61
7	0.872	0.847	0.000	0.13	0.12	1.37	1.62	0.00	70	68	0	0.80	0.20	103	0.024	101	101	64.6	0.40	305	70	71	67	-0.058	0.02	11.31
8	0.997	0.971	0.000	0.13	0.12	1.36	1.62	0.00	70	68	0	0.80	0.20	103	0.024	101	101	64.2	0.40	305	71	71	68	-0.057	0.02	11.23
9	1.122	1.094	0.000	0.13	0.12	1.35	1.62	0.00	70	68	0	0.80	0.20	103	0.024	101	100	63.7	0.50	305	71	71	68	-0.057	0.02	11.20
10	1.246	1.218	0.000	0.12	0.12	1.35	1.61	0.00	71	68	0	0.80	0.20	103	0.024	100	101	63.3	0.40	304	71	71	67	-0.057	0.03	11.03
11	1.372	1.342	0.000	0.13	0.12	1.36	1.61	0.00	70	69	0	0.81	0.20	104	0.024	101	101	62.8	0.50	309	71	71	68	-0.059	0.03	11.33
12	1.496	1.466	0.000	0.12	0.12	1.36	1.62	0.00	71	69	0	0.80	0.20	106	0.024	100	101	62.2	0.60	316	71	72	67	-0.060	0.01	12.63
13	1.621	1.589	0.000	0.13	0.12	1.35	1.62	0.00	71	69	0	0.80	0.20	107	0.024	101	100	61.7	0.50	318	72	72	68	-0.061	0.01	12.69
14	1.745	1.713	0.000	0.12	0.12	1.35	1.62	0.00	71	69	0	0.80	0.20	107	0.024	100	101	61.1	0.60	320	72	72	68	-0.062	0.03	12.47
15	1.869	1.836	0.000	0.12	0.12	1.35	1.62	0.00	71	69	0	0.80	0.20	108	0.024	100	100	60.5	0.60	321	72	72	68	-0.061	0.06	12.37
16	1.994	1.959	0.000	0.13	0.12	1.35	1.62	0.00	71	69	0	0.80	0.20	108	0.024	101	100	60.0	0.50	320	72	72	68	-0.061	0.08	12.06
17	2.119	2.082	0.000	0.13	0.12	1.34	1.62	0.00	71	69	0	0.80	0.20	108	0.024	101	100	59.5	0.50	320	72	72	68	-0.062	0.13	11.62
18	2.243	2.206	0.000	0.12	0.12	1.34	1.62	0.00	71	69	0	0.80	0.20	108	0.024	100	101	59.0	0.50	321	73	73	68	-0.062	0.11	11.66
19	2.368	2.330	0.000	0.13	0.12	1.34	1.62	0.00	71	69	0	0.80	0.20	108	0.024	101	101	58.5	0.50	321	73	73	68	-0.060	0.14	11.32
20	2.492	2.454	0.000	0.12	0.12	1.34	1.61	0.00	71	69	0	0.80	0.20	108	0.024	100	101	58.0	0.50	320	73	73	68	-0.060	0.13	11.09
21	2.617	2.578	0.000	0.13	0.12	1.35	1.62	0.00	71	69	0	0.80	0.20	108	0.024	101	101	57.6	0.40	320	73	73	68	-0.061	0.06	11.18
22	2.742	2.702	0.000	0.13	0.12	1.35	1.62	0.00	72	70	0	0.80	0.20	110	0.024	101	101	57.0	0.60	327	73	73	68	-0.064	0.03	11.94

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
23	2.866	2.825	0.000	0.12	0.12	1.34	1.62	0.00	72	70	0	0.79	0.20	111	0.024	100	100	56.4	0.60	334	73	73	68	-0.065	0.01	13.22
24	2.990	2.949	0.000	0.12	0.12	1.34	1.62	0.00	72	70	0	0.80	0.20	112	0.024	100	101	55.7	0.70	339	74	74	68	-0.066	0.01	13.75
25	3.114	3.073	0.000	0.12	0.12	1.34	1.61	0.00	72	70	0	0.80	0.20	113	0.024	100	101	55.0	0.70	341	74	74	68	-0.065	0.01	13.96
26	3.239	3.196	0.000	0.13	0.12	1.34	1.62	0.00	72	70	0	0.79	0.20	113	0.024	101	100	54.4	0.60	340	74	74	67	-0.063	0.01	13.38
27	3.364	3.320	0.000	0.13	0.12	1.34	1.61	0.00	72	70	0	0.80	0.20	113	0.024	101	101	53.9	0.50	339	74	74	67	-0.064	0.01	12.95
28	3.488	3.443	0.000	0.12	0.12	1.34	1.62	0.00	72	70	0	0.79	0.20	113	0.024	100	100	53.3	0.60	338	74	74	68	-0.065	0.01	12.59
29	3.612	3.566	0.000	0.12	0.12	1.34	1.61	0.00	72	70	0	0.79	0.20	113	0.024	100	100	52.8	0.50	339	74	74	68	-0.065	0.01	12.75
30	3.736	3.690	0.000	0.12	0.12	1.33	1.62	0.00	72	70	0	0.79	0.20	113	0.024	100	101	52.2	0.60	340	74	74	68	-0.065	0.01	12.56
31	3.861	3.814	0.000	0.13	0.12	1.34	1.61	0.00	72	70	0	0.79	0.20	113	0.024	101	101	51.7	0.50	340	74	74	68	-0.065	0.01	12.40
32	3.986	3.937	0.000	0.13	0.12	1.34	1.61	0.00	72	70	0	0.79	0.20	112	0.024	101	100	51.1	0.60	340	74	74	68	-0.064	0.01	13.46
33	4.110	4.061	0.000	0.12	0.12	1.33	1.62	0.00	72	71	0	0.79	0.20	112	0.024	100	101	50.5	0.60	341	75	74	68	-0.064	0.01	13.09
34	4.235	4.185	0.000	0.13	0.12	1.34	1.62	0.00	72	71	0	0.79	0.20	112	0.024	101	101	50.0	0.50	340	75	74	68	-0.065	0.01	12.70
35	4.359	4.309	0.000	0.12	0.12	1.34	1.62	0.00	72	71	0	0.79	0.20	112	0.024	100	101	49.5	0.50	337	74	74	68	-0.064	0.01	12.19
36	4.483	4.433	0.000	0.12	0.12	1.33	1.62	0.00	72	71	0	0.79	0.20	112	0.024	100	101	49.0	0.50	339	74	74	68	-0.065	0.01	12.00
37	4.608	4.556	0.000	0.13	0.12	1.34	1.62	0.00	72	71	0	0.79	0.20	112	0.024	101	100	48.5	0.50	337	74	74	68	-0.064	0.01	11.93
38	4.733	4.680	0.000	0.13	0.12	1.34	1.62	0.00	72	71	0	0.79	0.20	111	0.024	101	101	48.0	0.50	333	74	74	68	-0.062	0.01	11.66
39	4.857	4.804	0.000	0.12	0.12	1.34	1.62	0.00	72	71	0	0.79	0.20	111	0.024	100	101	47.5	0.50	331	74	74	68	-0.063	0.03	11.16
40	4.981	4.927	0.000	0.12	0.12	1.33	1.62	0.00	72	71	0	0.79	0.20	111	0.024	100	100	47.0	0.50	329	74	74	68	-0.063	0.04	10.97
41	5.106	5.050	0.000	0.13	0.12	1.33	1.62	0.00	72	71	0	0.79	0.20	111	0.024	101	100	46.5	0.50	330	74	74	68	-0.062	0.02	11.44
42	5.231	5.174	0.000	0.13	0.12	1.34	1.62	0.00	72	71	0	0.79	0.20	112	0.024	101	101	45.9	0.60	331	74	74	68	-0.064	0.01	11.61
43	5.355	5.298	0.000	0.12	0.12	1.34	1.62	0.00	72	71	0	0.79	0.20	112	0.024	100	101	45.4	0.50	334	74	74	68	-0.064	0.01	11.70
44	5.479	5.421	0.000	0.12	0.12	1.33	1.62	0.00	72	71	0	0.79	0.20	113	0.024	100	100	44.8	0.60	339	74	74	68	-0.066	0.01	12.19
45	5.604	5.545	0.000	0.13	0.12	1.33	1.61	0.00	72	71	0	0.79	0.20	114	0.024	101	101	44.3	0.50	341	74	74	68	-0.066	0.01	12.26
46	5.728	5.669	0.000	0.12	0.12	1.33	1.61	0.00	72	71	0	0.79	0.20	114	0.024	100	101	43.7	0.60	343	74	74	68	-0.066	0.01	11.94
47	5.853	5.793	0.000	0.13	0.12	1.33	1.62	0.00	72	72	0	0.79	0.20	115	0.024	101	101	43.1	0.60	344	75	74	68	-0.066	0.01	12.27
48	5.977	5.916	0.000	0.12	0.12	1.34	1.61	0.00	72	72	0	0.79	0.20	115	0.024	100	100	42.5	0.60	347	75	74	68	-0.066	0.01	13.59
49	6.101	6.040	0.000	0.12	0.12	1.33	1.62	0.00	72	72	0	0.79	0.20	115	0.024	100	101	41.9	0.60	348	75	74	68	-0.066	0.01	13.22
50	6.225	6.163	0.000	0.12	0.12	1.33	1.62	0.00	72	72	0	0.79	0.20	115	0.024	100	100	41.3	0.60	347	75	75	68	-0.066	0.01	12.81
51	6.349	6.287	0.000	0.12	0.12	1.33	1.62	0.00	72	72	0	0.79	0.20	116	0.024	101	101	40.7	0.60	347	75	74	68	-0.067	0.01	12.55
52	6.474	6.411	0.000	0.13	0.12	1.33	1.62	0.00	72	72	0	0.79	0.20	116	0.024	101	101	40.1	0.60	347	75	75	68	-0.067	0.01	12.34
53	6.599	6.534	0.000	0.13	0.12	1.33	1.62	0.00	72	72	0	0.79	0.20	116	0.024	101	100	39.5	0.60	347	75	75	68	-0.067	0.01	12.09
54	6.723	6.657	0.000	0.12	0.12	1.33	1.61	0.00	72	72	0	0.79	0.20	115	0.024	100	100	38.9	0.60	345	75	75	68	-0.066	0.02	12.12
55	6.847	6.780	0.000	0.12	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	115	0.024	100	100	38.3	0.60	346	75	75	68	-0.066	0.01	13.02
56	6.971	6.904	0.000	0.12	0.12	1.32	1.62	0.00	73	72	0	0.78	0.20	115	0.024	100	101	37.6	0.70	346	75	75	68	-0.067	0.01	12.50
57	7.095	7.028	0.000	0.12	0.12	1.33	1.60	0.00	72	72	0	0.78	0.20	115	0.024	100	101	37.1	0.50	345	75	75	68	-0.066	0.01	12.22
58	7.219	7.151	0.000	0.12	0.12	1.32	1.61	0.00	72	72	0	0.78	0.20	115	0.024	100	100	36.4	0.70	346	75	75	68	-0.067	0.02	11.83
59	7.344	7.275	0.000	0.13	0.12	1.33	1.61	0.00	73	72	0	0.78	0.20	116	0.024	101	101	35.8	0.60	346	75	75	68	-0.067	0.02	11.70
60	7.467	7.399	0.000	0.12	0.12	1.32	1.62	0.00	72	72	0	0.78	0.20	116	0.024	100	101	35.3	0.50	346	75	75	68	-0.067	0.02	11.53
61	7.591	7.522	0.000	0.12	0.12	1.34	1.61	0.00	73	72	0	0.82	0.20	116	0.024	100	100	34.9	0.40	345	75	75	68	-0.067	0.02	11.32
62	7.717	7.646	0.000	0.13	0.12	1.33	1.61	0.00	73	72	0	0.79	0.20	116	0.024	102	101	34.3	0.60	344	74	75	68	-0.068	0.04	11.08

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
63	7.842	7.769	0.000	0.13	0.12	1.33	1.62	0.00	73	72	0	0.78	0.20	116	0.024	101	100	33.7	0.60	342	75	75	68	-0.067	0.05	10.82
64	7.967	7.893	0.000	0.13	0.12	1.33	1.62	0.00	73	72	0	0.78	0.20	116	0.024	101	101	33.1	0.60	340	75	75	68	-0.066	0.06	10.75
65	8.090	8.016	0.000	0.12	0.12	1.32	1.61	0.00	72	72	0	0.78	0.20	116	0.024	100	100	32.6	0.50	339	75	75	68	-0.065	0.07	10.56
66	8.214	8.140	0.000	0.12	0.12	1.32	1.61	0.00	73	72	0	0.78	0.20	115	0.024	100	101	32.0	0.60	337	75	75	68	-0.066	0.11	10.42
67	8.338	8.263	0.000	0.12	0.12	1.32	1.61	0.00	72	72	0	0.78	0.20	115	0.024	100	100	31.5	0.50	336	75	75	68	-0.065	0.12	10.39
68	8.462	8.386	0.000	0.12	0.12	1.32	1.61	0.00	72	72	0	0.78	0.20	114	0.024	100	100	30.9	0.60	334	75	75	68	-0.066	0.08	10.59
69	8.587	8.509	0.000	0.13	0.12	1.32	1.62	0.00	72	72	0	0.78	0.20	114	0.024	101	100	30.3	0.60	334	75	75	68	-0.066	0.07	10.79
70	8.711	8.633	0.000	0.12	0.12	1.32	1.61	0.00	72	72	0	0.78	0.20	114	0.024	100	101	29.8	0.50	334	75	75	68	-0.064	0.05	11.06
71	8.834	8.756	0.000	0.12	0.12	1.32	1.61	0.00	73	72	0	0.77	0.20	114	0.024	99	100	29.2	0.60	334	75	75	68	-0.065	0.03	11.30
72	8.958	8.880	0.000	0.12	0.12	1.32	1.61	0.00	73	72	0	0.77	0.20	113	0.024	100	101	28.6	0.60	335	75	75	68	-0.065	0.02	11.54
73	9.082	9.003	0.000	0.12	0.12	1.32	1.60	0.00	73	72	0	0.77	0.20	113	0.024	100	100	28.0	0.60	335	75	75	68	-0.064	0.02	11.61
74	9.207	9.127	0.000	0.13	0.12	1.32	1.61	0.00	73	72	0	0.77	0.20	113	0.024	101	101	27.5	0.50	334	75	75	68	-0.063	0.01	11.72
75	9.331	9.250	0.000	0.12	0.12	1.32	1.61	0.00	73	72	0	0.77	0.20	113	0.024	100	100	26.9	0.60	334	75	75	68	-0.064	0.02	11.75
76	9.454	9.374	0.000	0.12	0.12	1.31	1.61	0.00	73	72	0	0.77	0.20	112	0.024	99	101	26.3	0.60	333	75	75	68	-0.064	0.02	11.80
77	9.577	9.497	0.000	0.12	0.12	1.31	1.61	0.00	73	72	0	0.77	0.20	112	0.024	99	100	25.8	0.50	331	75	75	68	-0.064	0.02	11.57
78	9.701	9.621	0.000	0.12	0.12	1.31	1.62	0.00	73	72	0	0.77	0.20	112	0.024	100	101	25.2	0.60	330	75	75	68	-0.063	0.01	11.55
79	9.825	9.744	0.000	0.12	0.12	1.31	1.60	0.00	73	72	0	0.77	0.20	111	0.024	100	100	24.5	0.70	331	75	75	68	-0.063	0.00	12.41
80	9.949	9.868	0.000	0.12	0.12	1.32	1.61	0.00	73	72	0	0.77	0.20	111	0.024	100	101	23.9	0.60	333	75	75	68	-0.062	0.00	13.30
81	10.073	9.991	0.000	0.12	0.12	1.32	1.61	0.00	73	72	0	0.77	0.20	111	0.024	100	100	23.4	0.50	334	75	75	68	-0.065	0.00	12.96
82	10.198	10.114	0.000	0.13	0.12	1.32	1.61	0.00	73	73	0	0.77	0.20	111	0.024	101	100	22.8	0.60	336	75	75	68	-0.065	0.00	13.30
83	10.321	10.238	0.000	0.12	0.12	1.32	1.61	0.00	73	73	0	0.77	0.10	110	0.024	99	100	22.2	0.60	335	75	75	68	-0.063	0.00	12.85
84	10.445	10.361	0.000	0.12	0.12	1.32	1.61	0.00	73	73	0	0.78	0.10	110	0.024	100	100	21.7	0.50	333	75	74	68	-0.065	0.00	12.48
85	10.569	10.485	0.000	0.12	0.12	1.32	1.61	0.00	73	73	0	0.78	0.10	109	0.024	100	100	21.2	0.50	331	75	74	68	-0.062	0.00	12.33
86	10.693	10.609	0.000	0.12	0.12	1.32	1.61	0.00	73	73	0	0.77	0.20	109	0.024	100	100	20.7	0.50	328	75	74	68	-0.063	0.00	12.26
87	10.818	10.733	0.000	0.13	0.12	1.32	1.62	0.00	73	73	0	0.78	0.20	101	0.024	100	100	20.2	0.50	310	74	74	68	-0.057	0.15	13.28
88	10.942	10.857	0.000	0.12	0.12	1.32	1.60	0.00	73	73	0	0.79	0.20	91	0.024	98	99	19.8	0.40	270	74	73	68	-0.053	1.35	16.45
89	11.066	10.981	0.000	0.12	0.12	1.32	1.62	0.00	73	73	0	0.79	0.20	86	0.024	98	98	19.6	0.20	250	73	73	68	-0.052	0.09	15.51
90	11.191	11.105	0.000	0.13	0.12	1.32	1.62	0.00	73	73	0	0.79	0.20	83	0.024	98	98	19.4	0.20	237	73	72	68	-0.050	0.00	13.01
91	11.316	11.229	0.000	0.13	0.12	1.32	1.62	0.00	73	73	0	0.79	0.20	81	0.024	98	98	19.2	0.20	228	73	72	68	-0.048	0.03	11.27
92	11.441	11.353	0.000	0.13	0.12	1.33	1.62	0.00	73	73	0	0.79	0.20	80	0.024	98	98	19.1	0.10	220	72	71	68	-0.047	0.36	9.63
93	11.566	11.477	0.000	0.13	0.12	1.33	1.62	0.00	72	73	0	0.80	0.20	79	0.024	98	98	19.0	0.10	213	72	71	68	-0.046	1.12	7.70
94	11.691	11.601	0.000	0.13	0.12	1.33	1.62	0.00	72	73	0	0.80	0.20	78	0.024	98	98	18.9	0.10	207	72	70	67	-0.047	1.03	6.97
95	11.815	11.726	0.000	0.12	0.13	1.34	1.61	0.00	72	73	0	0.80	0.20	87	0.024	98	99	18.8	0.10	234	72	70	67	-0.052	0.86	5.73
96	11.941	11.850	0.000	0.13	0.12	1.35	1.63	0.00	73	73	0	0.80	0.20	93	0.024	100	99	18.5	0.30	260	72	71	68	-0.053	0.77	6.72
97	12.067	11.975	0.000	0.13	0.13	1.35	1.63	0.00	73	73	0	0.80	0.20	95	0.024	100	100	18.1	0.40	269	72	71	68	-0.057	0.12	11.25
98	12.192	12.099	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	98	0.024	100	99	17.5	0.60	291	73	71	67	-0.059	0.01	14.05
99	12.317	12.223	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	101	0.024	100	100	16.9	0.60	309	73	72	67	-0.059	0.01	14.84
100	12.442	12.347	0.000	0.13	0.12	1.34	1.63	0.00	73	73	0	0.79	0.20	103	0.024	100	100	16.3	0.60	316	73	72	68	-0.062	0.01	14.78
101	12.567	12.471	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	103	0.024	100	100	15.8	0.50	319	73	72	68	-0.061	0.01	14.61
102	12.692	12.594	0.000	0.13	0.12	1.34	1.62	0.00	72	73	0	0.79	0.20	103	0.024	100	99	15.4	0.40	319	73	72	67	-0.060	0.00	13.94

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
103	12.817	12.718	0.000	0.13	0.12	1.34	1.61	0.00	72	73	0	0.79	0.20	103	0.024	100	100	14.9	0.50	315	73	72	67	-0.061	0.01	12.60
104	12.942	12.842	0.000	0.13	0.12	1.33	1.62	0.00	73	73	0	0.79	0.20	102	0.024	100	100	14.5	0.40	312	73	72	67	-0.059	0.01	11.82
105	13.067	12.966	0.000	0.13	0.12	1.33	1.62	0.00	73	73	0	0.79	0.20	102	0.024	100	100	14.0	0.50	309	73	72	67	-0.059	0.02	11.37
106	13.193	13.090	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	101	0.024	101	100	13.6	0.40	306	73	72	67	-0.059	0.05	11.00
107	13.317	13.214	0.000	0.12	0.12	1.34	1.63	0.00	73	73	0	0.79	0.20	100	0.024	99	100	13.2	0.40	302	73	72	67	-0.059	0.08	10.81
108	13.442	13.338	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	100	0.024	100	100	12.8	0.40	299	72	72	67	-0.057	0.09	10.79
109	13.567	13.462	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	99	0.024	100	100	12.4	0.40	296	72	72	67	-0.057	0.08	10.82
110	13.693	13.587	0.000	0.13	0.13	1.34	1.62	0.00	73	73	0	0.79	0.20	98	0.024	100	100	12.1	0.30	293	72	72	67	-0.057	0.07	10.92
111	13.818	13.711	0.000	0.13	0.12	1.35	1.62	0.00	73	73	0	0.79	0.20	98	0.024	100	99	11.7	0.40	292	72	71	67	-0.056	0.02	11.56
112	13.943	13.835	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	98	0.024	100	99	11.2	0.50	292	72	71	67	-0.056	0.01	12.07
113	14.068	13.958	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	97	0.024	99	99	10.8	0.40	291	72	71	67	-0.056	0.00	12.27
114	14.193	14.083	0.000	0.13	0.13	1.34	1.63	0.00	73	73	0	0.79	0.20	97	0.024	99	100	10.4	0.40	290	72	71	67	-0.055	0.00	12.18
115	14.319	14.207	0.000	0.13	0.12	1.34	1.62	0.00	73	73	0	0.79	0.20	96	0.024	100	99	10.0	0.40	288	72	71	67	-0.055	0.01	12.02
116	14.444	14.332	0.000	0.13	0.13	1.34	1.63	0.00	73	72	0	0.79	0.20	96	0.024	99	100	9.6	0.40	286	72	71	67	-0.055	0.00	11.89
117	14.569	14.456	0.000	0.13	0.12	1.34	1.63	0.00	73	72	0	0.79	0.20	96	0.024	99	99	9.2	0.40	285	72	71	67	-0.055	0.00	12.52
118	14.694	14.581	0.000	0.13	0.13	1.35	1.63	0.00	73	72	0	0.79	0.20	95	0.024	99	100	8.8	0.40	284	72	71	67	-0.055	0.00	13.22
119	14.820	14.705	0.000	0.13	0.12	1.35	1.63	0.00	73	72	0	0.79	0.20	95	0.024	100	99	8.3	0.50	284	72	71	67	-0.055	0.00	13.32
120	14.945	14.829	0.000	0.13	0.12	1.35	1.63	0.00	73	72	0	0.79	0.20	94	0.024	99	99	7.9	0.40	283	72	71	67	-0.054	0.00	13.04
121	15.070	14.954	0.000	0.13	0.13	1.35	1.62	0.00	73	72	0	0.79	0.20	94	0.024	99	100	7.5	0.40	281	72	71	67	-0.054	0.00	12.56
122	15.195	15.077	0.000	0.13	0.12	1.34	1.63	0.00	73	72	0	0.79	0.20	93	0.024	99	98	7.2	0.30	278	72	71	67	-0.053	0.00	12.08
123	15.321	15.202	0.000	0.13	0.13	1.35	1.62	0.00	73	72	0	0.79	0.20	93	0.024	100	100	6.9	0.30	276	71	71	67	-0.053	0.00	11.72
124	15.447	15.326	0.000	0.13	0.12	1.35	1.62	0.00	72	72	0	0.79	0.20	92	0.024	100	99	6.5	0.40	274	71	71	67	-0.053	0.00	11.38
125	15.571	15.451	0.000	0.12	0.13	1.34	1.63	0.00	73	72	0	0.79	0.20	92	0.024	98	100	6.3	0.20	271	71	71	67	-0.052	0.00	11.30
126	15.697	15.575	0.000	0.13	0.12	1.34	1.63	0.00	72	72	0	0.79	0.20	91	0.024	100	99	5.9	0.40	267	71	71	67	-0.052	0.01	11.17
127	15.823	15.700	0.000	0.13	0.13	1.35	1.63	0.00	72	72	0	0.79	0.20	90	0.024	100	100	5.6	0.30	261	71	71	67	-0.052	0.01	11.31
128	15.949	15.824	0.000	0.13	0.12	1.35	1.63	0.00	72	72	0	0.79	0.20	89	0.024	100	99	5.3	0.30	257	71	71	67	-0.052	0.01	11.39
129	16.073	15.949	0.000	0.12	0.13	1.35	1.64	0.00	72	72	0	0.79	0.20	89	0.024	98	100	5.0	0.30	254	71	70	67	-0.051	0.01	11.54
130	16.199	16.073	0.000	0.13	0.12	1.35	1.63	0.00	72	72	0	0.79	0.20	88	0.024	100	99	4.7	0.30	252	71	70	67	-0.051	0.01	11.61
131	16.324	16.197	0.000	0.13	0.12	1.35	1.63	0.00	72	72	0	0.79	0.20	88	0.024	99	99	4.5	0.20	250	70	70	66	-0.051	0.01	11.70
132	16.451	16.322	0.000	0.13	0.13	1.35	1.64	0.00	72	72	0	0.79	0.20	87	0.024	100	99	4.2	0.30	248	70	70	66	-0.051	0.00	11.94
133	16.576	16.446	0.000	0.13	0.12	1.35	1.63	0.00	72	72	0	0.79	0.20	87	0.024	99	99	3.9	0.30	248	70	70	67	-0.051	0.00	12.19
134	16.701	16.571	0.000	0.13	0.13	1.35	1.63	0.00	72	72	0	0.80	0.20	87	0.024	99	99	3.6	0.30	248	70	70	66	-0.051	0.00	12.41
135	16.827	16.696	0.000	0.13	0.13	1.35	1.64	0.00	72	72	0	0.79	0.20	87	0.024	100	99	3.3	0.30	248	70	70	66	-0.051	0.00	12.28
136	16.953	16.820	0.000	0.13	0.12	1.35	1.63	0.00	72	72	0	0.79	0.20	87	0.024	100	99	3.0	0.30	248	70	70	66	-0.051	0.00	12.05
137	17.078	16.945	0.000	0.13	0.13	1.36	1.63	0.00	72	72	0	0.80	0.20	87	0.024	99	99	2.7	0.30	248	70	70	66	-0.051	0.00	11.87
138	17.204	17.070	0.000	0.13	0.13	1.35	1.64	0.00	72	72	0	0.79	0.20	87	0.024	100	99	2.5	0.20	248	70	70	66	-0.051	0.00	11.74
139	17.329	17.194	0.000	0.13	0.12	1.35	1.63	0.00	72	72	0	0.80	0.20	87	0.024	99	99	2.2	0.30	247	70	70	66	-0.050	0.01	11.58
140	17.455	17.318	0.000	0.13	0.12	1.35	1.63	0.00	72	72	0	0.79	0.20	86	0.024	99	99	1.9	0.30	247	70	70	66	-0.051	0.01	11.55
141	17.581	17.443	0.000	0.13	0.13	1.36	1.64	0.00	72	72	0	0.79	0.20	86	0.024	99	99	1.7	0.20	246	70	69	66	-0.051	0.01	11.48
142	17.706	17.567	0.000	0.13	0.12	1.36	1.63	0.00	72	72	0	0.80	0.20	86	0.024	99	99	1.4	0.30	245	70	69	66	-0.050	0.02	11.38

Elapsed Time	Particulate Sampling Data																	Fuel Weight, lb		Temperature Data, oF				Stack		
	Gas Meter Cubic Feet (1)	Gas Meter Cubic Feet (2)	Gas Meter Cubic Feet (amb)	Sample Rate, cfm (1)	Sample Rate, cfm (2)	Orifice dH (1)	Orifice dH (2)	Orifice dH (amb)	Meter oF (1)	Meter oF (2)	Meter oF (amb)	Meter Vac. In. Hg. (1)	Meter Vac. In. Hg. (2)	Dilution Tunnel Temp.	Dilution Tunnel dP	Pro. Rate (%) (1)	Pro. Rate (%) (2)	Scale Reading	Weight Change	Stack	Filter (1)	Filter (2)	Ambient	Draft In. H2O	CO (%)	CO_2(%)
143	17.832	17.692	0.000	0.13	0.13	1.35	1.64	0.00	72	72	0	0.80	0.20	86	0.024	99	99	1.2	0.20	245	70	69	66	-0.050	0.03	11.24
144	17.958	17.817	0.000	0.13	0.13	1.35	1.63	0.00	72	72	0	0.80	0.20	86	0.024	99	99	0.9	0.30	246	69	69	66	-0.050	0.01	12.39
145	18.084	17.942	0.000	0.13	0.13	1.35	1.63	0.00	72	72	0	0.80	0.20	86	0.024	99	99	0.6	0.30	247	69	69	66	-0.050	0.00	12.93
146	18.209	18.067	0.000	0.13	0.13	1.35	1.63	0.00	72	72	0	0.80	0.20	86	0.024	99	99	0.0	0.60	248	69	69	66	-0.049	0.00	13.31
	18.209	18.067	0.000			1.33	1.61	0.00	72	71	0			104	0.024						72.82	72.52		-0.060	0.06	11.93

Hydronic Heating Appliances - Test Method ASTM E2618-13 Annex A2
Water Test Data

Run: 4

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Test Date: 42439
Technician: AK/SB
Beginning Clock Time: 11:50
Recording Interval: 1 min.
Total Sampling Time: 146 min.

Boiler Dry Weight (lbs): 1814
Boiler Water Weight (lbs): 425
Tank Weight (lbs): 984
Tank Water Weight (lbs): 4678

Initial Average Tank Temp (°F): 124.0
Final Average Tank Temp (°F): 166.8

Elapsed Time	Flow, gpm		Water Temperature Data, oF																	
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
0	1.39	n/a	126.0	191	149	131	164	137	167	52	168	123	122	121	128	126	124	1.001	11.591	
1	1.18	n/a	128.6	193	149	132	165	139	166	52	166	125	122	121	129	126	125	1.001	9.840	1267
2	1.18	n/a	115.0	193	149	132	165	140	167	52	166	129	122	121	130	126	124	1.001	9.840	1133
3	1.35	n/a	113.9	193	149	131	165	138	167	53	167	134	122	121	133	126	125	1.001	11.257	1283
4	1.39	n/a	114.3	193	148	130	164	136	166	52	166	138	122	121	134	126	124	1.001	11.591	1327
5	1.33	n/a	114.4	192	148	130	164	138	166	53	166	136	122	121	136	126	124	1.001	11.091	1270
6	1.33	n/a	113.6	189	147	130	162	137	165	53	165	140	122	121	138	126	124	1.001	11.091	1262
7	1.33	n/a	113.3	187	146	130	161	135	163	53	163	141	122	121	139	126	124	1.001	11.091	1258
8	1.32	n/a	112.0	185	146	129	159	134	162	53	162	142	122	121	142	126	124	1.001	11.007	1234
9	1.31	n/a	110.2	184	145	129	158	133	161	53	161	142	122	121	144	126	125	1.001	10.924	1205
10	1.35	n/a	108.9	183	144	128	157	132	159	53	159	143	123	122	143	126	125	1.001	11.257	1227
11	1.49	n/a	107.7	182	143	126	155	129	158	53	158	142	123	122	144	126	125	1.001	12.425	1339
12	1.49	n/a	106.2	181	143	126	154	128	157	53	156	142	123	122	144	126	125	1.001	12.425	1321
13	1.49	n/a	104.7	181	142	126	154	127	156	53	155	144	123	122	146	127	125	1.001	12.425	1303
14	1.49	n/a	103.6	181	142	126	154	127	155	53	155	143	123	122	146	127	125	1.001	12.425	1289
15	1.51	n/a	102.9	181	142	125	153	126	155	53	155	145	123	122	145	127	125	1.001	12.592	1297
16	1.51	n/a	102.5	181	142	125	153	126	155	53	155	144	123	122	147	127	125	1.001	12.592	1293
17	1.49	n/a	102.4	181	142	125	153	126	155	53	154	145	123	122	147	127	125	1.001	12.425	1274
18	1.49	n/a	102.5	180	142	125	153	126	155	53	154	144	123	122	146	127	125	1.001	12.425	1275
19	1.51	n/a	102.2	180	142	125	153	126	155	53	154	146	123	122	147	127	125	1.001	12.592	1288
20	1.50	n/a	101.8	180	142	125	153	126	154	53	154	144	123	122	147	127	125	1.001	12.508	1275
21	1.50	n/a	102.0	180	142	125	152	126	154	53	154	146	123	122	147	128	126	1.001	12.508	1277
22	1.49	n/a	101.7	180	142	125	152	126	154	53	153	145	123	122	147	128	125	1.001	12.425	1265
23	1.55	n/a	101.5	180	142	125	152	125	154	53	153	146	124	122	148	129	125	1.001	12.925	1314
24	1.55	n/a	101.1	180	142	125	152	124	154	53	153	146	125	122	148	131	126	1.001	12.925	1309
25	1.55	n/a	100.8	181	142	125	152	125	154	53	153	146	126	122	148	133	125	1.001	12.925	1305
26	1.55	n/a	100.8	182	142	125	153	125	154	53	154	146	129	122	148	135	125	1.001	12.925	1305
27	1.54	n/a	101.2	182	143	125	153	125	155	53	154	147	131	122	148	137	126	1.001	12.842	1301
28	1.55	n/a	101.8	183	143	125	154	125	155	53	154	148	133	122	148	139	126	1.001	12.925	1317
29	1.51	n/a	102.1	183	143	125	154	126	155	53	155	148	135	122	149	140	125	1.001	12.592	1287
30	1.51	n/a	102.0	183	143	126	154	127	156	53	155	148	137	122	150	142	126	1.001	12.592	1286
31	1.50	n/a	102.7	183	143	126	154	127	156	53	155	147	139	122	149	143	126	1.001	12.508	1286
32	1.51	n/a	102.9	183	144	126	155	127	156	53	156	149	140	122	150	144	126	1.001	12.592	1298
33	1.50	n/a	103.4	184	144	126	155	127	156	53	156	149	141	122	150	145	126	1.001	12.508	1295
34	1.49	n/a	103.2	184	144	126	155	127	157	53	156	149	142	122	150	145	125	1.001	12.425	1284
35	1.51	n/a	103.8	184	144	126	155	127	157	53	156	149	143	122	150	146	126	1.001	12.592	1309
36	1.49	n/a	103.9	184	144	126	155	127	157	53	156	150	144	122	150	146	126	1.001	12.425	1293
37	1.50	n/a	103.9	184	144	126	155	128	157	53	156	149	144	122	151	147	126	1.001	12.508	1302
38	1.51	n/a	104.5	184	144	126	155	128	157	53	157	150	145	122	150	147	126	1.001	12.592	1317
39	1.49	n/a	104.2	184	144	126	155	128	157	53	157	151	145	122	151	147	126	1.001	12.425	1297
40	1.51	n/a	104.2	184	144	126	155	128	157	53	156	150	145	122	151	147	126	1.001	12.592	1314
41	1.50	n/a	104.2	183	144	126	155	127	157	53	156	150	146	122	151	147	126	1.001	12.508	1305
42	1.51	n/a	103.7	183	143	126	155	127	156	53	156	151	146	122	151	147	126	1.001	12.592	1307
43	1.51	n/a	104.0	183	143	126	155	127	156	53	156	150	146	122	151	148	126	1.001	12.592	1311
44	1.50	n/a	103.6	182	143	126	154	127	156	53	156	151	147	122	151	148	126	1.001	12.508	1298
45	1.51	n/a	103.3	182	143	126	154	127	156	53	155	151	147	122	151	148	126	1.001	12.592	1302
46	1.51	n/a	103.4	182	143	126	154	127	156	53	155	151	147	122	152	148	126	1.001	12.592	1303
47	1.49	n/a	103.3	183	143	126	155	127	156	53	155	151	147	122	152	149	126	1.001	12.425	1285
48	1.50	n/a	103.2	183	144	126	155	127	156	53	156	151	147	122	152	149	126	1.001	12.508	1293
49	1.51	n/a	103.2	183	144	126	155	127	157	53	156	151	148	122	152	149	126	1.001	12.592	1301
50	1.50	n/a	103.4	184	144	126	155	128	157	53	156	151	148	122	152	149	126	1.001	12.508	1295
51	1.51	n/a	103.9	184	144	127	155	127	157	53	156	151	148	122	152	149	126	1.001	12.592	1309
52	1.51	n/a	104.1	184	144	127	156	128	157	53	157	152	148	122	152	150	126	1.001	12.592	1312
53	1.51	n/a	104.4	184	144	127	156	128	158	53	157	152	149	122	153	150	126	1.001	12.592	1316
54	1.50	n/a	104.4	185	145	127	156	129	158	53	157	152	149	123	153	150	126	1.001	12.508	1308
55	1.50	n/a	104.5	185	145	128	157	129	158	53	158	152	149	123	153	150	126	1.001	12.508	1309
56	1.50	n/a	105.0	185	145	128	157	129	159	53	158	153	150	124	153	150	127	1.001	12.508	1315
57	1.49	n/a	105.5	185	145	129	158	130	159	53	158	153	150	124	153	151	128	1.001	12.425	1313
58	1.49	n/a	105.6	185	146	130	158	130	160	53	159	153	150	125	153	151	128	1.001	12.425	1313
59	1.49	n/a	106.4	185	146	130	159	130	160	53	159	153	150	127	154	151	129	1.001	12.425	1324
60	1.46	n/a	106.4	185	147	132	160	131	161	53	160	153	150	129	155	151	132	1.001	12.175	1297
61	1.51	n/a	107.3	185	147	132	160	131	161	53	161	154	151	132	154	151	132	1.001	12.592	1353
62	1.55	n/a	107.9	185	148	133	160	130	162	53	161	154	151	133	155	151	134	1.001	12.925	1397
63	1.43	n/a	108.6	185	148	135	162	132	162	53	162	154	151	135	155	151	134	1.001	11.924	1296
64	1.41	n/a	108.9	185	150	136	163	134	164	53	163	154	151	136	155	152	138	1.001	11.758	1282
65	1.40	n/a	109.7	185	150	137	163	135	164	53	164	156	151	138	156	152	138	1.001	11.674	1282
66	1.37	n/a	110.9	185	151	138	164	136	165	53	164	156	151	140	156	152	138	1.001	11.424	1269

Elapsed Time	Flow, gpm		Water Temperature Data, oF																	
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom	Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
67	1.39	n/a	111.7	185	151	139	164	136	165	53	165	156	151	140	156	152	141	1.001	11.591	1296
68	1.40	n/a	112.0	185	151	139	164	136	166	53	165	156	152	141	157	152	142	1.001	11.674	1309
69	1.39	n/a	112.4	186	152	140	165	136	166	53	165	156	152	142	156	152	143	1.001	11.591	1305
70	1.30	n/a	112.6	186	153	142	166	137	166	53	166	157	152	143	158	152	143	1.001	10.840	1222
71	1.26	n/a	113.0	186	153	142	166	139	167	53	166	157	152	143	158	152	144	1.001	10.507	1189
72	1.26	n/a	113.7	186	154	142	166	140	168	53	167	158	152	143	158	152	144	1.001	10.507	1196
73	1.31	n/a	114.3	187	154	142	167	139	168	53	168	159	152	144	158	152	144	1.001	10.924	1250
74	1.32	n/a	114.9	188	154	142	167	139	168	53	168	159	152	144	159	153	145	1.001	11.007	1266
75	1.34	n/a	115.0	189	155	143	168	140	169	53	168	159	153	145	159	153	146	1.001	11.174	1286
76	1.34	n/a	115.5	189	155	143	168	140	169	53	169	160	153	145	161	153	146	1.001	11.174	1292
77	1.33	n/a	115.9	190	156	143	169	140	170	53	169	159	153	145	160	153	146	1.001	11.090	1287
78	1.33	n/a	116.5	190	156	144	169	141	170	53	170	161	153	146	160	153	146	1.001	11.090	1293
79	1.34	n/a	116.8	191	156	144	169	141	171	53	170	161	153	146	161	154	146	1.001	11.174	1307
80	1.41	n/a	117.6	191	156	143	169	139	171	53	170	161	153	146	161	154	147	1.001	11.757	1384
81	1.34	n/a	117.7	192	157	144	170	141	171	53	170	162	154	146	162	154	147	1.001	11.174	1317
82	1.33	n/a	117.7	192	157	145	170	142	172	53	171	162	154	146	162	154	147	1.001	11.090	1307
83	1.33	n/a	118.0	193	157	145	171	143	172	53	172	162	154	147	162	154	147	1.001	11.090	1311
84	1.29	n/a	118.8	194	158	146	172	143	173	53	172	163	154	147	162	155	148	1.001	10.757	1280
85	1.30	n/a	119.4	194	158	146	172	144	173	53	173	163	155	147	163	155	148	1.001	10.840	1296
86	1.20	n/a	119.8	194	159	147	173	146	174	53	173	163	155	147	164	155	148	1.001	10.006	1201
87	1.20	n/a	120.1	194	159	148	173	146	174	53	174	164	155	147	165	155	148	1.001	10.006	1204
88	1.20	n/a	121.1	193	159	148	172	146	174	53	174	163	156	148	166	156	148	1.001	10.006	1213
89	1.19	n/a	121.6	192	159	148	172	147	174	53	173	164	156	148	166	156	149	1.001	9.923	1208
90	1.19	n/a	121.3	190	158	147	170	146	173	53	173	164	156	149	166	157	149	1.001	9.923	1205
91	1.21	n/a	120.5	188	158	147	169	145	172	53	171	164	157	149	166	157	149	1.001	10.090	1217
92	1.20	n/a	119.3	186	157	147	168	144	170	53	170	164	157	149	165	157	149	1.001	10.006	1195
93	1.18	n/a	118.4	183	156	146	166	143	169	53	169	164	158	149	165	158	149	1.001	9.839	1166
94	1.19	n/a	116.7	181	155	146	165	142	167	53	167	164	158	149	165	158	149	1.001	9.923	1160
95	1.20	n/a	115.6	180	154	145	164	141	166	53	166	164	158	150	165	159	150	1.001	10.006	1158
96	1.19	n/a	113.9	179	153	145	163	140	165	53	165	164	159	150	164	159	149	1.001	9.923	1131
97	1.20	n/a	112.7	178	153	145	163	139	165	53	164	164	159	150	165	159	150	1.001	10.006	1129
98	1.19	n/a	112.0	179	153	145	163	139	165	53	164	164	159	150	164	159	150	1.001	9.923	1113
99	1.18	n/a	111.7	181	154	145	165	140	166	53	165	164	160	150	164	160	150	1.001	9.839	1100
100	1.18	n/a	111.9	183	155	146	166	141	167	53	166	164	160	150	165	160	150	1.001	9.839	1102
101	1.20	n/a	112.6	184	156	146	167	142	168	53	167	164	161	150	165	161	150	1.001	10.006	1128
102	1.20	n/a	113.9	186	157	147	168	143	169	53	168	164	162	151	166	162	151	1.001	10.006	1141
103	1.18	n/a	115.0	188	157	147	169	143	170	53	169	165	162	151	166	163	151	1.001	9.839	1132
104	1.22	n/a	116.1	189	158	148	170	144	171	53	170	164	163	151	166	163	151	1.001	10.173	1183
105	1.29	n/a	117.4	189	158	147	170	143	171	53	171	165	163	151	166	163	151	1.001	10.757	1264
106	1.30	n/a	118.3	190	158	147	170	142	172	53	171	165	164	151	166	164	151	1.001	10.840	1284
107	1.28	n/a	118.5	191	158	148	171	143	172	53	172	166	164	151	166	164	151	1.001	10.673	1266
108	1.30	n/a	118.8	191	159	148	171	143	172	53	172	166	164	151	166	164	151	1.001	10.840	1290
109	1.29	n/a	119.3	191	159	148	171	144	173	53	172	166	164	151	166	164	151	1.001	10.757	1285
110	1.29	n/a	119.4	191	159	148	171	143	172	53	172	165	164	152	167	164	151	1.001	10.757	1286
111	1.30	n/a	119.4	190	159	148	171	143	172	53	172	166	164	152	167	164	151	1.001	10.840	1296
112	1.29	n/a	119.4	190	159	148	171	143	172	53	172	166	164	152	167	164	152	1.001	10.757	1285
113	1.29	n/a	119.7	190	159	148	171	143	172	53	172	166	164	152	168	164	152	1.001	10.757	1289
114	1.26	n/a	119.3	190	159	148	171	144	173	53	172	166	164	152	167	164	152	1.001	10.507	1255
115	1.31	n/a	119.3	191	159	148	171	143	173	53	172	167	164	152	167	164	152	1.001	10.923	1305
116	1.29	n/a	119.7	191	159	149	171	143	173	53	172	167	164	153	167	164	152	1.001	10.757	1289
117	1.30	n/a	119.7	191	159	149	171	143	173	53	172	166	164	153	168	164	153	1.001	10.840	1300
118	1.30	n/a	119.7	191	159	149	171	143	173	53	172	166	165	153	168	164	153	1.001	10.840	1299
119	1.30	n/a	119.7	191	159	149	171	143	173	53	172	167	165	154	168	164	153	1.001	10.840	1300
120	1.29	n/a	119.7	191	159	149	171	144	173	53	172	167	165	154	168	164	153	1.001	10.757	1289
121	1.29	n/a	119.9	191	160	150	172	144	173	53	173	167	165	154	168	165	154	1.001	10.757	1291
122	1.30	n/a	120.0	191	160	150	172	144	173	53	173	167	165	155	169	165	154	1.001	10.840	1303
123	1.31	n/a	119.9	191	160	150	172	143	173	53	173	167	165	155	168	165	154	1.001	10.923	1311
124	1.30	n/a	120.0	190	160	150	172	144	173	53	173	168	165	155	169	165	155	1.001	10.840	1302
125	1.29	n/a	120.2	190	160	150	172	144	173	53	173	168	165	156	169	165	155	1.001	10.757	1295
126	1.30	n/a	120.6	190	160	150	172	144	173	53	173	168	166	156	169	166	155	1.001	10.840	1309
127	1.30	n/a	120.2	190	160	150	172	144	173	53	173	168	166	156	169	166	155	1.001	10.840	1305
128	1.30	n/a	120.5	189	160	150	171	144	173	53	173	168	166	157	169	166	156	1.001	10.840	1308
129	1.31	n/a	120.5	189	160	151	171	144	173	53	172	168	166	157	169	166	156	1.001	10.924	1318
130	1.31	n/a	119.9	189	160	151	171	143	173	53	172	168	167	157	169	166	156	1.001	10.924	1311
131	1.31	n/a	119.7	189	160	151	171	143	173	53	172	168	167	158	169	166	157	1.001	10.924	1309
132	1.30	n/a	120.0	188	160	151	171	143	173	53	172	168	167	158	169	167	157	1.001	10.840	1302
133	1.27	n/a	119.7	188	160	152	171	144	173	53	172	168	167	159	169	167	158	1.001	10.590	1270
134	1.26	n/a	119.4	188	160	152	171	144	173	53	172	168	167	159	169	167	158	1.001	10.507	1256
135	1.26	n/a	119.8	188	161	152	171	145	173	53	172	168	167	160	169	167	158	1.001	10.507	1261
136	1.30	n/a	120.0	188	161	152	171	144	173	53	173	168	167	160	169	167	159	1.001	10.840	1303
137	1.30	n/a	120.2	188	161	152	171	143	173	53	172	168	168	160	170	167	159	1.001	10.840	1305
138	1.24	n/a	120.1	188	161	153	172	145	173	53	173	168	168	161	170	167	160	1.001	10.340	1243
139	1.24	n/a	120.1	188	161	154	172	145	174	53	173	169	168	162	170	168	160	1.001	10.340	1243
140	1.24	n/a	120.7	188	162	154	172	146	174	53	173	169	168	162	170	168	161	1.001	10.340	1250
141	1.24	n/a	120.8	188	162	154	172	145	174	53	173	169	169	162	170	168	161	1.001	10.340	1251
142	1.23	n/a	121.0	189	162	154	173	146	174	53	174	169	169	162	170	168	161	1.001	10.257	1243
143	1.23	n/a	120.9	189	162	154	173	146	174	53	174	169	169	162	170	168	162	1.001	10.257	1241
144	1.23	n/a	121.3	189	162	154	173	146	174	53	174	169	169	162	170	168	162	1.001	10.256	1246
145	1.23	n/a	121.1	189	162	154	173	146	174	53	174	169	169	163	170	168	162	1.001	10.256	1243

Elapsed Time	Flow, gpm		Water Temperature Data, oF															Specific Heat of Inlet Water (BTU/lb-°F)	Mass Flow Rate of Inlet Water (lb/min)	Heat Output, Btu
	HEX 2 Load Side Flow Rate	HEX 1 Boiler Side Flow Rate (optional)	HEX 2 Load Side Thermopile ΔT	Boiler out	Boiler In	HEX 1 Tank Side in	HEX 1 Tank Side Out	HEX 2 Tank Side In	HEX 2 Tank Side Out	HEX 2 Load In	HEX 2 Load Out	Tank #1 Top	Tank #1 Middle	Tank #1 Bottom	Tank #2 Top	Tank #2 Middle	Tank#2 Bottom			
146	1.23	n/a	121.4	189	163	155	173	146	175	53	174	169	169	163	170	168	162	1.001	10.256	1247
	1.36	#DIV/0!	112.5	186.5	151.8	138.6	163.7	136.5	165.3	52.8	164.8	156.6	149.9	138.9	157.6	151.2	140.2			1272
																			Total Heat Output	185705

Section 4

Quality Assurance/Quality Control

QUALITY ASSURANCE/QUALITY CONTROL

OMNI follows the guidelines of ISO/IEC 17025, "General Requirements for the Competence of Testing and Calibration Laboratories," and the quality assurance/quality control (QA/QC) procedures found in *OMNI*'s Quality Assurance Manual.

OMNI's scope of accreditation includes, but is not limited to, the following:

- ANSI (American National Standards Institute) for certification of product to safety standards.
- To perform product safety testing by the International Accreditation Service, Inc. (formerly ICBO ES) under accreditation as a testing laboratory designated TL-130.
- To perform product safety testing as a "Certification Organization" by the Standards Council of Canada (SCC).
- Serving as a testing laboratory for the certification of wood heaters by the U.S. Environmental Protection Agency.

This report is issued within the scope of *OMNI*'s accreditation. Accreditation certificates are available upon request.

The manufacturing facilities and quality control system for the production of the S3 Turbo 50 at Froling GmBH were evaluated to determine if sufficient to maintain conformance with OMNI's requirements for product certification. OMNI has concluded that the manufacturing facilities, processes, and quality control system are adequate to produce the appliance congruous with the standards and model codes to which it was evaluated.

This report shall not be reproduced, except in full, without the written approval of OMNI-Test Laboratories, Inc.

Sample Analysis

Analysis Worksheets
Tared Filter, Probe, and O-Ring Data

Test Method ASTM E2515-11
Lab Results

Manufacturer:	Froling	Equipment Numbers:	23, 131, 283A, 592
Model:	S3		
Tracking No.:	2152		
Project No.:	0456WB005E		
Run #:	1		
Date:	3/7/16		

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	C357	121.8	120.8	1.0
C. Rear filter catch	Filter				0.0
D. Probe catch*	Probe				0.0
E. Filter seals catch*	Seals				0.0

Sub-Total	Total Particulate, mg:	1.0

TRAIN 1 (Post First Hour Change-out)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	C358	123.0	120.8	2.2
C. Rear filter catch	Filter	C359	120.9	120.9	0.0
D. Probe catch*	Probe	15	114348.2	114348.1	0.1
E. Filter seals catch*	Seals	R387	3360.6	3360.3	0.3

Sub-Total	Total Particulate, mg:	2.6
Train 1 Aggregate	Total Particulate, mg:	**3.6**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	C360	124.6	121.5	3.1
B. Rear filter catch	Filter	C361	121.0	121.3	-0.3
C. Probe catch*	Probe	18	114405.0	114405.1	0.0
D. Filter seals catch*	Seals	R388	4128.4	4127.2	1.2

	Total Particulate, mg:	4.0

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter				0.0

	Total Particulate, mg:	0.0

*Particulate catch that results in a negative number, is assumed to be zero for probes and seals, negative numbers for filters are assumed to be part of the seal weight.

Component	Equations:
A. Front filter catch	Final (mg) - Tare (mg) = Particulate, mg
B. Rear filter catch	Final (mg) - Tare (mg) = Particulate, mg
C. Probe catch	Final (mg) - Tare (mg) = Particulate, mg

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 1

Model: S3 Tracking Number: 2152 Date: 3/7/16

Test Crew: A. Kravitz, S. Button

OMNI Equipment ID numbers: 23, 131, 283A, 502

ASTM E2515 Lab Sheet

Assembled By:

A.Kravitz

Date/Time in Dessicator:

3/7/16 @ 14:30

	Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
	Date: 3/9/16	Date: 3/10/16	Date: 3/4/16	Date: 3/14/16	Date:
	Time: 1400	Time: 1400	Time: 0800	Time: 1430	Time:
	R/H %: 15.8	R/H %: 12.2	R/H %: 12.3	R/H %: 7.7	R/H %:
	Temp: 73.7	Temp: 73.9	Temp: 69.0	Temp: 70.1	Temp:
	Audit: 100000.0	Audit: 100000.6	Audit: 100.0000	Audit: 100.0000	Audit:
	Initials:	Initials:	Initials:	Initials:	Initials:

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A	Front Filter (1st hour)	C357	120.8	121.8	121.8	-	-	
A	Front Filter (Remainder)	C358	120.8	123.1	123.0	-	-	
A	Rear Filter	C359	120.9	120.9	120.9	-	-	
A	Probe	15	114348.1	114348.2	114348.2	-	-	
A	O-Rings	R387	3360.3	3361.8	3361.85	3360.7	3360.6	
B	Front Filter	C360	121.5	124.7	124.6	-	-	
B	Rear Filter	C361	121.3	120.9	121.0	-	-	
B	Probe	18	114405.1	114404.9	114405.0	-	-	
B	O-rings	R388	4127.2	4129.4	4129.0	4128.6	4128.4	

Technician Signature: Date: 3/14/16

Test Method ASTM E2515-11
Lab Results

Manufacturer: Froling
Model: S3
Tracking No.: 2152
Project No.: 0456WB005E
Run #: 2
Date: 3/8/16

Equipment Numbers: 23, 131, 283A, 592

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	C362	124.3	120.7	3.6
C. Rear filter catch	Filter				0.0
D. Probe catch*	Probe				0.0
E. Filter seals catch*	Seals				0.0

Sub-Total Total Particulate, mg: 3.6

TRAIN 1 (Post First Hour Change-out)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	C363	124.3	121.4	2.9
C. Rear filter catch	Filter	C364	120.4	121.0	-0.6
D. Probe catch*	Probe	OES 3	114771.6	114771.6	0.0
E. Filter seals catch*	Seals	R389	3291.3	3290.3	1.0

Sub-Total Total Particulate, mg: 3.3

Train 1 Aggregate Total Particulate, mg: **6.9**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	C365	126.3	120.6	5.7
B. Rear filter catch	Filter	C366	121.1	120.9	0.2
C. Probe catch*	Probe	4	114863.8	114863.9	0.0
D. Filter seals catch*	Seals	R390	3609.1	3609.0	0.1

Total Particulate, mg: 6.0

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter				0.0

Total Particulate, mg: 0.0

*Particulate catch that results in a negative number, is assumed to be zero for probes and seals, negative numbers for filters are assumed to be part of the seal weight.

Component	Equations:
A. Front filter catch	Final (mg) - Tare (mg) = Particulate, mg
B. Rear filter catch	Final (mg) - Tare (mg) = Particulate, mg
C. Probe catch	Final (mg) - Tare (mg) = Particulate, mg

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 2

Model: S3 Tracking Number: 2152 Date: 3/8/16

Test Crew: A. Kravitz, S. Button

OMNI Equipment ID numbers: 23, 131, 283A, 592

ASTM E2515 Lab Sheet

Assembled By:

A.Kravitz

Date/Time in Dessicator:

3/8/16 @ 13:45

	Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
	Date: 3/9/16	Date: 3/10/16	Date: 3/11/16	Date: 3/14/16	Date: 3/15/16
	Time: 1400	Time: 1400	Time: 0860	Time: 1430	Time: 1200
	R/H %: 15.8	R/H %: 12.2	R/H %: 12.3	R/H %: 7.7	R/H %: 7.4
	Temp: 73.7	Temp: 73.9	Temp: 69.0	Temp: 70.1	Temp: 69.6
	Audit: 100000.0	Audit: 100000.6	Audit: 100.0000	Audit: 100.0000	Audit: 100000.6
	Initials:	Initials:	Initials:	Initials:	Initials:

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A	Front Filter (1st hour)	C362	120.7	124.4	124.3	-	-	-
A	Front Filter (Remainder)	C363	121.4	124.4	124.3	-	-	-
A	Rear Filter	C364	121.0	120.5	120.4	-	-	-
A	Probe	OES 3	114771.6	114771.6	114771.6	-	-	-
A	O-Rings	R389	3290.3	3292.9	3292.1	3291.7	3291.Ø3	3291.3
B	Front Filter	C365	120.6	126.5	126.3	-	-	-
B	Rear Filter	C366	120.9	121.3	121.1	-	-	-
B	Probe	4	114863.9	114863.8	114863.9	-	-	-
B	O-rings	R390	3609.0	3610.5	3610.0	3609.Ø2	3609.1	-

Technician Signature: _____ Date: 3/15/16

Test Method ASTM E2515-11
Lab Results

Manufacturer:	Froling	Equipment Numbers:	23, 131, 283A, 592
Model:	S3		
Tracking No.:	2152		
Project No.:	0456WB005E		
Run #:	3		
Date:	3/9/16		

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	C367	122.8	120.9	1.9
C. Rear filter catch	Filter				0.0
D. Probe catch*	Probe				0.0
E. Filter seals catch*	Seals				0.0

Sub-Total	Total Particulate, mg:	1.9

TRAIN 1 (Post First Hour Change-out)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	C368	122.8	120.5	2.3
C. Rear filter catch	Filter	C369	120.0	120.5	-0.5
D. Probe catch*	Probe	6	115355.4	115355.3	0.1
E. Filter seals catch*	Seals	R391	4520.6	4519.1	1.5

Sub-Total	Total Particulate, mg:	3.4
Train 1 Aggregate	Total Particulate, mg:	**5.3**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	C370	124.9	121.0	3.9
B. Rear filter catch	Filter	C371	120.8	121.3	-0.5
C. Probe catch*	Probe	7	114985.2	114985.0	0.2
D. Filter seals catch*	Seals	R392	3346.7	3345.1	1.6

Total Particulate, mg:	5.2

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter				0.0

Total Particulate, mg:	0.0

*Particulate catch that results in a negative number, is assumed to be zero for probes and seals, negative numbers for filters are assumed to be part of the seal weight.

Component	Equations:
A. Front filter catch	Final (mg) - Tare (mg) = Particulate, mg
B. Rear filter catch	Final (mg) - Tare (mg) = Particulate, mg
C. Probe catch	Final (mg) - Tare (mg) = Particulate, mg

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 3

Model: S3 Tracking Number: 2152 Date: 3/9/16

Test Crew: A. Kravitz, S. Button

OMNI Equipment ID numbers: 23, 131, 2834, 592

ASTM E2515 Lab Sheet

Assembled By:

A.Kravitz

Date/Time in Dessicator:

3/9/15 1330

	Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
	Date: 3/10/16	Date: 3/11/16	Date: 3/14/16	Date:	Date:
	Time: 1400	Time: 0800	Time: 1430	Time:	Time:
	R/H %: 12.2	R/H %: 12.3	R/H %: 7.7	R/H %:	R/H %:
	Temp: 73.9	Temp: 69.0	Temp: 70.1	Temp:	Temp:
	Audit: 100.0000	Audit: 100.0000	Audit: 100.0000	Audit:	Audit:
	Initials: A	Initials: A	Initials: A	Initials:	Initials:

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A	Front Filter (1st hour)	C367	120.9	123.0	122.8	-		
A	Front Filter (Remainder)	C368	120.5	122.9	122.8	-		
A	Rear Filter	C369	120.5 ~~121.0~~ A	120.1	120.0	-		
A	Probe	6	115355.3	115355.4	115355.4	-		
A	O-Rings	R391	4519.1	4521.6	4520.8	4520.6		
B	Front Filter	C370	121.0	125.0	124.9	-		
B	Rear Filter	C371	121.3	120.9	120.8	-		
B	Probe	7	114985.0	114985.1	114985.2	-		
B	O-rings	R392	3345.1	3348.5	3346.8	3346.7		

Technician Signature: _____ Date: 3/14/16

Test Method ASTM E2515-11
Lab Results

Manufacturer:	Froling	Equipment Numbers:	23, 131, 283A, 592
Model:	S3		
Tracking No.:	2152		
Project No.:	0456WB005E		
Run #:	4		
Date:	3/10/16		

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	C372	122.2	120.8	1.4
C. Rear filter catch	Filter				0.0
D. Probe catch*	Probe				0.0
E. Filter seals catch*	Seals				0.0

Sub-Total	Total Particulate, mg:	1.4

TRAIN 1 (Post First Hour Change-out)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	C373	122.1	120.9	1.2
C. Rear filter catch	Filter	C374	120.8	120.1	0.7
D. Probe catch*	Probe	8	115597.3	115597.3	0.0
E. Filter seals catch*	Seals	R393	3457.6	3456.6	1.0

Sub-Total	Total Particulate, mg:	2.9
Train 1 Aggregate	Total Particulate, mg:	**4.3**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	C375	124.3	121.6	2.7
B. Rear filter catch	Filter	C376	121.4	120.8	0.6
C. Probe catch*	Probe	9	115693.9	115693.9	0.0
D. Filter seals catch*	Seals	R394	3508.9	3508.1	0.8

Total Particulate, mg:	4.1

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter				0.0

Total Particulate, mg:	0.0

*Particulate catch that results in a negative number, is assumed to be zero for probes and seals, negative numbers for filters are assumed to be part of the seal weight.

Component	Equations:
A. Front filter catch	Final (mg) - Tare (mg) = Particulate, mg
B. Rear filter catch	Final (mg) - Tare (mg) = Particulate, mg
C. Probe catch	Final (mg) - Tare (mg) = Particulate, mg

OMNI-Test Laboratories, Inc. **ASTM 2618-13 Hydronic Heater Run Sheets**

Client: Froling Project Number: 0456WB005E Run Number: 4

Model: S3 Tracking Number: 2152 Date: 3/10/16

Test Crew: A. Kravitz, S. Button

OMNI Equipment ID numbers: 23, 13, 283A, 592

ASTM E2515 Lab Sheet

Assembled By:

A.Kravitz

Date/Time in Dessicator:

3/10/16

	Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
	Date: 3/14/16	Date: 3/15/16	Date:	Date:	Date:
	Time: 1430	Time: 1200	Time:	Time:	Time:
	R/H %: 7.7	R/H %: 7.4	R/H %:	R/H %:	R/H %:
	Temp: 70.1	Temp: 69.1	Temp:	Temp:	Temp:
	Audit: 100000.0	Audit: 100000.6	Audit:	Audit:	Audit:
	Initials:	Initials:	Initials:	Initials:	Initials:

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
✱ A	Front Filter (1st hour)	C372	120.8 ~~120.9~~ A	122.1	122.2			
✱ A	Front Filter (Remainder)	C373	120.9 ~~120.1~~ A	122.1	122.1			
✱ A	Rear Filter	C374	120.1 ~~121.6~~ A	120 ~~121.6~~ A 120.6 A	120.8 ~~121.4~~ A			
A	Probe	8	115597.3	115597.3	115597.3			
A	O-Rings	R393	3456.6	3457.6	3457.6			
✱ B	Front Filter	C375	121.6 ~~120.8~~ A	124.3	124.3			
✱ B	Rear Filter	C376	120.8 ~~120.7~~ A	121.6 ~~120.7~~ A	121.4 ~~120.8~~ A			
B	Probe	9	115693.9	115694.0	115693.9 ~~115694.0~~ A			
B	O-rings	R394	3508.1	3508.9	3508.9			
✱ Note: Filter transcription errors found & corrected on 7/5/2016								

Technician Signature: Date: 3/15/16

TARE SHEET - FILTERS

Date Placed in Dessicator: 1/15/16 16:30

Thermohygrometer ID #: 291

Cleaned By: S. Bufton

Balance ID #: 23

Audit Weight ID #:

Filter ID #	Date: 2/8/16 Time: 1600 RH %: 14.5 T (°F): 75.0 Audit: 500.2	Date: 2/12/16 Time: 1530 RH %: 11.1 T (°F): 73.5 Audit: 500.2	Date: Time: RH %: T (°F): Audit:	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
C353	120.9	120.8			[redacted]		
C354	121.0	120.9					
C355	121.1	121.1					
C356	121.1	120.9					
C357	121.0	120.8			3/7/16	0456WB005F	1
C358	120.8	120.8					
C359	120.8	120.9					
C360	121.5	121.5					
C361	121.3	121.3					
C362	120.7	120.7			3/8/16		2
C363	121.4	121.4					
C364	121.1	121.0					
C365	120.6	120.6					
C366	121.0	120.9					
C367	120.8	120.9			3/9/16	"	3
	Initials:	Initials:	Initials:	Initials:			

Final Technician Signature: [signature]

Date: 2/12/16

TARE SHEET - FILTERS

Date Placed in Dessicator: 1/15/16 16:30

Thermohygrometer ID #: 291

Cleaned By: J. Button

Balance ID #: 23

Audit Weight ID #:

Filter ID #	Date: 2/8/16 Time: 1600 RH %: 14.5 T (°F): 75.0 Audit: 560.2	Date: 2/12/16 Time: 1530 RH %: 11.1 T (°F): 73.5 Audit: 500.2	Date: Time: RH %: T (°F): Audit:	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
C368	120.7	120.5			3/9/16	0456WB005E	3
C369	120.5	120.5			↓	↓	↓
C370	121.1	121.0					
C371	121.3	121.3					
C372	120.8	120.8			3/10/16		4
C373	120.8	120.9					
C374	120.0	120.1					
C375	121.7	121.6					
C376	120.7	120.8					
C377	120.6	120.7			[redacted]		
C378	121.6	121.6					
C379	120.5	120.6					
C380	120.5	120.5					
C381	121.4	121.3					
C382	120.7	120.7					
	Initials: A	Initials: A	Initials:	Initials:			

Final Technician Signature: [signature]

Date: 2/12/16

TARE SHEET - PROBES

Date Placed in Dessicator: 11/5/15 1610

Thermohygrometer ID #: OMNI-00351

Cleaned By: B Davis

Balance ID #: OMNI 00023

Audit Weight ID #: OMNI-00283A

Probe ID #	Date: 1/12/16 Time: 1400 RH %: 15.6 T (°F): 74.2 Audit: 99.999	Date: 1/13/16 Time: 1000 RH %: 16.6 T (°F): 76.1 Audit: 100000.0	Date: 1/14/16 Time: 1130 RH %: 20.1 T (°F): 71.2 Audit: 100000.0	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
1	122770.9	122771.4	122771.5		[redacted]		
2	115017.4	115017.6	-				
OES 3	114771.2	114771.4	-				
4	114862.9	114863.7	114863.6				
6	~~115344.4~~ 115354.4	115355.0	115355.0				
OES 6	113701.9	113702.7	113702.5				
7	114984.7	114984.9	-				
8	115596.4	115597.0	115597.1				
9	115693.4	115693.7	115693.5				
11	114191.9	114192.4	114192.4				
12	114286.8	114287.4	114287.5				
13	114324.5	114325.2	114325.0				
14	114555.4	114555.6	-				
15	114347.9	114348.1	-		3/7/16	0456WB005F	1
18	114404.5	114405.2	114405.1		↓	↓	↓
	Initials: SB	Initials:	Initials:	Initials:			

Final Technician Signature: _____ Date: 1/14/16

TARE SHEET - PROBES

Date Placed in Dessicator: 2/18/16

Cleaned By: A. Kravitz

Balance ID #: 23

Thermohygrometer ID #: 592

Audit Weight ID #: 383A

Probe ID #	Date: 3/4/16 Time: 1230 RH %: 15.6 T (°F): 74.1 Audit: 100.0000	Date: 3/8/16 Time: 1000 RH %: 18.2 T (°F): 70.8 Audit: 100000.0	Date: Time: RH %: T (°F): Audit:	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
OES 3	114771.4	114771.6			3/8/16	0456WB005E	2
4	114863.9	114863.9			↓	↓	↓
6	115355.2	115355.3			3/9/16	↓	3
7	114985.0	114985.0			↓	↓	↓
8	115597.1	115597.3			3/10/16	↓	4
9	115693.7	115693.9			↓	↓	↓
11	114192.4	114192.6			[redacted]		
12	114287.6	114287.5					
24	114130.6	114130.8					
28	114758.6	114758.7					
37	114469.4	114169.3					
38	114154.5	114154.6					
52	122774.9	122775.0					
54	122837.3	122837.1					
55	123235.1	123235.3					
	Initials: A	Initials: A	Initials:	Initials:			

Final Technician Signature: [signature]

Date: 3/8/16

O-RING TARES

Date Placed in Desiccator: 9/24/15 Technician: A. Kranitz Balance ID # 23

Thermo/Hygro meter ID #: 291 Audit Weight ID # 283A (Balance audit mfr. Std.: 500 ± 0.72)

O-Ring Size/ID# (47)	Date: 10/1 Time: 1300 RH%: 23.1 T (F): 74.1 Initials: AK	Date: 10/2 Time: 1030 RH%: 24.2 T (F): 73.6 Initials: A	Date: 10/5 Time: 1200 RH%: 16.1 T (F): 75.0 Initials: A	Date: Time: RH%: T (F): Initials:	Manufacturer	Appliance	Project No.	Run No.
R379	3390.4	3390.5	-		[redacted]			
R380	4172.4	4172.4	"					
R381	3377.6	3377.7	"					
R382	4320.0	4319.8	"					
R383	4121.7	4121.5	"					
R384	3325.9	3325.8	"					
R385	3356.2	3356.6	"					
R386	4077.5	4077.2	4077.1					
R387	3360.8	3360.4	3360.3		Fealing	53 Large	0956 W8605E	1
R388	4127.6	4127.2	4127.2		"	"	"	"
R389	3290.5	3290.3	-		"	"	"	2
R390	3608.9	3609.0	-		"	"	"	"
R391	4519.5	4519.1	4519.1		"	"	"	3
R392	3345.6	3345.3	3345.1		"	"	"	"
Audit :	5000.2	5000.1	5000.1					

Final Technician signature: [signature] Date: 10/5/15

O-RING TARES

Date Placed in Desiccator: 10/27/15 11:20 Technician: J. Button Balance ID # 00023

Thermo/Hygro meter ID #: 00291 Audit Weight ID # 00131 (Balance audit mfr. Std.: 500 ± 0.72)

O-Ring Size/ID# 47	Date: 3/4/16 Time: 1245 RH%: 12.9 T (F): 74.4 ~~Initials~~: Audit 2.0003	Date: 3/8/16 Time: 1015 RH%: 15.2 T (F): 76.4 ~~Initials~~: Audit 20004	Date: Time: RH%: T (F): Initials:	Date: Time: RH%: T (F): Initials:	Manufacturer	Appliance	Project No.	Run No.
R393	~~3546.8~~ 3456.8 A	~~54~~ A ~~3456.8~~ 3456.8			Frolinq	S3 Large	0456WB005E	4
R394	3508.2	3508.1			↓	↓	↓	↓
R395	3505.1	3504.9			[redacted]			
R396	3579.7	3579.7						
R397	3432.6	3432.7						
R398	3280.2	3280.4						
R399	3332.9	3332.9						
R400	3301.5	3301.6						
R401	3373.0	3373.0						
R402	4163.8	4163.8						
R403	3402.0	3402.0						
R404	3370.5	3370.4						
R405	3376.1	3376.1						
R406	4334.4	4334.2						

Final Technician signature: Date: 3/8/16

Calibrations

Methods ASTM E2515, ASTM E2618

ID #	Lab Name/Purpose	Log Name	Attachment Type
23	Scale-Analytical Balance	Mettler Analytical Balance	Calibration Certificate
131	500 mg Weight	Ohaus Weight Standard, 500 mg	Calibration Certificate
132	10 lb Weight	Weight Standard, 10 lb.	Calibration Certificate
209	Barometer	Barometer – Princo	Equipment Record
283A	Calibration Weight Set	TW-2000-01T, Metric Set, Calibrated Weights	Calibration Certificate
296-T55	Tape Measure	DeWalt 25' Tape Measure	Calibration Log
340	Wood Moisture Meter	Moisture Meter - Delmhorst	Equipment Record
353	Platform Scale	Elec-Weighing Scale	Calibration Certificate
356	Platform Scale	Pro-Dec Scale (5000 lb)	Calibration Certificate
371	Sample Box / Dry Gas Meter	Apex Automated Emissions Sampling Box	Calibration Log
372	Sample Box / Dry Gas Meter	Apex Automated Emissions Sampling Box	Calibration Log
410	Microtector	Dwyer Microtector	Equipment Record
419	Combustion Gas Analyzer	Infrared Gas Analyzer	Equipment Record
428A	Sample Box / Dry Gas Meter	Apex Automated Emissions Sampling Box	Calibration Log
428B	Sample Box / Dry Gas Meter	Apex Automated Emissions Sampling Box	Calibration Log
431	Moisture Meter Calibrator	Delmhorst Moisture Content Calibrator	Calibration Log
513	Flow Meter	Omega Low Flow Meter	Calibration Log
533	RTD Logger	DAQPro 5300 Data Logger	Calibration Certificate
559	Vaneometer	Dwyer Vaneometer	Equipment Record
592	Thermohygrometer	Omega Digital Thermohygrometer	Calibration Log

Certificate of Calibration

Certificate Number: **615462**

JJ Calibrations, Inc.
7007 SE Lake Rd
Portland, OR 97267-2105
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

OnSite

PO: **160070**
Order Date: **03/04/2016**
Authorized By: **N/A**

0723.01
Calibration

Property #: **OMNI-00023**
User: **N/A**
Department: **N/A**
Make: **Mettler**
Model: **AE200**
Serial #: **E17657**
Description: **Scale, 205g**
Procedure: **DCN 500818/500887**
Accuracy: **±0.0004g ±1 LSD**

Calibrated on: **03/04/2016**
*Recommended Due: **09/04/2016**
Environment: **20 °C 40 % RH**
* As Received: **Out of Tolerance**
* As Returned: **Within Tolerance**
Action Taken: **Calibrated**
Technician: **123**

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.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
723A	Rice Lake	1mg-200g (Class O)	Mass Set	12/01/2016	603626

Measurement Data

Parameter / Measurement Description	Range Unit	Reference	Min	Max	*Error	UUT	Uncertainty
Before							Accredited = ✓
Force							
	g	0.00100	0.0005	0.0015	0.0001	0.0011 g	5.7E-04 ✓
	g	0.01000	0.0095	0.0105	0.0002	0.0102 g	5.7E-04 ✓
	g	0.10000	0.0995	0.1005	0.0002	0.1002 g	5.7E-04 ✓
	g	0.50000	0.4995	0.5005	0.0002	0.5002 g	5.7E-04 ✓
	g	1.00000	0.9995	1.0005	0.0002	1.0002 g	5.7E-04 ✓
	g	40.00000	39.9995	40.0005	0.0010	40.0010 g	5.7E-04 ✓
	g	80.00000	79.9995	80.0005	0.0019	80.0019 g	5.7E-04 ✓
	g	120.00000	119.9995	120.0005	0.0028	120.0028 g	5.7E-04 ✓
	g	160.00000	159.9995	160.0005	0.0039	160.0039 g	5.8E-04 ✓
	g	200.00000	199.9995	200.0005	0.0043	200.0043 g	5.7E-04 ✓
After		Reference	Min	Max	*Error		Accredited = ✓
	g	0.00100	0.0005	0.0015	0.0000	0.0010 g	5.7E-04 ✓
	g	0.01000	0.0095	0.0105	0.0000	0.0100 g	5.7E-04 ✓
	g	0.10000	0.0995	0.1005	0.0000	0.1000 g	5.7E-04 ✓
	g	0.50000	0.4995	0.5005	0.0001	0.4999 g	5.7E-04 ✓
	g	1.00000	0.9995	1.0005	0.0000	1.0000 g	5.7E-04 ✓
	g	40.00000	39.9995	40.0005	0.0002	40.0002 g	5.7E-04 ✓
	g	80.00000	79.9995	80.0005	0.0003	80.0003 g	5.7E-04 ✓
	g	120.00000	119.9995	120.0005	0.0002	120.0002 g	5.7E-04 ✓
	g	160.00000	159.9995	160.0005	0.0004	160.0004 g	5.8E-04 ✓
	g	200.00000	199.9995	200.0005	0.0004	200.0004 g	5.7E-04 ✓

Certificate of Calibration

Certificate Number: **547339**

JJ Calibrations, Inc.
7007 SE Lake Rd
Portland, OR 97267-2105
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

ACCREDITED
0723.01
Calibration

PO: OTL-13-035
Order Date: 11/19/2013
Authorized By: N/A

Property #: OMNI-00131
User: N/A
Department: N/A
Make: Ohaus
Model: 500mg
Serial #: 27503
Description: Mass
Procedure: DCN 500901
Accuracy: CLASS F (±0.72mg)

Calibrated on: 12/02/2013
*Recommended Due: 12/02/2018
Environment: 20 °C 34 % RH
As Received: Within Tolerance
As Returned: Within Tolerance
Action Taken: Calibrated
Technician: 34

Remarks: * Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired

Refer to attachment for measurement results.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
432A	Sartorius	C-44	Microbalance 5.1g	03/11/2014	517747
723A	Rice Lake	1mg-200g (Class O)	Mass Set	09/05/2014	540048

JJ Calibrations, Inc. certifies that this instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual with the stated procedure using standards that are traceable to the National Institute of Standards and Technology (NIST), or other National Measurement Institutes (NMI's), or by using natural physical constants, intrinsic standards or ratio calibration techniques. The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2005, 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 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 prior written consent of JJ Calibrations, Inc.
JJ Calibrations, Inc. quality system has been assessed and accredited to ISO/IEC 17025:2005.

Reviewer

3 Issued 12/06/2013 Rev # 14

Inspector

SCALE WEIGHT CALIBRATION DATA SHEET

Weight to be calibrated: 10 lb

ID Number: 132

Standard Calibration Weight: 10 lb

ID Number: 256

Scale Used: MTW-150K

ID Number: 353

Date: 2/19/13 By: A. Kravitz

Standard Weight (A) (Lb.)	Weight Verified (B) (Lb.)	Difference (A - B)	% Error
10.0	10.0	0.0	Ø

*Acceptable tolerance is 1%.

This calibration is traceable to NIST using calibrated standard weights.

Technician signature: Date: 2/19/13

OMNI-Test Laboratories, Inc.
Beaverton, OR (503) 643-3788

Equipment Record

Name: Fortin Type Mercurial Barometer

Type of Equipment: Barometer

S/N: 0674 **OMNI ID #:** OMNI-00209

Manufacturer: PRINCO Instruments, Inc.

Is Manufacturer's manual available in the equipment file? : Yes, if not why?

Date Received: June 2000 **Date Placed in Service:** June 2000

Condition When Received: : New 9 Used 9 Reconditioned

Location: Lab

Location of Calibration Procedures: All PRINCO Fortin mercurial barometers have scales which are set at the time of manufacture to a near zero correction by comparison with a Fortin type mercurial barometer whose scales were calibrated traceable to NIST. If the barometer is not abused an any way , it should never go out of calibration.

Location of Dates/Results of Calibrations: If the barometer is not abused an any way , it should never go out of calibration. The barometer currently hangs on the wall and is never moved.

Location of Maintenance Procedures: Maintenance is performed on an "as needed" basis.

Dates / Results of Maintenance: Regularly scheduled maintenance is not required. Pre-service and post-service maintenance is conducted per QA Manual Section 5.3.5. To date, maintenance has not been required beyond the in-service maintenance prescribed in QA Manual Section 5.3.5.

Any Planned Maintenance? : No, if yes what:

Equipment History of any damage, malfunction, modification and/or repair (including a statement on the suitability of the equipment for testing): To date, this instrument has not been damaged, has not malfunctioned, has not been modified, and has not been repaired.

Certificate of Calibration

Certificate Number: **543402**

JJ Calibrations, Inc.
7007 SE Lake Rd
Portland, OR 97267-2105
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

0723.01
Calibration

PO: OTL-13-031
Order Date: 09/27/2013
Authorized By: N/A

Property #: OMNI-00283A
User: N/A
Department: N/A
Make: Troemner Inc
Model: 1mg-100g (Class F)
Serial #: 47883
Description: Mass Set, 21 Pc.
Procedure: DCN 500901
Accuracy: Class F

Calibrated on: 10/09/2013
*Recommended Due: 10/09/2018
Environment: 20 °C 41 % RH
As Received: Other - See Remarks
As Returned: Within Tolerance
Action Taken: Calibrated
Technician: 34

Remarks: * Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired

Changed set from a Class 4 to a Class F per Jeremy Clark.
Received missing 1g weight.
Refer to attachment for measurement results.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
432A	Sartorius	C-44	Microbalance 5.1g	03/11/2014	517747
479A	Sartorius	MC210S	Scale, 210g	02/22/2014	517755
503A	Rice Lake	1mg-200g (Class O)	Mass Set	12/07/2013	517746
723A	Rice Lake	1mg-200g (Class O)	Mass Set	09/05/2014	540048

JJ Calibrations, Inc. certifies that this instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual with the stated procedure using standards that are traceable to the National Institute of Standards and Technology (NIST), or other National Measurement Institutes (NMI's), or by using natural physical constants, intrinsic standards or ratio calibration techniques. The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2005, 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 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 prior written consent of JJ Calibrations, Inc.
JJ Calibrations, Inc. quality system has been assessed and accredited to ISO/IEC 17025:2005.

Reviewer

3 Issued 10/11/2013 Rev # 14

Inspector

Tape Measure Calibration Log

Place the calibrated 12" ruler under the tape measure and verify that each ½" (i.e. 1.5", 2", 2.5") between 0 and 36" is within 1/8".

CALIBRATED USING OMNI - 00281

Tape Measure Number	Description	Cal Dates				Technician Initials			
00296 - T32	Stanley FatMax 16'	7/25/12	7/2/13	7/8/14	7/20/15	JC	JC	JC	JC
00296 - T51	Ace 26' Tape Measure	9/7/12	9/13/13	9/23/14	10/22/15	JC	JC	JC	BR
-T52	Stanley PowerLock 26'	9/7/12	9/13/13	9/22/14	10/22/15	JC	JC	JC	BR
-T53	Stanley PowerLock 16'	9/7/12				JC			
-T11	Stanley intermatic Tape Measure (cm)	11/30/12	2/28/14	2/25/15		JC	JC	JC	
-T21	MTH Tape Measure (cm)	11/30/12	11/21/13			JC	JC		
-T30	Workforce Tape Measure	11/30/12				JC			
-T31	Stanley Powerlock Tape Measure	11/30/12	11/21/13	11/18/14	11/25/15	JC	JC	JC	BR
-T47	Workforce Tape Measure	11/30/12	11/21/13	11/26/14	11/25/15	JC	JC	JC	BR
-T36 Removed from service 11/25/15	Stanley FatMax 16' Tape Measure	11/30/12	11/21/13	11/18/14	~~11/25/15~~ BR	JC	JC	JC	BD
~~-T42~~ -T40	Stanley FatMax 16' Tape Measure	11/30/12	11/21/13	11/18/14	11/25/15	JC	JC	JC	BR
-T54	DeWalt 16' Tape Measure	12/20/12	12/17/13	12/29/14	12/11/15	JC	JC	JC	BR
-T55	DeWalt 16' Tape Measure	12/20/12	12/18/13	12/29/14	12/11/15	JC	JC	JC	BR
-T56	DeWalt 25' Tape Measure	12/20/12	12/17/13	12/16/14	12/11/15	JC	JC	JC	BR
-T57	DeWalt 25' Tape Measure	12/20/12	12/17/13	12/16/14		JC	JC	JC	
-T58	DeWalt 25' Tape Measure	12/20/12	12/17/13	12/16/14		JC	JC	JC	
-T59	DeWalt 25' Tape Measure	12/20/12	12/17/13	12/16/14	12/11/15	JC	JC	JC	BR
-T42	Stanley PowerLock 26' Tape Measure	11/21/13	11/18/14	~~11/25/15~~ Removed from Service		JC	JC		BR

OMNI-Test Laboratories, Inc.
Beaverton, OR (503) 643-3788

Equipment Record

Name: Moisture Meter, 2 pin

Type of Equipment: Moisture detector for wood

S/N: 27495 **OMNI ID #:** OMNI-00340

Manufacturer: Delmhorst Instrument Company 877-335-6467 (1-877-DELMHORST)

Is Manufacturer's manual available in the equipment file? : Yes, if not why? Yes

Date Received: 7/06 **Date Placed in Service:** 8/06

Condition When Received: : New 9 Used 9 Reconditioned

Location: Saw Room

Location of Calibration Procedures: Calibrate prior to use with Moisture Content Calibrator OMNI-00431 or OMNI-00432 (both NIST Traceable through OMNI-00430). See page 7 of attached manual for additional calibration settings as well as the attached sheet with instructions for using the Moisture Content Calibrators.

Location of Dates/Results of Calibrations: See enclosed calibration logs.

Location of Maintenance Procedures: See page 9 of the enclosed owner's manual.

Dates / Results of Maintenance: Pre-service and post-service maintenance is conducted per QA Manual section 5.3.5. To date, maintenance has not been required beyond the in-service maintenance prescribed in QA Manual section 5.3.5.

Any Planned Maintenance? : No, if yes what:

Equipment History of any damage, malfunction, modification and/or repair (including a statement on the suitability of the equipment for testing): **EQUIPMENT TAKEN OUT OF SERVICE 4/18/2011 DUE TO A BROKEN DISPLAY ON THE UNIT. REPLACEMENT ORDERED.** Broken display replaced with functioning display 5/30/12 by Mark Ontiveros. Calibration verified, equipment returned to service 5/30/12.

Calibration sheet For MTW-150K S/N MKW04072 (OMNI-00353)

Calibration Interval: 12 months

Parameter	Date	Omni reference weights used	Weight	Scale readout	Compliance	
Mass in Lbs.	12-11-08	00132	10 lb	10.0 lbs	✓	
	12-11-08	00132, 255	20 lb	20.0 lbs	✓	
	12-11-08	00132, 255, 274	30 lb	30.0 lbs	✓	
	3/9/11	00132	10LBS	10LBS	X	SW
	3/9/11	132/255	10LBSx2	20LBS	X	SW
	3/9/11	132/255/274	10LBSx3	30LBS	X	SW
	8/10/2012	00132	10 lb	10.0 lb	✓	J. Clark
	8/10/2012	132, 255	20 lb	20.0 lb	✓	J. Clark
	8/10/2012	132, 255, 274	30 lb	30.0 lb	✓	J. Clark
	7/19/2013	00132	10 lb	10.0 lb	✓	J. Clark
	7/19/2013	132, 255	20 lb	20.0 lb	✓	J. Clark
	7/19/2013	132, 255, 274	30 lb	30.0 lb	✓	J. Clark
	7/8~~9~~/2014	- 00132	10 lb	10.0 lb	✓	J. Clark
	7/9/2014	- 00132, - 00255	20 lb	20.0 lb	✓	J. Clark
	7/9/2014	-00132, -00255, -00274	30 lb	30.0 lb	✓	J. Clark
	7/13/2015	-00132	10 lb	10.0 lb	✓	J. Clark
	7/13/2015	-00132, -00255	20 lb	20.0 lb	✓	
	7/13/2015	-00132, -00255, -00274	30 lb	30.0 lb	✓	

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

OMNI-Test Laboratories, Inc.
13327 NE Airport Way
Portland, OR 97230

Report Number: OMNE0353719151027

A2LA ACCREDITED
CERTIFICATE OF CALIBRATION WITH DATA

INSTRUMENT INFORMATION

Item	Make	Model	Serial Number	Customer ID	Location
Scale	Weigh-Tronix	125x5000	53719	356	Lab
Units	**Readability**	**SOP**	**Cal Date**	**Last Cal Date**	**Cal Due Date**
lbs	0.5	QC033	10/27/15	N/A	10/2016

FUNCTIONAL CHECKS

SHIFT TEST	LINEARITY	REPEATABILITY	ENVIRONMENTAL CONDITIONS
Test Wt: 300 Tol: 0.5	Test Wt: HB44 Tol: HB44	Test Wt: 500 Tol: 0.5	☐ Good ☑ Fair ☐ Poor
As-Found: Pass:☑ Fail:☐	As-Found: Pass:☑ Fail:☐	As-Found: Pass:☑ Fail:☐	Temperature: 18.8°C
As-Left: Pass:☑ Fail:☐	As-Left: Pass:☑ Fail:☐	As-Left: Pass:☑ Fail:☐	

CALIBRATION DATA

Standard	As-Found	As-Left	Expanded Uncertainty
1000	999.5	999.5	0.31
700	699.5	699.5	0.31
500	500.0	500.0	0.29
200	200.0	200.0	0.29
100	100.0	100.0	0.29
50	50.0	50.0	0.29

CALIBRATION STANDARDS

Item	Make	Model	Serial Number	Cal Date	Cal Due Date	NIST ID
Avoirdupois Cast W	Rice Lake	25 and 50lb	PWO990-CA	10/28/13	10/2015	34XX

Permanent Information Concerning this Equipment:

10/27/15: Tared with customer 1000+ lbs of weight: 1000lbs = 999.5lbs

Comments/Information Concerning this Calibration

Report prepared/reviewed by: J. Colacchio **Date:** 10/27/15 **Technician:** J. Colacchio **Signature:**

THIS CERTIFICATE SHALL NOT BE REPRODUCED, EXCEPT IN FULL, WITHOUT THE APPROVAL OF QUALITY CONTROL SERVICES, INC.

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 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.

Temperature Calibration
EPA Method 28 and 5G

BOOTH: 2	TEMPERATURE MONITOR TYPE:	IDENTIFICATION NUMBER:
Emissions	Type K. Thermocouple	OMNE-003741

REFERENCE TEMPERATURE MONITOR TYPE:	IDENTIFICATION NUMBER:
OMEGA Calibrator Model CL300	SB 9/15/15 ~~Serial Number 506~~ OMNE-373

CALIBRATION PERFORMED BY:	DATE:	AMBIENT TEMPERATURE:	BAROMETRIC PRESSURE:
S. Button	9/15/15	71	29.95

Reference Point Source	Temperature Monitor (EF)					
		Method 5G Dilution Tunnel				
OMEGA Thermocouple Simulator Serial #506	Method 28 Room	Meter (Tm)	Filters (Tf)	Tunnel (Tt)	~~Stack~~ Dryer (Ts) SB 9/15/15	DB
0	0	-1	-1	0	1	
100	99	100	99	100	101	
300	299	300	299	300	301	
500	499	500	500	500	501	
700	699	700	700	700	701	

	FB Top	FB Bottom	FB Back	FB Left	FB Right
0	0	0	0	0	0
100	100	100	100	100	100
300	300	300	300	300	300
500	500	500	500	500	500
700	700	700	700	700	700

Technician signature: _____ Date: 9/15/15

Reviewer: BD 9/15/15

Temperature Calibration
EPA Method 28 and 5G

BOOTH: 2	TEMPERATURE MONITOR TYPE:	IDENTIFICATION NUMBER:
Emissions	Type K - Thermocouple	OMNI -00372

REFERENCE TEMPERATURE MONITOR TYPE:	IDENTIFICATION NUMBER:
OMEGA Calibrator Model CL300	SB 9/15/15 ~~Serial Number 506~~ OMNI-00373

CALIBRATION PERFORMED BY:	DATE:	AMBIENT TEMPERATURE:	BAROMETRIC PRESSURE:
J. Button	9/15/15	71	29.95

Reference Point Source	Temperature Monitor (EF)					
		Method 5G Dilution Tunnel				
OMEGA Thermocouple Simulator Serial #506	Method 28 Room	Meter (Tm)	Filters (Tf)	Tunnel (Tt)	Stack Dryer ~~(Ts)~~ SB 9/15/15	DB
0	0	0	0	0	1	
100	99	100	100	100	101	
300	299	300	300	300	301	
500	499	500	500	500	501	
700	699	700	700	700	701	

Technician signature: _____ Date: 9/15/15

Reviewer: BD 9/15/15

Equipment Record

Name: Microtector

Type of Equipment: Hook Gage Liquid Manometer with Micrometer Gage in Inches

Model: 1430

S/N: 115004-00 **OMNI ID #:** OMNI-00410

Manufacturer: Dwyer Instruments

Vendor/Retailer: Dwyer Instruments

Is Manufacturer's manual available in the equipment file? ☒ Yes, if not why?

Date Received: December 2007 **Date Placed in Service:** December 2007

Condition When Received: ☒ New ☐ Used ☐ Reconditioned

Location: shop

Location of Calibration Procedures: Calibrate prior to use using NIST Traceable standard OMNI-00033. "Zeroing" instructions in attached manual.

Location of Dates/Results of Calibrations: N/A

Location of Maintenance Procedures: Maintenance is performed on an "as needed" basis as determined by calibrations.

Dates / Results of Maintenance: Regularly scheduled maintenance is not required. Pre- and post-service maintenance is conducted per QA Manual Section 5.3.5. To date, maintenance has not been required beyond the in-service maintenance prescribed in QA Manual Section 5.3.5.

Any Planned Maintenance? ☒ No, if yes what:

Equipment History of any damage, malfunction, modification and/or repair (including a statement on the suitability of the equipment for testing): To date, this instrument has not been damaged, modified or repaired, nor has it malfunctioned.

Equipment Record

Name: Infrared Gas Analyzer

Type of Equipment: gas analyzer **Model:** 300 NDIR

S/N: A8P9063T **OMNI ID #:** OMNI-00419

Manufacturer: California Analytical Instruments

Vendor/Retailer: California Analytical Instruments

Is Manufacturer's manual available in the equipment file? ☒ Yes, if not why?

Date Received: 5/2009 **Date Placed in Service:** 6/2009

Condition When Received: ☒ New ☐ Used ☐ Reconditioned

Location: shop

Location of Calibration Procedures: Unit is calibrated prior to use using procedures and specifications outlined in section 6 of instruction manual.

Location of Dates/Results of Calibrations: See attached calibration sheets.

Location of Maintenance Procedures: Maintenance is performed on an "as needed" basis as determined by calibrations.

Dates / Results of Maintenance: Regularly scheduled maintenance is not required. Pre- and post-service maintenance is conducted per QA Manual Section 5.3.5. To date, maintenance has not been required beyond the in-service maintenance prescribed in QA Manual Section 5.3.5.

Any Planned Maintenance? ☒ No, if yes what:

Equipment History of any damage, malfunction, modification and/or repair (including a statement on the suitability of the equipment for testing): To date, this instrument has not been damaged, modified or repaired, nor has it malfunctioned.

Thermal Metering System Calibration
Y Factor

Manufacturer:	Apex
Model:	XC-60
Serial Number:	N/A
OMNI Tracking No.:	OMN-428A
Calibrated Orifice:	☐ Yes

Previous Calibration Comparision

Date	7/2/2015	Acceptable Deviation (5%)	Deviation
y Factor	1.003	0.05015	0.008
Acceptance	Acceptable		

Average Gas Meter y Factor	Orifice Meter dH@
0.995	N/A

Calibration Date:	01/05/16	
Calibrated by:	A. Kravitz	
Calibration Frequency:	6 Months	
Next Calibration Due:	7/5/2016	
Instrument Range:	1.000	cfm
Standard Temp.:	68	oF
Standard Press.:	29.92	"Hg
Barometric Press., Pb:	29.67	"Hg
Signature/Date:		1/5/16

Current Calibration

Acceptable y Deviation	0.020
Maximum y Deviation	0.004
Acceptable dH@ Deviation	N/A
Maximum dH@ Deviation	N/A
Acceptance	Acceptable

Reference Standard *			
Standard Calibrator	Model	Standard Test Meter	
	S/N	1	
	Calib. Date	05-Nov-15	
	Calib. Value	0.9983	y factor (ref)

Calibration Parameters	Run 1	Run 2	Run 3
Reference Meter Pressure ("H2O), Pr	0.00	0.00	0.00
DGM Pressure ("H2O), Pd	2.65	1.20	0.87
Initial Reference Meter	603.436	616.449	623.853
Final Reference Meter	610.524	623.853	631.66
Initial DGM	0	0	0
Final DGM	7.093	7.404	7.821
Temp. Ref. Meter (°F), Tr	69.0	66.0	68.0
Temperature DGM (°F), Td	70.0	68.0	67.0
Time (min)			
Net Volume Ref. Meter, Vr	7.088	7.404	7.807
Net Volume DGM, Vd	7.093	7.404	7.821
Gas Meter y Factor =	**0.993**	**0.999**	**0.992**
Gas Meter y Factor Deviation (from avg.)	0.002	0.004	0.002
Orifice dH@	**N/A**	**N/A**	**N/A**
Orifice dH@ Deviation (from avg.)	N/A	N/A	N/A

where:

1. Deviation = |Average value for all runs - current run value|

** 2. $y = [Vr \times (y \text{ factor (ref)}) \times (Pb + (Pr/13.6)) \times (Td + 460)] / [Vd \times (Pb + (Pd/13.6)) \times (Tr + 460)]$

** 3. $dH@ = 0.0317 \times Pd / (Pb\ (Td + 460)) \times [\ (Tr + 460) \times time) / Vr\ ]^2$

* Reference calibration is traceable to NIST through NIST Test # 40674, Kimble ASTM E1272, or NIST traceable laboratory

** Equations come from EPA Method 5

The uncertainty of measurement is ±0.14 ft^3/min. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

Thermal Metering System Calibration
Y Factor

Manufacturer:	Apex
Model:	XC-60
Serial Number:	N/A
OMNI Tracking No.:	OMN-428B
Calibrated Orifice:	☐ Yes

Previous Calibration Comparision

Date	7/2/2015	Acceptable Deviation (5%)	Deviation
y Factor	0.988	0.0494	0.003
Acceptance	Acceptable		

Current Calibration

Acceptable y Deviation	0.020
Maximum y Deviation	0.008
Acceptable dH@ Deviation	N/A
Maximum dH@ Deviation	N/A
Acceptance	Acceptable

Average Gas Meter y Factor	Orifice Meter dH@
0.985	N/A

Calibration Date:	01/05/16	
Calibrated by:	A. Kravitz	
Calibration Frequency:	6 Months	
Next Calibration Due:	7/5/2016	
Instrument Range:	1.000	cfm
Standard Temp.:	68	oF
Standard Press.:	29.92	"Hg
Barometric Press., Pb:	29.67	"Hg
Signature/Date:		1/5/16

Reference Standard *			
Standard Calibrator	Model	Standard Test Meter	
	S/N	1	
	Calib. Date	05-Nov-15	
	Calib. Value	0.9983	y factor (ref)

Calibration Parameters	Run 1	Run 2	Run 3
Reference Meter Pressure ("H2O), Pr	0.00	0.00	0.00
DGM Pressure ("H2O), Pd	2.81	0.91	1.29
Initial Reference Meter	648.044	631.66	638.369
Final Reference Meter	653.087	638.369	648.044
Initial DGM	0	0	0
Final DGM	5.074	6.901	9.901
Temp. Ref. Meter (°F), Tr	65.0	67.0	64.0
Temperature DGM (°F), Td	69.0	73.0	70.0
Time (min)			
Net Volume Ref. Meter, Vr	5.043	6.709	9.675
Net Volume DGM, Vd	5.074	6.901	9.901
Gas Meter y Factor =	**0.993**	**0.979**	**0.984**
Gas Meter y Factor Deviation (from avg.)	0.008	0.006	0.002
Orifice dH@	**N/A**	**N/A**	**N/A**
Orifice dH@ Deviation (from avg.)	N/A	N/A	N/A

where:

1. Deviation = |Average value for all runs - current run value|

** 2. $y = [Vr \times (y \text{ factor (ref)}) \times (Pb + (Pr/13.6)) \times (Td + 460)] / [Vd \times (Pb + (Pd/13.6)) \times (Tr + 460)]$

** 3. $dH@ = 0.0317 \times Pd / (Pb\ (Td + 460)) \times [(Tr + 460) \times time) / Vr]^2$

* Reference calibration is traceable to NIST through NIST Test # 40674, Kimble ASTM E1272, or NIST traceable laboratory

** Equations come from EPA Method 5

The uncertainty of measurement is ±0.14 ft^3/min. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA SHEET

Instrument to be calibrated: 428B – Pressure Transducer

Maximum Range: 1.0" ID Number: 428B

Calibration Instrument: Digital Manometer ID Number: 396

Date: 1/4/16 By: S. Button

This form is to be used only in conjunction with Standard Procedure C-SPC.

Range of Calibration Point ("WC)	Digital Manometer Input ("WC)	Pressure Gauge Response ("WC)	Difference (Input - Response)	% Error of Full Span*
0-20% Max. Range	0.170"	0.188"	0.018	1.8%
20-40% Max. Range	0.260"	0.284"	0.024	2.4%
40-60% Max. Range	0.465"	0.488"	0.023	2.3%
60-80% Max. Range	0.604"	0.632"	0.028	2.8%
80-100% Max. Range	0.894"	0.934"	0.040	4%

*Acceptable tolerance is 4%.

The uncertainty of measurement is ±0.4" WC. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

Technician signature: _____ Date: 1/4/16

Reviewed by: _____ Date: 1/5/16

DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA SHEET

Instrument to be calibrated: 428A – Pressure Transducer

Maximum Range: 1.0" ID Number: 428A

Calibration Instrument: Digital Manometer ID Number: 396

Date: 1/4/16 By: S. Button

This form is to be used only in conjunction with Standard Procedure C-SPC.

Range of Calibration Point ("WC)	Digital Manometer Input ("WC)	Pressure Gauge Response ("WC)	Difference (Input - Response)	% Error of Full Span*
0-20% Max. Range	0.130"	0.147"	0.017"	1.7%
20-40% Max. Range	0.272"	0.284"	0.012"	1.2%
40-60% Max. Range	0.509"	0.527"	0.018"	1.8%
60-80% Max. Range	0.773"	0.781"	0.008"	0.8%
80-100% Max. Range	0.812"	0.825"	0.013"	1.3%

*Acceptable tolerance is 4%.

The uncertainty of measurement is ±0.4" WC. This is based on the reference standard having a TAR (Test Accuracy Ratio) of at least 4:1.

Technician signature: _____ Date: 1/4/16

Reviewed by: _____ Date: 1/5/16

Temperature Calibration
EPA Method 28 and 5G

Booth:	Temperature Monitor Type:	Identification Number:
E3	Type K TC	428 A/B

Reference Temperature Monitor Type:	Identification Number:
	373

Calibration Performed By:	Date:	Ambient Temperature:	Barometric Pressure:
A. Kravitz	1/5/2016	69	29.67

Reference Point Source	Temperature Monitor (EF)						
		Method 5G Dilution Tunnel					
OMEGA Thermocouple Simulator OMNI ID 373	Method 28 Room	Meter	Filters A	Filters B	Tunnel	Dryer	Stack
0	0	-1	-1	-1	-1	-1	-1
100	100	100	100	100	100	100	100
300	300	300	300	300	300	300	300
500	500	500	500	500	500	500	500
700	700	700	700	700	700	700	700

	FB Top	FB Bottom	FB Back	FB Left	FB Right	App out	App In
0	-1	-1	-1	-1	-1	1.0	1.0
100	100	100	100	100	100	100	100
300	300	300	300	300	300	301	301
500	500	500	500	500	500	501	501
700	700	700	700	700	700	701	701

Technician signature: _____ Date: 1/5/16

WOOD MOISTURE CONTENT CALIBRATION WORKSHEET

Moisture Content Standard OMNI ID #: OMNI-00431 (8440P)

Reference Moisture Content Standard: **OMNI # 00430**

[#430] ~~(#431)~~ ~~(#430)~~ JC

Date	Temp. (°F)	Barometric Pressure (in Hg)	Fixed Moisture %	Fixed Moisture %	Observed Moisture % [#431]		Initials
4/29/11	72	30.3	22%	12%	22% / 12%	22% / 12%	SW
8/10/11	85	29.2	22%	12%	22% / 12%	22% / 12%	SW
11/29/11	73	30.15	22%	12%	22% / 12%	22% / 12%	SW
6/14/12	71	30.21	22%	12%	12.0% / 22.0%	12.0% / 22.0%	AM
9/19/2012	74	30.20	22%	12%	12.0 / 22.0	12.0 / 22.0	JC
12/31/2012	67° F	30.25 in Hg	22%	12%	12.0	22.0	JC
3/28/2013	71 °F	30.10 in Hg	22%	12%	12.0	22.0	JC
6/28/2013	82 °F	30.14 in Hg	22%	12%	12.0	22.0	JC
9/19/2013	75 °F	29.95 in Hg	22%	12%	12.0	22.0	JC
12/17/2013	72 °F	30.29 in Hg	22%	12%	22.0	12.0	JC
3/13/2014	65.0 °F	30.23 in Hg	22%	12%	22.0	12.0	JC
7/2/2014	77.5 °F	30.04 in Hg	22%	12%	22.0 %	12.0 %	JC
10/2/2014	66.0 °F	30.08 in Hg	22%	12%	22.0 %	12.0 %	JC
12/31/2014	71 °F	30.56 in Hg	22%	12%	22.0 %	12.0 %	JC
4/3/2015	72 °F	30.30 in Hg	22%	12%	22.0 %	12.0 %	JC
6/29/2015	79 °F	30.10 in Hg	22%	12%	22.0 %	12.0 %	JC
10/21/2015	73 °F	30.21 in Hg	22%	12%	22.0 %	12.0 %	TS
			22%	12%			

Notes: _____

Technician signature: _____ Date: 4/29/11

Certificate of Calibration

Certificate Number: **614704**

JJ Calibrations, Inc.
7007 SE Lake Rd
Portland, OR 97267-2105
Phone 503.786.3005
FAX 503.786.2994

Omni-Test Laboratories
13327 NE Airport Way
Portland, OR 97230

ACCREDITED
0723.01
Calibration

PO: **160068**
Order Date: **02/18/2016**
Authorized By: **N/A**

Property #: **OMNI-00533**
User: **N/A**
Department: **N/A**
Make: **Fourier**
Model: **DaqPRO 5300**
Serial #: **0105287**
Description: **Data Acquisition / analysis**
Procedure: **404915**
Accuracy: **Temp. PT100 <400°C(0.5°% f/s)**

Calibrated on: **02/29/2016**
*Recommended Due: **02/28/2017**
Environment: **22** °C **40** % RH
* As Received: **Within Tolerance**
* As Returned: **Within Tolerance**
Action Taken: **Calibrated**
Technician: **40**

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.

Received, return with case, manual, AC/DC power supply, USB cable, TC probe, 2 PT100 RTD probes, 1 PT100 RTD probe received with bent and found calibration performance does not effect operation.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
552A	Hart Scientific	7103	MICRO BATH	03/22/2016	584232
499A	Hart Scientific	6035	CALIBRATION BATH	08/16/2016	599335
497A	Hart Scientific	1502A	Precision Digital Thermometer	07/25/2016	597507
601A	Burns Engineering	200G05B085	INDUSTRIAL PRT	02/01/2018	612101

Measurement Data

Parameter / Measurement Description	Range Unit	Reference	Min	Max	kError	UUT	Uncertainty
Before/After							Accredited = ✓
Temperature							
PT/100 RTD Probe CH 1	-10 °C	-10.0540	-12.054	-8.054	0.654	-9.400 °C	2.3E+00 ✓
PT/100 RTD Probe CH 2	-10 °C	-10.0540	-12.054	-8.054	0.554	-9.500 °C	2.3E+00 ✓
PT/100 RTD Probe CH 1	0 °C	0.0260	-1.974	2.026	0.574	0.600 °C	2.3E+00 ✓
PT/100 RTD Probe CH 2	0 °C	0.0260	-1.974	2.026	0.274	0.300 °C	2.3E+00 ✓
PT/100 RTD Probe CH 1	120 °C	119.9770	117.977	121.977	0.623	120.600 °C	2.3E+00 ✓
PT/100 RTD Probe CH 2	120 °C	119.9770	117.977	121.977	0.823	120.800 °C	2.3E+00 ✓
PT/100 RTD Probe CH 1	200 °C	199.9890	197.989	201.989	1.011	201.000 °C	2.4E+00 ✓
PT/100 RTD Probe CH 2	200 °C	199.9890	197.989	201.989	0.189	199.800 °C	2.4E+00 ✓

JJ Calibrations, Inc. certifies that this instrument has been calibrated in accordance with the JJ Calibrations Quality Assurance Manual with the stated procedure using standards that are traceable to the National Institute of Standards and Technology (NIST), or other National Measurement Institutes (NMI's), or by using natural physical constants, intrinsic standards or ratio calibration techniques. The quality system and this certificate are in compliance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025-2005, 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 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 prior written consent of JJ Calibrations, Inc.
JJ Calibrations, Inc. quality system has been assessed and accredited to ISO/IEC 17025:2005.

Reviewer

3 Issued 03/01/2016 Rev # 15

Inspector

Equipment Record

Name: Vaneometer Air Velocity Meter

Type of Equipment: Air Velocity Meter **Model:** 480

S/N: T36Z **OMNI ID #:** OMNI-00559

Manufacturer: Dwyer Instruments

Vendor/Retailer: Dwyer Instruments

Is Manufacturer's manual available in the equipment file? ☒ **Yes, if not why?** _____

Date Received: 9/5/2014 **Date Placed in Service:** 9/5/2014

Condition When Received: ☒ New ☐ Used ☐ Reconditioned ☐ Unknown

Location: Cabinet 1

Location of Calibration Procedures: The meter is equipped with a factory pre-calibrated vane. The vane is replaced at least every six months, or in case of damage.

Location of Dates/Results of Calibrations: See attached calibration record.

Location of Maintenance Procedures: Maintenance is performed on a six month basis by replacing the pre-calibrated vane.

Dates / Results of Maintenance: See attachments.

Any Planned Maintenance? ☒ **No, if yes what:** _____

Equipment History of any damage, malfunction, modification and/or repair (including a statement on the suitability of the equipment for testing): _____

Flow Meter Calibration Check

Manufacturer: Froling Date: 3/7/2016
Appliance: S3 Run Number: 1
Project Number: 0456WB005E

Density = 1000(1 - (T+288.9414)/(508929.2*(T+68.12963))*(T-3.9863)^2) kg/m^3
1 kg/m^3 = 0.008345 lb/gal

Time (min)	Water T (°F)	Water T (°C)	Density (kg/m^3)	Density (lb/gal)	Weight (lb)	Calc Flow (gpm)	Indicated Flow	Elapsed Test Time (min)	+1%	-1%
3.00	52.4	11.3	999.599	8.342	135.5	5.41	5.45	PB	5.468	5.360
2.00	51.23	10.7	999.665	8.343	81.1	4.861	4.92	44	4.909	4.812
2.00	51.31	10.7	999.661	8.343	70	4.195	4.25	120	4.237	4.153

Flow Meter Calibration Check

Manufacturer: Froling Date: 3/8/2016
Appliance: S3 Run Number: 2
Project Number: 0456WB005E

Density = 1000(1 - (T+288.9414)/(508929.2*(T+68.12963))*(T-3.9863)^2) kg/m^3
1 kg/m^3 = 0.008345

Time (min)	Water T (°F)	Water T (°C)	Density (kg/m^3)	Density (lb/gal)	Weight (lb)	Calc Flow (gpm)	Indicated Flow	Elapsed Test Time (min)	+1%	-1%
10.00	53.7	12.1	999.520	8.341	64	0.77	0.78	Pre-test	0.775	0.760
4.00	54.9	12.7	999.441	8.341	24.6	0.737	0.73	20	0.745	0.730
7.00	56.3	13.5	999.341	8.340	30	0.514	0.51	49	0.519	0.509
7.00	56.6	13.7	999.319	8.340	27	0.463	0.46	118	0.467	0.458

Flow Meter Calibration Check

Manufacturer: Froling Date: 3/9/2016
Appliance: S3 Run Number: 3
Project Number: 0456WB005E

Density = 1000(1 - (T+288.9414)/(508929.2*(T+68.12963))*(T-3.9863)^2) kg/m^3
1 kg/m^3 = 0.0083454 lb/gal

Time (min)	Water T (°F)	Water T (°C)	Density (kg/m^3)	Density (lb/gal)	Weight (lb)	Calc Flow (gpm)	Indicated Flow	Elapsed Test Time (min)	+1%	-1%
4.50	53.8	12.1	999.513	8.341	46.2	1.23	1.24	PB	1.243	1.219
5.00	55.4	13.0	999.406	8.340	28.5	0.683	0.69	30	0.690	0.677
5.00	54.05	12.3	999.497	8.341	28.1	0.674	0.685	102	0.681	0.667
4.00	54.8	12.7	999.447	8.341	21.6	0.647	0.66	EOT	0.654	0.641

Flow Meter Calibration Check

Manufacturer: Froling Date: 3/10/2016
Appliance: S3 Run Number: 4
Project Number: 0456WB005E

Density = 1000(1 - (T+288.9414)/(508929.2*(T+68.12963))*(T-3.9863)^2) kg/m^3
1 kg/m^3 = 0.0083454 lb/gal

Time (min)	Water T (°F)	Water T (°C)	Density (kg/m^3)	Density (lb/gal)	Weight (lb)	Calc Flow (gpm)	Indicated Flow	Elapsed Test Time (min)	+1%	-1%
3.00	51.76	11.0	999.636	8.342	72.6	2.90	2.92	PB	2.930	2.872
4.00	52.6	11.4	999.587	8.342	43.9	1.316	1.32	6	1.329	1.302
4.00	52.6	11.4	999.587	8.342	49.5	1.483	1.495	55	1.498	1.469
4.00	52.9	11.6	999.569	8.342	39.2	1.175	1.18	92	1.187	1.163
3.50	52.7	11.5	999.581	8.342	36.3	1.243	1.26	130	1.256	1.231

VWR Temperature Hygrometer Calibration Procedure and Data Sheet

Frequency: Every Two Years

Step 1: Locate NIST traceable standard.

Step 2: Place unit to be calibrated, tracking No. OMNI- 00592 , inside OMNI desiccate box on the same shelf with the NIST traceable standard.

Step 3: After a period of not less than four hours record the temperature and humidity of both units in the spaces provide below.

Step 4: If the unit to be calibrated matches the NIST standard within ± 4%, it is acceptable. If not, the unit needs to be sent to a repair company or replaced.

Verification Data:

Date: 1/13/16 Technician: B Davis

Time in desiccate: 10:30 Recording time: 14:30

NIST Standard Temperature: 74.5 °F NIST Standard Humidity: ~~21.7~~ 19.2 (30)

Test Unit Temperature Reading: 74.4 °F Test Unit Humidity Reading: 16.8

Test unit OMNI- 00592 is X or was not ___ within acceptable limits.

Technician Signature: B Davis

Comments: Hygrometer OMNI-00291 was used to verify new unit. A difference of 2.4% RH was found, this result is within ± 4%, with a full scale of 100% for OMNI-00291, and 95% for OMNI-00592

Example Calculations

Equations and Sample Calculations – Wood-fired Hydronic Heater

Manufacturer: Froling
Model: S3
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.

TI_{avg}	Average temperature of appliance water at start of the test, °F
TF_{avg}	Average temperature of appliance water at the end of the test, °F
MC_{avg}	Average fuel moisture content in percent based on dry fuel weight
$Q_{in\ gross}$	Gross heat input from all fuel sources, Btu
$Q_{in\ net}$	Net heat input, Btu
Q_{unit}	Net energy content change of appliance and on-board water, Btu
M_i	Mass flow rate of water at interval i, lb/min
Q_{load}	Total heat delivered to simulated load, Btu
$Q_{storage}$	Net energy content change in storage, Btu
$Q_{out\text{-}total}$	Total heat output, Btu
Total Heat Output Rate	Total heat output rate, Btu/hr
Load Heat Output Rate	Simulated load heat output rate, Btu/hr
m_n	Total Particulate Matter Collected, mg
$V_{m(std)}$	Volume of gas sampled corrected to standard conditions, dscf
v_s	Average dilution tunnel gas velocity, ft/sec
C_s	Particulate concentration, g/dscf
Q_{std}	Dilution tunnel gas flow rate, dscf/min
E_T	Total particulate emissions, grams
PR	Proportional rate variation, %
$E_{g/MJ}$	Emission rate, g/MJ
$E_{lb/MMBtu\ output}$	Emission rate, lb/MMBtu output
$E_{g/kg}$	Emission factor, g/kg
$E_{g/hr}$	Emission rate, g/hr
η_{del}	Delivered efficiency, %

TI_{avg} – Average temperature of appliance water at start of the test, °F

ASTM E2618 Equation (1):

$$TI_{avg} = (T1 + T2) / 2$$

Where,

T1 = Temperature of water at the inlet on the supply side of HEX 1, °F

T2 = Temperature of water at the outlet on the supply side of HEX 1, °F

Sample Calculation:

Using data at beginning of test (t=0)

$$TI_{avg} = \frac{180 + 134}{2}$$

TI_{avg} = **157** **°F**

TF_{avg} – Average temperature of appliance water at the end of the test, °F

ASTM E2618 Equation (2):

$$TI_{avg} = (T1 + T2) / 2$$

Where,

T1 = Temperature of water at the inlet on the supply side of HEX 1, °F

T2 = Temperature of water at the outlet on the supply side of HEX 1, °F

Sample Calculation:

Using data at end of test (t=138)

$$TI_{avg} = \frac{171 + 134}{2}$$

TI_{avg} = **152.5** **°F**

MC_{avg} – Average fuel moisture content in percent based on dry fuel weight

ASTM E2618 Equation (3):

$$MC_{avg} = \frac{\left[\sum W_i \cdot MC_i\right]}{\sum W_i}$$

Where,

W_i = Weight of individual fuel pieces in pounds

MC_i = Average moisture content of individual fuel pieces on percent dry weight basis

Sample Calculation:

$$MC_{avg} = \frac{[(\ 10.5\ *\ 24.4\ )\ +\ (\ \ 7.4\ \ *\ 22.3\ )\ \ldots +\ (\ \text{ו Test}\ *\ 96.9\ )]}{10.5\ +\ 7.4\ \ldots +\ \ \text{Main Te}}$$

MC_{avg} = **22.99 % dry basis**

= **18.69 % wet basis**

$Q_{in\ gross}$ – Gross heat input from all fuel sources, Btu

ASTM E2618 Equation (A2.2):

$$Q_{ingross} = \left[\left(\frac{W_{kindling}}{1+(MC_{Kindling}/100)}\right)\right] + \left[\left(\frac{W_{fuel}}{1+(MC_{fuel}/100)}\right)\right] \bullet HHV + Q_{ign}$$

Where,

$W_{kindling}$ = Weight of kindling, lb

$MC_{kindling}$ = Average kindling moisture content, percent dry basis

W_{fuel} = Weight of main test fuel load, lb

MC_{fuel} = Average fuel moisture content, percent dry basis

HHV = The assumed higher heating value of the fuel, 8600 Btu/lb

Q_{ign} = Heat input from automatic ignition source, if used, Btu

Sample Calculation (Hot Start, No Kindling or Ignition Source):

$$Q_{in\ gross} = \frac{68.1}{1 + (\ \ 22.99\ \ /100)} * 8600$$

$Q_{in\ gross}$ = **476197** **Btu**

$Q_{in\ net}$ – Net heat input, Btu

ASTM E2618 Equation (A2.3):

$$Q_{in\ net} = [Q_{in\ gross} - (W_{Res} \cdot HHV_{Res})]$$

Where,

W_{Res} = Mass of residual unburned fuel after ash is sifted out, lb

HHV_{Res} = Assumed HHV of unburned fuel - 12 000 Btu/lb

Sample Calculation:

$Q_{in\ net}$ = 476197 - (0 · 12000)

$Q_{in\ net}$ = **476197** **Btu**

Q_{unit} – Net energy content change of appliance and on-board water, Btu

ASTM E2618 Equation (A2.4):

$$Q_{unit} = (W_{app} \cdot C_{steel} + C_{Pa} \cdot W_{water}) \cdot (TF_{avg} - TI_{avg})$$

Where,

W_{app} = Weight of empty appliance in pounds

C_{steel} = Specific heat of steel (0.1 Btu/lb·ºF)

C_{pa} = Average specific heat of water in appliance Btu per pound ºF

W_{water} = Weight of water in supply side of the system in pounds

Sample Calculation:

$$C_{Pa} = 1.0014 + (-0.000003485 \cdot (TI_{avg} + TI_{avg})/2)$$ ASTM E2618 Equation (13)

C_{pa} = 1.0014 + (-0.000003485 · (157 + 152.5)/2)

C_{pa} = **1.000860696** **Btu/lb·°F**

Q_{unit} = (1814 · 0.1 + 1.00086069625 · 425)·(152.5 - 157)

Q_{unit} = **-2730** **Btu**

M_i – Mass flow rate of water at interval i, lb/min

ASTM E2618 Equation (9):

$$M_i = V_{fi} \times \sigma_i$$

ASTM E2618 Equation (10):

$$\sigma = (62.56 + (-0.0003413 \times T_{3i}) + (-0.00006225 \times T_{3i}^2)) \times 0.1337$$

Where,

V_{fi} = Volumetric flow rate of load water at interval *i* , gal/min

σ = Density of water at time interval *i* , lb/gal

T_{3i} = Temperature of water at the inlet to the load side of HEX 2, °F

Sample Calculation:

Using data from sampling interval at t=1

σ = (62.56 +(-0.0003413 · 51) + (-0.00006225 · 51^2)) x 0.1337

σ = **8.34** **lb/gal**

M_i = 5.55 x 8.34

M_i = **46.29** **lb/min**

Q_{load} – Total heat delivered to simulated load, Btu

ASTM E2618 Equation (A2.5):

$$Q_{load} = \left| \sum (C_{pi} \times \Delta T_i \times M_i \times t_i) \right|$$

Where,

C_{pi}	=	Specific heat of water during time interval *i* , BTU/lb·°F
ΔT_i	=	Temperature difference between simulated load water entering and exiting HEX 2
M_i	=	Mass flow rate of water at interval *i* , lb/min
t_i	=	Data sampling interval, minutes

Sample Calculation:

Using data from sampling interval at t=1

$Q_{load\ @\ t=1}$ = 1.0012 x 64.23 x 46.29 x 1

$Q_{load\ @\ t=1}$ = **2977** **Btu**

Sum for Run 1:

Q_{load} = **382,247** **Btu**

$Q_{storage}$ – Net energy content change in storage, Btu

ASTM E2618 Equation (A2.6):

$$Q_{storage} = (W_{tan\,k} \cdot C_{tan\,k} + C_{Pa} \cdot W_{water}) \cdot (TF_{Tank_avg} - TI_{Tank_avg})$$

Where,

W_{tank} = Weight of storage tanks in pounds

C_{tank} = Specific heat of storage tank material, steel, 0.1 lb/Btu·°F

W_{water} = Weight of water in storage tanks in pounds

TF_{Tank_avg} = Final average storage tank temperature, °F

TI_{Tank_Avg} = Initial average storage tank temperature, °F

Sample Calculation:

$Q_{storage}$ = (984 x 0.1 + 1.001 x 4678) · (128.5 - 126)

$Q_{storage}$ = **11952** **Btu**

Q_{out_total} – Total heat output, Btu

ASTM E2618 Equation (A2.7):

$$Q_{Out_total} = Q_{Load} + Q_{Unit} + Q_{storage}$$

Sample Calculation:

$Q_{Out-Total}$ = 382,247 + -2730 + 11952

$Q_{Out-Total}$ = **391,468 Btu**

Total Heat Output Rate – Total heat output rate, Btu/hr

ASTM E2618 Equation (15):

Heat Output Rate = $Q_{out\text{-}Total}/\theta$

Where,

θ = Total length of test run in hours

Sample Calculation:

θ = 138 /60

θ = 2.3 hrs

Heat Output Rate = 391,468 / 2.3

Heat Output Rate = **170204** **Btu/hr**

Load Heat Output Rate – Simulated load heat output rate, Btu/hr

Load Heat Output Rate = Q_{load}/θ

Sample Calculation:

Load Heat Output Rate = 382,247 / 2.3

Load Heat Output Rate = **166194** **Btu/hr**

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

$$m_n = m_p + m_f + m_g$$

Where:

m_n = Total particulate matter collected, mg
m_p = Particulate matter from probe, mg
m_f = Particulate matter from filters, mg
m_g = Particulate matter from filter seals, mg

Sample Calculation:

Using equation for Train 1 (first-hour):

m_n = 0.0 + 1.0 + 0.0

m_n = 1.0 mg

Using equation for Train 1(Post First Hour Change-out):

m_n = 0.1 + 2.2 + 0.3

m_n = 2.6 mg

Train 1 Aggregate:

m_n = 1.0 + 2.6

m_n = 3.6 mg

Using equation for Train 2:

m_n = 0.0 + 2.8 + 1.2

m_n = 4.0 mg

$V_{m(std)}$ – Volume of Gas Sampled Corrected to Dry Standard Conditions, dscf
ASTM E2515 equation (6)

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

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_b	=	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 1:

$$V_{m(std)} = \frac{17.143 \times 0.995 \times 17.64 \times (30.01 + \frac{1.33}{13.6})}{(71.47 + 460)}$$

$V_{m(std)}$ = 17.05 ft3

Using equation for Train 2:

$$V_{m(std)} = \frac{16.893 \times 0.985 \times 17.64 \times (30.01 + \frac{1.58}{13.6})}{(70.89 + 460)}$$

$V_{m(std)}$ = 16.66 ft3

Using equation for ambient train:

$$V_{m(std)} = \frac{0 \times 1.000 \times 17.64 \times (30.01 + \frac{0.00}{13.6})}{(0 + 460)}$$

$V_{m(std)}$ = 0.00 ft3

Using equation for First Hour Train:

$$V_{m(std)} = \frac{7.409 \times 0.995 \times 17.64 \times (30.00 + \frac{1.31}{13.6})}{(71 + 460)}$$

$V_{m(std)}$ = 7.368 ft3

v_s – Dilution Tunnel Gas Velocity, ft/sec
ASTM E2515 equation (7)

$$v_s = F_P \times k_p \times C_p \times (\sqrt{\Delta P})_{avg} \times \sqrt{\frac{T_{s(avg)}}{P_s \times M_s}}$$

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, $85.49 \frac{ft}{\sec}\left[\frac{(lb/lb-mole)\times(inches\,Hg)}{(R)\times(inches\,H_2O)}\right]^{1/2}$

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:

$$M_s = 29 \times (1 - 0.02) + 18.0 \times 0.02 = 28.78$$

$$V_s = \frac{0.879}{} \times 85.49 \times \frac{0.99}{} \times \frac{0.167}{} \times \left(\frac{\frac{108.24}{} + 460}{\left(\frac{30.01}{} + \frac{-0.26}{13.6} \right) \times 28.78} \right)^{1/2}$$

V_s = 10.10 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.

C_s – Particulate Concentration, 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
C_s	=	Concentration of particulate matter in stack gas, dry basis, corrected to standard conditions, g/dscf
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 1:

$$C_s = 0.001 \times \frac{3.6}{17.05}$$

C_s = 0.000211 g/dscf

For Train 2

$$C_s = 0.001 \times \frac{4.0}{16.66}$$

C_s = 0.000240 g/dscf

For Ambient Train

$$C_s = 0.001 \times \frac{0.0}{0.00}$$

C_s = 0.000000 g/dscf

For First Hour Train:

$$C_s = 0.001 \times \frac{1.0}{7.37}$$

C_s = 0.000136 g/dscf

Q_{sd} – Average Dilution Tunnel Gas Flow Rate, dscf/hr
ASTM E2515 equation (3)

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

Where:

Q_{sd}	=	Gas flow rate corrected to dry, standard conditions, dscf/hr
3600	=	Conversion from seconds to hours (ASTM method uses 60 to convert in minutes)
B_{ws}	=	Moisture content of dilution tunnel gas, ratio; assume 2%
v_s	=	Average dilution tunnel gas velocity, ft/sec
A	=	Cross sectional area of dilution tunnel, ft^2
T_{std}	=	Standard absolute temperature, 528 °R
$T_{s(avg)}$	=	Average absolute dilution tunnel temperature, °R, (°R = °F + 460)
P_b	=	Barometric pressure at test site, in. Hg
P_g	=	Dilution tunnel static pressure, in. Hg
P_s	=	Absolute dilution tunnel gas pressure, in Hg, (Hg = P_b + P_g)
P_{std}	=	Standard absolute pressure, 29.92 in Hg

Sample calculation:

$$Q_{sd} = 3600 \times (1 - 0.02) \times \underline{10.10} \times \underline{0.785} \times \frac{528}{\underline{108.2} + 460} \times \frac{\underline{30.01} + \frac{\underline{-0.26}}{13.6}}{29.92}$$

Q_{sd} = <u>26061.54</u> dscf/hr

E_T – Particulate Emissions, grams
ASTM E2515 equation (15) section

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

Where:

E_T	=	Particulate emissions, g
C_s	=	Concentration of particulate matter in the stack, g/dscf
C_r	=	Concentration of ambient particulate matter, g/dscf
Q_{std}	=	Average dilution tunnel gas flow rate, dscf/hr
θ	=	Total time of test run, minutes

Sample calculation:

For Train 1

E_T = (0.000211 - 0.000000) x 26061.54 x 138 /60

E_T = 12.66 g

For Train 2

E_T = (0.000240 - 0.000000) x 26061.5 x 138 /60

E_T = 14.39 g

Average

E = 13.53 g

For First Hour Train

E_T = (0.000136 - 0.000000) x 26061.54 x 60 /60

E_T = 3.54 g

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

7.5% of the average =	1.01
Train 1 difference =	0.87
Train 2 difference =	0.87

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 = Time of test, min

θ_i = Time of interval, 1 min

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

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

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

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

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

T_m = Average dry gas meter temperature, ^oR

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

T_s = Average gas temperature in the dilution tunnel, ^oR

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

$$PR = \left(\frac{138 \times 0.107 \times 10.1 \times (71.47 + 460) \times (118.0 + 460)}{1 \times 17.14 \times 10.19 \times (68.00 + 460) \times (108.2 + 460)} \right) \times 100$$

PR = 87.44 %

Emission Rates, g/MJ, lb/MMBTU, g/kg, g/hr
ASTM E2618 Equations (16)(17)(18)(19)

$$E_{g/MJ} = E_T / (Q_{out-total} \times 0.001055)$$

$$E_{lb/MMBtu\ output} = (E_T / 453.59) / (Q_{out-total} \times 10^{-6})$$

$$E_{g/kg} = E_T / (W_{fuel} / (1 + MC/100))$$

$$E_{g/hr} = E_T / \Theta$$

Sample calculation:

$E_{g/MJ}$ = 13.53 / (391,468 x 0.001055)
$E_{g/MJ}$ = **0.0328** **g/MJ**

$E_{lb/MMBtu\ output}$ = (13.53 / 453.59)/(391468 x 10^{-6})
$E_{lb/MMBtu\ output}$ = **0.076** **lb/MMBtu output**

$E_{g/kg}$ = 13.53 /((68.1 x 0.4536) / (1 + 23 /100))
$E_{g/kg}$ = **0.539** **g/kg**

$E_{g/hr}$ = 13.53 / (138 / 60)
$E_{g/hr}$ = **5.88** **g/hr**

$$E_{g/hr\ 10{,}000\ Btu} = \frac{13.53}{((138 / 60) \times (391468 / 10{,}000))}$$

First hour emissions:

$E_{g/kg}$ = 3.54 /((30.1 x 0.4536) / (1 + 23 /100))
$E_{g/kg}$ = **0.319** **g/kg**

$E_{g/hr}$ = 3.54 / (60 / 60)
$E_{g/hr}$ = **3.54** **g/hr**

η_{del} – Delivered Efficiency, %
ASTM E2618 Equation (20)

$$\eta_{del} = (Q_{out-total} / Q_{in-net}) \times 100$$

Sample calculation:

η_{del} = (391468 / 476197) x 100

η_{del} = **82.21** %

Section 5

Labeling & Owner's Manual

S3 Turbo

WOOD FIRED GASIFICATION HYDRONIC FURNANCE - FOR USE WITH SOLID FUEL ONLY!
FOURNAISE À GAZÉIFICATION DE BOIS - CHAUFFEZ DU BOIS UNIQUEMENT!

Manufactured By: Froling GmbH, Grieskirchen, Austria
Test Standards: ANSI/UL 2523-2013, CAN/CSA B415.1-10
Test Date: March 7, 2016
Serial #:

This appliance needs periodic inspection and repair for proper operation. Consult owner's manual for further information.
It is against federal regulations to operate this appliance in a manner inconsistent with operating instructions in the owner's manual.

Tested to ASTM E2618-13, average emissions of 0.10 lbs/mmbtu.
U.S. ENVIRONMENTAL PROTECTION AGENCY Certified to comply with the 2020 particulate emission standards using cord wood.

Model Modèle	Fuel Combustible	BTU/h (kW) Output Puissance Calorifique	Electrical Rating Classification Électrique	Date of Manufacture / Date de Fabrication
S3 Turbo 50	Wood	170,000 (50 kW)	230V, 60Hz, 120W	

Tested & Listed By O-T-L C US Portland Oregon USA
OMNI-Test Laboratories, Inc.
Report #0456WB007S

Do Not Remove or Cover This Label
Ne pas enlever ou recouvir cette étiquette

CE
2006/42/EC
2014/35/EU
EN 303-5

FLOORING MUST BE A MINIMUM 3/8“ (10MM) NON-COMBUSTIBLE MATERIAL COVERING THE INSTALLATION CLEARANCE AREA!
LE REVÊTEMENT DE SOL COUVRANT L'INSTALLATION DE LA FOURNAISE DOIT AVOIR UNE ÉPAISSEUR MINIMUM DE 3/8” (10MM) DE MATÉRIEL ININFLAMMABLE.

DO NOT OPERATE WITH FLUE DRAFT EXCEEDING 0.12 INCHES IN WATER COLUMN (30 Pa), IF NO DRAFT LIMITER IS INSTALLED!
NE PAS METTRE EN SERVICE AVEC UN TIRAGE SUPÉRIEUR À 0.12 POUCES COLONNE D'EAU (30 Pa), SI AUCUN LIMITEUR DE TIRAGE N'EST INSTALLÉ.

DO NOT CONNECT THIS UNIT TO A CHIMNEY FLUE SERVING ANOTHER APPLIANCE!
NE JAMAIS RELIER CETTE FOURNAISE À UNE CHEMINÉE COMMUNE.

ONLY USE SUPPLIED HOT WATER BOILER SAFETY RELIEF VALVE FOR FIELD ASSEMBLY!
INSTALLER UNIQUEMENT LA SOUPAPE DE SURPRESSION FOURNIE AVEC LA FOURNAISE.

Fuel / Combustible: Log Wood 21“ (51 cm) only! Exlusivement Bois de 21“ (51cm)!
Chimney Connector Size / Diamètre du tube des fumées: 6“ (150 mm)
Maximum Overcurrent Protection - Regular Type / Protection Maximum du Courant - type régulaire: 15 Amp / 250V

Clearances to Combustibles / Espaces Libres aux Combustibles

Side Wall to Appliance / Mur Latéral à l'Appareil	9” (250 mm)
Back Wall to Appliance / Mur Arrière à l'Appareil	14” (350 mm)
Front of Appliance to Combustibles / Front de l'Appareil aux Combustibles	36” (900 mm)
Combustibles to Flue Pipe / Matériaux Combustibles au Tuyau de Fumée	18” (460 mm)
Ceiling to Appliance / Haute de la chaudiére au Plafond	18“ (460 mm)

Owner´s Manual

S3 Turbo

Tested & Listed By O-T-L Portland Oregon USA
c US
OMNI-Test Laboratories, Inc.
Report #0456WB007S

Do Not Remove or Cover This Label
Ne pas enlever ou recouvir cette étiquette

Read and follow the operating instructions and safety information!
Subject to technical change!

Froling Heizkessel- und Behälterbau Ges.m.b.H, Industriestraße 12, A-4710 Grieskirchen
Tel +43 (0) 7248 606-0 Fax +43 (0) 7248 606-600 info@froeling.com www.froeling.com

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Supplementary instructions

These instructions ensure safe and efficient use of the S3 Turbo (hereinafter referred to as the “system"). These instructions are a component part of the system and must be kept next to the system and within the immediate reach of staff at all times.

Staff must carefully read and understand these instructions before commencing all work. All the safety instructions and operating guidelines specified in this manual must be observed to ensure safety at work. In addition, the local accident prevention regulations and general safety regulations apply to the area of application of the system.

Images in these instructions are intended solely to aid understanding and may differ from the actual design.

NOTICE

SAVE THESE INSTRUCTIONS!

Copyright

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1 Overview

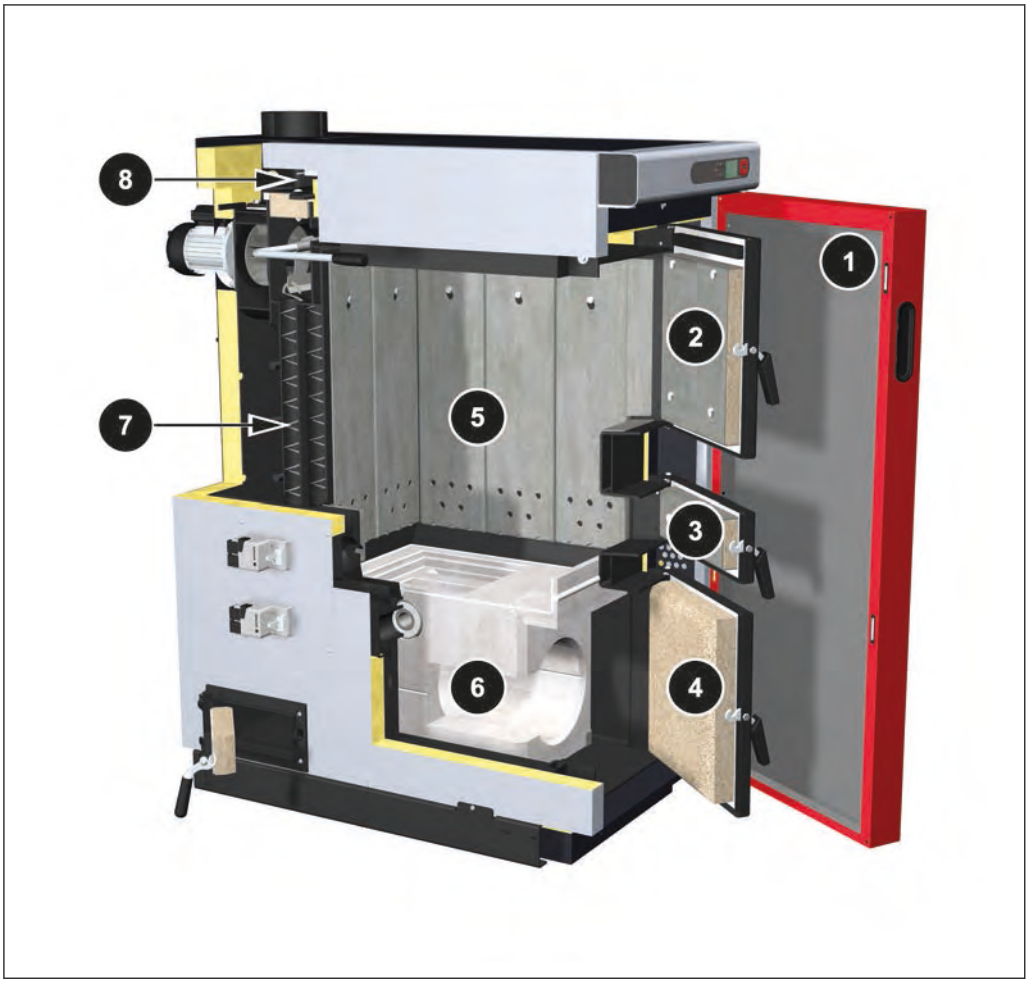
1.1 Front view

1	Boiler S3 Turbo
2	Boiler controller control panel
3	WOS lever
4	Actuator of primary air flap
5	Actuator of secondary air flap
6	Heat exchanger cleaning door

1.2 Back view

1	Boiler flow connection
2	Induced draft fan
3	Thermal discharge safety device connection
4	Drainage
5	Boiler return connection

1.3 Cross-section



1	Insulated door
2	Fuel-loading chamber door
3	Pre-heating chamber door
4	Combustion chamber door
5	Fuel-loading chamber
6	Combustion chamber
7	Heat exchanger with spiral springs
8	In flue gas nozzle: Flue gas temperature sensor and broadband lambda probe

1.4 Boiler manufacture and testing

Your boiler was manufactured by Froling, a world leader on hot water (hydronic) heating for over 50 years. The S3 Turbo boiler confirms to traditional high standards for quality and reliability. It offers modern fire wood boiler technology with operating efficiencies of over 90% based on net calorific value of fuel. If treated properly and operated according tot he guidelines in this manual, it will provide years of safe, dependable and cost-effective heating.

S3 Turbo boilers are designed and built in accordance with European standard EN 303-5. This unit was safety and performance tested and listed to ANSI/UL 2523-2013 and CAN/CSA B415.1-10 by OMNI Test Laboratories, Inc; Portland, Oregon. The installer should follow local or state installation requirements.

The S3 Turbo fire wood boiler is designed and constructed for the highly efficient combustion of fire wood. Do not burn other fuels in the fire wood boiler S3 Turbo. The S3 Turbo boiler is a not self-contained, weather-tight boiler. It should be installed within the heating building. S3 Turbo boilers should be installed with a thermal storage tank system.

1.5 Wood heater description and compliance status

The S3 Turbo wood boiler is a down-draft type wood gasification boiler with an output rating of between 51,250 btu/h and 102,500 (30 kW), or between 85,000 btu/h and 170,000 btu/h (50 kW). This appliance is not fitted with a catalytic combustor. This appliance meets the 2015 US Environmental Protection Agency´s cord wood emissions limits for wood heaters sold after May 15, 2015.

1.6 Cleaning kit provided

The cleaning kit below is provided for cleaning the boiler:

- Furnace tool
- Ash shovel
- Cleaning brush (Ø 53 mm)
- Cleaning brush (30 x 20 mm)

2 Safety

2.1 Explanation of symbols

Safety information

Safety information in these instructions is indicated by symbols. The safety information is preceded by signal words which reflect the extent of the risk.

⚠ DANGER **This symbol and signal word combination indicates a hazardous situation which will lead to death or serious injury if it is not avoided.**

⚠ WARNING **This symbol and signal word combination indicates a hazardous situation which could lead to death or serious injury if it is not avoided.**

⚠ CAUTION **This symbol and signal word combination indicates a hazardous situation which could lead to slight or minor injuries if it is not avoided.**

NOTICE **This signal word indicates important, but not safety-related information e.g. damage to property or pollution**

Safety information in operating instructions

Safety information can refer to certain, individual operating instructions. To avoid disrupting the flow of the text when you are performing the action, this safety information is not incorporated in the operating instruction. The signal words set out above are used.

Example:

❒ Undo screw
❒ **CAUTION! Pinching hazard at cover**
Take care when closing the cover.
❒ Tighten the screw

Special safety information

The following symbols are used to draw your attention to particular hazards

Tips and recommendations

Italics indicate useful tips and recommendations as well as information for efficient and smooth running.

Other markers

The following markers are used in these instructions to highlight operating guidelines, results, lists, references, and other elements:

Marker	Explanation
❒	Step-by-step operating instructions
➥	Results of actions
▪	Lists without a specified order
[Button]	Operating elements (e.g. button, switch), display elements (e.g. signal lights)
“Display“	Screen elements (e.g. buttons, assignment of function keys)

Units used

All units of measure are specified in these operating instructions in both SAE units and SI units. The SAE unit appears first, followed by the SI unit in brackets.

Example using information about heat output: 17 (5) BTU/h (kW) equals
17 BTU/h (SAE system) or 5 kW (SI system).

2.2 Permitted Uses

The S3 Turbo boiler is designed exclusively for heating domestic water. Only use those fuels specified in the “Permitted fuels” section.

Permitted use includes compliance with all the specifications in this instruction manual.

Any use other than or above and beyond the permitted use is considered misuse.

⚠ WARNING

Danger of misuse

- ❒ Do not install the system in a mobile home.
- ❒ Do not operate the system in an explosive atmosphere.
- ❒ Keep the air inlet to the boiler room clear at all times.
- ❒ Only use fuels permitted by the manufacturer.
- ❒ Never store flammable materials close to the boiler.
- ❒ Never set flammable objects on the boiler to dry (e.g. clothing).
- ❒ Do not use any hydrogen halides or cleaning agents containing chlorine in the boiler installation room.
- ❒ Keep covers and doors closed during operation.
- ❒ The chimney is only to be used as an outlet for one heating system.
- ❒ Do not use the hot water directly in swimming pools or thermal baths and do not use as drinking water.
- ❒ Do not alter the boiler controller.
- ❒ DO NOT BURN GARBAGE, GASOLINE, NAPHTA, ENGINE OIL OR OTHER IN-APPROPRIATE MATERIALS.
- ❒ DO NOT USE CHEMICALS OR FLUIDS TO START THE FIRE.
- ❒ DO NOT OPERATE WITH FLUE DRAFT EXCEEDING 0.12 INCHES WATER COLUMN (30 Pa).
- ❒ UNSAFE TO ADJUST FLUE DRAFT HIGHER THAN 0.12 INCHES WATER COLUMN (30 Pa).
- ❒ THE HEAT EXCHANGER, DRAFT INDUCES, FLUE PIPE, AND CHIMNEY MUST BE CLEANED REGULARLY TO REMOVE ACCUMULATED CREOSOTE AND ASH. ENSURE THAT THE HEAT EXCHANGER, FLUE PIPE, AND CHIM-NEY ARE CLEANED AT THE END OF HEATING SEASON TO MINIMIZE COR-ROSION DURING THE SUMMER MONTHS. THE APPLIANCE, FLUE PIPE, AND CHIMNEY MUST BE IN GOOD CONDITION. THESE INSTRUCTIONS AL-SO APPLY TO A DRAFT INDUCER IF USED.

  ↪ Misuse of the boiler can create hazardous situations.

2.3 Requirements at the place of installation

2.3.1 Approval for the heating system

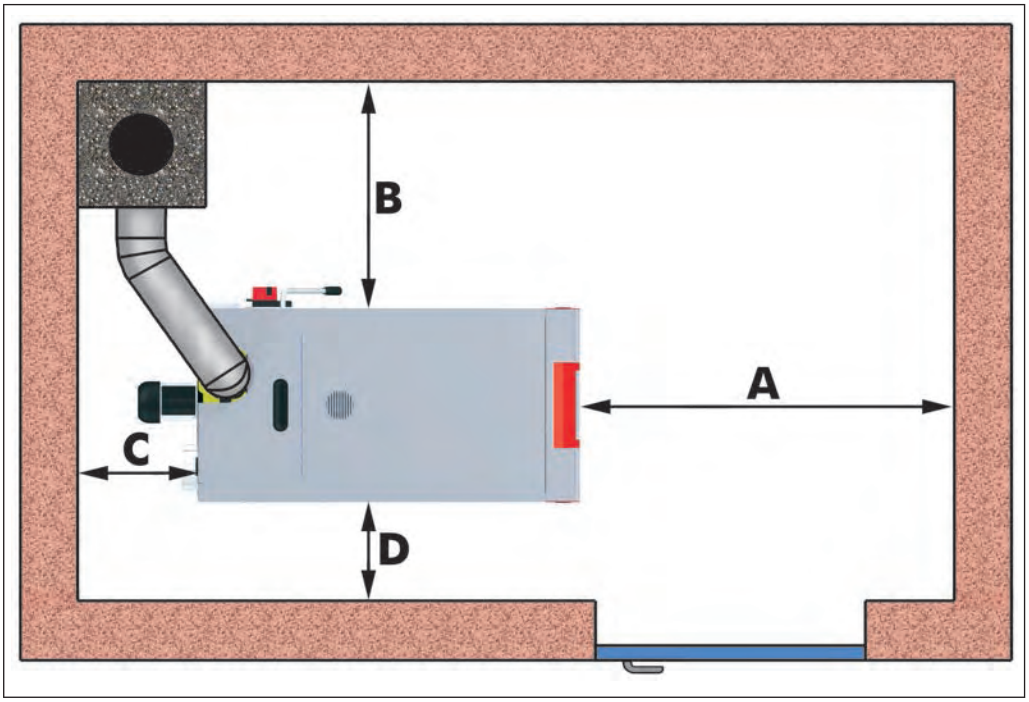
The appropriate supervisory authority (inspection agency) must always be informed when installing or modifying a heating system, and authorization must be obtained from the building authorities. Also observe ANSI/NFPA 211 and CAN/CSA B365 for the installation.

2.3.2 Space required

FOR SAFE INSTALLATION AND OPERATION CLEARANCES TO COMBUSTIBLES MUST BE MAINTAINED.

The diagram below shows how much space is required for the system in the boiler room.

The boiler may only be installed on non-combustible floors with these clearances.



Dimen-sion	Name	S3 Turbo
A	Distance - front of boiler to wall	36“ (900 mm)
B	Distance – side of boiler to wall	32“ (800 mm)
C	Distance – back to wall	14“ (350 mm)
D	Distance – side of boiler to wall	9“ (250 mm)
Distance between ceiling and boiler		18“ (460 mm)

2.3.3 Requirements for central heating water

Water quality

Water of the following quality is required for the first fill:

- The water must be clean, pure or purified as well as odorless and must not contain suspended matter.
- The water hardness must not exceed 190 grain/fl.oz. or 100 ppm $CaCO_3$ (100 mg/L), i.e. soft water is required.
- The chlorine concentration in the water must not exceed 58 grain/fl.oz. (30 mg/L).
- The pH value in the heating system must be between 8.0 and 8.6.
- If the water quality is too poor, use additives to prepare the water. If you are topping up with small amounts, always use clean water.

NOTICE

The hot water must not be used directly in swimming pools or thermae. Use a heat consumer of the right size to consume the heat. Do not use the heating water as drinking water.

To ensure good water quality during operation, avoid leaks and use a closed heating system. If necessary, use a return temperature control.

First fill

To prevent air from getting into the heating system during the first fill, fill the filling hose with water.

Frost protection

You can add anti-freeze to the heating water, however, this can reduce the heating efficiency. Always follow the manufacturer's dosing instructions when using anti-freeze, as using the incorrect amount can cause corrosion. Check the concentration of the anti-freeze at regular intervals.

2.3.4 Ventilation requirement for boiler room

Introduction

The external combustion air must meet certain requirements to ensure that adequate combustion air is supplied to the boiler and no by-products from the combustion get into the boiler room.

Ventilation air for the boiler room must be taken from and expelled directly outside, and the openings and air ducts must be designed to prevent weather conditions (e.g. from foliage or snowdrifts), plants or animals from obstructing the air flow. Permanent ventilation is required to ensure that the boiler runs smoothly.

In North America there are several regulations which govern the minimum requirements of combustion air for chimneys.

The boiler must be installed in such a way that it receives adequate ventilation and combustion air and that the fuel in the boiler burns. The exhaust air must be expelled safely outside via the chimney and maintained within a safe temperature range.

Boiler rooms are usually so small that normal ventilation does not provide enough air and air must be brought in from outside. External air openings and air channels must be of an appropriate size to supply adequate combustion air. The design must comply with NFPA 211.

Consult your local chimney inspector for the installation and install the boiler in accordance with the applicable local regulations.

Recommended size of air openings according to NFPA 54 and NFPA 211:

The boiler requires a fresh air supply of between 1 sq.in. per 2,500 BTU/h and 1 sq.in. per 4,000 BTU/h (550 mm²/kW and 880 mm²/kW), depending on local conditions and the climate zone. Local conditions may necessitate an additional air supply.

2.3.5 Requirements for the heating system

- The whole heating system must be designed in accordance with relevant national and local regulations.
- The boiler’s nominal load must be adjusted to the calculated heating requirements of all the consumer loads connected in the heating circuit in summer and winter.
- The heating system must be big enough to transport the heat generated by the boiler and an additional heat source (if present). The pressure throughout the whole system including all heating zones must be even.
- Special equipment must be available for filling and ventilating the heating circuit. Flow valves and zone valves must be fitted to set the correct water flow volume.
- All fitted pipes must be water-tight and air-tight and safely insulated.
- If there is a risk of parts of the heating system freezing, add anti-freeze to the water in these heat zones.

2.3.6 Requirements for the boiler room

- There must not be a potentially explosive atmosphere in the boiler room as the boiler is not suitable for use in potentially explosive environments!
- The boiler room must be frost-free.

- There is no lighting on the boiler. Therefore, the customer must provide sufficient lighting in the boiler room in accordance with national workplace design regulations.
- Always consult the manufacturer when using the boiler at more than 2000 meters above sea level.
- Always keep the air suction opening of the boiler free from dust.
- The boiler room must be at least (mm) high.

2.3.7 Combination with thermal storage

Your S3 Turbo boiler must be installed with a Thermal Storage System. The purpose of the thermal storage system is to absorb heat produced by the boiler if the building load cannot use all of the heat being produced. This means that the boiler will be batch fired. Batch firing requires that the boiler only be loaded with fuel and ignited when the thermal storage temperature is depleted adequately so that it can absorb the energy produced from the next fire. There may be some instances when the heating load will use all of the heat being produced by the boiler. In such cases, the boiler may be loaded continuously.

Your boiler is equipped with a timer that provides feedback about how many hours of run time (active burning) or slumber time (boiler is stopped because no heat is being taken from it) are accumulating. Slumber hours should be minimized as much as possible. If you find slumber hours increasing, it is likely that you are over-filling the boiler with wood and it is cycling on and off rather than having continuous run times.

Over filling the boiler may result in corrosion of the firebox wall, damage to the combustion chamber, damage to the firebox aprons, soot accumulation in the heat exchange and dirty emissions.

Your thermal storage system may require periodic maintenance. Please review the periodic maintenance requirements of your thermal storage system with your installer.

2.3.8 Return temperature control

It is recommended you fit a return temperature control when installing the heating system. If the hot water return is below the minimum return temperature, some of the hot water outflow will be mixed in via the return temperature control.

NOTICE

Risk of dropping below dew point/condensation formation if operated without return temperature control.

The manufacturer stipulates using a return temperature control. The minimum return temperature is 140°F (60°C). It is recommended you fit some kind of control device (e.g. thermometer). The controller of the return temperature control can be integrated in the boiler controller.

❒ Condensation water forms an aggressive condensate when combined with combustion residue, leading to damage to the boiler. If the outside temperature is low, condensation water can freeze at the chimney outlet, which can result in inadequate chimney escape, limited boiler output and a system breakdown.

2.3.9 Requirements for the chimney connection

The chimney connection must be big enough to channel flue gases from the building. The whole flue gas system must be designed to prevent possible seepage, insufficient feed pressure and condensation.

The manufacturer recommends fitting a draft regulator to limit the pressure to 0.12 inch WC (30 Pa). The draft regulator should be fitted directly on the chimney connection where the pressure is very low.

The boiler must be connected to a brick chimney or a shop-made chimney in accordance with UL 103 HT (ULC S629 in Canada). The chimney must be clean and in good condition at the time of installation.

The pipe unions within the chimney must be made of stainless special steel (with 304, 316 or 321 alloys). The flue gas connection pipe must be made of untreated steel or stainless steel with a thickness of 24 Gauge. The minimum rise of the pipe must be ¼" per foot for the progression towards the chimney. The chimney and the flue gas connection pipe must have a diameter of at least 6" (150 mm). The individual pipe sections must be joined together with at least three self-tapping screws and the joins sealed using high-temperature silicone. The flue gas pipe must not contain more than two 90° bends.

All connections must conform to NFPA 211. Consult your local chimney sweep for the installation and install the boiler in accordance with the applicable local regulations.

The chimney connection, ventilation ducts and fresh air openings must not be closed over or blocked.

The flue gas pipe must not be displaced by an attic, loft, fuel store or similar areas.

Basic data for designing the chimney connection

Name		S3 Turbo	
		30	50
Flue gas temperature at nominal load	°C	170	170
	°F	340	340
Flue gas temperature at partial load	°C	110	110
	°F	230	230
Flue gas mass flow at nominal load	kg/h	76	122
	lb/h	167	270
Flue gas mass flow at partial load	kg/h	43	65
	lb/h	95	143
Required feed pressure at nominal load	Pa	8	8
	in WC	0.03	0.03
Maximum permissible feed pressure	Pa	30	30
	in WC	0.12	0.12
Flue pipe diameter	mm	150	150
	inches	6	6

⚠ CAUTION

ADJUSTMENT OF THE FLUE DRAFT HIGHER THAN 0.12 INCHES WATER COLUMN (30 Pa) COULD CAUSE A FIRE TO BURN OUT OF CONTROL AND AN UNSAFE CONDITION!

❒ Maximum permitted setting: 0.12 inches WC (30 Pa)
Ideal setting: 0.04 inches WC (10 Pa)

2.4 Safety markers

⚠ WARNING

Danger if signage is illegible!

❒ Ensure that all safety, warning and operating instructions are always in a clearly legible condition.

❒ Replace damaged stickers and signs immediately.

➥ Over time stickers and signs can get dirty or otherwise unrecognizable which means that dangers cannot be identified and the necessary operating information cannot be observed. This poses a risk of injury.

The following stickers are located in the work area. They refer to the area immediately surrounding where they are affixed.

2.4.1 Mandatory signs

Refer to the operating instructions

Only use the indicated system once you have read the operating instructions.

Wear hearing protection

This sign indicates that hearing protection must be worn in the area concerned.

Wear protective gloves

This sign indicates that protective gloves must be worn in the area concerned.

Wear safety shoes

This sign indicates that safety shoes must be worn in the area concerned.

Wear a dust mask

This sign indicates that a dust mask must be worn in the area concerned.

Keep the doors closed

Keep the doors closed during operation.

Turning off the main switch

Switch off the main switch and take precautions to prevent accidental switching on before carrying out work to the system

Switch off the main switch for the fuel infeed and take precautions to prevent accidental switching on before entering the fuel storage room.

Securing the main switch

Switch off the main switch and secure with a padlock when carrying out maintenance work to the boiler.

2.4.2 Prohibitions

Unauthorized access prohibited

Only persons authorized by the operator may enter the danger zone and fuel storage room. Keep children away! Keep the fuel storage room locked and keep the access key in a safe place. Protect the fuel from moisture.

No fire, open flames or smoking

Areas marked with this are at risk of fire or explosion. Keep ignition sources away from these areas.

2.4.3 Warning signs

Automatic start-up

This sign indicates that there is a risk of the system starting up automatically. Work may only be carried out in areas with this marking if the system has been secured.

Electric current

Only licensed electricians may work in workspace with this marking.

Unauthorized persons are not permitted to enter work areas with this marking or open the cabinet with this marking.

Harmful or irritant materials

These materials can be irreparably harmful to health, trigger allergic reactions or irritate the mucous membranes.

Observe the information on the packaging and containers.

Danger from carbon monoxide

There is a risk of poisoning from a possible concentration of carbon monoxide in the fuel storage room and boiler room. Ventilate the fuel storage room for at least 15 minutes before entering. Two people must always be present when working in the fuel storage room. The access door must be kept open at all times. Also wear a dust mask because of the high dust levels.

Hand injuries

Keep hands away from areas bearing this warning.

There is a risk that your hands could get trapped, pulled in or otherwise injured.

Hot surfaces

Hot surfaces, such as hot system parts, may not always be obvious. Do not touch these parts without protective gloves.

Risk of falling

There is a risk of falling in the fuel store because of slippery surfaces or fuel lying about. Take extreme care and wear personal protective equipment.

Risk of injury at fans

Keep hands away from areas bearing this warning.

There is a risk that your hands could get trapped, pulled into or otherwise injured in automatic fans.

2.4.4 Signage on the boiler

Notice of risks during installation

S3 Turbo - WOOD FIRED GASIFICATION HYDRONIC FURNACE

INSTALLATION HAZARDS

Install, modify and use only in accordance with manufacturer's manuals. Refer to authorities having jurisdiction for proper installation. Contact local building and fire officials about restrictions and installation inspection in your area. If there are no applicable local codes, follow ANSI/NFPA 211 and CAN/CSA B365. Special precautions are required for passing the chimney through a combustible wall or ceiling.
Inspect and clean exhaust system, loading chamber, burning chamber, ash-pits, and heat exchanger frequently in accordance with owner's manual.

Basic boiler data for layout of chimney system		S3 Turbo	
Quantity	**Unit**	**30**	**50**
Flue gas temperature Rated / partial load	°C °F	170 / 110 340 / 230	170 / 110 340 / 230
Flue gas mass flow Rated / partial load	kg / h lb / h	76 / 43 167 / 95	122 / 65 270 / 143
Minimum draft at boilers flue gas connection		8 Pa (0.03 inches water column)	
Maximum draft at boilers flue gas connection		30 Pa (0.12 inches water column)	
Flue gas connector Diameter		150 mm (6 inches)	
Maximum water temperature		88 °C (190 °F)	
Maximum allowable working pressure		2 bar (30 psi)	
Test Pressure		4.5 bar (67.27 psi)	
Mimimum Pressure Relief Valve Capacity		155 kW (535,000 Btu/h)	

For detailed design information please refer to Installation Manual!
For unit specifications, see the plaque located directly on the boiler!

DANGER!

⚠ **Working on electrical components may cause severe injuries from electric shocks!**

WARNING!

⚠ **The electrical system of the boiler shall be supplied from a double 115 V 60 Hz (nominal 230 V AC) 15 amp branch circuit including neutral and earth connection. For wiring instructions please refer to installation Manual!**

⚠ **Chimney must be 6" (150 mm) diameter listed UL-103 HT or ULC-S629 residential all-fuel type or tile-lined masonry. Flue connector pipe must be 6" (150 mm) diameter made of a minimum 24 MSG black steel.**

⚠ **Inadequate design, installation and maintenance of the flue gas system will lead to insufficient chimney draft and could result in Danger of Life or Severe Injury caused by serious faults in combustion, e.g. explosively** combustion of carbonization gases and flash fires!

⚠ **This boiler requires fresh air for safe operation and must be installed so there are provision for adequate combustion and ventilation air!**

CAUTION!

⚠ **DO NOT CONNECT THIS UNIT TO A CHIMNEY FLUE SERVING ANOTHER APPLIANCE!**

⚠ **LOAD FUEL CAREFULLY OR DAMAGE WILL RESULT.**

⚠ **REFER TO OWNER'S MANUAL. DO NOT ALTER THIS EQUIPMENT IN ANY WAY.**

⚠ **UNSAFE TO ADJUST FLUE DRAFT HIGHER THAN 0.12 INCHES WATER COLUMN (30 Pa).**

⚠ **MAY BE CONNECTED TO AN EXISTING BOILER SYSTEM.**

⚠ **Flooring must be a minimum 3/8" (10 mm) non-combustible material covering the installation clearance area! The base shall be horizontally, planar and reinforced if required. For construction of base please mind the weight of** boiler, water content and wood fuel according Installation Manual!

⚠ **This boiler is not for use with an automatic stoker**

⚠ **Connection to an existing boiler system in combination with heat storage only!**

⚠ **Use original spare parts only. Installation of non-licensed replacement parts will void the warranty!**

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Notice of risks during operation

S3 Turbo - WOOD FIRED GASIFICATION HYDRONIC FURNACE

OPERATION HAZARDS

NOTICE! BURN WOOD ONLY, MAX. LENGTH 21" (51CM)!

Load fuel carefully or damage will result!

Build the wood fire directly on the boiler Fuel Loading Chamber refractory floor!

Do not use small pieces or wood waste that could fall through the center slot in the refractory.

DANGER! RISK OF FIRE OR EXPLOSION!

- ⚠ **Do not burn garbage, gasoline, drain oil or other flammable liquids.**
- ⚠ **DO NOT BURN GARBAGE, GASOLINE, NAPHTA, ENGINE OIL, OR OTHER INAPPROPRIATE MATERIALS!**
- ⚠ **Do not use chemicals to start up unit firing.**
- ⚠ **DO NOT USE CHEMICALS OR FLUIDS TO START THE FIRE.**
- ⚠ **Use of inappropriate fuels can result in Danger of Life or Severe injury caused by explosive combustion and flash fires!**
- ⚠ **Burning fuels other than designated will void the warranty!**

DANGER! EXPLOSIVE GASES!

- ⚠ **Never open Combustion Chamber Door, Ash-Pit Door, Ash-Pit Cask Cover or Heat Exchanger Cask Cover** during operation or refueling!
- ⚠ **Faulty operation of boiler system will cause Danger of Life or Severe injury and Material Damage!**
- ⚠ **Flue gases can cause fatal poisoning! In case of strong smell of flue gas:**
  1. For safety keep all boiler doors and ash-pit doors tightly closed!
  2. Air the room where boiler is installed!
  3. Close the door of the boiler room and doors to living areas!

WARNING! RISK OF FIRE!

- ⚠ **KEEP ALL BOILER DOORS, FUEL STORAGE DOOR AND ALL COVERS TIGHTLY CLOSED DURING OPERATION!**
- ⚠ **AFTER OPENING BOILER DOORS OR COVERS CLOSE ALL DOORS, COVERS AND CASING TIGHTLY!**
- ⚠ **DO NOT OPERATE WITH FLUE DRAFT EXCEEDING 0.12 INCHES WATER COLUMN (30 Pa)!**
- ⚠ **UNSAFE TO ADJUST FLUE DRAFT HIGHER THAN 0.12 INCHES WATER COLUMN (30 Pa)!**
- ⚠ **THE HEAT EXCHANGER, DRAFT INDUCER, FLUE PIPE, AND CHIMNEY MUST BE CLEANED REGULARLY TO REMOVE ACCUMULATED CREOSOTE AND ASH. ENSURE THAT THE HEAT EXCHANGER, FLUE PIPE, AND CHIMNEY ARE CLEANED AT THE END OF HEATING SEASON TO MINIMIZE CORROSION DURING THE SUMMER MONTHS. THE APPLIANCE, FLUE PIPE, AND CHIMNEY MUST BE IN GOOD CONDITION. THESE INSTRUCTIONS ALSO APPLY TO A DRAFT INDUCER IF USED.**
- ⚠ **Do not store fuel, clothing, furniture or other combustible material within marked installation clearances!**
- ⚠ **Faulty operating conditions not complying with Owner's Manual, such as insufficient combustion air, incorrect or insufficient cleaning and maintenance or non-permitted fuel could result in Danger of Life or Severe injury caused by serious faults in combustion (e.g. spontaneous combustion of carbonization gases or flash fires)!**
- ⚠ **Inspect and clean appliance, flues and chimney regularly!**
- ⚠ **First firing during start-up of boiler system shall be carried out in accordance to Instruction Label at Fuel Loading Chamber Door and in attendance of an authorized installer or manufacturer's representative only! Disregarding of** warning may cause damage or explosion of combustion chamber and severe injuries unfavorably!
- ⚠ **Gas performed during solid-fuel combustion may cause a small explosion when the boiler is refueled!**

CAUTION! HOT SURFACES!

- ⚠ **Hot parts and the flue pipe can cause serious burns!**
- ⚠ **Do not touch during operation!**
- ⚠ **Maximum draft marked on nameplate!**
- ⚠ **Unauthorized access to the boiler room could result in personal injury and damage to property!**
- ⚠ **FOR SAFETY KEEP FIRING AND ASHPIT DOORS TIGHTLY CLOSED.**
- ⚠ **Keep children away!**
- ⚠ **Always use protective gloves while loading boiler or carry out other work on boiler! Also mind the risk of injuries by splinters of fire wood!**
- ⚠ **Always use control handles when open boiler doors!**
- ⚠ **Insulate flue pipe or do not touch during operation!**
- ⚠ **Do not carry out maintenance when the boiler is hot!**
- ⚠ **Do not touch hot surfaces behind Insulation Door!**

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Notice regarding procedures in an emergency

S3 Turbo - WOOD FIRED GASIFICATION HYDRONIC FURNACE

HAZARDS DURING REFUELING AND EMERGENCY PROCEDURES

⚠ DANGER! In case of strong smell of flue gas!

Flue gases can cause fatal poisoning!

1. **For safety keep all boiler doors and ash-pit doors tightly closed!**
2. **Air the room where boiler is installed!**
3. **Close the door oft he boiler room and doors to living areas!**

⚠ DANGER! In the event of loss of electrical power!

- **Do not open any Boiler or Ash-pit Door!**
- **Do not load fuel into the boiler!**
- **Boiler Control automatically restarts after power fail restart**
- **One hour after power has returned, check system for normal operation and compare manometer reading to initial settings. If system pressure is below, replenish water to the hydronic system according plumber's instructions.**

⚠ DANGER! In the event of runaway fire!

- **Turn off Emergency Switch, if installed.**
- **Do not open any Boiler or Ash-pit Door!**
- **DO NOT SWITCH OFF MAIN ISOLATOR AT CONTROL SYSTEM!**
- **In case no Emergency Switch is installed:**
  1. **Open Insulation Door slightly and keep it opened**
  2. **Push Arrow-Down Key at Boiler Control to switch off ID-Fan**
  3. **Keep Insulation Door opened**
  4. **Do not open Ash-pit Door or any Boiler Door behind Insulation Door**
- **When there is no more risk of runaway fire, turn on Emergency Switch and close Insulation Door and resume to normal operation of the system.**

To cool overheated boiler (over 220°F / 105°C)!

- **Do not open any Boiler or Ash-pit Door!**
- **Turn all thermostats in your house to their highest temperature settings and open all windows.**
- **Open all hot water faucets.**
- **When boiler temperature has dropped below 180°F (82°C), reverse the above steps.**
- **In case Safety Temperature Limit Switch automatically has been activated please refer to Owner's Manual.**

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2.5 Residual risks

2.5.1 Basic risks

Incorrect operation

WARNING

Risk of injury from operating the system incorrectly!

❒ Modifications to the boiler controller must only be undertaken in consultation with the manufacturer.

➥ Modifying parameters on the boiler controller can cause malfunctions.

2.5.2 Risks from electricity

Electric current

DANGER

Risk of death from electrocution!

❒ Only allow licensed electricians to carry out electrical work to the electrical system.

❒ If the isolation gets damaged, switch off the power supply immediately and have it repaired.

❒ Prior to commencing work to active parts, shut off electrical systems and equipment so that they are no longer live and secure so that they remain off for the duration of the work. Follow the five safety rules:
- Disconnect.
- Secure against switching back on.
- Check the system is no longer live.
- Earth and short circuit.
- Cover or shield any adjacent live parts.

❒ Never bypass or disable fuses. When replacing fuses, use the correct amperage.

❒ Always lay lines and cables far away from hot surfaces.

❒ Use shielded cables when using frequency converters.

❒ Ensure that the system is properly earthed with a protective earth system. Have all component assemblies checked at regular intervals to ensure the correct earthing.

❒ Keep moisture away from live parts. This can cause short circuits.

➥ Touching live parts can cause immediate death by electrocution. Damage to the isolation or individual components can be perilous.

2.5.3 Danger from fire and explosion

Risk of fire and explosion

⚠ WARNING

Risk of fire and explosion around the boiler!

- ❒ DO NOT BURN GARBAGE, GASOLINE, NAPHTHA, ENGINE OIL OR OTHER INAPPROPRIATE MATERIALS.
- ❒ DO NOT USE CHEMICALS OR FLUIDS TO START THE FIRE.
- ❒ DO NOT OPERATE WITH FLUE DRAFT EXCEEDING 0.12 INCHES WATER COLUMN (30 Pa).
- ❒ UNSAFE TO ADJUST FLUE DRAFT HIGHER THAN 0.12 INCHES WATER COLUMN (30 Pa).
- ❒ THE HEAT EXCHANGER, DRAFT INDUCER, FLUE PIPE, AND CHIMNEY MUST BE CLEANED REGULARLY TO REMOVE ACCUMULATED CREOSOTE AND ASH.
- ❒ DO NOT INSTALL IN A MOBILE HOME.
- ❒ Keep covers on the boiler and the access door to the storeroom closed during operation.
- ❒ Smoking, fire and naked flames are not permitted in the store and boiler room.
- ❒ Do not store flammable materials in the boiler room.
- ❒ Do not set flammable objects on the boiler to dry (e.g. clothing).
- ❒ Always ensure that the boiler room is adequately ventilated.
- ❒ Maintain and inspect the heating system at the prescribed intervals. Ensure that the chimney vent is cleaned regularly.
- ❒ Do not use any hydrogen halides or cleaning agents containing chlorine in the boiler room.
- ❒ Observe the safety signs around the system.
  - ➥ Using the boiler incorrectly can cause fire or explosions.

Fire protection

⚠ WARNING

Risk of injury from limited or incorrect firefighting!

- ❒ Ensure that all fire extinguishers provided are suitable for the fire class.
- ❒ Test that the fire extinguishers are fit for use every two years or in accordance with the regulations set out by the fire authorities.
- ❒ Refill the fire extinguisher after each use.
- ❒ Only use approved extinguishing agents and spare parts that match the prototype on the fire extinguisher.
- ❒ When using the fire extinguisher, follow the safety and operating instructions on it.
- ❒ Note the operating temperature range when using the extinguisher.
  - ➥ If, in the event of a fire, the fire extinguisher is not fit for use or unsuitable for the specific fire class, this can result in serious injuries or even death and significant damage to property.

Flue gas system

⚠ WARNING

Risk of injury and damage to property from obstructing the flue gas system!

- ❒ The chimney is only to be used as an outlet for one heating system.
- ❒ Optimum performance can only be guaranteed if the flue gas system is functioning correctly. It is, therefore, important to have the flue gas system cleaned regularly to ensure that the flue gas can escape properly.
- ❒ Arrange for the chimney sweep to check the chimney connection and chimney for tar oil deposits twice a month during the heating period.
  - ➥ Problems with the flue system, such as poor cleaning of the flue pipe or insufficient chimney escape can cause serious faults in combustion (such as spontaneous combustion of carbonization gases/explosion).

2.5.4 Danger from high temperatures

Hot surfaces

⚠ WARNING

Risk of injury from hot surfaces!

- ❒ FOR SAFETY REASONS, KEEP ALL DOORS TIGHTLY CLOSED.
- ❒ Before all work on the boiler, burn out the fuel-loading chamber and let the boiler cool.
- ❒ Protective gloves must generally be worn for work on the boiler. Only touch the boiler using the handles provided.
- ❒ Insulate the flue gas pipes and do not touch them during operation.
- ❒ Keep children and unauthorized persons away from the boiler.
- ❒ Allow the boiler to cool before carrying out any maintenance work.
  - ➥ Touching hot surfaces on the boiler, on the flue gas pipe and on heating pipes can cause serious burns.

Hot media

⚠ WARNING

Risk of scalding from hot media!

- ❒ Temperature adjustments on the boiler controller must only be undertaken in consultation with the manufacturer.
- ❒ Do not touch heating pipes and consumer loads in the heating circuit (radiator etc.) during operation.
- ❒ Allow the system to cool before carrying out any maintenance work. Always wear protective gloves when working on the system.
- ❒ Keep children and unauthorized persons away from the heating system.
  - ➥ Heating pipes and consumer loads in the heating circuit can heat up considerably from the hot water. An incorrect setting at the boiler controller means that the water obtained can be extremely hot. Contact with hot water or hot surfaces can cause scalding to skin.

Hot ashes

WARNING

Risk of injury from hot ashes!

- ❒ Always wear protective clothing and protective gloves when working on the system.
- ❒ Before handling ash, check whether or not it is still hot. Allow to cool if necessary.
  - ➥ Ash is extremely hot after the combustion process. Contact can cause serious burns.

2.5.5 Risks from flue gases, lubricants and other equipment

Proposition 65

WARNING

CALIFORNIA Proposition 65

This product may contain chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

Tar oil

WARNING

Health risk from tar oil!

- ❒ Always proceed with caution and wear personal protective equipment (protective clothing, safety shoes, protective gloves) when cleaning the boiler.
- ❒ Have a chimney sweep regularly clean tar oil deposits from the chimney connection and chimney.
- ❒ Regularly check the air inlet to the boiler room to ensure a controlled combustion process in the boiler.
  - ➥ The combustion of firewood can cause tar oil deposits in the boiler and chimney. Skin contact can be seriously harmful to health.

Leaking flue gas

WARNING

Risk of poisoning from flue gases in the boiler room!

- ❒ If you smell flue gas keep all the doors on the boiler closed.
- ❒ Ventilate the boiler room.
- ❒ Close the fire door and doors to living areas.
  - ➥ Contact with flue gases can cause perilous situations.

Explosive dusts

WARNING

Risk of death from fire and explosion due to dispersed dust deposits!

- ❒ Do not smoke within or close to the danger zone or boiler. Do not work with any kind of naked flame, fire or ignition sources.
- ❒ Keep the danger zone free from dust. Dust deposits over 5 mm thick are not permitted and must be removed.
- ❒ Stop work immediately in the event of a fire. Leave the danger zone until you get the all-clear and notify the fire brigade.
  - ➥ Dust deposits could catch fire or form an explosive compound if dispersed with the ambient air. This can result in serious and even fatal injuries.

Incorrect fuel

WARNING

Risk of injury and damage to the boiler if the incorrect fuel is added!

- ❒ Only use fuels permitted by the manufacturer in the boiler.
- ❒ Never burn corn, cereal, coal, coke, garbage, painted or treated wood, bark, petrol, oil or other flammable liquids in the boiler.
- ❒ Never store fuel or other flammable materials in the boiler room.
- ❒ Never use chemicals, kerosene, charcoal, spirits or other flammable liquids to start or reignite the combustion process in the boiler.

2.6 What to do in the case of danger

What to do if the system overheats (at temperatures above 220°F (105°C))

WARNING

Risk of injury from switching the system off prematurely at the main switch!

- ❒ The system must only be switched off at the main switch once the boiler has cooled down sufficiently (operating status "Fire Off").
  - ➥ Switching off the main switch when the boiler is in heating mode can cause major combustion faults leading to serious accidents.

If the system overheats, proceed as follows:

- ❒ Keep all the doors on the boiler closed.
- ❒ Open all mixing valves; switch on all pumps. The Froling heating circuit control takes on this function in automatic operation.
- ❒ Leave the boiler room and close the access door.
- ❒ Ensure that heat is being consumed. To do this, activate all consumer loads.
- ❒ Once the boiler temperature has fallen to 185°F (85°C), return the heating circuit to normal status.
- ❒ If the temperature does not drop:
  - ➥ Inform the installer or Froling customer service.

In the event of a power failure proceed as follows:

- ❒ Keep all the doors on the boiler closed.
- ❒ The boiler controller will start again automatically after the restart.
  - ➥ Half an hour after the boiler restart, compare the values in the boiler controller and the values on the pressure gauges with the original values. If the pressure level is too low, add water to the heating system in accordance with the heating installer's instructions.

In the event of excessive temperature the high-limit thermostat may have triggered. You may have to release this to allow the boiler to restart.

What to do if there is a smell of flue gas

If you smell flue gas, proceed as follows:

- ❒ Keep all the doors on the boiler closed.
- ❒ Ventilate the boiler room where the boiler is located.
- ❒ Close the fire door and doors to living areas.

What to do in the event of fire

In the event of a fire proceed as follows:

- ❒ Keep all the doors on the boiler closed.

❒ Leave the main switch switched on.
❒ Close the fire door
❒ Leave the boiler room and the building.
❒ Inform the fire department.

2.7 Staff requirements

Risk of injury from inadequate qualification of staff!

⚠ WARNING

Risk of injury from inadequate qualification of staff!

If unqualified staff work on the system, or are within the danger zone of the system, this creates hazards which could cause serious injuries and considerable damage to property.

❒ All such activities should be carried out only by suitably qualified staff.
❒ Keep unqualified staff away from danger zones.

Definition of staff qualifications

The staff qualifications listed here for the United States are based on the descriptions of professional qualifications in the Occupational Outlook Handbook 2011-12 edition of the United States Department of Labor, Bureau of Labor Statistics.

Operator

The operator is the person who operates the heating system for commercial or economic purposes by himself or cedes use/application to a third party and bears the legal responsibility concerning the product for the protection of the user or third parties during the operation.

He has been trained by the manufacturers and the suppliers in dealing with the system and its components and can independently detect potential hazards and avoid the associated risks.

Froling customer service or an authorized partner

The Froling customer service or its authorized partner is able to perform the tasks assigned to it and recognize and avoid possible dangers thanks to its professional, product-related training, knowledge and experience as well as its knowledge of the relevant local regulations.

Heating system installer

The heating system installer has demonstrably received specific instructions by the manufacturer regarding the tasks entrusted to him and potential dangers associated with improper conduct. The heating system installer must have read and understood these instructions. The heating system installer must have undertaken training and have professional experience of at least one year in his field of application.

The skills of the heating system installer include:

❒ Understanding technical contexts
❒ Reading and understanding technical drawings and diagrams
❒ Installing system components
❒ Installing and connecting of heating lines
❒ Performing maintenance work
❒ Dismantling and repairing or replacing system components, if a problem occurs

Licensed electrician

Thanks to his training, knowledge, experiences and knowledge of relevant standards and provisions the licensed electrician is capable of performing the following tasks on electrical systems professionally and according to safety requirements:

- ❒ Planning and connecting electrical systems based on circuit and current flow diagrams
- ❒ Assembling pipes and connecting electric components
- ❒ Analyzing, measuring and testing electrical systems and functions
- ❒ Performing safety checks on electrical systems, components and devices
- ❒ Troubleshooting electrical systems

The licensed electrician is able to independently recognize and avoid hazards associated with these works.

Chimney sweep

The chimney sweep is able to perform the tasks assigned to him and recognize and avoid possible dangers thanks to his professional training, knowledge and experience as well as his knowledge of the relevant standards and regulations.

The skills of the chimney sweep include:

- ❒ Understanding technical contexts
- ❒ Reading and understanding technical drawings and diagrams
- ❒ Checking heating, flue gas and ventilation systems as well as fuel stores for proper operation and fire safety
- ❒ Cleaning heating plants, smoke ducts and ventilation systems
- ❒ Knowledge of provisions under building law and environmental protection law, as well as knowledge in the field of energy efficiency, fire protection and climate protection
- ❒ Performing seal checks

Basic requirements

Only persons expected to carry out their work reliably are admitted as staff. Persons, whose responsiveness is influenced e.g. by drugs, alcohol or medicine are not admitted.

When choosing staff, observe the applicable age and profession-specific regulations on site.

Unauthorized

⚠ WARNING

Risk of death for unauthorized persons due to hazards in the danger zone and work area!

- ❒ Keep unauthorized persons away from the danger zone and work area.
- ❒ In case of doubt, address the persons and direct them to leave the danger zone and work area.
- ❒ Suspend the work as long as there are unauthorized persons in the danger zone and work area.
  - ➥ Unauthorized persons that do not meet the requirements described here, do not know the dangers in the work area. Therefore, unauthorized persons are exposed to risk of serious injury and even death.

Instruction

The operator must regularly instruct the staff. For the purposes of traceability, you must create a training log containing the following at minimum:

- ❒ Date of training
- ❒ Name of the trainees
- ❒ Contents of the training
- ❒ Name of the instructor
- ❒ Signatures of the trainees and the instructor

2.8 Personal protective equipment

Description of the personal protective equipment

The personal protective equipment is as follows:

Protective workwear:

Protective workwear is tight-fitting work clothing with low tear resistance, narrow sleeves and without any protruding parts.

Protective goggles

Protective goggles are used to protect the eyes from flying parts when cleaning the system.

Protective gloves

Protective gloves are used to protect the hands against friction, abrasion, puncture, or deeper injuries and contact with hot surfaces.

Safety shoes

Safety shoes protect feet from crushing and falling parts as well as from sliding on slippery surfaces.

Dust mask

The dust mask is used for protection against dust when cleaning the system and when working in the fuel store.

2.9 Replacement parts

Incorrect replacement parts

⚠ WARNING

Danger of injury when using incorrect replacement parts!

- ❒ Use only original Froling replacement parts or spare parts approved by Froling.
- ❒ In case of doubt, always contact our customer service.
  - ➥ Hazards for the staff can arise through the use of incorrect or faulty spare parts and cause damage, malfunction or total failure.

Spare parts can be obtained from the manufacturer or importer.

2.10 Environmental protection

NOTICE

Danger to the environment resulting from incorrect handling of environmentally hazardous substances!

❒ Always follow the instructions below when handling hazardous substances and their disposal.

❒ If hazardous substances are accidentally released into the environment, take appropriate measures immediately. In case of doubt, inform the competent authority about the damage and request that proper measures be taken.

➥ Incorrect handling of environmentally hazardous substances, in particular incorrect disposal, can cause significant damage to the environment.

The following hazardous substances are used:

Ash

Ashes should be placed in a steel container with a tight-fitting lid. The closed container of ashes should be placed on a non-combustible floor on the ground, well away from all combustible materials, pending final disposal. If the ashes are disposed of by burial in soil or otherwise locally dispersed, they should be retained in the closed container until all cinders have thoroughly cooled. For the disposal of ash from the heat exchanger, consult the local chimney sweep or waste disposal service of the municipality or province. Other waste should not be placed in this container.

Firebricks

The combustion chamber must be disposed of as construction waste.

2.11 The operator's responsibilities

Operator

The operator is the person who operates the system for commercial or economic purposes by himself or cedes use to a third party and bears the legal responsibility concerning the product for the protection of the user, staff or third parties during the operation.

Operator duties

The system operator is subject to the legal obligations for safety at work.

In addition to the safety instructions in this manual, the applicable regulations on safety, safety at work and environmental protection must be observed.

Therefore, in particular, the following applies:

- The "Occupational Safety and Health Act" of 1970 lays down that a safe workplace must be provided at all times during the execution of work.
- The operator must be aware of the applicable occupational safety regulations. Additionally, he must perform a risk assessment to determine hazards arising from special working conditions at the site where the system is used. He must implement these in the form of operating instructions for system operation.
- The operator must check throughout the entire period of use of the system whether the operating instructions created by him correspond to the current version of the regulations, and, if necessary, adjust them.

- The operator must clearly manage and determine the responsibilities for operation, troubleshooting, maintenance and cleaning.
- The operator must ensure that all persons who deal with the system have read and understood this manual. In addition, he must train the staff at regular intervals and inform them about possible dangers. Moreover, the operator must ensure that unauthorized persons do not get close to the system.
- The operator must provide the required protective equipment to staff and instruct them that it is obligatory to wear the necessary protective equipment.
- The operator must ensure that only fuels approved by the manufacturer are used.
- The operator must ensure that the prescribed safety tests are performed.
- The operator must ensure that the regulatory approval requirements are respected.
- The operator must ensure compliance with the requirements of the installation site and the safety measures when working in the storeroom.
- Furthermore, the operator is responsible for ensuring that the system is always in full working order. Therefore the following applies:
- The operator must ensure that the maintenance intervals described in these instructions are respected.
- The operator must ensure that the safety devices are regularly checked for proper functioning and completeness.

3 Description of the boiler

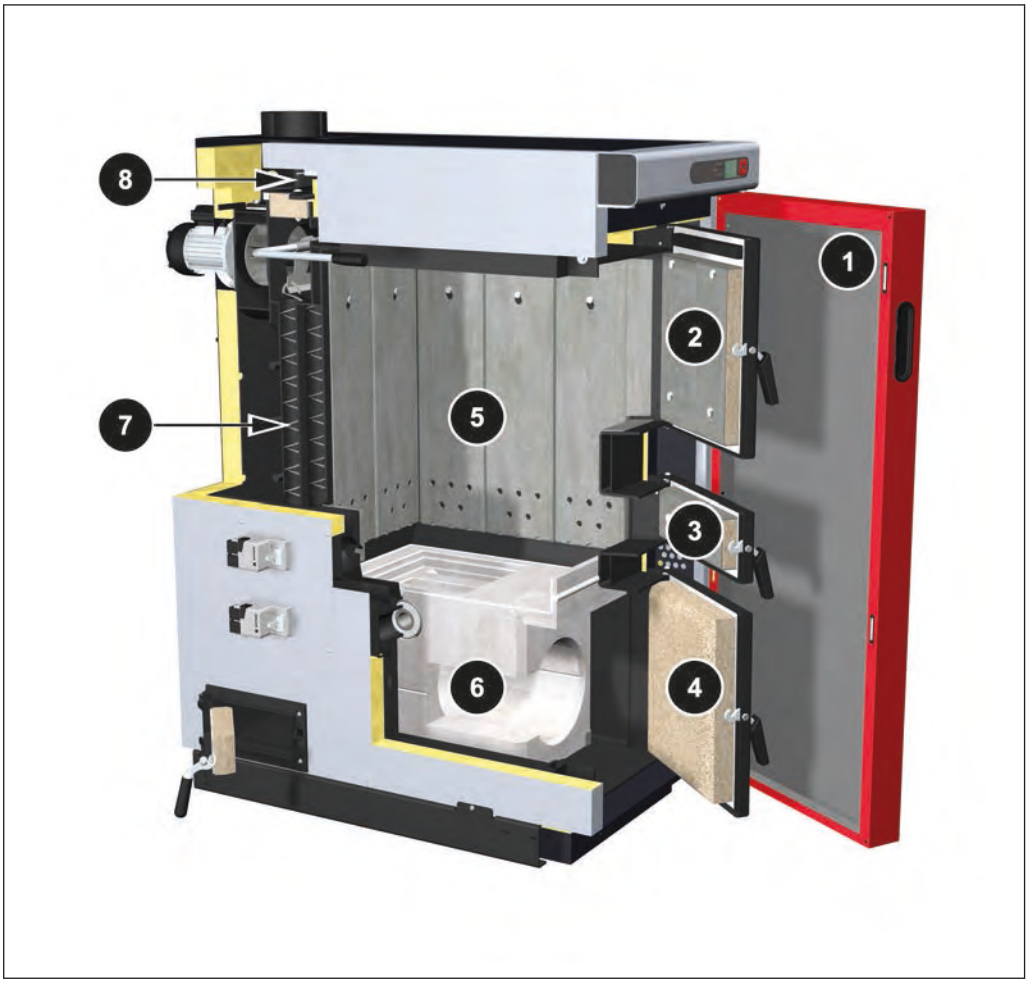
3.1 Front view

1	Boiler S3 Turbo
2	Boiler controller control panel
3	WOS lever
4	Actuator of primary air flap
5	Actuator of secondary air flap
6	Heat exchanger cleaning door

3.2 Back view

1	Boiler flow connection
2	Induced draft fan
3	Thermal discharge safety device connection
4	Drainage
5	Boiler return connection

3.3 Cross-section



1	Insulated door
2	Fuel-loading chamber door
3	Pre-heating chamber door
4	Combustion chamber door
5	Fuel-loading chamber
6	Combustion chamber
7	Heat exchanger with spiral springs
8	In flue gas nozzle: Flue gas temperature sensor and broadband lambda probe

3.4 Functional description

The S3 Turbo wood boiler is a down-draft type wood gasification boiler with an output rating of between 51,250 btu/h and 102,500 (30 kW) or between 85,000 btu/h and 170,000 btu/h (50 kW). This appliance is not fitted with a catalytic combustor. This appliance meets the 2015 US Environmental Protection Agency´s cord wood emissions limits for wood heaters sold after May 15, 2015.

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

In order to maximize efficiency and minimize emissions it is important to light a new fire quickly. It is recommended that a 3“ layer (7 cm) of ash is maintained on the floor of the upper firebox of the appliance. When starting a new fire the boiler should be off. Place approximately ten pieces of kindling with a cross-section of approximately 1” (2 – 3 cm) and a length of approximately 18“ (46 cm) in the bottom of the primary (upper) firebox. This kindling should be placed on the left and right side of the firebox so that there is a slot of about 1“ (2 – 3 cm) to the wood gas transfer slot. Place a layer of cardboard on top of the kindling and add start-up fuel on top of the cardboard. Start up fuel is smaller splits of wood with a cross-section of at least 2“ (6 cm) and a length of approximately 18“ (46 cm). Add enough start-up fuel so that the amount is approximately 10% of the weight of the expected firewood load; in other words, if you expect to load 100 pounds of firewood into the boiler, use ten pounds of start-up fuel. Once the kindling and start-up fuel is in place, add the amount of firewood required to recharge your thermal storage.

Once the firebox is loaded with kindling, cardboard, start-up fuel and firewood, place several sheets of crumpled newspaper inside the lighting door. With the fuel loading door and the lighting door open, turn on the boiler. As the draft induction fan comes on light the newspaper in several places using a match, lighter or small hand-held homeowner-type gas torch. Once the newspaper is ignited, close the fuel loading door securely and position the lighting door so that it is open approximately 1“ (2 – 3 cm). Monitor the exhaust temperature on the boiler control panel. Once the exhaust temperature reaches 130 degrees C, typically in five to ten minutes, close the lighting door and the large outer door. Remain with the boiler during the entire lighting process. Refuel and re-start the boiler when your thermal storage is nearly depleted (storage temperature is approaching minimum usable temperature).

Because the primary and secondary air settings and the fan speed of the S3 Turbo are continuously and automatically adjusted, no manual adjustment of the boiler is required.

Removing ash from the boiler is a simple process. Use the supplied rounded ash scoop to remove ash from the secondary combustion tunnel as needed. A 3“ layer (7cm) of ash should be maintained in the upper firebox. Ash may be pushed into the wood gas transition slot with the supplied ash tool so that it may be removed via the secondary combustion tunnel. Residual ash that accumulates in front of and around the sides of the secondary combustion tunnel should be removed as needed using the provided ash tool. Ash should be placed in a metal container with a tight fitting lid. The closed container of ashes should be placed on a noncombustible floor or on the ground, away from all combustible material pending final disposal. The ashes should be retained in the closed container until all cinders have thoroughly cooled.

The heat exchange tubes in the boiler will accumulate fly ash on their inner surface resulting in lowered boiler efficiency. These tubes should be cleaned daily by moving the tube cleaning lever on the side of the boiler back and forth several times. Ash should be removed as needed from the area below the heat exchange tubes via the small ash door. This ash door may be located either on the left or right side of the boiler and is down low on the boiler near the back. The turbulators should be removed from the boiler and the heat exchange tubes manually brushed with the provided wire brush on an annual basis. At the same time, the vanes of the draft induction fan should be cleaned with a stiff paint brush and a vacuum cleaner. The flue gas temperature sensor should be wiped clean with a clean dry cloth and the oxygen sensor inspected and cleaned if necessary also on an annual basis.

Gaskets on the fuel loading, lighting and ash removal doors should be checked for air tightness periodically.

While the S3 Turbo burns exceptionally cleanly and produces little or no visible smoke, it will, from time to time, produce small amounts of visible smoke and wood smoke odor. Because of this, the boiler and chimney should be located so as not to disturb building occupants or neighbors. Adequate chimney height is important and installation in small valleys and too close to neighbors should be avoided.

This appliance’s rated efficiency was determined by an independent testing lab using the higher heating value of wood and the test protocol prescribed by the US Environmental Protection Agency. Because the S3 Turbo is a batch-fed boiler and is intended to burn at maximum output whenever it is operating, daily operating efficiency and Annual Fuel Utilization Efficiency are the same regardless of time of year or outdoor temperatures.

Because of the S3 Turbo´s Lambdatronic control, this boiler is able to burn efficiently using firewood with a moisture content of up to 25%. That being said, higher moisture content fuel is inherently less efficient than drier fuel because more energy is used to dry the wood before it can be burned. We recommend firewood with a moisture content of between 15% and 20%.

The S3 Turbo is meant to be installed inside an insulated structure; preferable the dwelling that it is heating. While a boiler installed indoors has heat loss from the boiler jacket, that standby heat “loss” is recovered and contributes to the heating and so is not in fact, “lost”. Thermal storage tanks will also have heat losses into the building. If you are planning to use the boiler to produce your domestic hot water during the warmer months, we recommend that you insulate the thermal storage tanks especially well so as to minimize these losses and the resulting warming of your home.

The combustion of any fuel produces potentially harmful emissions of smoke and Carbon Monoxide. The emissions data for this appliance may be found on the table listing all boiler specifications found in chapter „Technical specifications“ in this manual. As a batch-fed and Lambda controlled appliance, emissions are relatively consistent throughout the burn cycle.

We recommend the use of both smoke detectors and Carbon Monoxide detectors in buildings where this appliance is installed.

3.5 Permitted fuels

❒ Burn natural, seasoned, hard or soft firewood or wood-only manufactured wood bricks in this appliance only, length between 18“ (46 cm) and maximum 21“ (52 cm)

Chemically treated or painted wood is unsuitable as fuel. The S3 Turbo boiler is designed for burning fire wood only. Wood briquettes or manufactured pure wood logs can also be used as fuel provided they have a minimum cross section of 2.5 sq in (16 cm²). The fuel loading chamber can be filled to the top. Excessively small and compact pieces of wood or wood pellets are not suitable. Coal cannot be used as it destroys the combustion chamber!

The S3 Turbo is made to burn natural forest wood. Both hardwood and softwood are suitable, but oak should not be burned as the only source of wood for long periods because of its high acid content.

For effective gasification, the wood must be dry, i.e. moisture content 15-20%. Please follow the instructions included with the moisture meter provided to correctly determine wood moisture content. In addition to increasing the likelihood of generating creosote in the boiler, burning wet wood uses a substantial amount of the wood energy to evaporate the water present in the wood, reducing the available energy for heat. Using non-approved fuels will result in lower efficiency, higher emissions and may cause boiler components to fail prematurely and/or operate incorrectly.

The wood will dry out most quickly if it is cut into the appropriate length and split into pieces 4 – 5“ (10 – 12 cm) thick. The best length is 21“ (52 cm) for the S3 Turbo boiler. The wood is best stored in the open air under cover. Wood will dry most quickly if it is carefully stacked alternatively lengthwise and crosswise so that air can penetrate into the stack. Ideally the wood should be stored for at least one and a half years (two summer seasons). Do not burn small pieces of wood or wood chips in the boiler as they can block the combustion slot. Also, it can be difficult to control the combustion process with small wood pieces and chips.

3.6 Non-permitted fuels

⚠ DANGER

Non-permitted fuels

Burning non-permitted fuels increases cleaning requirements and leads to a build-up of aggressive sedimentation and condensation, which can result in damage to the boiler and void the warranty! Using non-standard fuels can result in severe combustion malfunctions.

Only use the fuels specified in the section "Permitted Uses" in these operating instructions!

❒ Do not burn corn, grain, coal, fuel coke, garbage or other residual materials, painted or treated wood, bark, gasoline, diesel, fuel oil, naphtha, engine oil, drain oil or other flammable liquids, or any other organic or inappropriate materials!

❒ Do not store fuel or other combustible material within marked installation clearances. Keep away from boiler while it is in operation!

❒ Do not use chemicals, gasoline, gasoline-type lantern fuel, kerosene, charcoal lighter fuel or similar liquids, or any other combustible fluids to start or rekindle the fire in this boiler.

4 Transport, Installation und Initial start-up

4.1 Safety

Transport as well as installation and commissioning are carried out exclusively by the manufacturer's employees or staff authorized by the manufacturer.

⚠ WARNING

Risk of death from incorrect transport and faulty installation and commissioning!

- ❒ Transport, installation and commissioning must be carried out exclusively by the manufacturer's employees or staff authorized by the manufacturer.
- ❒ Consult the manufacturer even in case of a subsequent change of location.
- ❒ Refrain from unauthorized transport, unauthorized installation and commissioning, as well as changes of location.
  - ➥ An error during transport and installation/commissioning can lead to perilous situations or cause substantial damage to property.

4.2 Conditions for initial start-up

NOTICE

Optimum efficiency and efficient, low-emission operation can only be guaranteed if the system is set up by trained professionals and the standard factory settings are observed.

Take the following precautions:

- ❒ Initial startup should be carried out with an authorized installer or with Froling customer services.

The customer is responsible for ensuring the following prior to initial start-up of the system by Froling customer services or an authorized partner:

- Electrical installation
- Installation of water pipes
- Connect flue gas including all insulation work
- Work must comply with local fire protection regulations

- When heating up the boiler for the first time to dry out the fireclay concrete, the customer must provide approx. 0.5 m³ of dry firewood.
- It is essential that the electrician who has carried out the installation work is available when starting up the system for the first time to make any changes to the wiring which may become necessary.
- During initial start-up, operating staff are shown how to use the boiler. It is imperative for proper handover of the product that those involved are present as this is a one-off opportunity.

NOTICE

Escaping condensation during the initial heat-up phase does not indicate a fault.

- ❒ Tip: If this occurs, clean it up with a cleaning rag.

5 Heating the boiler

5.1 Safety instructions for heating

Incorrect operation

⚠ WARNING

Risk of injury due to incorrect operation!

Incorrect operation can cause serious injuries and considerable property damage.

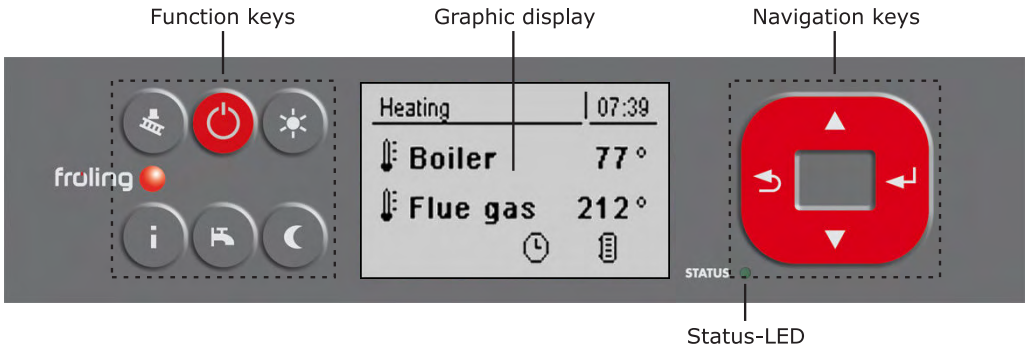
- ❒ Perform all operating steps according to the information and instructions in this manual.
- ❒ Only trained staff may carry out work to the system.
- ❒ Check the system externally for any visible damage or defects at least once a day.
- ❒ Before starting work, make sure that all covers and safety devices are installed and work properly.
- ❒ Never disable or bypass safety equipment during operation.
- ❒ Do not alter the boiler controller.

⚠ WARNING

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

5.2 Operation via the boiler controller

5.2.1 Control keys and display



Navigation keys

Navigation keys are used to move within the menu and to change parameter values.

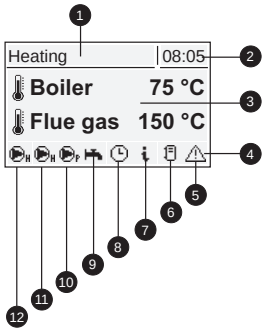
Key	Function used for	
UP arrow	Navigation: move up a menu level	
	Parameter change:	Depending on how long the key is pressed: - Short: increases value - Long: increases value in increments of 10 - Long (>10 secs): increases value in increments of 100
DOWN arrow	Navigation: move down a menu level	
	Parameter change:	Depending on how long the key is pressed: - Short: reduces value - Long: reduces value in increments of 10 - Long (>10 secs): reduces value in increments of 100
Enter key	Navigation: go to selected menu	
	Parameter change:	Releases the parameter for editing, or saves the parameter value after changing
Back key	Navigation: go back up a menu level	
	Parameter change:	Depending on how long the key is pressed: - Short: does not save parameter - Long: back to basic display without saving

Status LED

The status LED shows the operating status of the system:

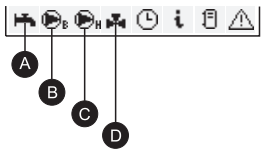
- GREEN flashing (interval: 5 sec OFF, 1 sec ON): Off
- GREEN constant: **BOILER SWITCHED ON**
- ORANGE flashing: **WARNING**
- RED flashing: **FAULT**

Graphic display



Item	Description	
1	Shows operating status or menu name	
2	Shows the current time	
3	Displays the main values in the basic display (adjustable), menu contents, parameters and info texts	
4	Status toolbar	
5	Displayed when there is a fault/malfunction. Press the info key to display texts describing the fault and the solution.	
6	Shows the storage tank loading status (storage tank is optional)	
7	Indicates that an info text is displayed. Info texts are also identified by a frame	
8	Shows which function is active Function keys	
9	Shows that the DHW tank loading pump is active.	Only shown in the basic display!
10	Shows that the storage tank loading pump is active.	
11	Shows that the heating circuit pump of the second heating circuit is active.	
12	Shows that the heating circuit pump of the first heating circuit is active.	

At the service technician user level, the function of the respective components is also shown in the individual status menus by the corresponding status display:



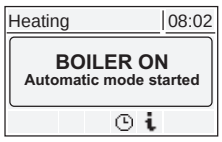
Item	Description	
A	Shows whether the storage tank (or oil boiler) is hot enough for hot water preparation.	Only for service technicians in the status menus.
B	Shown when the DHW tank or return temperature control pump is active.	
C	Shown when the heating circuit or storage tank loading pump is active.	
D	Shows the status of the heating circuit mixer.	

Function keys

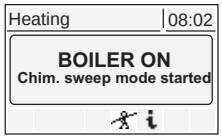
The function keys of the S-Tronic Lambda have dual assignments. Short or long pressing of the keys can access different functions (see below):

short keystroke …….. < 1 sec
long keystroke …….. > 4 sec

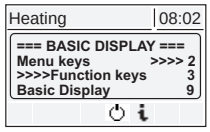
Standby key

Keystroke			Function
			Heating circuits and domestic hot water are controlled according to the programs and times set. Function remains active until another function key is pressed.

Service program key

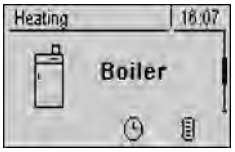
Keystroke			Function
	short		The chimney sweep function is used for measuring boiler emissions using the chimney sweeper. For further information and the procedure for measuring emissions, see the operating instructions of the boiler and/or the “Instructions for the procedure for measuring emissions for the firewood boiler”.
	long		Function not used

Info key

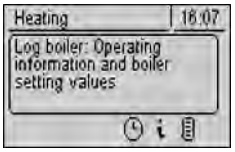
Keystroke			Function
	Short		Shows plain text information about the menu items or fault messages.
	Long		Choose language: Deutsch, Polski, Cesky, Slovenski, Italiano, Francais, English

The info key can be pressed at any time to display information about the current menu item or the current fault message; fault messages have the highest priority.

Info key in normal mode:

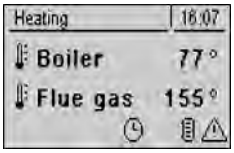


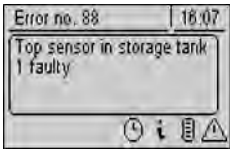
In normal operation (without pending fault messages) the info key can be pressed to display information or an explanation for every menu item or parameter.



The info text is also identified by the frame and the info symbol on the status line.

Info key when there is a pending fault:





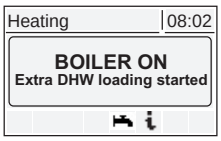
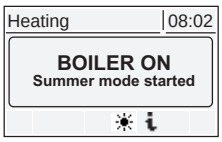
If a fault has been acknowledged after it occurs but it has not resolved, a warning symbol is displayed at the bottom right on the status line.

Pressing the info key calls up the information on the currently pending fault message again.

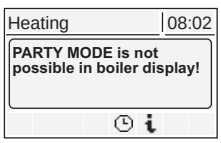
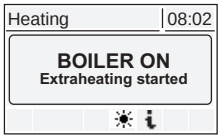
Procedure for troubleshooting:

Troubleshooting

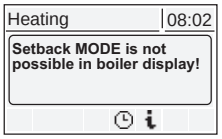
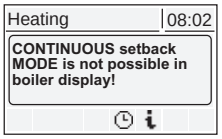
Boiler program key

Keystroke		Function	
	short		One-off manual loading of domestic hot water. The function is indicated during DHW tank loading by the tap symbol in the status line. After loading, the mode that was previously set becomes active again.
	long		To change to summer mode. The mode is indicated by the tap symbol on the status line. Domestic hot water loading is controlled according to the program that is set, the heating circuit controller is deactivated.

Party program key

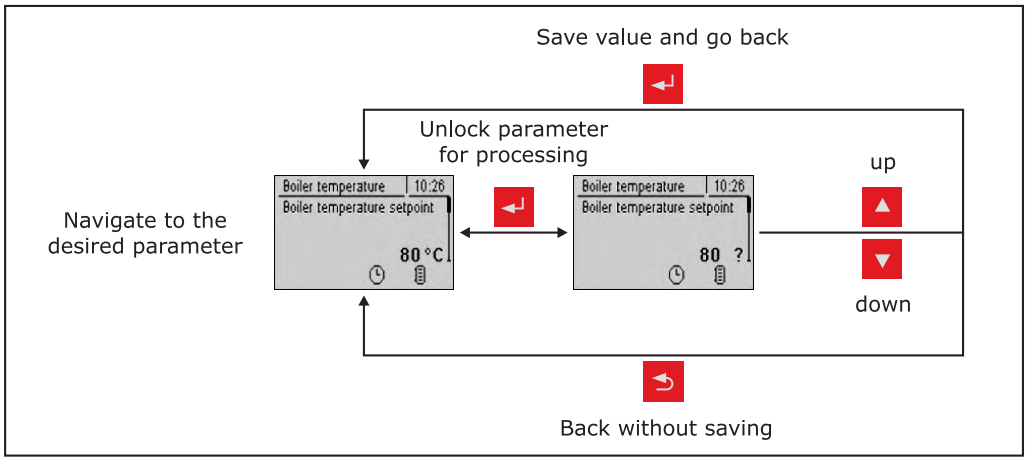
Keystroke		Function	
	short		To activate party mode on the room console. **Caution: Function only possible on the room console!** After an optional change to the room temperature setpoint, the heating circuit controller remains in heating mode until the end of the next heating period or another mode is activated. This function is not possible in summer mode! Observe the additional information in the operating instructions of the room console.
	long		During extra heating, heating and domestic hot water are heated for 6 hours. The mode setting is ignored. The function is indicated by the sun symbol in the status line. **Caution: The external temperature heating limit set in the "Heating" menu is active and can prevent release of the heating circuits.**

Setback program key

Keystroke		Function	
	short		To activate setback mode on the room console. **Caution: Function only possible on the room console!** After an optional change to the setback temperature the heating circuit controller remains in setback mode until the start of the next heating time or until activation of another mode. Observe the additional information in the operating instructions of the room console.
	long		To activate continuous setback mode on the room console. **Caution: Function only possible on the room console!** The room temperature is reduced to the preset setback temperature until automatic mode is activated. Observe the additional information in the operating instructions of the room console.

5.2.2 Setting parameters

Values for all parameters are changed in the following way:



5.3 Before heating up the boiler

5.3.1 Always move the WOS lever

❒ Move the lever of the cleaning system several times before the heating-up process
➥ 5-10 times up and down!

5.3.2 Reloading intervals

Reloading intervals should be determined exclusively according to the thermal storage for efficient and environmentally-friendly heating.

5.3.3 Conversion tables and right amount of fuel

The amount of fuel added should allow the thermal storage to be heated to 100% charge status without on/off cycling of the boiler. 100% charge status means an average thermal storage temperature of boiler setpoint temperature (standard: 185 °F; 85 °C) minus a certain temperature which is set in the boiler controller (standard: 7 °F; 4 °C). Please note that the amount to reload also depends on the type of fuel.

100% charge status = 185 °F (85 °C) – 7 °F (4 °C) = 178 °F (81°C)

When the insulated door is opened the boiler display shows the required fuel quantity to load the thermal storage to 100%. Values are shown in SI units.

Conversion tables

conversion weight													
lbs	10	15	20	25	30	35	40	45	50	55	60	75	80
kg	5	7	9	11	14	16	18	20	23	25	27	34	36
lbs	85	90	95	100	105	110	115	120	125	130	135	140	145
kg	39	41	43	45	48	50	52	54	57	59	61	64	66

	conversion thermal storage volume												
gal	400	450	500	550	600	650	700	750	800	850	900	950	1000
l	1514	1703	1893	2082	2271	2461	2650	2839	3028	3218	3407	3596	3785

Calculation

To calculate the energy required we use the formula **Q = m x c x Δt.**

Q = energy required
m = mass of the medium to be heated
c = heat capacity of the medium to be heated (constant for water)
Δt = temperature difference between start and end temperature

The amount of fuel can be calculated from the energy required and the energy content of the fuel. The energy content of the fuel varies according to the type of wood and the water content. (⇨ See "Fuel table" [page 48])

Right amount of fuel

The following tables give you an idea of the required amount to heat the thermal storage.

The calculation of the tables below is based on the formula above and as fuel hardwood with a water content of w=20% is in use. It does not take into account pipe losses and energy required to heat the boiler and heating system.

Example: Heat a 600 gal thermal storage from actual 130 °F average temperature to 100% charge.

Answer: 82 lbs

amount of fuel hardwood (w=20%) to heat a thermal storage to 100% [lbs]

average temperature of thermal storage [°F] \ effective thermal storage volume to be heated up [gal]	400	450	500	550	600	650	700	750	800	850	900	950	1000
165	15	17	18	20	22	24	26	28	30	31	33	35	37
160	20	23	26	28	31	33	36	38	41	43	46	49	51
155	26	29	33	36	39	42	46	49	52	55	59	62	65
150	32	36	40	44	48	52	56	60	64	68	72	75	79
145	37	42	47	52	56	61	66	70	75	80	84	89	94
140	43	49	54	59	65	70	75	81	86	92	97	102	108
135	49	55	61	67	73	79	85	92	98	104	110	116	122
130	54	61	68	75	82	89	95	102	109	116	123	129	136
125	60	68	75	83	90	98	105	113	120	128	135	143	150
120	66	74	82	91	99	107	115	123	132	140	148	156	165
115	72	80	89	98	107	116	125	134	143	152	161	170	179
110	77	87	96	106	116	125	135	145	154	164	174	183	193
105	83	93	104	114	124	135	145	155	166	176	186	197	207
100	89	100	111	122	133	144	155	166	177	188	199	210	221
95	94	106	118	130	141	153	165	177	188	200	212	224	236
90	100	112	125	137	150	162	175	187	200	212	225	237	250

Example: Heat a 600 gal thermal storage about 40 °F

Answer: 68 lbs

amount of fuel hardwood (w = 20%) [lbs]

ΔT [°F] \ effective thermal storage volume to be heated up [gal]	400	450	500	550	600	650	700	750	800	850	900	950	1000
20	23	26	28	31	34	37	40	43	45	48	51	54	57
25	28	32	35	39	43	46	50	53	57	60	64	67	71
30	34	38	43	47	51	55	60	64	68	72	77	81	85
35	40	45	50	55	60	65	70	74	79	84	89	94	99
40	45	51	57	62	68	74	79	85	91	96	102	108	114
45	51	57	64	70	77	83	89	96	102	109	115	121	128
50	57	64	71	78	85	92	99	106	114	121	128	135	142
55	62	70	78	86	94	101	109	117	125	133	140	148	156
60	68	77	85	94	102	111	119	128	136	145	153	162	170
65	74	83	92	101	111	120	129	138	148	157	166	175	184
70	79	89	99	109	119	129	139	149	159	169	179	189	199
75	85	96	106	117	128	138	149	160	170	181	192	202	213
80	91	102	114	125	136	148	159	170	182	193	204	216	227
85	96	109	121	133	145	157	169	181	193	205	217	229	241
90	102	115	128	140	153	166	179	192	204	217	230	243	255

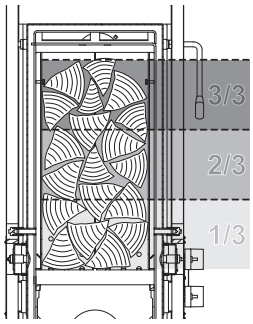
5.3.4 Fuel table

The table below shows a selection of wood types with the corresponding energy content depending on the water content:

Wood type	Energy content with water content [Btuh/lbs (kWh/kg)]		
	w = 15%	w = 20%	w = 25%
Softwood	6560 (4.3)	6190 (4.0)	5730 (3.7)
Hartwood	6350 (4.1)	5880 (3.8)	5420 (3.5)

5.3.5 Fill level in boiler

The table below shows the relationship between fill level and weight. It compares spruce (example of soft wood) and beech (example of hardwood) with a water content of approx. 20%. Using our example above with beech, the fill level of an S3 Turbo 40 would, therefore, be approx. one third.



Fill level		Weight at fill level	
		S3 Turbo 30	S3 Turbo 50
3/3	Soft wood	approx. 53 lbs (24 kg)	approx. 86 lbs (39 kg)
	Hardwood	approx. 88 lbs (40 kg)	approx. 143 lbs (65 kg)
2/3	Soft wood	approx. 35 lbs (16kg)	approx. 57 lbs (26 kg)
	Hardwood	approx. 60 lbs (27 kg)	approx. 95 lbs (43 kg)
1/3	Soft wood	approx. 18 lbs (8 kg)	approx. 29 lbs (13kg)
	Hardwood	approx. 29 lbs (13 kg)	approx. 49 lbs (22 kg)

5.3.6 Reloading intervals when operating without thermal storage or if the thermal storage is too small

NOTICE

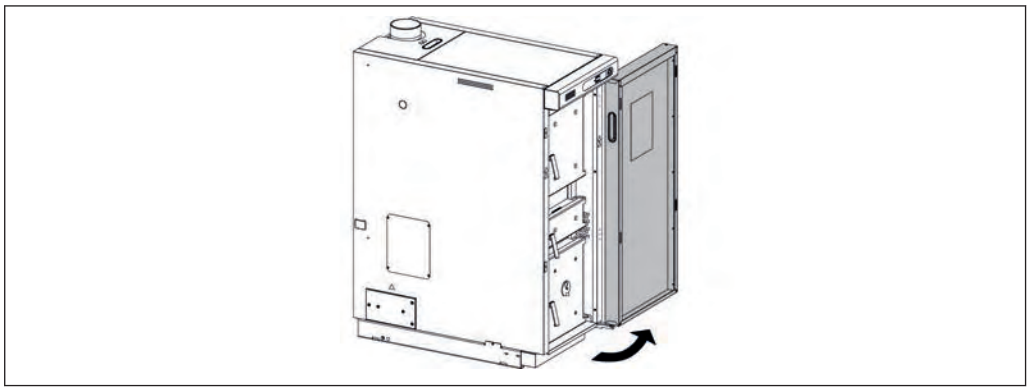
Performance-related loading:

Only refuel if energy is required!

❒ If too much fuel is added, the boiler will drop below its minimum output limit and enter into the “Slumber” operating status (blower fan is switched off)

↪ During “Slumber”, the efficiency drops, emissions increase and tar may form in the boiler.

5.4 Heating up the boiler

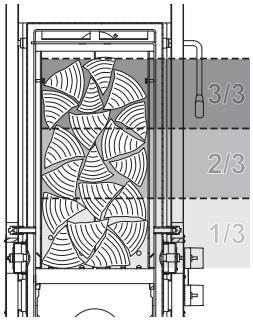


❒ Open the insulated door.

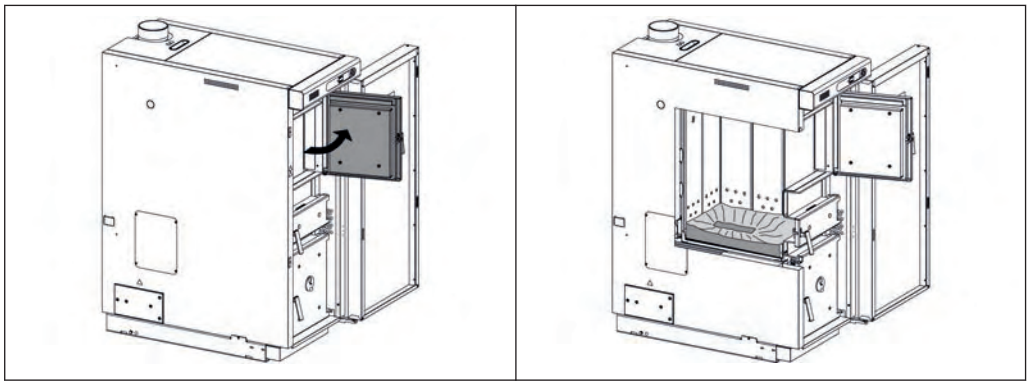
➥ The induced draft fan starts running and the boiler display alternately shows the boiler's current values and the required fuel quantity to load the thermal storage.

NOTICE! When calculating the fuel quantity to load into the storage tank, the energy required for heating up the boiler (boiler water, combustion chamber) is not taken into consideration.

❒ Prepare the fuel quantity according to what is shown on the display.

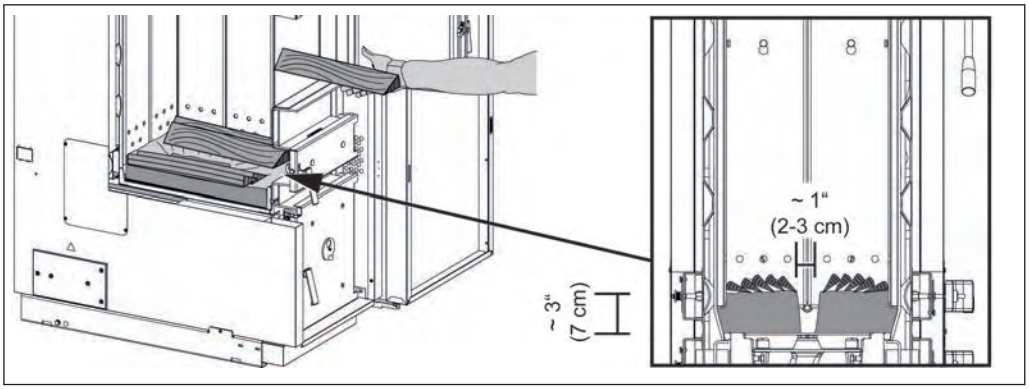


Fill level		Weight at fill level	
		S3 Turbo 30	S3 Turbo 50
3/3	Soft wood	approx. 53 lbs (24 kg)	approx. 86 lbs (39 kg)
	Hardwood	approx. 88 lbs (40 kg)	approx. 143 lbs (65 kg)
2/3	Soft wood	approx. 35 lbs (16 kg)	approx. 57 lbs (26 kg)
	Hardwood	approx. 60 lbs (27 kg)	approx. 95 lbs (43 kg)
1/3	Soft wood	approx. 18 lbs (8 kg)	approx. 29 lbs (13 kg)
	Hardwood	approx. 29 lbs (13 kg)	approx. 49 lbs (22 kg)



❒ Open the fuel loading door and check the ash level

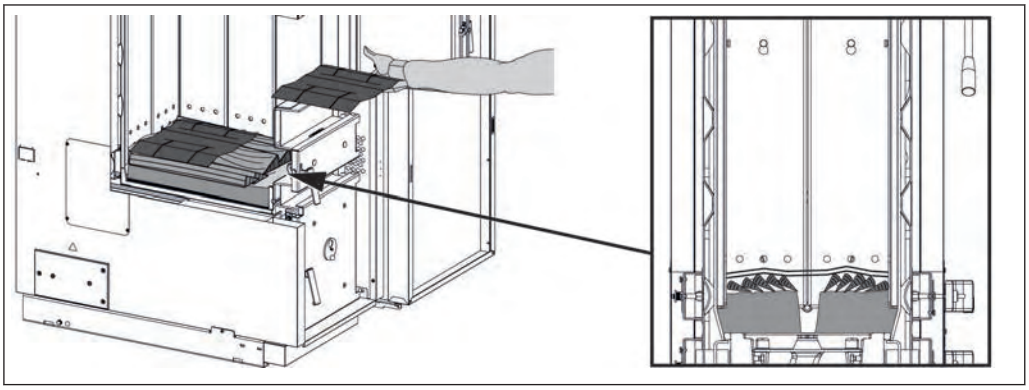
➥ Ash should remain in the boiler up to the height between the lowest and middle rows of holes, about 3" (7 cm) of the aprons. It is recommended that you do not remove the ash in the combustion chamber during each heating-up process, but rather only when the middle row of holes is no longer visible, until the remaining amount is about 3" (7 cm). This protects the combustion chamber and accelerates the heating-up process.



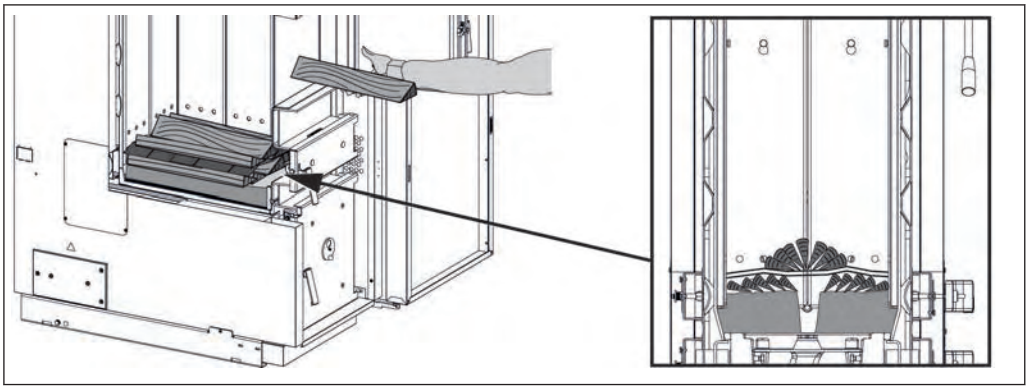
❒ Insert one layer of small-sized firewood.

➥ Approximately ten pieces of kindling with a cross-section of approximately 1“ (2-3 cm) and a length of approximately 18“ (46 cm)

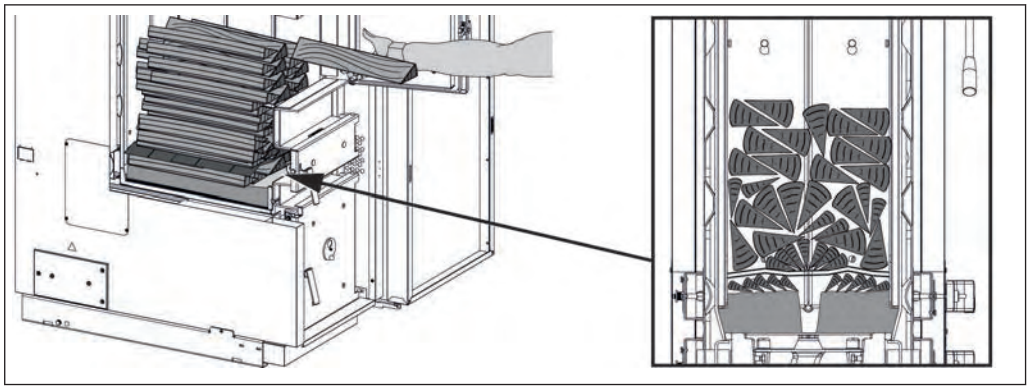
➥ Do not cover the flame slot entirely (approx. 1”, 2-3cm).



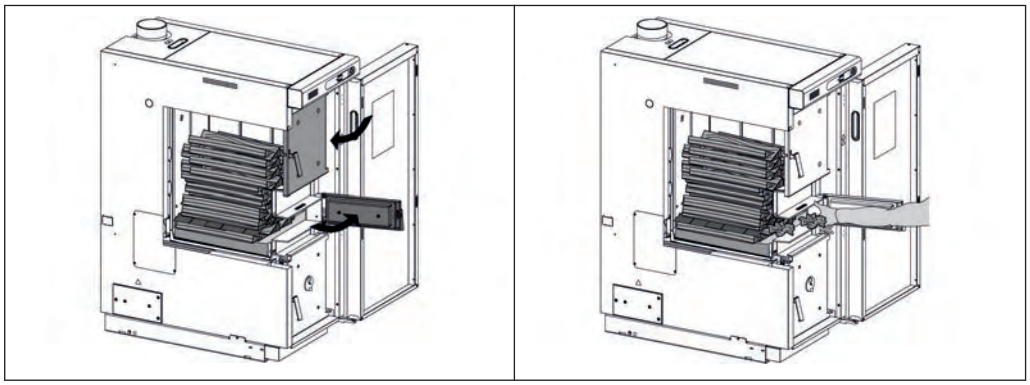
❒ After the first layer of wood, lay cardboard across the whole area.



❒ Add start-up fuel so that the amount is approximately 10% of the weight of the expected firewood load; in other words, if you expect to load 100 pounds of firewood into the boiler, use ten pounds of start-up fuel.

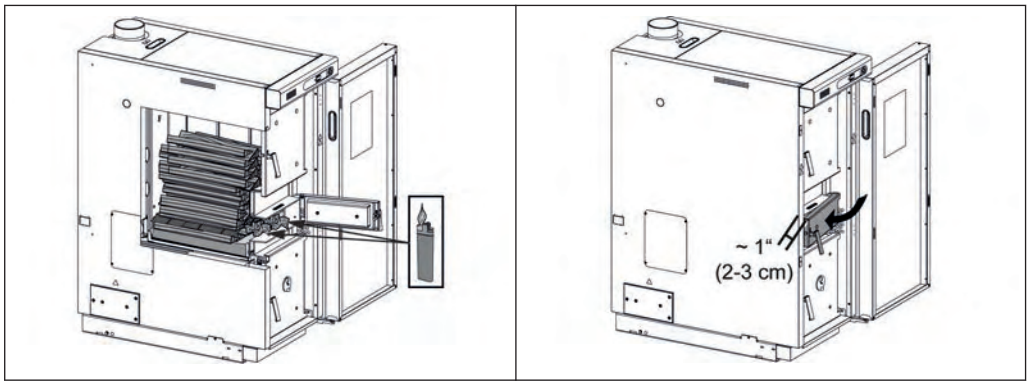


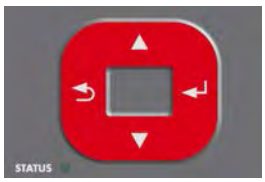
❒ Once the kindling and start-up fuel is in place, add the amount of firewood required to recharge your thermal storage.



❒ Close the fuel loading door and open the pre-heating chamber door.

❒ Once the firebox is loaded with kindling, start-up fuel and firewood, place several sheets of crumpled newspaper inside the lighting door.





❒ Briefly press the DOWN arrow on the navigation keys.

➥ The induced draft fan switches off.

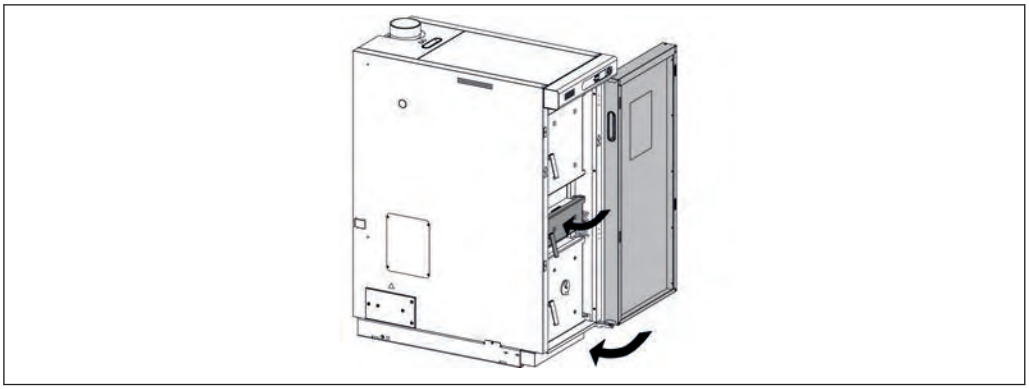
❒ Ignite paper with a lighter at several positions.

❒ Press the UP arrow in the navigation keys.

➥ The induced draft fan switches on.

❒ Leave the pre-heating chamber door open about 1” (2-3 cm) and watch the flue gas temperature.

➥ A bed of embers forms.



❒ If the flue gas temperature has reached a value of > 130°C (> 266°F), close the pre-heating chamber door and insulated door.

NOTICE! Remain with the boiler during the entire lighting process!

5.5 Add more firewood during the operation

⚠ WARNING

When touching hot surfaces behind the insulated door:

Hot surfaces can cause serious burns!

By the nature of its operation, the surfaces and operating elements in the area behind the insulated door get hot! There is also a risk of injury from splinters when working with firewood.

❒ When working on the boiler during operation, particularly when reloading fuel, always wear protective gloves

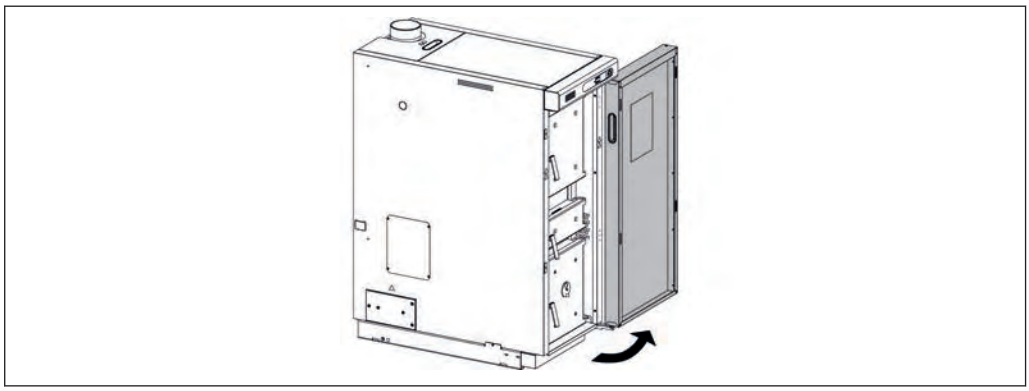
⚠ WARNING

When opening the fuel loading door:

May result in injury or damage or flue gas generation!

❒ Open the fuel loading door slowly and carefully

❒ Close the fuel loading door immediately after checking or adding more firewood



❒ Open the insulated door und observe the boiler's basic display parameter

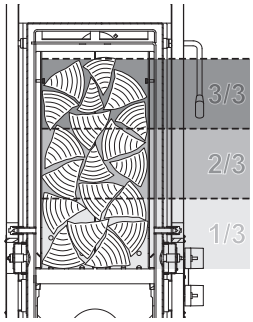
➥ The induced draft fan starts running and the boiler display now alternately shows the boiler's current values and the required fuel quantity to load the thermal storage.

➥ When a fuel quantity below 20 lbs (9 kg) is displayed, we recommend that you do not add any more firewood and instead wait until a later time.

Display under 20 lbs (9 kg):

❒ Close the fuel loading door and insulated door again.

Display above 20 lbs (9 kg):



❒ Assess the remaining fuel in the fuel-loading chamber.

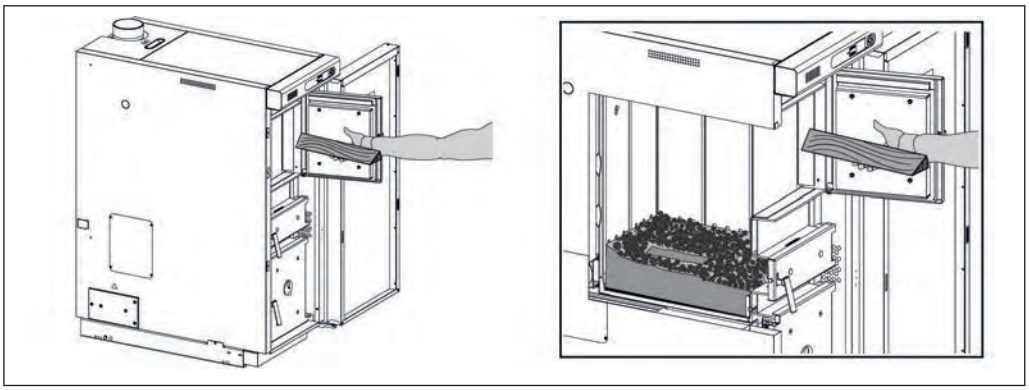
Fill level		Weight at fill level	
		S3 Turbo 30	S3 Turbo 50
3/3	Soft wood	approx. 53 lbs (24 kg)	approx. 86 lbs (39 kg)
	Hardwood	approx. 88 lbs (40 kg)	approx. 143 lbs (65 kg)
2/3	Soft wood	approx. 35 lbs (16 kg)	approx. 57 lbs (26 kg)
	Hardwood	approx. 60 lbs (27 kg)	approx. 95 lbs (43 kg)
1/3	Soft wood	approx. 18 lbs (8 kg)	approx. 29 lbs (13 kg)
	Hardwood	approx. 29 lbs (13 kg)	approx. 49 lbs (22 kg)

❒ Prepare the fuel quantity actually needed to load the thermal storage.

➥ The fuel quantity actually required is determined by the difference of the fuel quantity shown on the display and the current remaining fuel in the fuel-loading chamber.

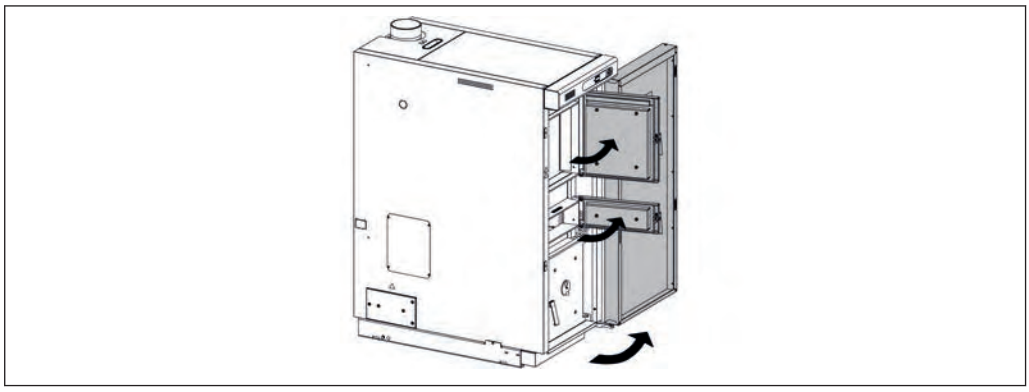
❒ The optimal time for adding fuel is when the basic firebed is achieved.

➥ A firebed is “basic” when it reaches the top row of holes in the cladding.

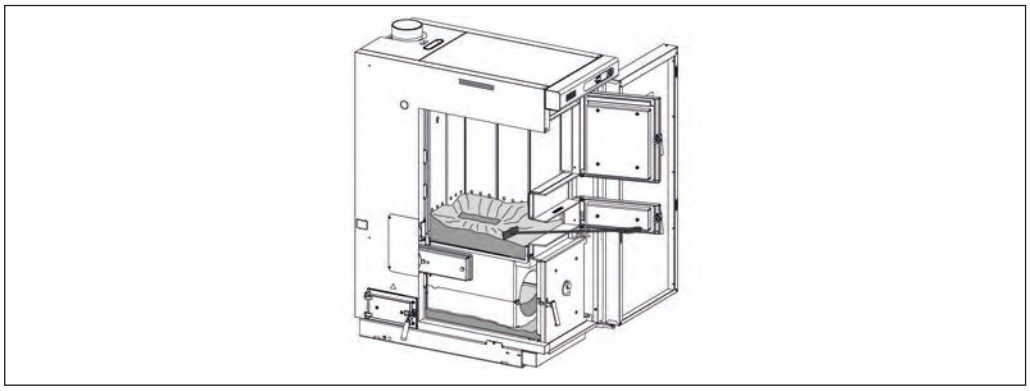


❒ Open the fuel loading door, add the prepared fuel quantity, then close the fuel loading door and insulated door again.

5.6 Remove ash

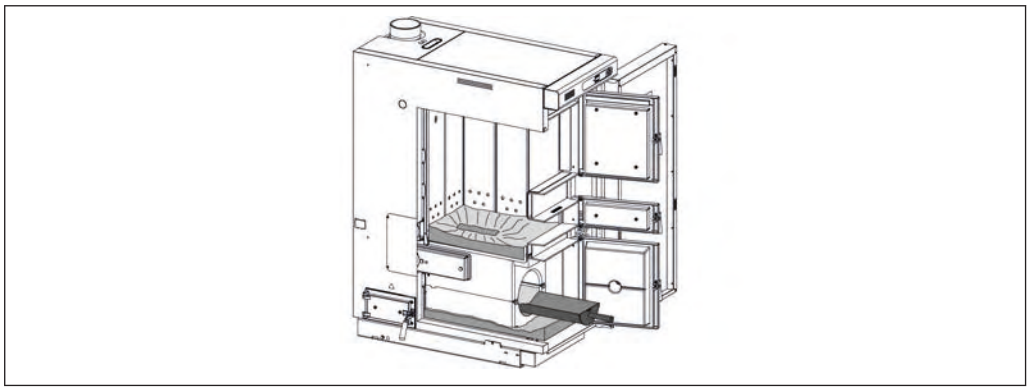


❒ Open the insulated door, pre-heating chamber door and the fuel loading chamber door



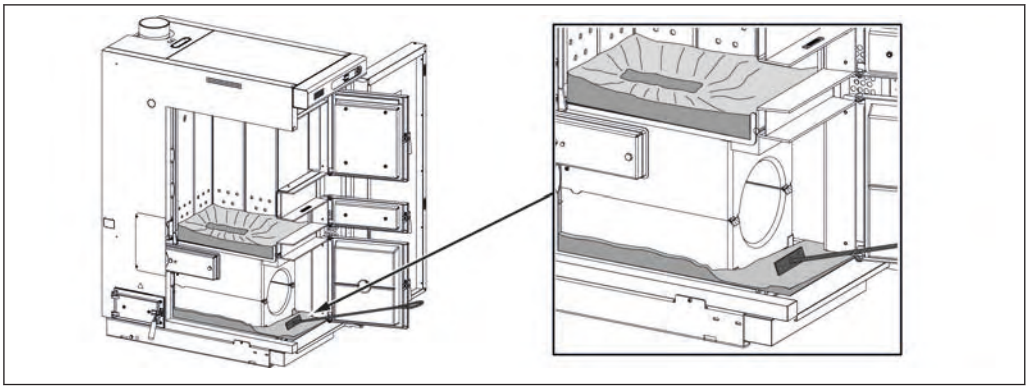
❒ Scrape the ash from the fuel loading chamber into the combustion chamber using the furnace tool.

➥ Ash should remain in the boiler up to the height between the lowest and middle rows of holes, about 3” (7 cm) of the aprons. It is recommended that you do not remove the ash in the combustion chamber during each heating-up process, but rather only when the middle row of holes in the combustion chamber guards is no longer visible, until the remaining amount is about 3” (7 cm). This protects the combustion chamber and accelerates the heating-up process.

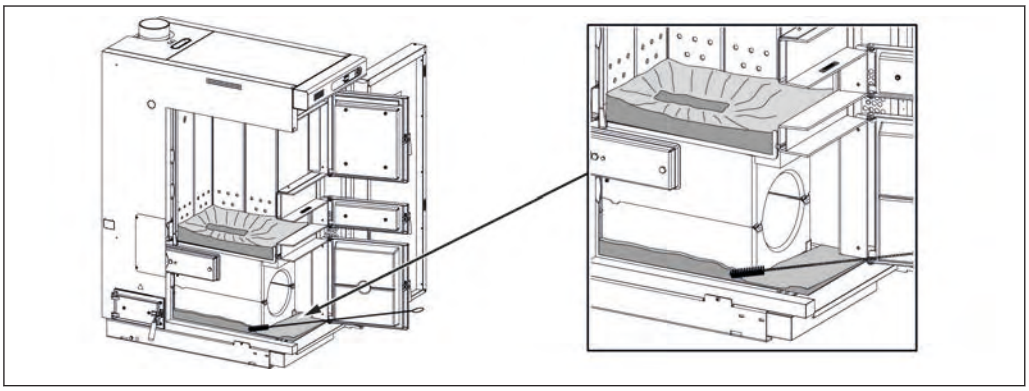


❒ Open the combustion chamber door and remove ash with a round ash shovel

➥ Fire-proof container with cover!



❒ Remove ash in the area in front of the combustion chamber with the furnace tool.
➥ Fire-proof container with cover!



❒ Clean the passage to the left and right of the combustion chamber with small brush and remove ash
❒ Shovel the ash into the container provided
➥ Fire-proof container with cover!

❒ Close all boiler doors again after removing the ash.

6 Maintaining the boiler

6.1 Safety instructions for maintenance

Improper maintenance work

⚠ WARNING

Risk of injury due to improperly performed maintenance work!

- ❒ Before starting any work, the boiler must be in the “Fire Off” operating condition. Allow the boiler to cool sufficiently. Once the boiler has cooled down, switch off the emergency switch and take precautions to prevent it being accidentally switched on.
- ❒ Only operate the boiler using the handles provided.
- ❒ Perform all inspection and cleaning work to the boiler in the proper way.
- ❒ Pay attention to order and cleanliness in the boiler room.
- ❒ Any maintenance work not permitted for the operator must be carried out exclusively by Froling customer service or an authorized partner.
- ❒ Always wear personal protective equipment for work (protective clothing, safety shoes, protective gloves).
- ❒ Before starting up again, make sure that there is no-one in the danger zone and that all covers and safety devices are installed and work properly.
- ❒ THE HEAT EXCHANGER, DRAFT INDUCES, FLUE PIPE, AND CHIMNEY MUST BE CLEANED REGULARLY TO REMOVE ACCUMULATED CREOSOTE AND ASH. ENSURE THAT THE HEAT EXCHANGER, FLUE PIPE, AND CHIMNEY ARE CLEANED AT THE END OF THE HEATING SEASON TO MINIMIZE CORROSION DURING THE SUMMER MONTHS. THE APPLIANCE, FLUE PIPE, AND CHIMNEY MUST BE IN GOOD CONDITION. THESE INSTRUCTIONS ALSO APPLY TO A DRAFT INDUCER IF USED.
  - ➥ Incorrect or insufficient inspection and cleaning of the boiler can cause serious faults in combustion (e.g. spontaneous combustion of carbonization gases or explosion) and this can lead to serious accidents and damage.

Automatic start-up

⚠ WARNING

Risk of injury from automatic start-up!

- ❒ Before starting any work, the boiler must be in the “Fire Off” operating condition.
- ❒ Switch off the emergency switch and take precautions to prevent accidental switching on.
  - ➥ There is a risk of serious injury from the system starting up automatically if it is switched on during inspection and cleaning.

6.2 Securing the system so that it cannot be switched on again

⚠ WARNING

Risk to life from unauthorized or uncontrolled switching on!

- ❒ Before switching on again, ensure that all safety equipment has been fitted and is functioning correctly and that there is no risk to persons.
- ❒ Always follow the procedure set out below to secure the system against being switched back on:
  - Disconnect.
  - Secure against switching back on.
  - Check the system is no longer live.
  - Earth and short circuit.
  - Cover or shield any adjacent live parts.

  ➥ **Unauthorized or uncontrolled switching on of the boiler can cause serious injury or death.**

6.3 Maintenance schedule

Interval	Maintenance work	Staff
Heating up each time	Always move the WOS lever	Operator
Every 100 operating hours	Visually inspect the system	Operator
	Check that safety equipment is functioning properly	Operator
	Remove ash and clean the grating	Operator
twice a month during the heating period	Remove soot, tar oil and ash deposits from the chimney connection and chimney	Chimney sweep
Annually or every 3000 operating hours	Clean the flue gas temperature sensor	Operator
	Clean the broadband probe	Froling customer service or an authorized partner
	Cleaning the low-temperature carbonization gas duct	Operator
	Cleaning the primary air openings	Operator
	Check the setting and seal on the doors	Operator
	Cleaning the heat exchanger pipes	Froling customer service or an authorized partner
	Cleaning the induced draft fan	Froling customer service or an authorized partner
	Clean the flue gas pipe and check the chimney draft	Chimney sweep
	Checking the draft controller flap	Chimney sweep

6.4 Maintenance work

6.4.1 Checking the safety equipment

Checking the system pressure

❒ Check the system pressure on the pressure gauge.

➥ The value must be 20% greater than the preload pressure of the expansion tank.

NOTICE! Check that the position of the pressure gauge and rated pressure of the expansion tank match your installer's specifications!

If the system pressure decreases:

❒ Add water.

NOTICE! If this happens frequently, the seal of the heating system is faulty! Inform your installer.

If large pressure fluctuations are observed:

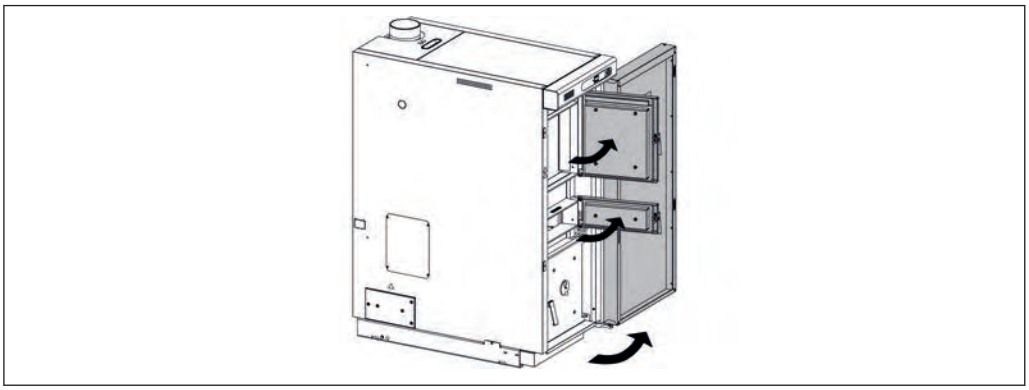
❒ Ask an expert to inspect the expansion tank.

Checking the safety valve

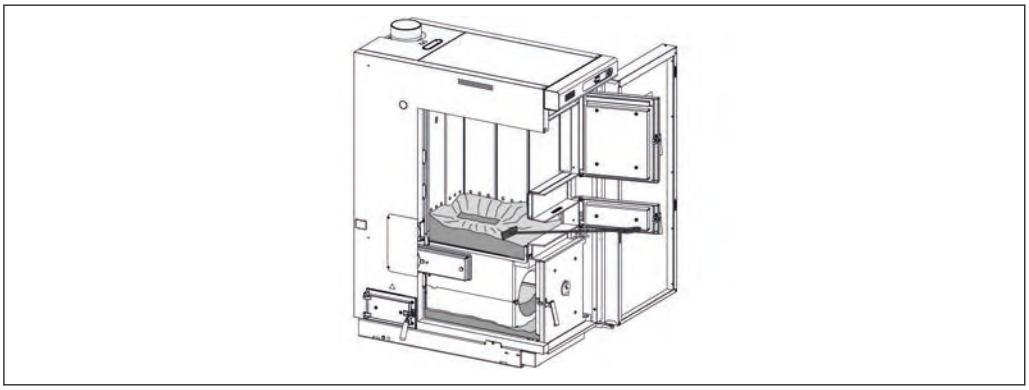
❒ Check the seal of the safety valve regularly and ensure that the valve is not dirty.

NOTICE! Inspection work must be carried out in accordance with the manufacturer's instructions.

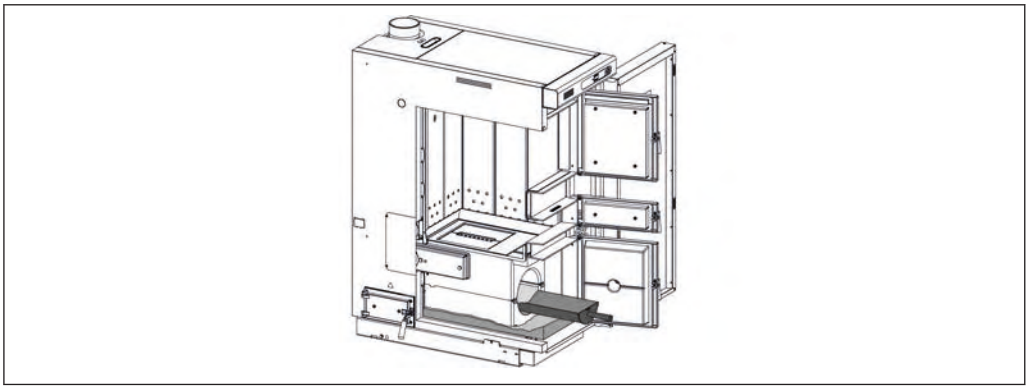
6.4.2 Remove ash



❒ Open the insulated door, pre-heating chamber door and the fuel loading chamber door

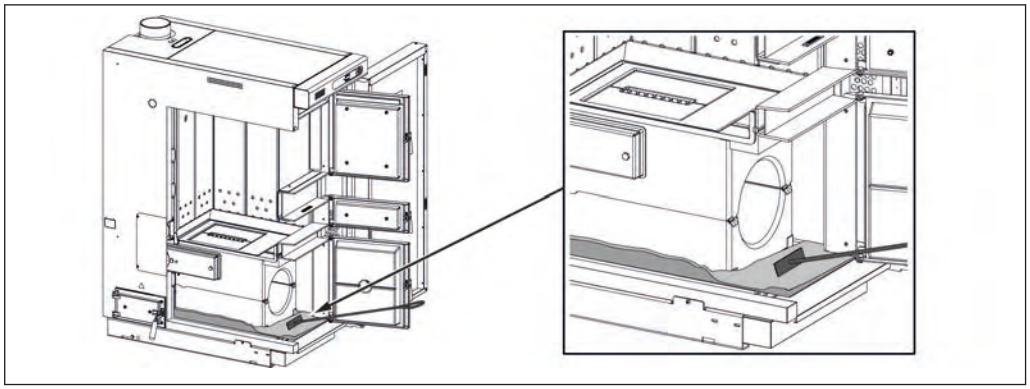


❒ Scrape the ash from the fuel loading chamber into the combustion chamber using the furnace tool.

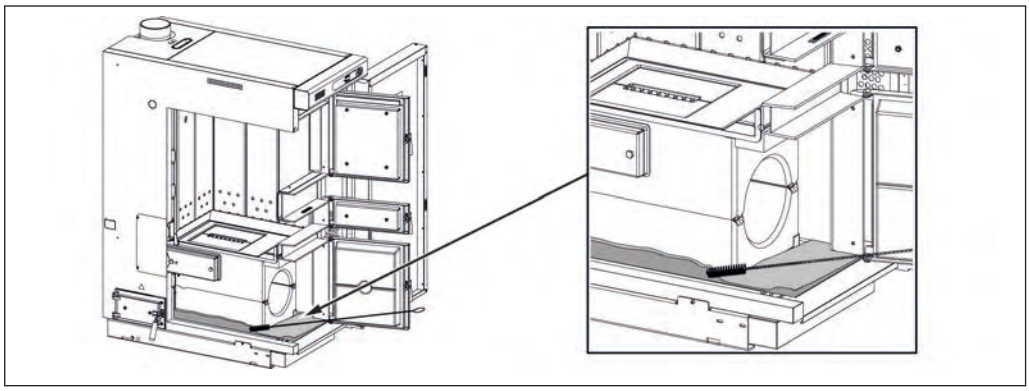


❒ Open the combustion chamber door and remove ash with a round ash shovel

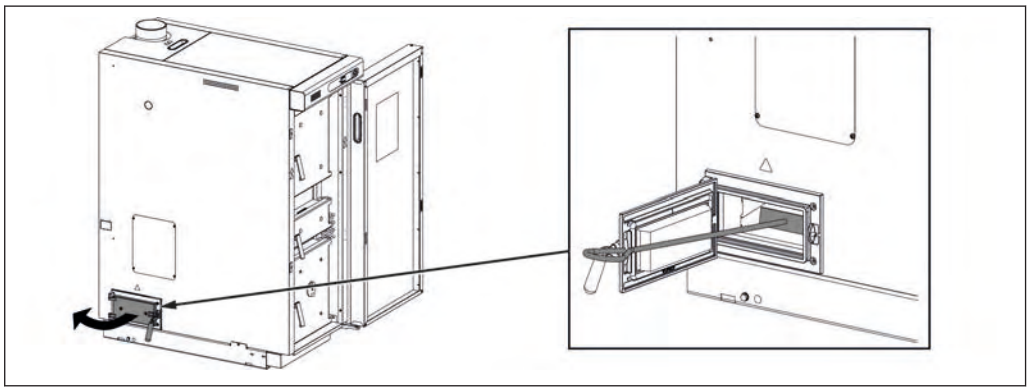
➥ Fire-proof container with cover.



❒ Remove ash in the area in front of the combustion chamber with the furnace tool.
➥ Fire-proof container with cover.



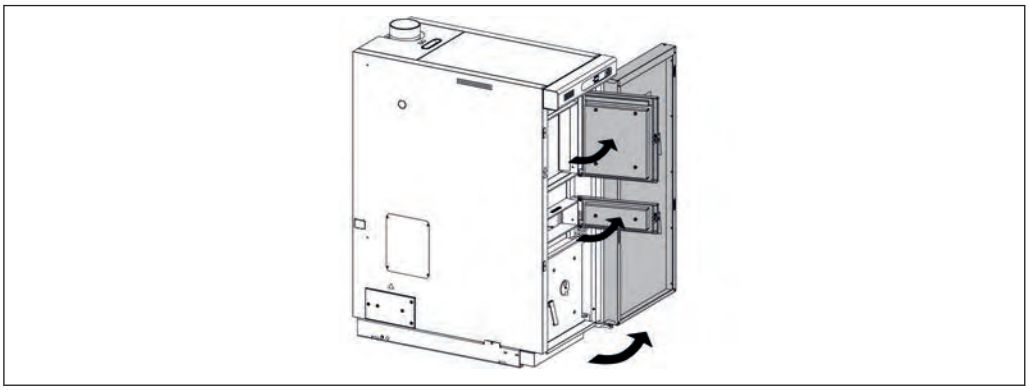
❒ Clean the passage to the left and right of the combustion chamber with small brush and remove ash
❒ Shovel the ash into a container
➥ Fire-proof container with cover



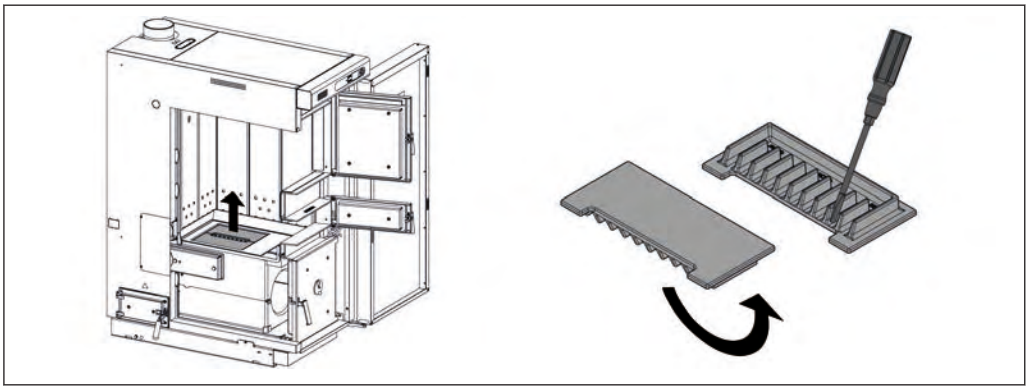
❒ Open the heat exchanger cleaning door and remove the ash with the furnance tool
➥ Fire-proof container with cover

❒ Close all boiler doors again after removing the ash.

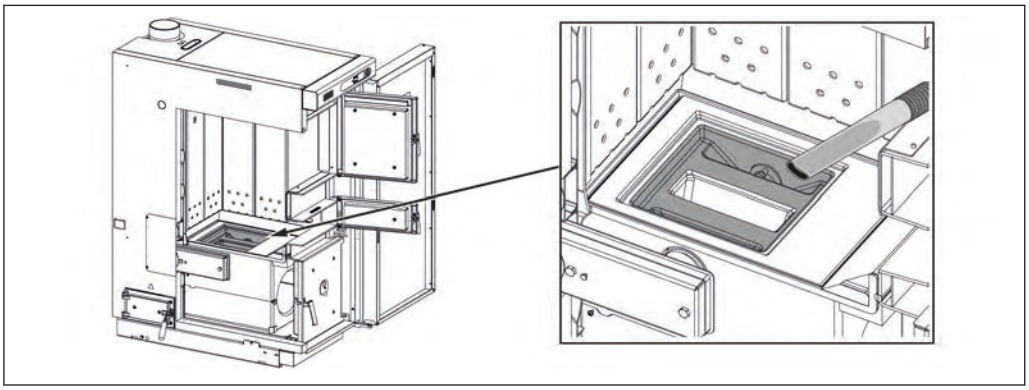
6.4.3 Cleaning the grate



❒ Open the insulated door, pre-heating chamber door and the fuel loading chamber door.



❒ Remove both halves of the grating from the fuel-loading chamber.
❒ Turn them over and scrape the ribs with a screwdriver.

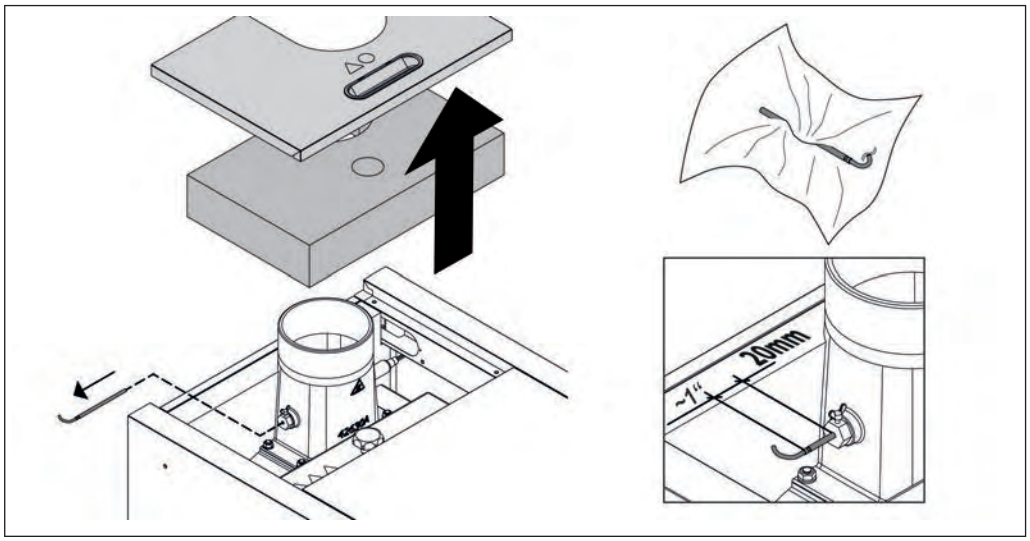


❒ Check the secondary air inlets and clean with an ash vacuum if necessary.

❒ Place the two halves of the grating back on the combustion chamber.
↪ Ensure that they are positioned correctly.

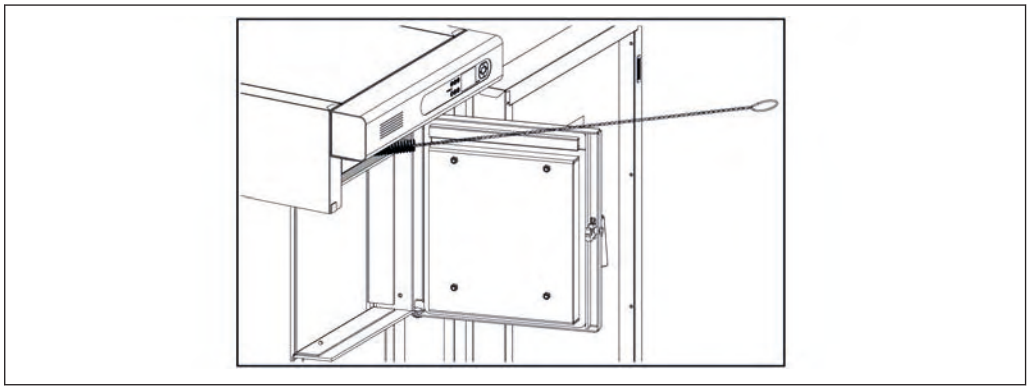
❒ Close all boiler doors after positioning the grating halves.

6.4.4 Cleaning the flue gas temperature sensor



- ❒ Remove the back insulating cover and thermal insulation.
- ❒ Release the retaining screw and remove the flue gas temperature sensor from the flue gas pipe.
- ❒ Wipe the flue gas temperature sensor with a clean cloth.
- ❒ Push in the flue gas temperature sensor until about 1” (20 mm) of the sensor remains protruding from the bushing and secure with fixing screw.
- ❒ Put the thermal insulation and rear insulating cover back in place.

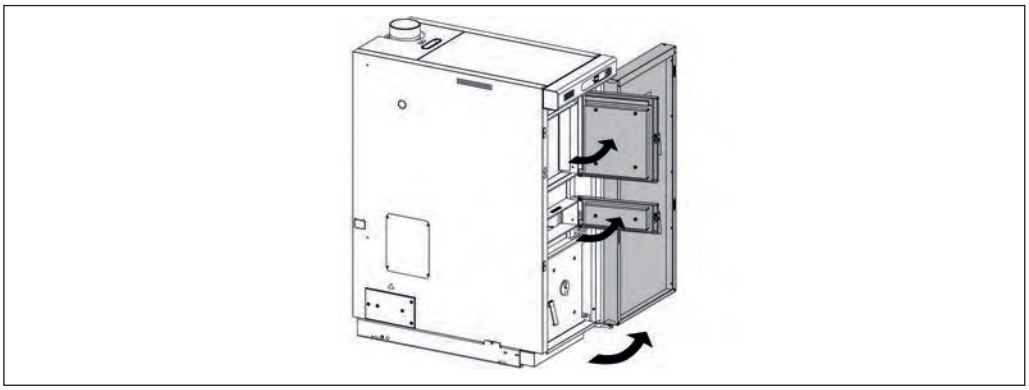
6.4.5 Cleaning the low-temperature carbonization gas duct



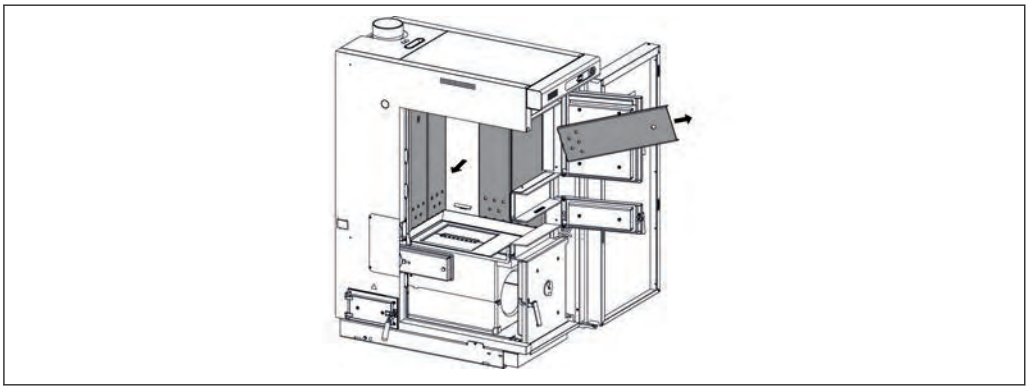
- ❒ Open the insulated door and the fuel loading chamber door
- ❒ Clean the low-temperature carbonization gas duct with a small brush

- ❒ Close all boiler doors after cleaning the low-temperature carbonization gas duct!

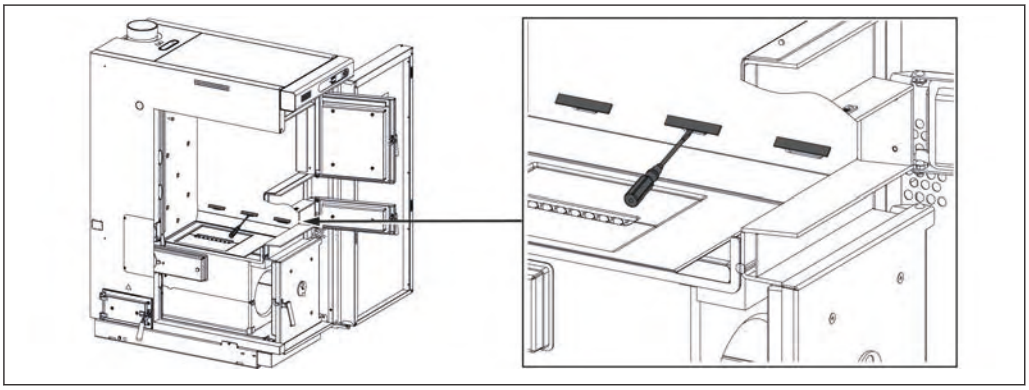
6.4.6 Cleaning the primary air openings



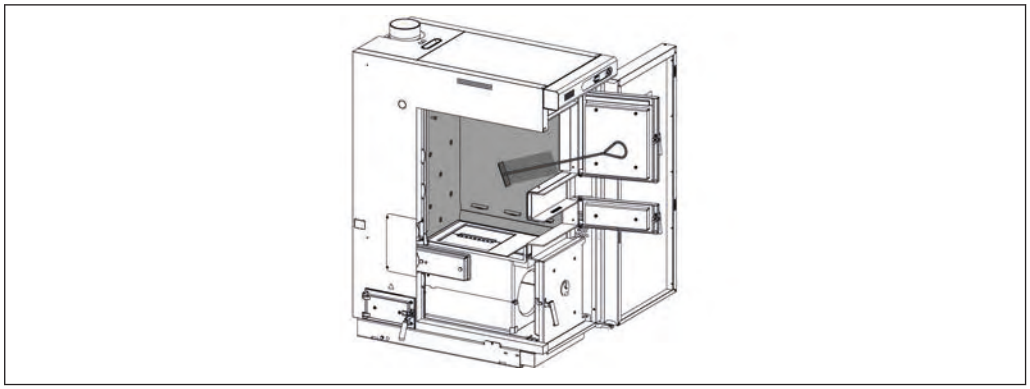
❒ Open the insulated door, pre-heating chamber door and the fuel loading chamber door.



❒ Unhinge all aprons and remove from the fuel-loading chamber.



❒ Check the primary air openings (left and right) for unobstructed air flow and clean with a screwdriver if necessary.



❒ Scrape off all the boiler walls behind the aprons with the furnace tool.

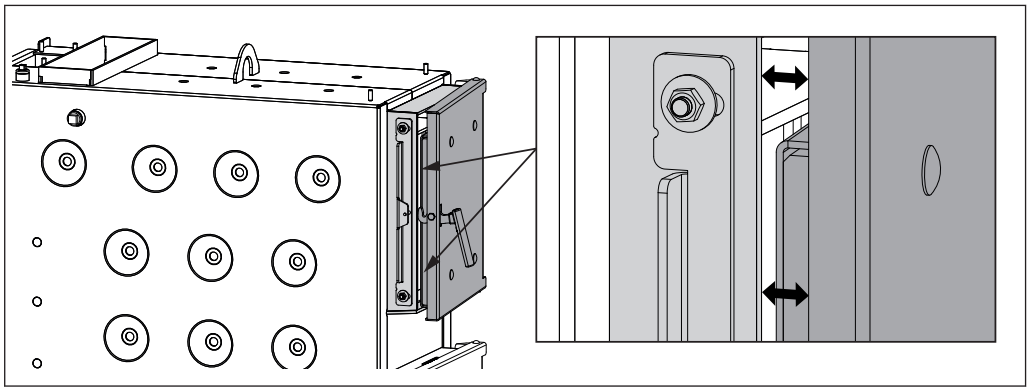
❒ After the primary air openings have been cleaned and the boiler walls scraped off, mount all aprons back in their previous position and close all the boiler doors.

6.4.7 Set and check the seal on the doors

The example below shows how to set and check the seals on the fuel loading doors. The procedure is the same for the combustion chamber door and the pre-heating chamber door!

On the side with the door stop

Checking the setting:



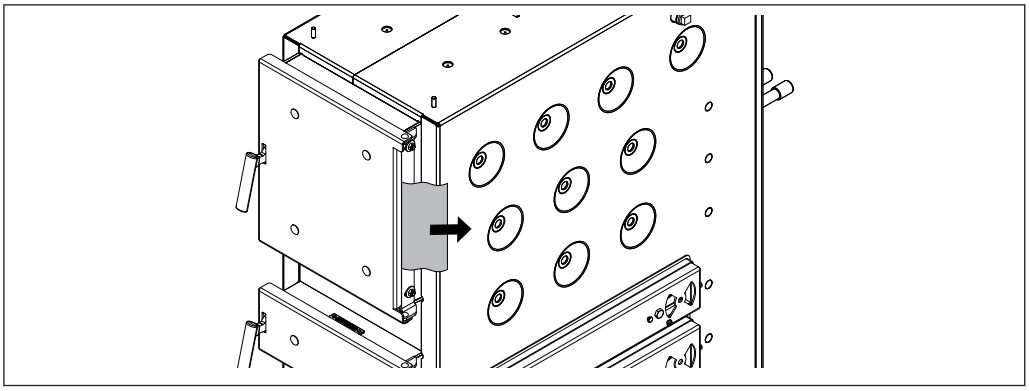
❒ Close the door

➥ A slight resistance must be felt when there is a gap of 1” (2- 3 cm):
Setting OK

➥ No resistance or only very slight resistance felt:
Setting must be corrected - push the hinge toward the back
⇨ See "Adjusting the doors" [page 67]

➥ Resistance noticeable at a gap of >1” (> 3 cm):
Setting must be corrected - push the hinge toward the front
⇨ See "Adjusting the doors" [page 67]

Checking the seal:



❒ Open the door

❒ Insert a sheet of paper at both the top and the bottom of the door stop between the door and the boiler

❒ Close the door

❒ Try to pull out the sheets of paper

↪ If the paper cannot be removed:
the door is sealed.

↪ If the paper can be removed:
The door is not sealed properly - push the hinge toward the back.
⇨ See "Adjusting the doors" [page 67]

On the side with the door handle

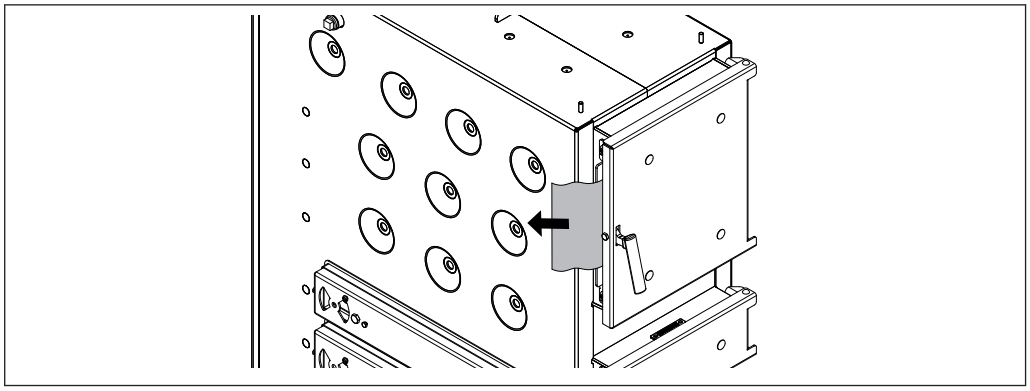
Checking the setting:

❒ Close the door

↪ The door can be closed with a normal amount of effort:
Setting OK

↪ If the door cannot be closed with the usual force or must be forced closed:
Push the locking plate toward the front
⇨ See "Adjusting the doors" [page 67]

Checking the seal:



❒ Open the door

❒ Insert a sheet of paper at both the top and the bottom area at the side of the door handle between the door and the boiler

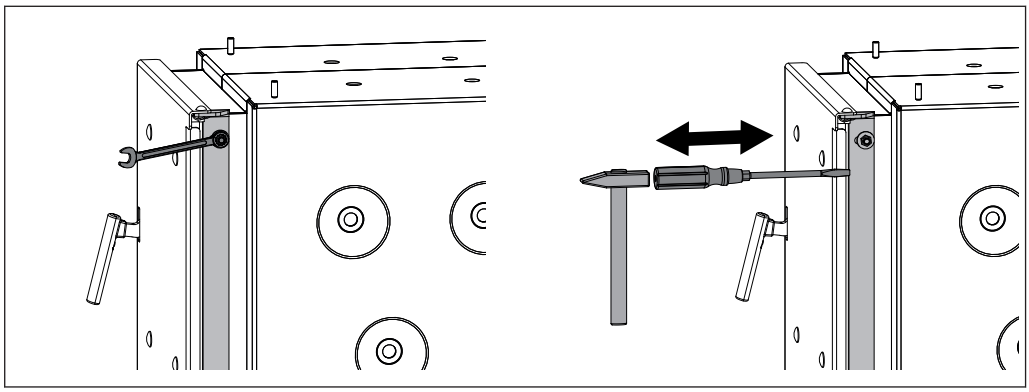
❒ Close the door

❒ Try to pull out the sheets of paper

➥ If the paper cannot be removed:
the door is sealed.

➥ If the paper can be removed:
The door is not sealed properly - push the locking plate toward the back.
⇨ See "Adjusting the doors" [page 67]

Adjusting the doors



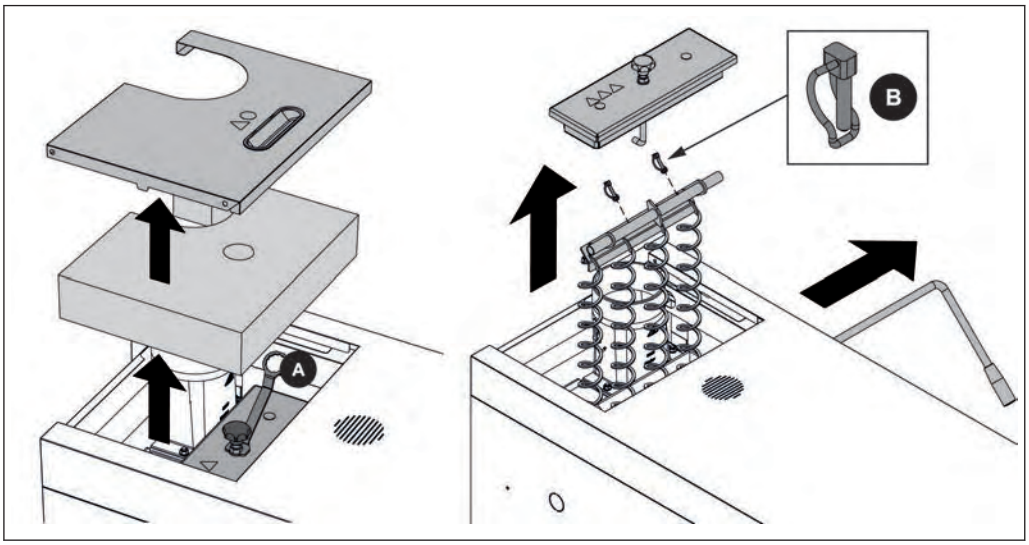
❒ Using an Allen key (AF 13), loosen the nuts on the locking plate and/or hinge at the top and bottom

❒ Use suitable tools (e.g. screwdriver and hammer) to move the locking plate and/or hinge to the rear or the front as needed

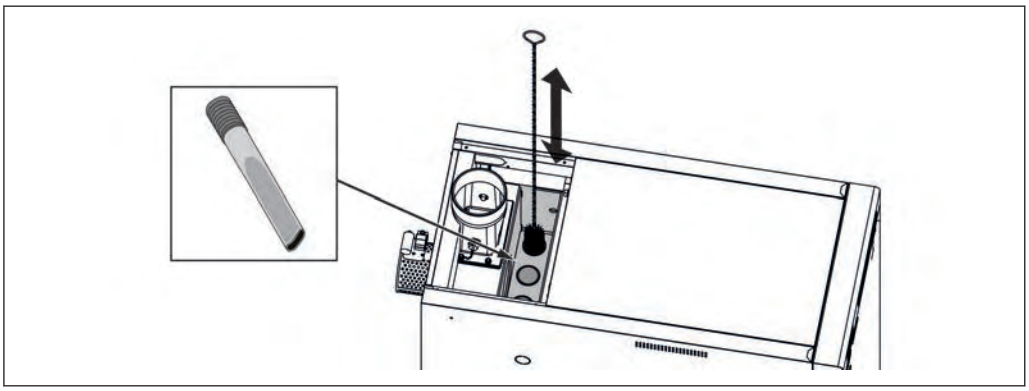
➥ Caution: the locking plate and/or hinge must be aligned in the same way at the top and bottom!

❒ Tighten the nuts at the top and bottom

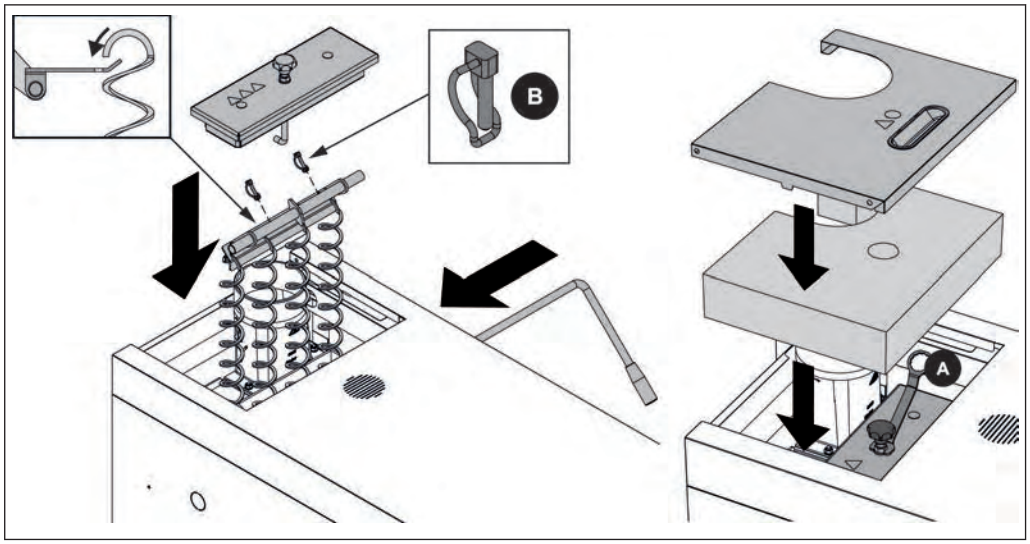
6.4.8 Cleaning the heat exchanger pipes



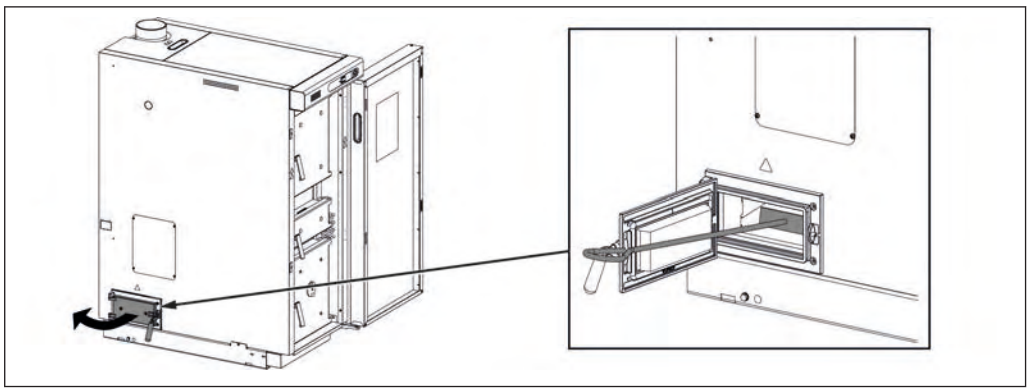
❒ Lift off the back insulating cover and remove the heat exchanger cover
  ➥ Use spanner (A) provided
❒ Remove both piping lock pins (B) and take out the WOS lever
❒ Lift out the turbolators together with the mounting bracket



❒ Remove the ash above the pipes with an ash vacuum and the ash build-up in the pipes using the cleaning brush
  ➥ The cleaning brush must be pushed all the way through before pulling it up
  ➥ The bristles cannot be turned in the pipe

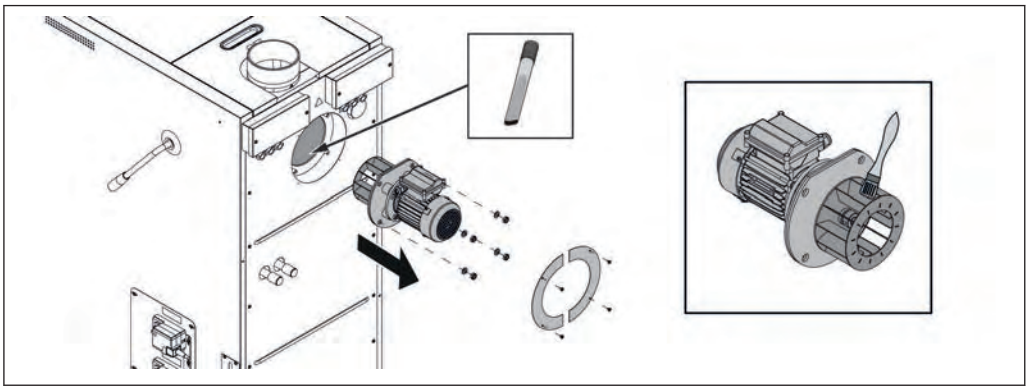


❒ Hang the WOS turbolators on the linking plate of the stay tube
  ➥ Make sure that you fit the turbolators in the right position:
  ➥ Hold the linking plate with the edge toward the top
  ➥ Hang the WOS turbolators over the edge
❒ Thread the turbolators into the heat exchanger pipes
❒ Insert the WOS lever and secure with pipe locking pins (B)
❒ Fit the heat exchanger cover by using spanner (A) and position back insulating cover



❒ Open the heat exchanger cleaning door and remove the ash with the furnance tool
  ➥ Fire-proof container with cover

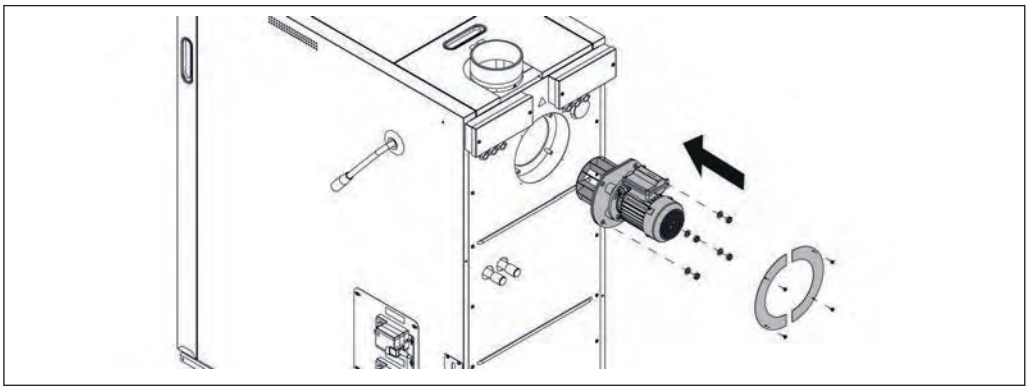
6.4.9 Cleaning the induced draft fan



❒ Remove the ID fan cover plates from the back of the boiler
❒ Remove the induced draft fan
  ➥ Take care not to damage the seal!
❒ Clean the fan wheel using a soft brush or paint brush

NOTICE! Do not move the balancing weights on the fan wheel!

❒ Remove dirt and deposits from the induced draft housing using a scraper
❒ Remove any ash which has gathered using an ash vacuum



❒ Fit the ID fan and the ID fan cover plates

6.4.10 Disposing of ash

Staff:	❒ Operator
Protective equipment:	❒ Protective workwear ❒ Protective goggles ❒ Protective gloves ❒ Safety shoes ❒ Dust mask

NOTICE

Environmental damage due to improper disposal!

❒ Collect ash in a metal container with a tight-fitting cover until its final disposal.

❒ Use metal containers exclusively for ash.

➥ The improper disposal of ash can lead to environmental damage.

❒ Carry or push the ash container to the metal container.

❒ Open the cover of the metal container.

❒ Empty the ash container.

❒ Close the cover of the metal container again.

Ashes should be places in a metal container with a tight-fitting lid. The closed container of ashes should be placed on a noncombustible floor or on the ground, well away from all combustible materials, pending final disposal. If the ashes are disposed of by burial in soil or otherwise locally dispersed, they should be retained in the closed container until all cinders have thoroughly cooled. Other waste should not be placed in this container.

⚠ WARNING

Soot and flyash – Formation and Need for Removal

The products of combustion will contain small particles of flyash. The flyash will collect in the exhaust venting system and restrict the flow of the flue gases. Incomplete combustion, such as occurs during start-up, shut-down, or incorrect operation of the heater will lead to some soot formation which will collect in the exhaust venting system. The exhaust venting system should be inspected at least once every year to determine if cleaning is necessary.

❒ Establish a routine for the storage of fuel, care of the appliance, and firing techniques.

❒ Check daily for creosote buildup until experience shows how often cleaning is necessary.

❒ Be aware that the hotter the fire, the less creosote is deposited, and that weekly cleanings can be necessary in mild weather, even though monthly cleanings can be enough in the coldest months.

❒ Have a clearly understood plan to handle a chimney fire.

⚠ WARNING

Creosote – Formation and Need for Removal
When wood is burned slowly, it produces tar and other organic vapors, which combine with expelled moisture to from creosote. The creosote vapors condense in the relatively cold 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 twice monthly 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.

6.4.11 After maintenance

After completion of maintenance work and before switching on the system perform the following steps:

- ❒ Check that all previously loosened screw connections are tightened.
- ❒ Check whether all previously removed safety devices and open doors and covers are closed again properly.
- ❒ Make sure that all tools, materials and other equipment used have been removed from the work area.
- ❒ Clean the work area and remove any substances that may have leaked such as liquids, processing materials or similar.
- ❒ Make sure that all safety devices on the system are functioning properly.

7 Boiler faults

7.1 Safety instructions for troubleshooting

⚠ WARNING

Risk of injury due to incorrect troubleshooting!

- ❒ Before starting work, ensure that there is sufficient space for assembly.
- ❒ Pay attention to order and cleanliness at the assembly site. Loosely overlapping or scattered components and tools are sources of accident.
- ❒ If components have been removed, pay attention to correct assembly, refit all fasteners and observe tightening torques for screws.
- ❒ Do not release the blockage until you have ensured that the release will not lead to a dangerous movement of system components.
- ❒ Do not acknowledge the fault until it is eliminated or its cause is resolved.
- ❒ In case of doubt contact Froling customer service.
- ❒ Before starting up again, please note the following:
  - ➥ Make sure that all troubleshooting operations have been performed and completed according to the instructions in this manual.
  - ➥ Make sure that there is no-one in the danger zone.
  - ➥ Make sure that all covers and safety devices are installed and work properly.
  - ➥ Improperly performed troubleshooting operations can cause serious injuries and considerable property damage.

7.2 Troubleshooting table

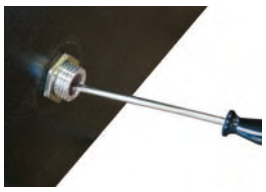
Fault description	Cause	Remedy	Staff
Display is blank	General power failure	Check the power supply	Operator
No power to the controller	Main switch is turned off	Turn on the main switch	Operator
	Residual-current circuit breaker, circuit-breaker or boiler controller circuit-breaker tripped	Switch the protective circuit breaker on the control cabinet back on	Operator
High-limit thermostat has activated	Over-temperature	▪ Allow system to cool ▪ Check status of the system (note the fault messages) ▪ Reset the high-limit thermostat	Operator
Boiler combustion faults	Insufficient chimney draught due to deposits in the chimney	Have a chimney sweep clean soot, ash and tar oil deposits from the chimney connection and chimney.	Chimney sweep
	Insufficient combustion air	Check the air inlet to the boiler room and clean, if necessary	Operator

7.2.1 Reset the high-limit thermostat.

Staff:	❒ Operator
Protective equipment:	❒ Protective workwear ❒ Protective gloves ❒ Safety shoes
Special tools:	❒ Screwdriver

The high-limit thermostat switches off the boiler at a temperature of 203-212°F (95-100°C). The pumps continue to run.

Once the temperature falls below approx. 167°F (approx. 75°C), the high-limit thermostat can be reset mechanically.



❒ Unscrew the cap of the high-limit thermostat.
❒ Unlock the high-limit thermostat by pressing with a screwdriver.
❒ Refit the cap of the high-limit thermostat.

7.3 After troubleshooting

Once the fault is eliminated, perform the following steps to start the boiler up again:

❒ Reset the emergency stop device.
❒ Acknowledge the fault message at the boiler controller.
❒ Make sure that there is no one in the danger zone.
❒ Start the boiler according to the instructions in the “Heating the boiler” section.

8 Dismantling and disposal

Dismantling is carried out exclusively by the manufacturer or by staff authorized by the manufacturer.

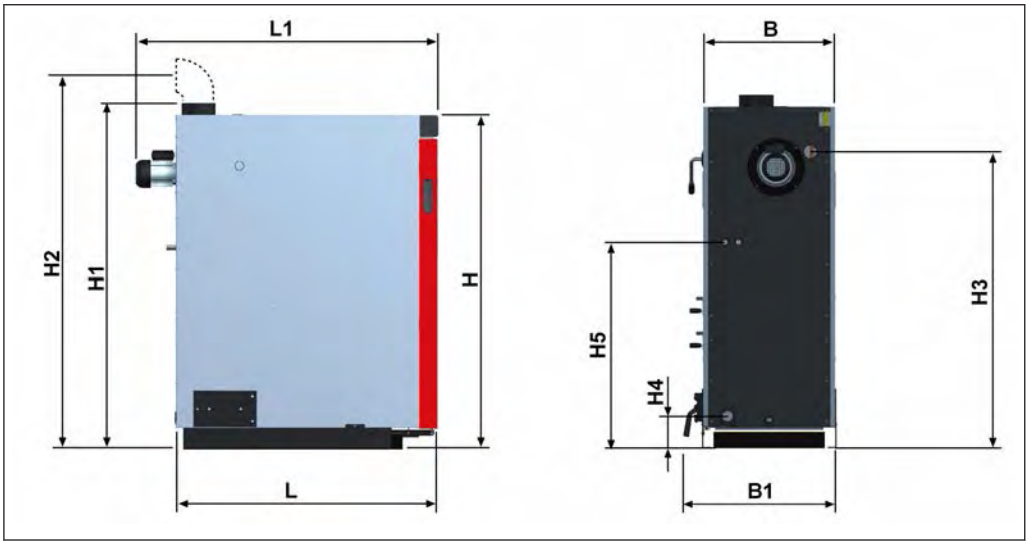
⚠ WARNING

Risk of death from improper dismantling!

- ❒ Dismantling must be carried out exclusively by employees of the manufacturer or staff authorized by the manufacturer.
- ❒ Consult the manufacturer even in case of a subsequent relocation.
- ❒ Refrain from unauthorized dismantling and relocation.
  - ➥ An error during dismantling can lead to life-threatening situations or cause substantial damage to property.

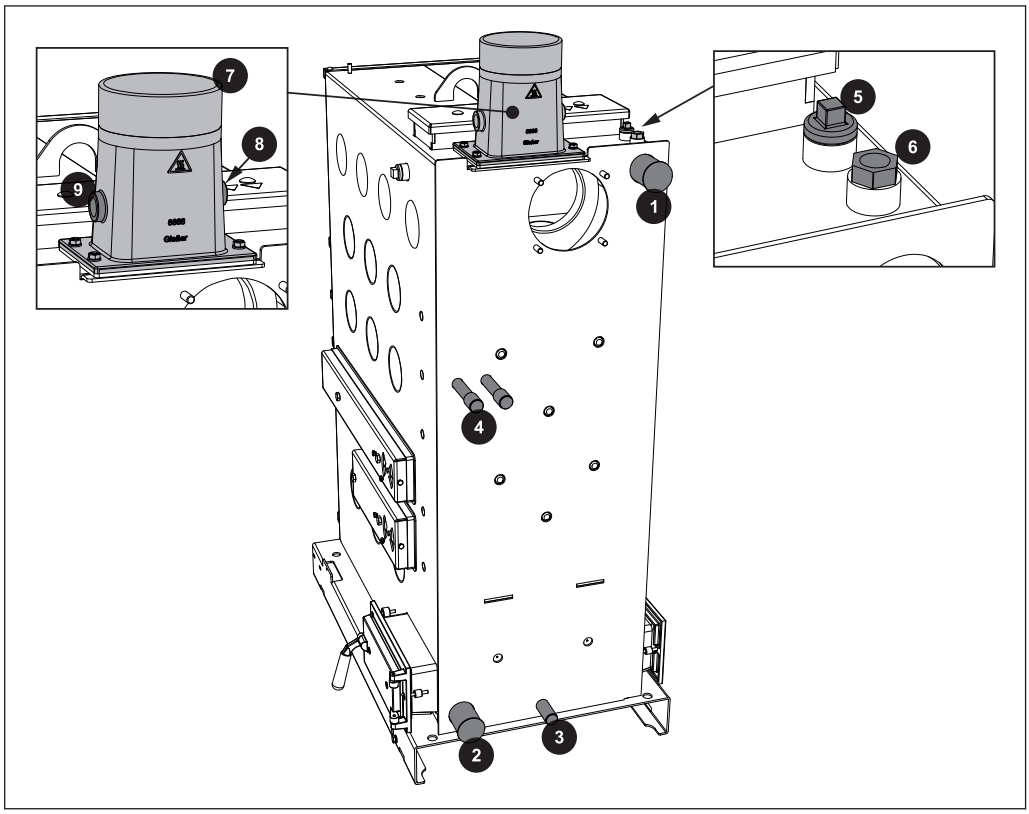
9 Technology

9.1 Dimensions



Dim.	Name	Unit	S3 Turbo 30	S3 Turbo 50
L	Length of boiler	mm inches	1160 45 ¾	1250 49 ¼
L1	Total length including induced draft fan		1260 49 ½	1350 53 ¼
B	Width of boiler		570 22 ½	670 26⅓
B1	Total width inc. side cleaning door		680 26 ¾	780 30 ¾
H	Height of boiler		1470 58	1570 62
H1	Total height incl. flue gas nozzle		1530 60 ¼	1630 64 ¼
H2	Height of flue pipe connection		1750 69	1850 73
H3	Height of flow connection		1280 50 ½	1380 54 ⅓
H4	Height of return connection		140 5 ½	140 5 ½
H5	Height of safety battery connection		890 35	970 38 ¼
H6	Height of drainage connection		120 4 ¾	120 4 ¾

9.2 Components and connections



Pos.	Name	Unit	S3 Turbo
1	Boiler flow connection	inches	6/4
2	Boiler return connection	inches	6/4
3	Drainage connection	inches	1/2
4	Safety battery connection	inches	1/2
5	Immersion sleeve for thermal discharge valve (supplied by the customer)	inches	1/2
6	Immersion sleeve for boiler sensor and STL	inches	1/2
7	Flue gas pipe connection	mm inches	150 6
8	Flue gas temperature sensor connection	inches	1/2
9	Broadband probe connection	inches	3/4

9.3 Technical data

Name		S3 Turbo 30	S3 Turbo 50
Nominal heat output	kW Btu/h	30 102,500	50 170,000
Electrical connection	230V / 50Hz / fused 15A		
Power consumption at nominal load	W Btu/h	120 410	180 615
Weight of boiler incl. insulation and control	kg lbs	530 1170	620 1370
Total boiler capacity (water)	l gal	120 32	190 50
Minimum boiler return temperature	°C °F	60 140	
Maximum permitted operating temperature		88 190	
Permitted operating pressure	bar psi	2 30	
Airborne sound level	dB(A)	< 70	
Permitted fuel as per EN ISO 17225	Part 5: Firewood class A2 / D15 L50		
Fuel loading door dimensions (width / height)	mm inches	330 / 370 13 / 14.5	330 / 370 13 / 14.5
Fuel loading chamber capacity	l gal	140 37	210 55
Combustion time[1)] – hardwood	h	3.9 - 5.6	3.9 - 5.6
Combustion time[1)] – soft wood		2.8 - 3.9	2.7 - 4.0

1. Values specified for combustion time are guideline values at nominal load and will vary depending on water content (15-25%) and fill level (80-100%)