Non-Confidential Business Information (Non-CBI)

Certification Test Report

Froling GmbH

Wood-Fired Boiler

Model: S3 Turbo 30

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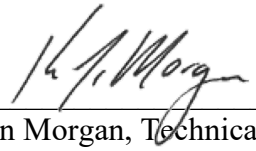
AUTHORIZED SIGNATORIES

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

Evaluator



Ken Morgan, Technical Services Director
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1. Introduction

Froling GmbH retained *OMNI* to perform U.S. Environmental Protection Agency (EPA) certification testing on the S3 Turbo 30 wood-fired boiler. The S3 Turbo 30 boiler is a manually fueled hydronic heater utilizing a Partial Thermal Storage system (PTS) of a nominal 400-gallon capacity. 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 September 7, 2021 and labeled with *OMNI* ID #2448. *OMNI* representatives Tony Tong and Ken Morgan conducted the testing, which began on June 13, 2022, and was completed on June 16, 2022. No observers were present. 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.

The testing methodology used is composed of two distinct aspects:

- **Particulate Matter Emissions**:
  - *ASTM E2618-13 "Standard Test Method for Measurement of Particulate Emissions and Heating Efficiency of Solid Fuel-Fired Hydronic Heating*". This document prescribes the methodology for the instrumentation, fueling, operation and all other aspects of operating the appliance for the purpose of emissions sampling. The appliance is brought to operating temperature before adding the test fuel charge, providing for a hot-to-hot test cycle (categories III and IV), and a "cold start" (categories I and II for units with partial thermal storage) with measurements taken under constant heat draw conditions within pre-determined target ranges. There is no attempt by the standard to modulate heat demand to simulate an indoor thermostat cycling on and off in response to changes in the indoor environment. Because this appliance uses partial thermal storage, annex A2 were used with four target test categories are used within the "Operation" scope:
  -

    Category I: Heat Output less than 15% of Manufacturer's Rated Heat Output Capacity
    Category II: Heat Output 16 To 24% of Manufacturer's Rated Heat Output Capacity
    Category III: Heat Output 25 To 60% of Manufacturer's Rated Heat Output Capacity
    Category IV: 100% Manufacturer's Rated Heat Output Capacity

  - *ASTM E2515-11 "Standard Test Method for Determination of Particulate Matter Emissions Collected by a Dilution Tunnel".* This document prescribes all matters (operation and measurement) related to securing emissions samples from a dilution tunnel.

- **Stack Loss Efficiency**
  - *CSA B415.1:22 "Performance testing of solid-biofuel-burning heating appliance".* This document prescribes the processes and methods in securing data that may be computed to arrive at an efficiency based on flue-gas losses. It is also used to calculate the emissions of carbon monoxide. Results obtained for this report were calculated using version 2.4 of the spreadsheet provided by CSA for use in conjunction with the current edition of the CSA B415.1 standard. Example calculations for CSA B415.1:22 are not provided in this report since the approved software is controlled by password protection.

Executive Summary

The S3 Turbo 30 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.

Test No. (Run No.)	Burn Category	Load Output Btu/hr.	Particulate Emissions lb./MMBtu Output	Delivered Efficiency, (% HHV)
1	IV	99,594	0.061	77.1
2	I	12,997	0.120	67.7
3	II	19,350	0.126	68.5
4	III	50,400	0.080	78.9

Appliance Description

The Fröling GmbH model S3 Turbo 30 is a gasification-type boiler which utilizes a lambda-type oxygen sensor together with internal temperature sensors to provide information to the control system. The control system can control the speed of the draft fan and open/close both primary and secondary air openings to maintain a consistent fire in response to demand. The appliance is intended only for use with a nominal 400-gallon capacity or larger partial thermal storage reservoir. Its heavy gauge mild 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.

The over-all dimensions of the appliance are 58 in. high, 22.5 in. wide and 45.75 in. long (deep). The appliance is also equipped with a thermostatic valve that regulates the amount of flow from the supply (outlet) of the boiler by forcing it to instantly return to the boiler if the return temperature is not of sufficient temperature. The nominal rating of the thermostatic valve is 61 °C. (See call-outs in figures 4 and 6.)

Prior to and during setup of the test rig and apparatus, the appliance and partial thermal storage weights were determined as were the water mass of each and a firebox calculation was performed:

Appliance weight:	1,471.6 lb.
Partial Thermal Storage Tank Weight:	736 lb.
Appliance water weight:	274.5 lb.
Appliance Water Volume:	32 gal.
Partial Thermal Storage water weight:	3,145 lb.
Firebox volume:	4.45 ft^3

Figure 1
Fröling model S3 Turbo 30, Front View

Figure 2
Fröling model S3 Turbo 30, Front ¾ View

1. Draft Fan
2. Heat Exchanger with Spiral Springs
3. Insulated Cabinet
4. Primary and Secondary Air actuators
5. Heat Exchanger Cleaning Access Door
6. Control Panel and Display
7. Smoke Spillage management
8. Fire Chamber
9. Fuel Load
10. Pre-Heating Chamber Door
11. Combustion (gasification) Chamber

Figure 3 – Fröling S3 Turbo 30 Nomenclature

2. Test rig set-up and preparations

General over-view of test rig

Figure 2 below is a schematic representation of the hydronic piping system used for these tests, which is identical to the FIG. A2.1 of ASTM E2618-13 with the following three exceptions:

- No optional appliance destratification pump was as the appliance essentially has this ability
- No optional appliance flowmeter was used as the appliance was fitted with a mechanical one that could be observed if necessary
- An addition pressure expansion tank was added to the top of the partial thermal storage vessel.

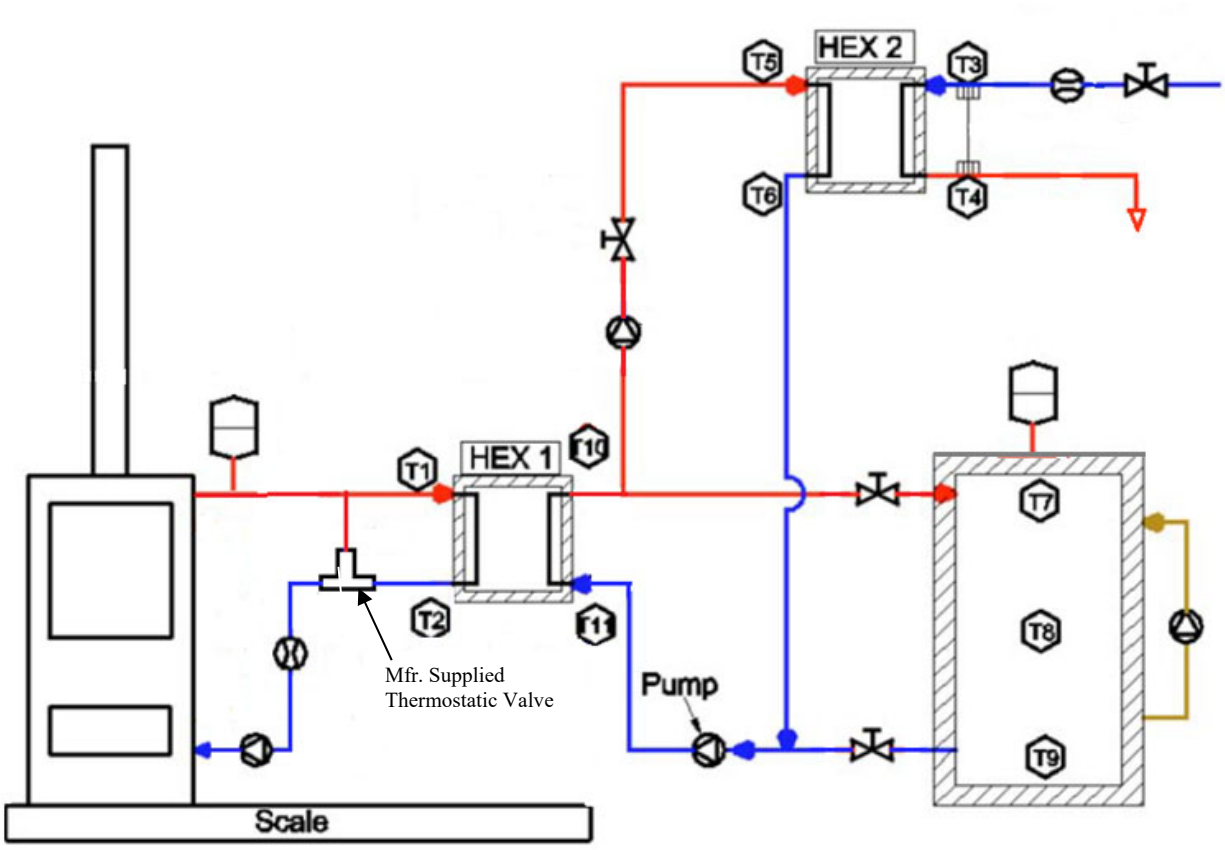


Figure 4 – Hydronic piping schematic

The temperature nodes in Figure 4 (T1, T2, etc.) are used as identities on the data that was secured, analyzed, and presented for clarity.

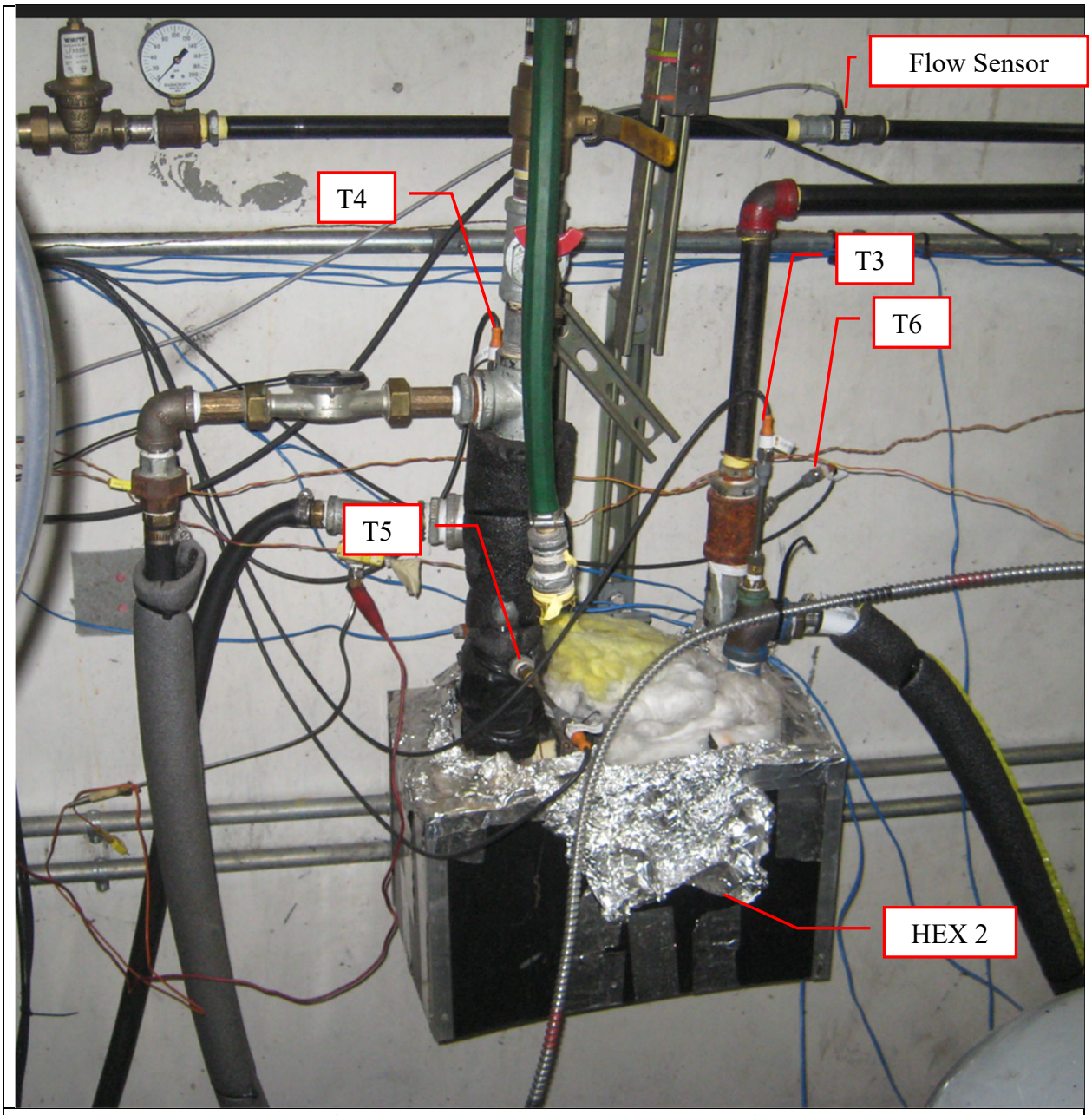


Figure 5 – Load Heat Exchanger (HEX 2)

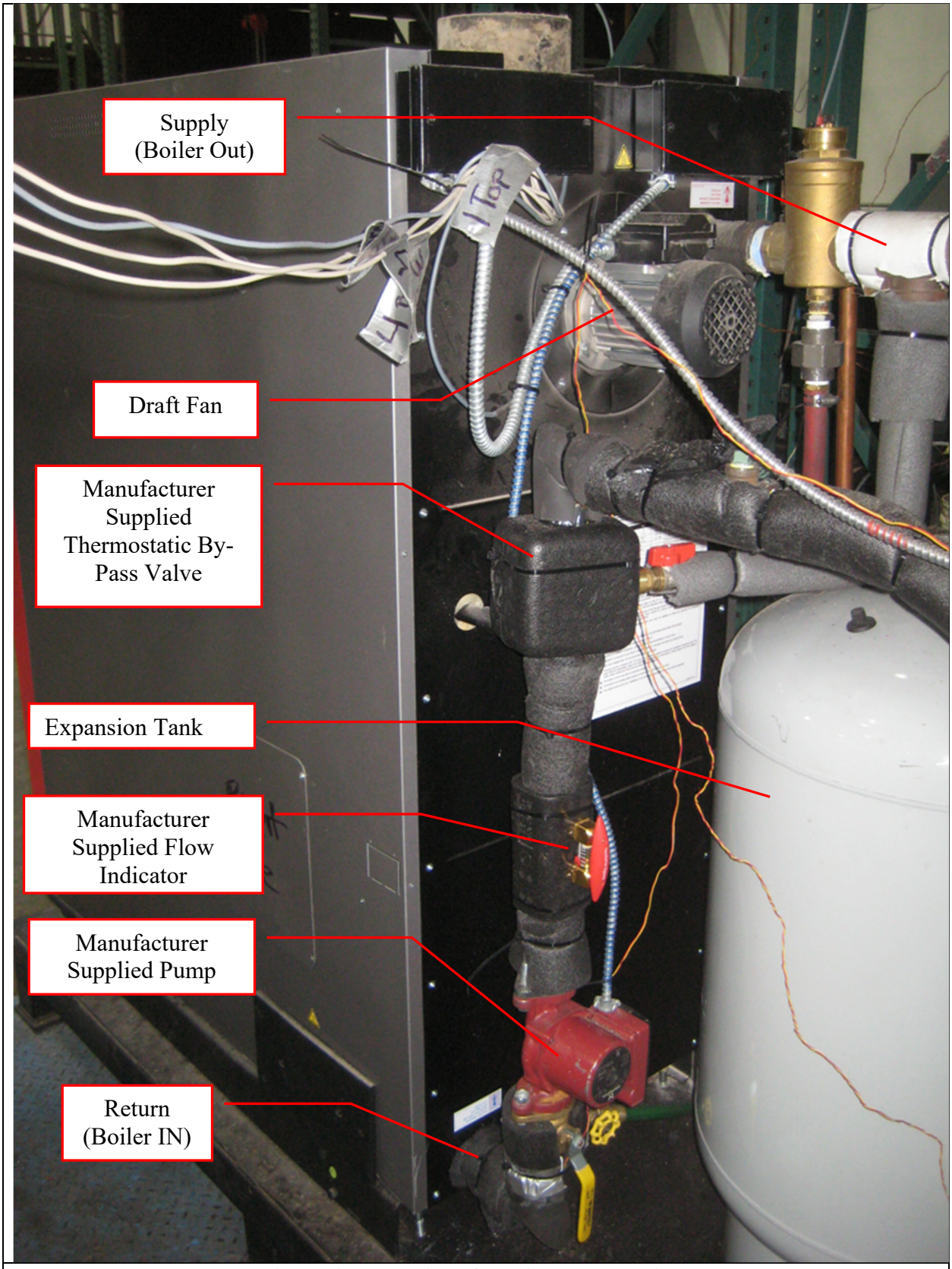


Figure 6 – Back side of appliance connections

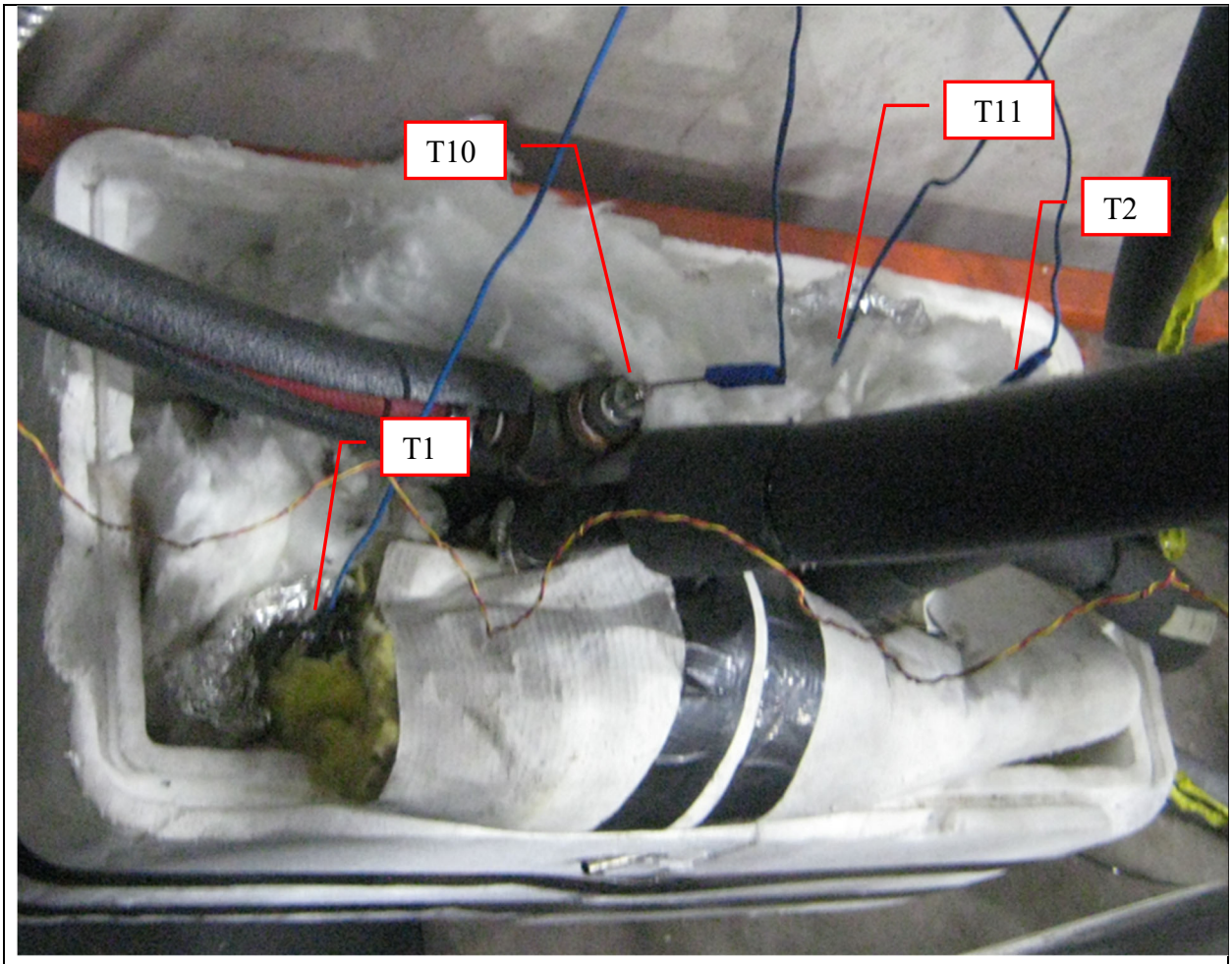


Figure 7 – Heat Exchanger 1, "HEX 1" (Buried in insulation)

Dilution Tunnel

The dilution tunnel used is 12 inches in diameter and is fully compliant with the specifications set forth in ASTM E2515-11 and illustrated in Figure 8 below. Prior to testing, sample point and travers point locations are verified to ensure placement is within specifications. Collection hood, tunnel diameter, and mixing section length are also verified to be within specifications. The dilution tunnel was cleaned prior to testing.

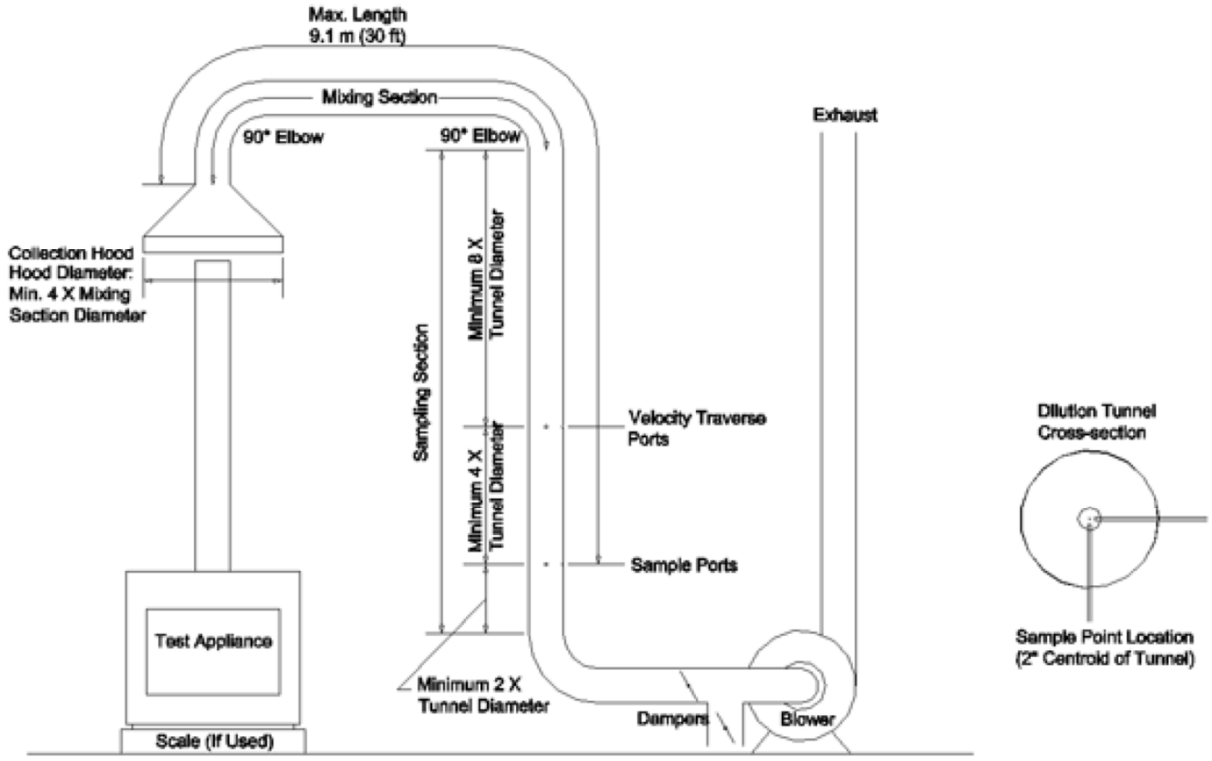


Figure 8 – Dilution tunnel specifications from ASTM E2515-11

Figure 9-Appliance installed under dilution tunnel

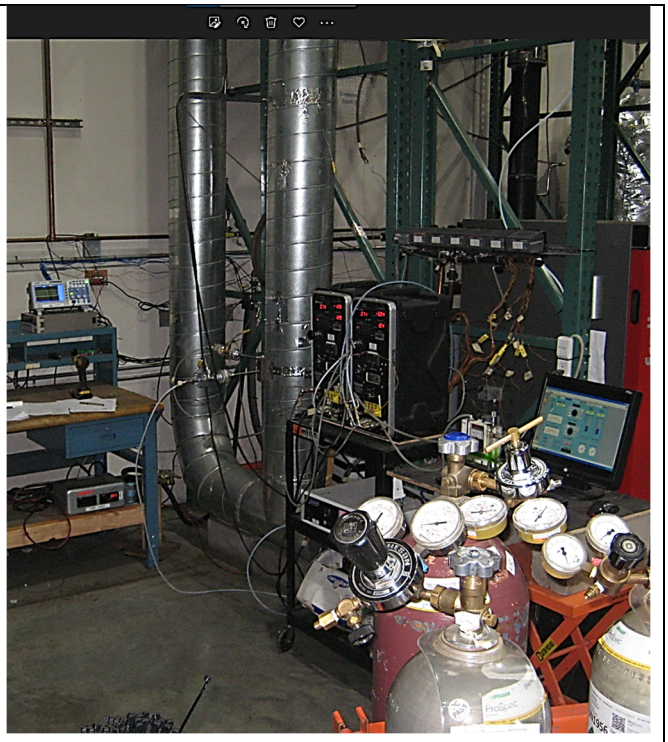


Figure 10 - General work environment

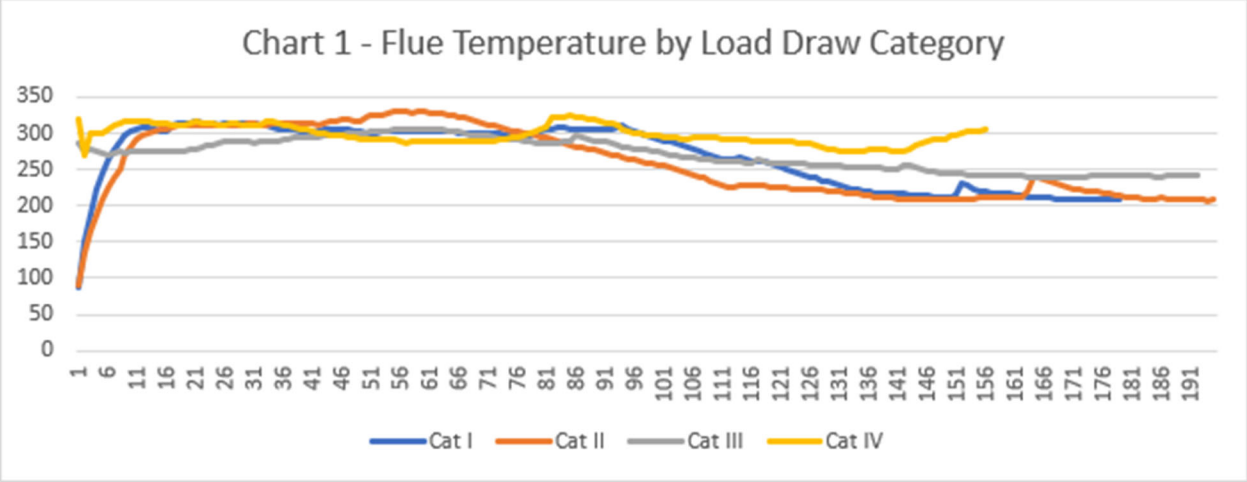
Fuel Acquisition

The test fuel used was Maple (Black) with a nominal length of 16 inches. It was acquired by a local individual who was advertising on Craigslist in OMNI's local area. OMNI personnel visited the solicitor's location where the wood was stored and verified its suitability before purchasing.

Conditioning

In preparation for testing, the appliance was conditioned for 50 hours prior to testing by operating it at Category II, and III heat output rates. See section 4 of this report for the conditioning data. The requirements for documentation of conditioning data in clause 11.1 simply state "*Record and report hourly flue gas exit temperature data and the hours of operation"*. The test rig used employs two datalogging systems; one for emissions data and one for hydronic data. The scale used for testing was connected to the hydronic data collection system and conditioning was performed using the hydronic data sampling system. The flue gas temperature probe was assigned to the emissions sampling data system, and therefore no flue gas temperature readings were subsequently taken during the conditioning process.

It is apparent that the purpose of the flue gas temperature data is to provide evidence that the appliance was operated at the prescribed medium-draw settings and that the temperatures should be comparable with temperatures produced by the appliance when operated at medium heat draw settings. Due to the nature of this appliance, which is paired with a partial thermal storage system, the flue gas temperatures are essentially the same at any heat draw-rate. This is due to the excess heat being absorbed by the partial thermal storage system resulting in a very consistent fuel-consumption rate for all heat draw categories. This can be evidenced by comparing flue gas temperatures of the four load draw categories described in this report and comparatively illustrating them as in Chart 1 below. The actual loads drawn in Btu/hr were recorded during the conditioning process offering absolute evidence that the appliance was indeed operated at the medium load draw. It would not have been possible to ascertain medium load categories based on the flue temperatures. Due to this reasoning, the conditioning data was deemed as meeting the intent of this standard.



Factory-Set Parameters / Settings used on all tests

Parameter	Set Value	Unit
Boiler temperature setpoint	85	°C
Shutdown if current boiler temperature is higher than boiler setpoint +	5	°C
Always switch off at maximum boiler setpoint +	3	°C
Minimum boiler temperature to release all pumps	65	°C
Maximum heating up time, during which HEATING status must be reached	10	min
Minimum flue gas temperature	120	°C
Maximum flue gas temperature	250	°C
Flue gas temperature, below which boiler switches to SHUTDOWN status	80	°C
Minimum difference between flue gas- and boiler temperature in HEATING	15	°C
Minimum ID fan speed	50	%
ID fan max	95	%
residual oxygen content setpoint	8	%
Residual oxygen content, above which it switches to SHUTDOWN	19.5	%

Firebox Volume Calculation

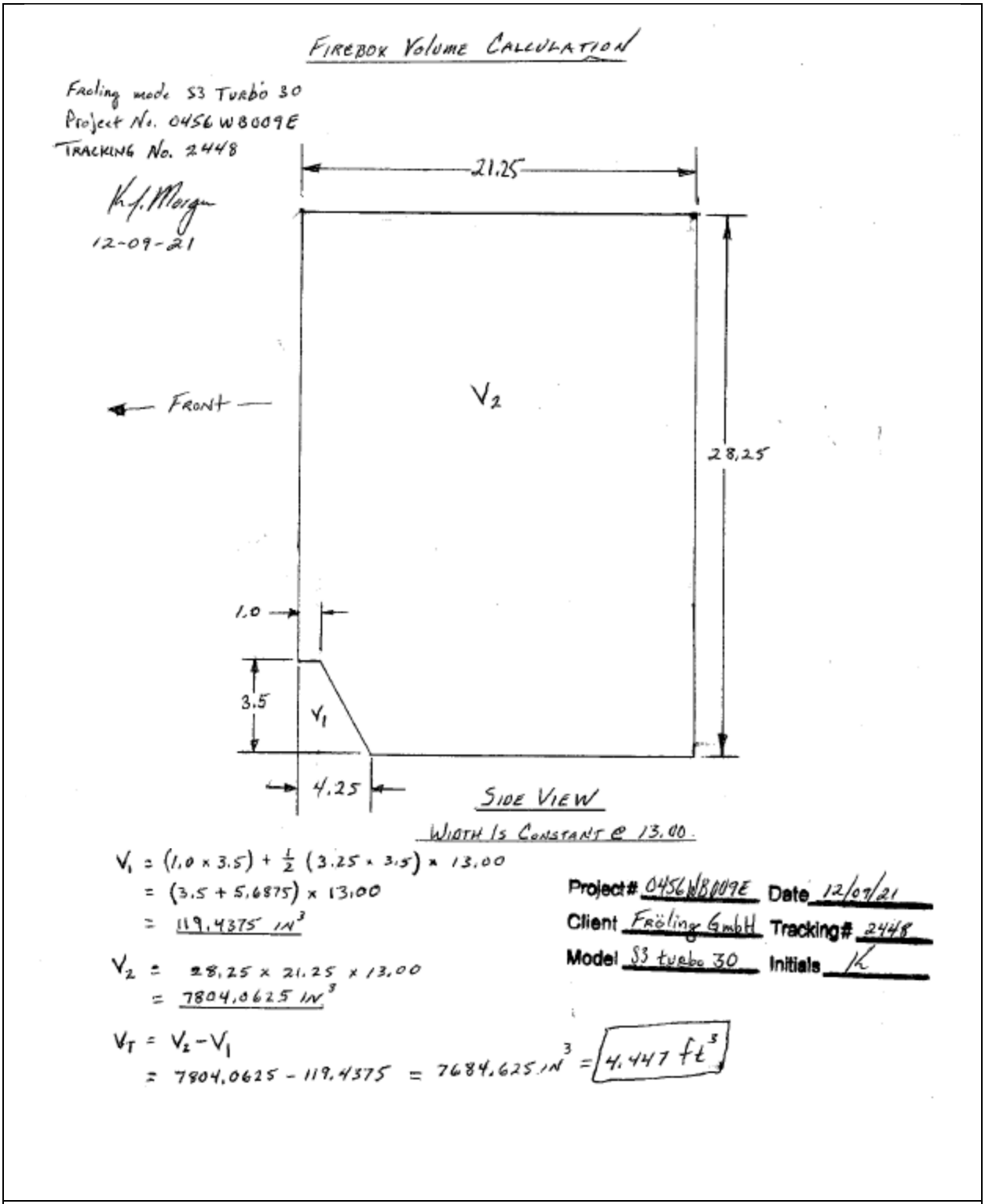
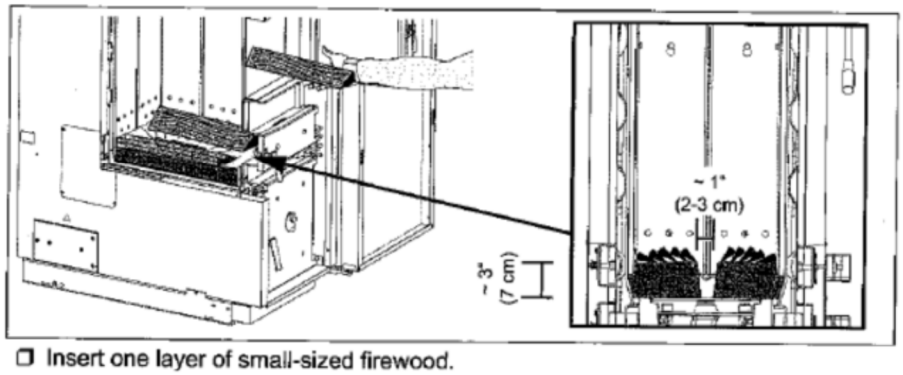


Figure 11 – Firebox Volume Calculation

Specific Manufacturer's Operation Instructions

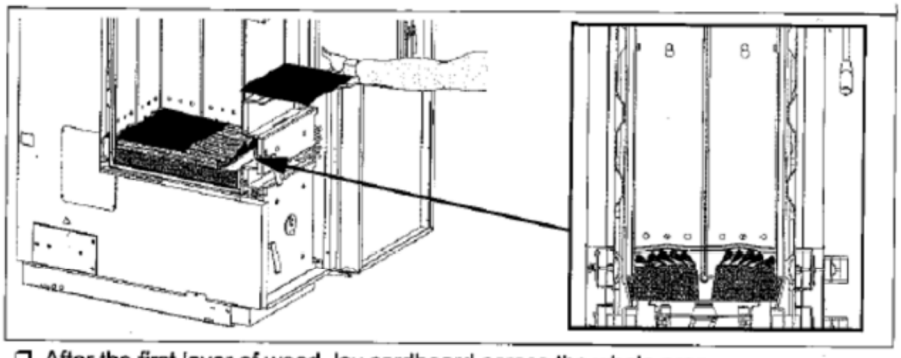
The manufacturer instructed to use the instructions provided in their printed operator's manual for all testing.



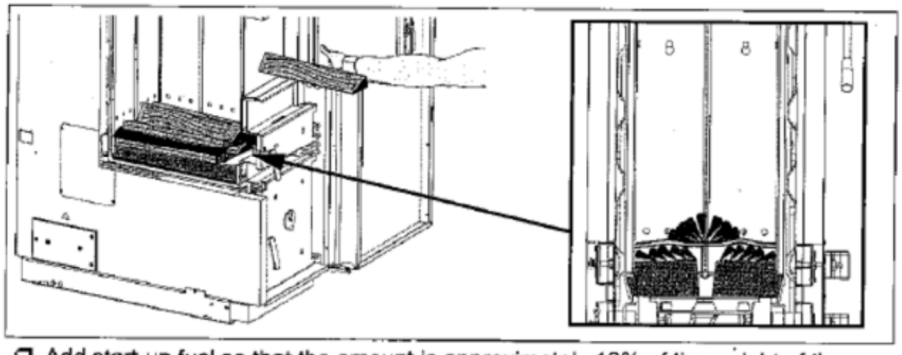
❒ Insert one layer of small-sized firewood.

↳ Approximately ten pieces of kindling with a cross-section of approximately 1" (2-3 cm) and a length of approximately 18" (46 cm)

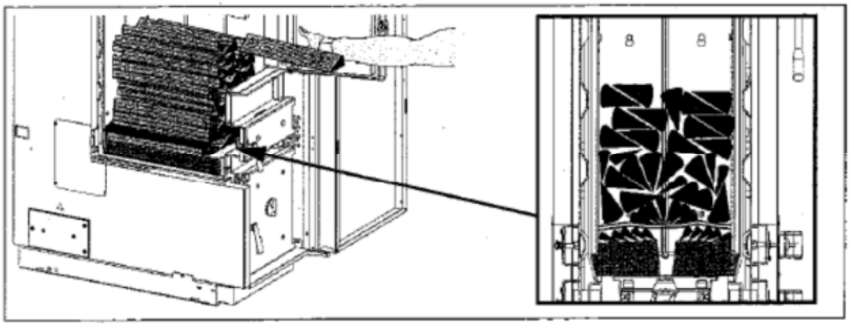
↳ Do not cover the flame slot entirely (approx. 1", 2-3cm).



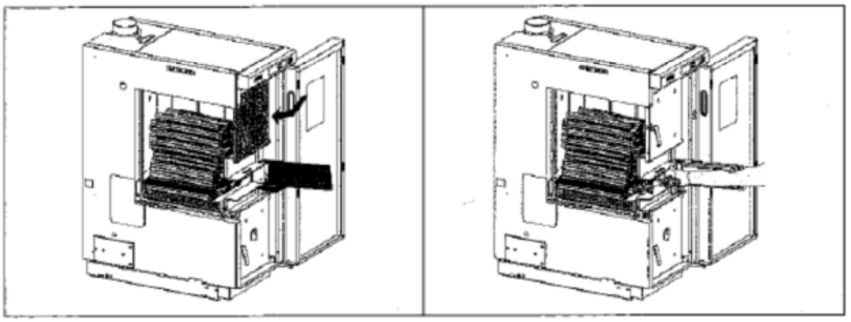
❒ After the first layer of wood, lay cardboard across the whole area.



❒ 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.

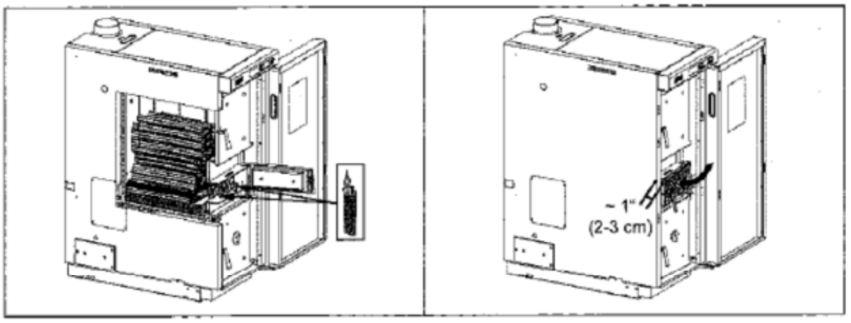


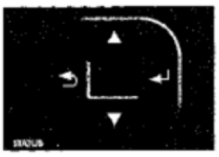
❒ Once the kindling and start-up fuel is in place, add the amount of firewood required to recharge your thermal storage.



❒ 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.

3. SAMPLING PROCEDURES AND TEST RESULTS

RUN NARRATIVES

Run 1 – Category IV, (Target: 100% of manufacturer's stated output rating)

The target output rate was the manufacturer's specified rating of 102,364 Btu/hr. (30kW). The Partial Thermal Storage system (PTS) was partially isolated from the boiler and load loops and acted simply as a pass-through for output heat energy, however over the course of the test, 2.6 °F of temperature was removed from the PTS. The resultant over-all output was 96,174 Btu/hr. which is within 10 percent of the manufacturer's stated rating as required by ASTM 2618-13. This test was performed as a hot start in accordance with procedures specified by ASTM 2618-13, Annex A2. The appliance was operated with scrap fuel for approximately 2 hours and then was scooped-out and the scale was re-zeroed. A final pre-burn charge of 45.5 pounds was added and the appliance was allowed to operate with at the pre-determined target load draw of approximately 100,000 Btu/hr. The pre-burn lasted one hour and 18 minutes before the appropriate coal bed weight was obtained. The test fuel charge was loaded simultaneously with the start of the emissions sampling system.

Negative filter weights were found on the rear filters of train A (both pre and post first-hour). This was caused by filter material transferring to the O-ring gaskets. Transfer weight can be seen as a positive weight on the O-rings. Negative filter is added back into the calculation to prevent transfer weight as being counted as emissions. No other sampling anomalies occurred. This test run was determined to be valid and appropriate for inclusion in the weighted average.

Run 1 Start-up procedures

- Fuel Loading: Done within 2 minutes.
- Door: Closed by 2 minutes.
- First hour filter change at 60 minutes.
- Notes: Hot start test.

Fig. 12 - Run 1, Fuel Load

Fig 13 - Freshly Loaded Appliance

Run 2 – Category I, (Target: <15% of manufacturer's stated output rating)

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. The PTS was charged from operation the day before and a target load was drawn from the system for more than one hour until the PTS and heater were within the 125 +/- 5 °F requirement. The test concluded when no measurable change in weight loss of more than 1 lb. over a 10-minute period was determined. The coals were removed and allowed to cool in an airtight container, after which they were sifted through a 0.125-inch sieve. The resultant remaining coals weighed 1.7 lb.

Negative filter weight was found on the rear filters of Train A (both Pre and Post -First Hour). This was caused by filter material transferring to the O-ring gaskets. Transfer weight can be seen as a positive weight on the O-rings, negative filter is added back into the calculation to prevent transfer weight as being counted as emissions. No additional sampling anomalies occurred, this test run was determined to be valid and appropriate for inclusion in the weighted average.

Run 2 Start-up procedures

- Fuel Loading: Done within 2.0 min.
- Door: Closed by 2.0 min.
- First hour filter change at 60 minutes.
- Notes: Cold-start test.

Fig. 14 - Run 2 Fuel Load

Fig. 15 - Run 2 Freshly Loaded Appliance

Fig. 16 - Run 2 Remaining Coals (1.7 lb.)

Run 3 – Category II, (Target: 16 - 24% of manufacturer's stated output rating)

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. The PTS was charged from operation the day before and a target load was drawn from the system more than one hour until the PTS and heater were within the 125 +/- 5 °F requirement. The test concluded when no measurable change in weight loss greater than 1 lb. was determined over a 10-minute period. The coals were removed and allowed to cool in an airtight container, after which they were sifted through a 0.125-inch sieve. The resultant remaining coals weighed 1.9 lb.

Negative filter weight was found on the rear filters of Train A (Post First Hour), as well as Train B. This was caused by filter material transferring to the O-ring gasket. Transfer weight can be seen as a positive weight on the O-rings, negative filter is added back into the calculation to prevent transfer weight as being counted as emissions. No additional sampling anomalies occurred, this test run was determined to be valid and appropriate for inclusion in the weighted average.

Run 3 Start-up procedures

- Fuel Loading: Done within 2.0 Min.
- Door: Closed by 2.0 Min.
- First hour filter change at 60 minutes.
- Notes: Cold-start test.

Fig. 17 - Run 3 Fuel Load

Fig. 18 - Run 3 Freshly Loaded Appliance

Fig. 19 - Run 3 Remaining Coals (1.9 lb.)

Run 4 – Category III, (Target: 25 – 60% of manufacturer's stated output rating)

The target output rate was approximately 50% of the manufacturer's maximum specified output rating of 102,364 Btu/hr. The partial thermal storage system was utilized during this run to absorb excess heat energy not absorbed by the load and was charged from operation the day before. In order to achieve three main pre-burn parameters of 1) a 125 +/- 5 °F storage system temperature, 2) a minimum of one continuous hour of operation at test load output and 3), arriving at an appropriate coal bed range, several adjustments to the output load and additions of pre-burn fuel were necessary to synchronize all three of these parameters. This extended pre-burn likely led to the effect of the CSA B415.1 SLM efficiency being 1.3% less than the measured delivered efficiency. Note: In the other three test categories, SLM efficiencies were slightly higher than their respective measured delivered efficiencies.

Negative filter weights were found on the rear filters of both Trains A first-hour and Train B. This was caused by filter material transferring to the O-ring gaskets. Transfer weight can be seen as a positive weight on the O-rings. Negative filter is added back into the calculation to prevent transfer weight as being counted as emissions. No other sampling anomalies occurred. This test run was determined to be valid and appropriate for inclusion in the weighted average

Run 4 Start-up procedures

- Fuel Loading: Done within 2.0 min.
- Door: Closed by 2.0 min.
- First hour filter change at 60 minutes.
- Notes: Hot start test.

Fig. 20 - Run 4 Fuel Load

Fig. 21 - Run 4 Freshly Loaded Appliance

Summary Tables

Table 1 – Particulate Emissions & Delivered Heat Output

Run	Heat Input (Btu/hr, HHV)	Delivered Efficiency (%)	Delivered Heat Output* (BTU/hr)	ASTM E2515 Emissions (g/hr)	Emissions Rate (lb./MMBtu Output) Corrected[1]	Emissions Rate (lb./MMBtu Output) Uncorrected[2]
1	124,906	77.1	96,251	2.65	0.061	0.067
2	99,084	67.7	67,082	3.11	0.102	0.136
3	95,903	68.5	65,692	3.76	0.126	0.162
4	99,651	78.9	78,583	2.86	0.080	0.091

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

[1] Corrected refers to gravimetric analysis that takes negative filter weights as a negative value in cases where filter residue was transferred to (stuck to) O-ring gaskets to account for the mass transfer.

[2]Uncorrected refers to gravimetric analysis where negative filter weights are taken as zero, thus reporting a higher value by over-reporting of transferred filter material. The uncorrected values were added to this revision of this report in response to a request by the US EPA in a deficiency letter dated 10/24/2022

Table 2 – Burn Rate Categories

Run	Burn Rate Category	Load Heat Output* (BTU/hr)	Load Percentage (% of Max**)
1	IV	99,594	97.4
2	I	12,997	12.7
3	II	19,350	18.9
4	III	50,400	49.3

*Represents heat output to load water only
**Maximum Manufacturer's Stated Rating

Table 3 – Particulate Emissions (First Hour)

Run	ASTM E2515 Emissions – First Hour (g/hr)
1	3.34
2	4.76*
3	6.33*
4	4.08

*Cold start tests

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	g/min
1	100,178	80.3	85.9	0.56	9.06	59.64	0.994
2	83,447	76.4	81.7	3.06	46.71	269.30	4.488
3	75,905	73.8	78.9	1.85	27.33	148.42	2.474
4	77,317	77.6	83.0	1.37	21.29	111.95	1.866

Table 5 – Test Facility Conditions

Run	Room Temperature (°F)		Barometric Pressure (Hg)		Air Velocity (ft/min)	
	Before	After	Before	After	Before	After
1	66	67	30.16	30.19	<50	<50
2	66	68	30.24	30.24	<50	<50
3	70	71	29.98	29.93	<50	<50
4	74	76	29.90	29.85	<50	<50

Table 6.1 – 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	45.6	10.25	37.49	5	2
4	44.9	10.09	36.89	4	2

Table 6.2 – 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 60% Range
2	40.3	2.8	4.2	10.63	37.70	3	3
3	41.5	3.2	3.8	10.90	38.71	3	3

Table 7 – 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	155	10.04	446.9	92
2	178	7.4	331.8	91
3	194	8.7	387.2	91
4	191	10.4	458.07	95

Table 8 – ASTM 2618 Test Condition Summary Table

						θ	W_{fuel}	MC_{ave}	Q_{inLHV}	Q_{inHHV}	Q_{out}
Category	Run No	Load % Capacity	Target Load	Actual Load[1]	Actual Load	Test Duration	Wood Weight As-fired	Wood Moisture	Heat Input (LHV)	Heat Input (HHV)	Heat Output[3]
			Btu/hr	Btu/hr	% of max[2]	min	Lb.	% DB	Btu	Btu	Btu
I	2	<15355	12,997	12.7	12.7	178	45.6	20.97	271,578	293,948	199,010
II	3	16,378–24,567	19,350	18.9	18.9	194	46.6	20.39	286,397	310,086	212,403
III	4	25,591–61,418	50,400	49.2	49.3	191	44.9	21.73	294,648	317,223	250,156
IV	1	102,364	99,594	97.3	97.4	155	45.6	21.53	299,712	322,674	248,649

[1]Load applied to secondary heat exchanger and taken away from system
[2]Maximum means manufacturer's maximum stated rating
[3]Total heat output to Storage tanks and load draw heat exchanger

Table 9 – ASTM 2618 Test Results Summary Table

			T2 Min	E_T	E	E	$E_{g/hr}$	$E_{g/kg}$	η_{del}	η_{SLM}
Category	Run No	Load % Capacity	Min Return Water Temp.	Total PM Emissions	PM Output Based	PM Output Based	PM Rate	PM Factor	Delivered Efficiency (HHV)	Stack Loss Efficiency (HHV)
			°F	g	lb./MMBtu Out	g/MJ	g/hr	g/kg	%	%
I	2	< 15% of max	118	9.22	0.102	0.044	3.11	0.54	67.7	76.4
II	3	16-24% of max	100	12.16	0.126	0.054	3.76	0.69	68.5	73.8
III	4	25-60% of max	139	9.11	0.080	0.035	2.86	0.54	78.9	77.6
IV	1	Max capacity	138	6.85	0.061	0.026	2.65	0.40	77.1	80.3

Table 10 - Year-Round Use Weighting

Category	Weighting Factor (F_i)	$\eta_{del,i}$ x F_i	Stack Loss (HHV)Efficiency x F_i (%)	$E_{g/MJ,i}$ x F_i	$E_{g/kg,i}$ x F_i	$E_{lb/MMBtu\ Out,i}$ x F_i	$E_{g/hr,i}$ x F_i
I	0.437	29.585	33.39	0.019	0.236	0.045	1.359
II	0.238	16.303	17.56	0.013	0.164	0.030	0.895
III	0.275	21.698	21.34	0.010	0.149	0.022	0.787
IV	0.05	3.855	4.02	0.001	0.200	0.003	0.133
Totals	1	71.441	76.31	0.043	0.749	0.100	3.174

Table 11 - Heating Season Weighting

Category	Weighting Factor (F_i)	$\eta_{del,i}$ x F_i	Stack Loss (HHV)Efficiency x F_i (%)	$E_{g/MJ,i}$ x F_i	$E_{g/kg,i}$ x F_i	$E_{lb/MMBtu\ Out,i}$ x F_i	$E_{g/hr,i}$ x F_i
I	0.175	11.848	13.37	0.008	0.095	0.018	0.544
II	0.275	18.838	20.30	0.015	0.199	0.035	1.034
III	0.45	35.505	34.92	0.016	0.243	0.036	1.287
IV	0.1	7.71	8.03	0.003	0.040	0.006	0.265
Totals	1	73.901	76.62	0.042	0.577	0.095	3.130

Table 12 – Year – Round Use Weighting – Carbon Monoxide Emission Rates

Category	Weighting Factor (F_i)	CO Emission Rate (g/hr, unweighted)	CO Emission Rate (g/hr) x F_i	CO Emission Rate (g/min, unweighted)	CO Emission Rate (g/hr) x F_i
I	0.437	269.30	117.68	4.49	1.96
II	0.238	148.42	35.32	2.47	0.59
III	0.275	111.95	30.79	1.87	0.51
IV	0.05	59.64	2.98	0.99	0.05
Totals	1	(N/A)	186.77	(N/A)	3.11

Table 13 – Heating Season Weighting – Carbon Monoxide Emission Rates

Category	Weighting Factor (F_i)	CO Emission Rate (g/hr, unweighted)	CO Emission Rate (g/hr) x F_i	CO Emission Rate (g/min, unweighted)	CO Emission Rate (g/hr) x F_i
I	0.175	269.30	47.13	4.49	0.79
II	0.275	148.42	40.82	2.47	0.68
III	0.45	111.95	50.38	1.87	0.84
IV	0.1	59.64	5.96	0.99	0.10
Totals	1	(N/A)	144.29	(N/A)	2.41

4. Test Data by Test Run

Conditioning Data

Hydronic Heating Appliances - Test Method ASTM E2618-13
Conditioning Data

Manufacturer:	Froling
Model:	S3 Turbo 30
Tracking No.:	2448
Project No.:	0456WB009E
Test Date:	10/14-18/21 BD, 5/9-25/21 KM
Technician:	B Davis / K. Morgan
Operation Category:	CAT II - CAT III (26 - 60 %)
Stove Weight (lb):	1471.6
Water Weight (lb):	3145

Operated at medium (16 - 60%) heat draw.

Elapsed Time (hr)	Fuel Weight, Avg MC, DB%	Flue Gas Temp (°F)	Average Load, (Btu/hr.)
10/14/2021			
0	19.8, 25.3 %		52280
1	16.9		83070
2	15.4		28815
3	17.5		91950
4	16.0		41473
5	11.6		34880
6	10.1		31339
7	2.6		27829
8	13.8		34497
9	15.2, 24.2%		108271
10	3.4		39703
11	3.7		42037
12	1.4		20390
10/18/2021			
13	24.7, 25.5%	265.5	
14	12.5	325.7	
15	8.6	235.8	
16	5	246.9	
17	1.5	205.7	
18	1.7	225.0	
19	50.3, 22.5%	217.8	
20	34.6	250.5	
21	21.9	237.4	
22	9.7	245.8	
10/26/2021			
23	21.8, 21.0 %		50720
24	42.8, 23.0%		47240
25	19.2		67369
26	38.4, 20.2 %		49190
27	26.6		49327
28	12.4		49708
29	0.9		49877
12/20/2021			
30	51.2, 25.4 %		50123
31	23.5		54005
32	25		61185
33	51.6, 25.6 %		56370
34	27.7		53137
35	8.1		28707

Continuation of Conditioning Data			
Elapsed Time (hr)	Fuel Weight	Flue Gas Temp (°F)	Average Load, (Btu/hr.)
5/9/2022			
36	13, 19.0 %		63140
37	11		44910
38	17.5, 18.8 %		19725
39	8.7		54669
40	14.9, 18.7 %		54180
41	17.9, 19.3 %		92356
42	7.2		67674
5/10/2022			
43	4.1, 25 %		62649
44	9.4, 21 %		60381
45	7.9		36712
46	4.1		16595
5/11/2022			
47	39.4, 25.4 %		60272
48	21.4		59392
49	9		65126
50	12.1, 25.2 %		64242
51	3.1		77764
52	2.9		57868
5/17/2022			
53	9, 18.5 %		26,034
54	0.1		28651
5/25/2022			
55	11.9, 18.9 %		60655
56	3.2		60074

Run 1 (Category IV)

Hydronic Heating Appliances - Test Method ASTM E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run: 1
Test Date: June 13, 2022

Burn Rate	**6.59 kg/hr dry**
Average Tunnel Temperature	92 degrees F
Average Gas Velocity in Dilution Tunnel - vs	10.04 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	26814 dscf/hour
Average Delta p	0.032 inches H20
Average Delta H	1.29 inches H20
Total Time of Test	155 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**3.34** g/hr
	0.46 g/kg
Complete Run:	**2.65** g/hr
	0.40 g/kg
	0.06 lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	24.87 cubic feet	24.74 cubic feet	33.08 cubic feet
Average Gas Meter Temperature	76 degrees F	76 degrees F	70 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	24.8 dscf	24.7 dscf	33.6 dscf
Total Particulates - mn	2.5 mg	2.4 mg	0 mg
Particulate Concentration (dry-standard)	0.000101 grams/dscf	0.000097 grams/dscf	0.000000 grams/dscf
Particulate Emissions	6.97 grams	6.73 grams	
Particulate Emission Rate	2.70 grams/hour	2.60 grams/hour	
Difference from Average	0.12 grams	0.12 grams	
Emissisons Factor	0.41 g/kg	0.40 g/kg	

Results Are Acceptable

AVERAGE

Total Sample Volume - Vm	24.80 cubic feet
Average Gas Meter Temperature	76 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	24.8 dscf
Train Precesion 7.5%	**1.80 grams**
Train Precision 0.5g/kg	0.01 grams/kg
Particulate Concentration (dry-standard)	0.00010 grams/dscf
Particulate Emissions	6.85 grams
7.5% of the average particulate emissions	0.51 grams

ADDITIONAL ACCEPTANCE CRITERIA

PTS Water Temperature at test start >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	9.59 cubic feet
Average Gas Meter Temperature	73 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	9.63 dscf
Total Particulates - mn	1.2 mg
Particulate Concentration (dry-standard)	0.00012 grams/dscf
Particulate Emissions	3.34 grams
Burn Rate	7.25 (dry kg/hr)

Method ASTM E2618 with PTS Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Comments:	

Parameters:

Run Number:	1
Test Date:	6/13/22
Total Fuel Weight (lb):	45.6
Average Moisture of Fuel (% dry):	21.53
Average Moisture of Fuel (% wet):	17.72
Average Temperature of Appliance Water at Start of Test (°F):	165.4
Average Temperature of Appliance Water at End of Test (°F):	165.7
Average Thermopile Reading (°F):	46.6
Average Load Side Liquid Flow Rate (gal/min):	4.3
Time Interval (min):	155
Burn Rate (kg/hr):	6.59
Emissions (g):	6.85
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

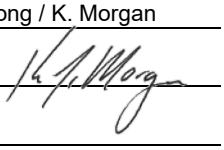
Calculations:

HHV Heat Input (Btu):	322674
Net HHV Heat Input (Btu):	322674
Net HHV Heat Input Rate (Btu/hr):	124906
LHV Heat Input (Btu):	299712
Net LHV Heat Input (Btu):	299712
Net LHV Heat Input Rate (Btu/hr):	116017
Appliance Water Specific Heat (Btu/lb°F):	1.001
Tank Water Specific Heat (Btu/lb°F):	1.001
Q_{unit} (Btu):	110
Q_{Load} (Btu):	257284
$Q_{Storage}$ (Btu):	-8746
Total Heat Output (Btu):	248649
Total Heat Output Rate (Btu/hr):	96251
Total Particulate Emissions (g):	6.85
Time Interval (hr):	2.6
Load Output Rate (Btu/hr):	99594
Emissions Factor(g/kg):	0.40
Total Particulate Emissions Rate (g/MJ):	0.026
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.061**
Total Particulate Emissions (g/hr):	2.65
Delivered Efficiency, HHV (%):	**77.1**
First Hour Emissions Factor (g/kg):	0.46
First Hour Emissions Rate (g/hr):	3.34

Flue Loss Efficiency

Manufacturer: Froling GmbH
Model: S3 Turbo 30
Date: 06/13/22
Run: 1
Control #: 2448
Test Duration: 155
Output Category: IV

Technicians: T. Tong / K. Morgan



Test Results in Accordance with CSA B415.1-10

	HHV Basis	LHV Basis
Overall Efficiency	80.3%	85.9%
Combustion Efficiency	99.5%	99.5%
Heat Transfer Efficiency	81%	86.3%

Output Rate (kJ/h)	105,605	100,178	**(Btu/h)**
Burn Rate (kg/h)	6.59	14.51	**(lb/h)**
Input (kJ/h)	131,529	124,769	**(Btu/h)**

Test Load Weight (dry kg)	17.01	37.49	**dry lb**
MC wet (%)	17.72		
MC dry (%)	21.54		
Particulate (g)	6.85		
CO (g)	154		
Test Duration (h)	2.58		

Emissions	Particulate	CO
g/MJ Output	0.03	0.56
g/kg Dry Fuel	0.40	9.06
g/h	2.65	59.64
lb/MM Btu Output	0.06	1.31

Air/Fuel Ratio (A/F)	11.29

VERSION: **2.4** **4/15/2010**

OMNI-Test Laboratories, Inc. **ASTM E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 1

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/13/2022

Test Crew: Titong K. Morgan

OMNI Equipment ID numbers: 00335, 00336, 00594, 00356

Wood Heater Run Notes

Air Control Settings

Primary:

N/A - Automatic
Target Load: MAX (~100,000)

Secondary: N/A - Automatic

Tertiary/Pilot: N/A - Automatic

DRAFT
Fan: N/A - Automatic

Preburn Notes

Time	Notes
10:52	Added Preburn Charge = 45.5 lb.
12:44	End Pre-Burn, start sampling Run

Test Notes

Sketch test fuel configuration:

See Fuel Photos in Test Report.

Start up procedures & Timeline:

Bypass: N/A
Fuel loaded by: Less than 2 minute
Door closed at: By one minute
Primary air: N/A - Auto matic

Notes: No further Start-up Notes

Time	Notes
60 min	First-hour Filter change.
12:44	Test started at 45.6 lbs
	Loaded within 2 min

13:44 First hour filters change
15:19 Test ended

Technician Signature: K. J. Morgan Date: 6-13-22

ASTM E2780 Wood Heater Run Sheets

Client: Froling GmbH Project Number: 0456WB009E Run Number: 1
Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/13/2022
Test Crew: T. Tong K. Morgan
OMNI Equipment ID numbers: 00594, 00335, 00336, 00410, 00716, 00322, 00255, 00677

Wood Heater Supplemental Data

Start Time: 12:44 Booth #: 3
Stop Time: 15:19

Stack Gas Leak Check:
Initial: _____ Final: _____

Sample Train Leak Check:
A: 0.000 @ 15.83 "Hg A1 0.000 @ 15.83 "Hg
B: 0.000 @ 16.70 "Hg

Calibrations: Span Gas CO_2: 16.94 % CO: 4.32 %

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	11:10	11:12	15:30	15:33
CO_2	0.00	16.90	0.02	16.96
CO	0.00	4.30	0.00	4.31

Air Velocity (ft/min): Initial: <50 Final: <50
Scale Audit (lbs): Initial: 10 Final: 10
Pitot Tube Leak Test: Initial: good Final: good
Stack Diameter (in): 6
Induced Draft: 0.041
% Smoke Capture: 100
Flue Pipe Cleaned Prior to First Test in Series:
Date: 12/16/21 Initials: KM

	Initial	Middle	Ending
P_b (in/Hg)	30.16		30.19
RH (%)	53		54
Ambient (°F)	66		67

Tunnel Traverse

Microtector Reading		dP (in H_2O)		T(°F)
1	7	.022	.018	99
2	8	.024	.022	
3	9	.024	.028	
4	10	.028	.028	
5	11	.026	.022	
6	12	.020	.016	99
Center:				
		.033		

STATIC .246

Tunnel Static Pressure (in H_2O):	
Beginning of Test	End of Test
-0.246	-0.254

Background Filter Volume: 33.080 ft^3

Technician Signature: Tom Tong Date: 06/13/22

Project# 0456WB009E Date 6-13-22
Client Froling Tracking# 2448
Model S3 TURBO 30 Initials K

FROLING - RUN 1 (CAT IV) 0456WB009E

6/13/22

TIME: 10:32 TEST FUEL LOAD CAL CHECK: 12.0 = 12.0, 22.0 = 22.0

	PC. No.	Weight (lb)	L x W x h	Moisture
	1	8.6	16 8 4	19.0, 24.9, 24.3, 22.0, 24.2
15.2	2	~~6.6~~ 6.6	16 7 5	19.7, 19.0, 23.9, 19.4, 22.1
22.4	3	7.2	16 6.75 4.5	19.0, 25.7, 24.2, 24.9, 21.0
29.5	4	7.1	16 7 4	19.4, 20.5, 19.6, 20.1, 19.4
36.6	5	7.1	16 5 2/4 5 3/4	22.3, 23.1, 20.0, 23.0, 20.8
41.2	6	4.6	16 5 3	19.3, 22.1, 19.2, 21.4, 19.4
45.6	7	4.4	16 4 6	20.6, 21.2, 19.8, 22.8, 21.9
		45.6 lb →	4.6 - 9.1 coal bed	(00431 moisture REF; 00340 moisture meter; 296-TSS tape Measure)

PREBURN

PC	Weight	Moisture
1	10.5	22.3, 24.8
2	7.3	24.6, 22.1
3	4.7	21.2, 18.9
4	6.7	24.2, 23.8
5	6.8	25.2, 23.8
6	5.4	23.4, 20.8
	41.4 lb	

K. A. Morgan
6/13/22

WATER FLOW CHECKS

PRETEST

Time Interval RANGE OF WATER DATA =

T 268-273, 35.3 lb., 60.18 s

MID-TEST

T = 367-370, 35.7 lb., 61.71 s

END TEST

T = 457-466, 35.6 lb, 60.85 s

00648 Stop Watch
00353 SCALE

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

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Run #:	1
Test Date:	June 13, 2022

Time: 11:40

Calibration	
12% =	12.0
22% =	22.0

Cordwood Fuel Type	Wet Weight (lb)	% Moisture					
Maple, Black 8 x 4 x 16"	8.6	19	24.9	24.3	22	24.2	196.8
Maple, Black 7 x 5 x 16"	6.6	19.7	19	23.9	19.4	22.1	137.4
Maple, Black 6.75 x 4.5 x 16"	7.2	19	25.7	24.2	24.9	21	165.3
Maple, Black 7 x 4 x 16"	7.1	19.4	20.5	19.6	20.1	19.4	140.6
Maple, Black 5.75 x 5.75 x 16"	7.1	22.3	23.1	20	23	20.8	155.1
Maple, Blacx 5 x 3 x 16"	4.6	19.3	22.1	19.2	21.4	19.4	93.3
Maple, Black 4 x 6 x 16"	4.4	20.6	21.2	19.8	22.8	21.9	93.5
							0.0
							0.0
							0.0
							0.0
							0.0

Total Weight of Load (lb): 45.6

Total Moisture of Load (%): 21.53

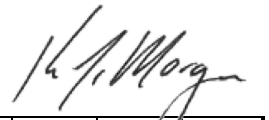
Equipment Numbers:
00296-T55, 00340, 00431

Hydronic Heating Appliances - Test Method ASTM E2618-13
Pre-Burn Data

Manufacturer: Froling
Model: S3 Turbo 30
Tracking No.: 2448
Project No.: 0456WB009E
Run: 1
Test Date: June 13, 2022

Load Average
97846.71 Btu / hr

Appliance				LOAD										PTS				
Time, Min	Supply (T1)	Return (T2)	ΔT	Load IN, °F (T3)	Load OUT, °F (T4)	Flow Hz	Water Flow, GPM	Cpi	ΔT	Mass Flow Rate, lb/min	Btu/Min	**Btu/Hr**	Fuel Weight, LB	PTS TOP (T7)	PTS Bottom (T9)	PTS Mid (T8)	PTS ΔT	Boiler Return
187	175.8	74.0	101.8	61.939	88.602	848.612	4.210	1.001	26.663	35.080	936.4	**56186.28**	8.67	125.9	125.9	124.2	0.0	135.4545
188	177.2	73.3	103.9	61.674	85.059	833.189	4.133	1.001	23.385	34.440	806.4	**48381.09**	45.37	125.9	125.9	124.1	0.0	137.7141
189	177.6	72.0	105.6	61.521	84.287	851.773	4.226	1.001	22.766	35.213	802.6	**48156.15**	44.63	125.9	125.9	124.1	0.0	136.8467
190	178.9	71.6	107.3	61.418	83.319	850.493	4.220	1.001	21.901	35.160	771.0	**46257.44**	44.15	125.9	125.9	124.1	0.0	136.7643
191	179.9	71.8	108.1	61.325	82.918	850.873	4.221	1.001	21.593	35.176	760.5	**45628.17**	44.26	125.9	125.9	124.1	0.0	136.4378
192	181.1	81.4	99.7	61.267	83.118	850.201	4.218	1.001	21.851	35.149	768.9	**46136.46**	43.84	121.0	125.8	124.1	4.8	136.3184
193	181.9	99.8	82.1	61.208	92.681	849.780	4.216	1.001	31.473	35.131	1107.0	**66419.71**	43.03	121.4	125.8	124.0	4.4	138.9893
194	183.0	103.0	80.0	61.167	104.590	849.231	4.213	1.001	43.423	35.109	1526.3	**91580.55**	42.67	123.2	125.6	123.9	2.4	137.914
195	184.4	103.7	80.7	61.134	106.670	848.747	4.211	1.001	45.536	35.089	1599.7	**95982.94**	42.57	123.6	125.4	123.5	1.8	137.8743
196	185.9	109.4	76.5	61.106	106.096	848.529	4.210	1.001	44.990	35.080	1580.1	**94807.31**	42.27	123.9	125.3	123.4	1.4	138.696
197	187.0	107.8	79.3	61.069	107.970	849.135	4.213	1.001	46.902	35.105	1648.4	**98906.76**	41.80	124.1	125.1	123.0	1.0	138.5602
198	188.1	107.8	80.3	61.036	108.229	848.907	4.212	1.001	47.193	35.096	1658.3	**99495.13**	41.13	124.0	124.9	123.2	0.9	138.2571
199	188.8	107.9	80.9	61.008	108.564	847.988	4.207	1.001	47.556	35.058	1669.2	**100152.49**	41.15	124.0	124.8	123.2	0.8	138.5708
200	189.1	107.8	81.3	60.978	108.760	843.270	4.184	1.001	47.781	34.862	1667.7	**100063.80**	40.70	124.1	124.9	123.2	0.8	138.5547
201	189.0	107.9	81.0	60.970	109.207	827.394	4.104	1.001	48.237	34.203	1651.8	**99108.20**	39.97	124.1	124.7	123.1	0.6	138.4986
202	188.8	107.7	81.2	60.961	108.452	856.050	4.247	1.001	47.492	35.393	1682.9	**100971.99**	39.55	123.9	124.7	123.0	0.8	138.6906
203	188.5	107.6	80.9	60.950	108.349	855.323	4.244	1.001	47.400	35.363	1678.2	**100690.53**	39.43	123.9	124.6	123.0	0.8	138.5789
204	188.4	107.5	80.8	60.918	108.233	855.220	4.243	1.001	47.315	35.359	1675.0	**100498.57**	39.12	123.8	124.6	122.8	0.8	138.4815
205	188.1	107.5	80.7	60.880	108.137	855.917	4.247	1.001	47.257	35.388	1674.3	**100458.64**	38.28	123.7	124.4	122.7	0.7	138.4606
206	188.3	107.4	80.9	60.864	108.112	855.004	4.242	1.001	47.248	35.350	1672.2	**100332.36**	38.07	123.6	124.5	122.7	0.9	138.4814
207	188.3	107.4	80.9	60.850	108.066	855.029	4.242	1.001	47.216	35.351	1671.1	**100267.82**	37.85	123.6	124.4	122.7	0.8	138.7068
208	188.4	107.3	81.0	60.830	108.132	854.686	4.240	1.001	47.301	35.337	1673.5	**100407.73**	37.10	123.6	124.3	122.6	0.7	138.524
209	188.8	107.4	81.4	60.804	108.203	855.737	4.246	1.001	47.400	35.381	1679.0	**100741.12**	36.83	123.6	124.3	122.5	0.7	138.5638
210	189.2	107.3	81.9	60.756	108.209	854.490	4.239	1.001	47.453	35.329	1678.5	**100707.30**	36.73	123.6	124.2	122.5	0.7	138.5919
211	189.5	107.3	82.3	60.712	107.892	841.905	4.177	1.001	47.180	34.807	1644.1	**98648.41**	35.89	123.4	124.2	122.5	0.8	138.5783
212	189.9	107.2	82.7	60.688	108.135	857.131	4.253	1.001	47.446	35.439	1683.5	**101007.34**	35.68	123.5	124.1	122.3	0.6	138.6951
213	190.2	107.2	83.0	60.677	108.169	858.019	4.257	1.001	47.492	35.476	1686.8	**101209.52**	34.98	123.5	124.0	122.2	0.6	138.612
214	191.0	107.1	83.9	60.668	107.990	857.060	4.252	1.001	47.323	35.436	1678.9	**100735.41**	34.94	123.3	123.9	122.2	0.7	138.6176
215	190.9	107.1	83.7	60.659	108.168	857.121	4.253	1.001	47.509	35.439	1685.6	**101138.93**	34.24	123.4	123.9	122.2	0.5	138.6175
216	191.4	107.2	84.2	60.643	108.310	857.226	4.253	1.001	47.667	35.443	1691.5	**101487.85**	34.24	123.5	123.9	122.2	0.4	138.5175
217	191.3	107.2	84.1	60.627	108.401	856.910	4.252	1.001	47.774	35.430	1694.6	**101678.88**	33.63	123.5	123.9	122.4	0.4	138.8061
218	191.5	107.0	84.6	60.603	108.402	857.069	4.252	1.001	47.799	35.437	1695.9	**101751.64**	33.32	123.3	123.9	122.4	0.5	138.5859
219	192.0	106.9	85.1	60.571	107.336	856.612	4.250	1.001	46.765	35.418	1658.3	**99496.96**	32.69	123.2	123.8	122.3	0.5	138.7916
220	192.1	107.1	84.9	60.520	108.351	857.110	4.253	1.001	47.831	35.439	1697.1	**101824.57**	32.62	123.4	123.8	122.2	0.4	138.6577
221	192.3	107.1	85.2	60.472	108.502	857.002	4.252	1.001	48.030	35.435	1703.9	**102236.55**	31.89	123.4	123.7	122.2	0.3	138.7838
222	192.9	107.4	85.5	60.419	109.388	835.230	4.143	1.001	48.969	34.531	1692.9	**101576.14**	31.39	123.4	123.6	122.2	0.2	138.9076
223	193.6	107.1	86.4	60.350	108.140	837.900	4.157	1.001	47.789	34.642	1657.5	**99448.18**	31.31	123.4	123.6	122.2	0.2	139.0879



224	194.0	107.1	86.9	60.297	108.733	851.365	4.224	1.001	48.436	35.201	1707.1	**102423.04**	30.90	123.4	123.6	122.1	0.2	138.989
225	194.8	106.9	87.9	60.287	108.672	858.456	4.259	1.001	48.385	35.496	1719.5	**103170.62**	30.53	123.3	123.6	122.0	0.3	139.3802
226	194.9	107.1	87.8	60.273	108.874	858.403	4.259	1.001	48.602	35.494	1727.1	**103626.67**	29.92	123.5	123.5	122.1	0.0	139.0341
227	195.3	107.1	88.2	60.243	108.980	858.500	4.259	1.001	48.737	35.498	1732.1	**103927.07**	29.73	123.5	123.5	122.1	0.1	139.0924
228	196.2	107.0	89.1	60.221	108.749	856.890	4.251	1.001	48.528	35.431	1721.4	**103286.34**	29.29	123.3	123.5	122.0	0.2	139.0967
229	195.7	107.1	88.5	60.198	109.007	858.053	4.257	1.001	48.808	35.479	1733.7	**104024.64**	28.92	123.5	123.5	122.0	0.0	138.8599
230	195.6	107.1	88.5	60.169	109.156	858.421	4.259	1.001	48.986	35.495	1740.8	**104450.06**	28.39	123.5	123.5	122.0	0.1	138.8101
231	193.1	107.1	86.1	60.120	109.094	857.845	4.256	1.001	48.975	35.471	1739.3	**104355.26**	28.20	123.5	123.5	122.0	0.0	139.0181
232	195.6	107.1	88.5	60.054	108.960	857.950	4.257	1.001	48.906	35.476	1737.1	**104223.50**	28.00	123.5	123.5	122.0	0.0	139.1086
233	195.6	106.9	88.8	59.971	108.997	857.786	4.256	1.001	49.027	35.469	1741.0	**104460.77**	27.18	123.3	123.4	122.0	0.2	139.3516
234	196.0	106.6	89.4	59.930	108.276	858.393	4.259	1.001	48.345	35.495	1718.0	**103082.91**	27.44	123.0	123.4	122.1	0.4	139.1071
235	195.6	106.6	89.0	59.910	107.860	858.277	4.258	1.001	47.951	35.490	1703.8	**102227.39**	26.46	123.0	123.4	122.0	0.4	138.9978
236	195.7	106.8	88.9	59.889	108.204	858.112	4.258	1.001	48.315	35.483	1716.4	**102984.55**	26.47	123.2	123.3	122.0	0.2	139.0816
237	195.9	106.8	89.1	59.862	108.409	858.090	4.257	1.001	48.546	35.482	1724.6	**103475.78**	27.13	123.2	123.3	122.0	0.1	139.0497
238	195.8	106.9	88.9	59.812	108.542	857.986	4.257	1.001	48.730	35.478	1730.9	**103855.87**	25.54	123.4	123.4	121.9	0.0	138.8797
239	195.9	106.9	88.9	59.766	108.802	858.164	4.258	1.001	49.036	35.486	1742.2	**104530.38**	25.10	123.4	123.3	121.9	0.1	138.8606
240	196.1	107.0	89.1	59.761	108.937	857.636	4.255	1.001	49.176	35.464	1746.0	**104762.86**	25.03	123.4	123.4	121.9	0.1	139.001
241	196.0	107.0	89.1	59.755	108.928	856.810	4.251	1.001	49.173	35.430	1744.2	**104654.91**	24.79	123.4	123.3	121.9	0.1	138.8182
242	195.8	106.9	88.9	59.737	108.883	857.157	4.253	1.001	49.146	35.444	1744.0	**104640.15**	24.36	123.4	123.3	121.9	0.1	139.0158
243	195.6	106.9	88.8	59.720	108.748	857.583	4.255	1.001	49.028	35.462	1740.7	**104441.89**	23.66	123.4	123.3	121.9	0.0	138.9191
244	196.3	106.4	89.8	59.688	108.101	857.281	4.253	1.001	48.412	35.450	1718.2	**103094.74**	23.44	122.8	123.3	121.9	0.5	139.2047
245	195.6	106.5	89.0	59.651	107.589	857.186	4.253	1.001	47.938	35.446	1701.2	**102072.80**	23.20	123.0	123.3	121.9	0.3	139.2411
246	194.5	106.7	87.8	59.613	108.314	857.586	4.255	1.001	48.701	35.463	1729.1	**103746.89**	23.02	123.2	123.3	121.8	0.1	138.9516
247	194.2	106.8	87.4	59.606	108.318	857.656	4.255	1.001	48.711	35.465	1729.6	**103777.77**	22.80	123.1	123.3	121.9	0.2	138.8369
248	195.2	106.2	88.9	59.616	107.293	857.510	4.255	1.001	47.677	35.459	1692.6	**101557.41**	22.38	122.7	123.2	121.8	0.6	139.3056
249	194.0	106.6	87.4	59.615	107.631	857.221	4.253	1.001	48.016	35.447	1704.1	**102243.53**	22.00	122.9	123.2	121.8	0.3	138.8118
250	193.1	106.5	86.6	59.598	107.969	857.364	4.254	1.001	48.372	35.453	1717.0	**103018.85**	21.81	122.9	123.2	121.7	0.3	138.6798
251	194.6	105.8	88.8	59.575	104.854	857.748	4.256	1.001	45.279	35.469	1607.9	**96475.39**	21.72	122.3	123.1	121.6	0.8	138.5655
252	195.0	105.3	89.7	59.576	104.761	857.662	4.255	1.001	45.184	35.466	1604.4	**96264.87**	21.33	121.4	123.1	121.6	1.7	139.8513
253	194.4	105.3	89.1	59.570	105.053	858.821	4.261	1.001	45.482	35.514	1617.2	**97031.25**	20.87	121.7	123.0	121.5	1.3	139.4906
254	195.2	105.7	89.5	59.564	104.698	858.558	4.260	1.001	45.134	35.503	1604.3	**96257.52**	20.54	122.3	122.9	121.4	0.6	139.445
255	196.2	105.8	90.4	59.539	105.238	858.421	4.259	1.001	45.699	35.498	1624.2	**97449.17**	20.58	122.1	122.8	121.4	0.6	139.0269
256	194.7	106.2	88.4	59.525	107.538	858.126	4.258	1.001	48.013	35.485	1705.8	**102347.51**	20.01	122.5	122.7	121.4	0.1	138.9989
257	194.8	106.3	88.5	59.512	107.860	858.591	4.260	1.001	48.348	35.505	1718.6	**103117.24**	19.50	122.6	122.7	121.2	0.0	138.7945
258	195.1	106.3	88.7	59.496	108.082	858.771	4.261	1.001	48.586	35.512	1727.5	**103647.87**	19.56	122.6	122.7	121.2	0.0	138.828
259	195.6	106.4	89.2	59.479	108.148	857.743	4.256	1.001	48.668	35.470	1728.3	**103698.36**	19.06	122.6	122.6	121.2	0.0	138.9006
260	195.8	106.4	89.4	59.464	108.175	858.117	4.258	1.001	48.711	35.485	1730.6	**103834.69**	18.99	122.7	122.6	121.1	0.1	138.8171
261	196.1	106.4	89.7	59.446	108.306	856.133	4.248	1.001	48.860	35.403	1731.8	**103910.43**	18.24	122.7	122.6	121.2	0.1	138.8839
262	195.9	106.3	89.6	59.408	108.299	858.410	4.259	1.001	48.891	35.498	1737.6	**104255.10**	18.42	122.7	122.6	121.1	0.1	139.1485
263	195.5	106.4	89.1	59.369	108.235	857.750	4.256	1.001	48.866	35.470	1735.4	**104122.30**	17.68	122.7	122.6	121.1	0.1	138.6484
264	198.6	105.2	93.4	59.341	105.317	855.560	4.245	1.001	45.976	35.380	1628.5	**97712.90**	17.36	121.2	122.5	121.2	1.3	139.6535
265	197.9	105.2	92.6	59.325	106.555	842.032	4.177	1.001	47.230	34.818	1646.4	**98783.99**	17.56	120.9	122.6	121.1	1.7	139.7268
266	197.3	105.3	92.0	59.319	105.755	848.837	4.211	1.001	46.436	35.100	1631.9	**97912.83**	17.14	121.2	122.5	121.0	1.3	139.2229
267	196.5	104.9	91.6	59.303	105.664	858.397	4.259	1.001	46.361	35.498	1647.7	**98859.30**	16.76	121.0	122.3	120.9	1.3	139.8327
268	195.3	105.4	89.8	59.269	106.585	856.474	4.249	1.001	47.315	35.418	1677.8	**100668.15**	16.38	121.8	122.3	120.9	0.4	139.5737
269	195.7	105.7	89.9	59.251	107.177	855.981	4.247	1.001	47.925	35.397	1698.5	**101907.53**	16.14	121.9	122.2	120.8	0.3	138.7747
270	195.5	106.0	89.5	59.238	107.656	857.107	4.252	1.001	48.418	35.444	1718.2	**103090.19**	15.64	122.3	122.2	120.8	0.0	138.9073
271	195.9	105.9	90.0	59.239	107.721	859.242	4.263	1.001	48.482	35.533	1724.7	**103484.84**	15.33	122.2	122.2	120.8	0.1	138.7075
272	195.9	106.0	89.9	59.233	107.831	858.702	4.260	1.001	48.598	35.510	1727.8	**103667.82**	14.93	122.3	122.2	120.8	0.1	138.949
273	195.9	106.0	89.9	59.211	107.867	857.931	4.257	1.001	48.657	35.479	1728.3	**103699.89**	14.78	122.2	122.2	120.7	0.1	138.9095
274	195.7	106.0	89.7	59.188	107.911	850.275	4.218	1.001	48.724	35.161	1715.2	**102911.63**	14.84	122.3	122.2	120.7	0.1	138.7869
275	195.5	106.1	89.4	59.164	108.343	833.680	4.136	1.001	49.179	34.471	1697.3	**101837.72**	14.19	122.4	122.2	120.7	0.2	138.8333
276	196.1	105.7	90.4	59.134	107.050	858.067	4.257	1.001	47.916	35.485	1702.3	**102137.83**	13.96	122.0	122.2	120.7	0.2	138.8651

277	196.4	105.4	91.0	59.111	105.459	856.843	4.251	1.001	46.347	35.434	1644.2	**98653.30**	13.62	121.9	122.1	120.8	0.3	139.0198
278	195.5	105.4	90.1	59.084	106.807	857.486	4.254	1.001	47.723	35.461	1694.3	**101659.37**	13.43	121.9	122.2	120.7	0.3	139.6807
279	196.7	105.4	91.3	59.076	106.176	857.548	4.255	1.001	47.101	35.463	1672.3	**100340.11**	13.42	121.7	122.1	120.7	0.5	138.6892
280	196.8	105.3	91.5	59.072	107.030	857.279	4.253	1.001	47.958	35.452	1702.2	**102134.80**	12.85	121.4	122.0	120.6	0.7	138.9621
281	195.1	105.7	89.4	59.078	106.736	856.936	4.252	1.001	47.658	35.438	1690.9	**101454.36**	12.78	122.0	122.0	120.5	0.0	138.575
282	195.9	105.4	90.5	59.069	104.954	857.888	4.256	1.001	45.885	35.477	1629.8	**97788.43**	12.42	121.9	122.0	120.5	0.1	138.6099
283	196.5	104.9	91.6	59.040	106.872	857.507	4.254	1.001	47.832	35.462	1698.2	**101893.88**	12.35	120.7	122.0	120.5	1.4	140.3391
284	195.4	104.8	90.6	59.014	106.571	857.986	4.257	1.001	47.556	35.482	1689.4	**101363.82**	11.91	120.8	121.9	120.5	1.1	139.6028
285	194.9	105.0	89.9	58.988	104.969	858.007	4.257	1.001	45.981	35.483	1633.5	**98009.22**	11.60	121.7	121.9	120.4	0.2	138.8225
286	196.1	105.5	90.6	58.955	104.169	858.022	4.257	1.001	45.213	35.483	1606.2	**96374.67**	11.69	121.2	121.8	120.3	0.6	139.4509
287	195.4	105.8	89.6	58.946	104.846	857.835	4.256	1.001	45.901	35.476	1630.3	**97818.22**	11.37	121.5	121.8	120.1	0.3	138.5295
288	195.7	105.7	90.0	58.940	105.022	857.800	4.256	1.001	46.083	35.474	1636.7	**98201.86**	10.96	121.1	121.6	120.2	0.5	139.0939
289	195.0	105.9	89.0	58.951	106.349	858.172	4.258	1.001	47.398	35.490	1684.1	**101048.99**	11.07	121.2	121.6	120.1	0.4	138.8683
290	194.7	104.8	89.9	58.962	107.762	857.202	4.253	1.001	48.801	35.449	1732.0	**103921.17**	11.03	120.7	121.6	119.9	0.8	138.2712
291	194.1	106.5	87.6	58.961	104.308	857.279	4.253	1.001	45.347	35.453	1609.6	**96574.40**	10.62	121.6	121.6	119.8	0.0	139.259
292	194.3	105.0	89.3	58.959	106.942	854.754	4.241	1.001	47.983	35.348	1698.1	**101887.21**	10.47	120.0	121.5	119.8	1.4	139.5932
293	194.5	105.1	89.3	58.956	106.031	858.164	4.258	1.001	47.076	35.489	1672.7	**100361.25**	10.00	120.6	121.5	119.8	0.9	138.7638
294	195.9	104.7	91.2	58.952	103.789	857.076	4.252	1.001	44.837	35.444	1591.1	**95465.84**	9.60	120.0	121.5	119.8	1.4	139.1763
295	196.2	104.7	91.5	58.947	102.912	856.833	4.251	1.001	43.965	35.434	1559.7	**93582.63**	9.69	119.7	121.3	119.7	1.6	139.2383
296	194.5	105.1	89.4	58.945	104.029	849.971	4.217	1.001	45.084	35.149	1586.6	**95193.10**	9.70	120.2	121.2	119.6	1.0	138.9455
297	193.4	105.3	88.2	58.932	104.721	855.293	4.243	1.001	45.789	35.370	1621.5	**97290.69**	8.84	120.6	121.2	119.4	0.6	138.9427
298	193.3	105.1	88.2	58.919	105.218	858.093	4.257	1.001	46.299	35.487	1645.0	**98697.97**	9.14	120.1	121.0	119.4	0.9	138.5952
299	192.9	105.1	87.8	58.916	104.469	858.762	4.261	1.001	45.552	35.514	1619.7	**97180.99**	8.65	120.3	121.0	119.3	0.7	138.9801

Hydronic Heating Appliances - Test Method ASTM E2515-11

Emissions Sampling Data

Run: 1

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Test Date: June 13, 2022
Technician: TT / KM
Beginning Clock Time: 12:44
Recording Interval: 1 min.
Total Sampling Time: 155 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	0.024	0.024	0.028	0.026	0.020	0.018	0.022	0.028	0.028	0.022	0.016	0.033	"H2O
Initial Temp.	99	99	99	99	99	99	99	99	99	99	99	99	99	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: 12/16/2021

V_{strav} 10.30 ft/sec
V_{scent} 12.34 ft/sec
F_p 0.835

	(1)	(2)	(amb)	
Meter Box Y Factor:	1.003	1.003	1.011	
Barometric Pressure:	Begin	Middle	End	Average
	30.16		30.19	30.18 "Hg

PM Control Module: 335, 336
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: -0.246 "H2O
Pitot Tube Cp: 0.99

Tunnel Velocity: 10.04 ft/sec.
Intial Tunnel Flow: 453.0 scfm
Average Tunnel Flow: 446.9 scfm
Tunnel Area: 0.785398 ft2

Post-Test Leak Check (1): 0.000 cfm @ -16 in. Hg
Post-Test Leak Check (2): 0.000 cfm @ -17 in. Hg
Fuel Moisture (dry basis %): 21.5
Total Particulate (1): 2.5
Total Particulate (2): 2.4

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			1.23	1.00	0.34	70	69	70	2.60	2.60	100	0.033			45.6		319	67	66	66	0.060	0.31	6.89
1	0.146	0.146		0.15	0.15	1.27	1.08	0.34	70	69	70	2.71	2.50	126	0.034	92	92	45.3	0.30	271	69	68	66	0.062	0.22	6.99
2	0.294	0.301		0.15	0.16	1.01	1.09	0.34	70	69	70	2.32	2.60	100	0.033	92	97	45.3	0.05	299	69	69	66	0.060	0.06	3.47
3	0.447	0.457		0.15	0.16	1.29	1.12	0.34	70	69	70	2.73	2.60	95	0.032	96	99	44.7	0.54	299	70	69	66	0.059	0.01	8.67
4	0.605	0.616		0.16	0.16	1.31	1.13	0.34	70	69	70	2.77	2.70	94	0.032	99	101	43.9	0.84	301	70	69	66	0.059	0.01	8.78
5	0.766	0.773		0.16	0.16	1.31	1.13	0.34	70	70	70	2.75	2.60	95	0.031	103	101	43.9	-0.04	307	70	69	66	0.060	0.02	9.72
6	0.926	0.931		0.16	0.16	1.31	1.12	0.34	70	70	70	2.75	2.60	96	0.032	101	100	43.6	0.29	311	70	69	66	0.060	0.02	9.94
7	1.087	1.089		0.16	0.16	1.31	1.13	0.34	70	70	70	2.75	2.70	96	0.032	101	100	43.0	0.59	313	71	69	67	0.060	0.01	10.04
8	1.246	1.247		0.16	0.16	1.30	1.13	0.34	70	70	70	2.75	2.70	97	0.033	99	99	42.7	0.31	316	71	69	66	0.060	0.01	10.15
9	1.406	1.406		0.16	0.16	1.30	1.13	0.34	70	70	70	2.75	2.70	97	0.032	101	101	42.1	0.60	318	71	70	67	0.060	0.01	10.46
10	1.565	1.563		0.16	0.16	1.30	1.12	0.34	70	70	70	2.76	2.70	96	0.032	100	99	42.2	-0.03	318	71	70	67	0.061	0.01	10.40
11	1.725	1.721		0.16	0.16	1.30	1.13	0.34	70	70	70	2.75	2.70	96	0.033	99	99	41.6	0.56	317	71	70	67	0.061	0.01	10.44
12	1.884	1.878		0.16	0.16	1.30	1.12	0.34	71	70	70	2.73	2.70	96	0.032	100	99	41.0	0.63	317	72	70	67	0.061	0.01	10.33
13	2.043	2.036		0.16	0.16	1.29	1.12	0.34	71	70	70	2.74	2.70	95	0.031	102	102	41.2	-0.26	315	72	70	67	0.060	0.01	10.15
14	2.203	2.195		0.16	0.16	1.30	1.13	0.34	71	71	70	2.74	2.70	95	0.032	101	100	40.8	0.47	314	72	70	67	0.061	0.01	10.51
15	2.362	2.353		0.16	0.16	1.30	1.14	0.34	71	71	70	2.74	2.70	94	0.034	97	97	40.1	0.62	313	72	70	67	0.060	0.01	10.08
16	2.522	2.513		0.16	0.16	1.29	1.14	0.34	71	71	70	2.72	2.70	95	0.032	101	101	40.3	-0.21	312	72	70	67	0.061	0.03	9.85
17	2.681	2.671		0.16	0.16	1.29	1.13	0.34	71	71	70	2.74	2.70	95	0.032	100	100	39.6	0.75	312	72	71	66	0.060	0.04	9.31
18	2.840	2.829		0.16	0.16	1.29	1.13	0.34	71	71	70	2.73	2.70	94	0.031	101	101	39.6	0.03	311	72	71	66	0.061	0.02	9.68
19	3.000	2.988		0.16	0.16	1.29	1.13	0.34	72	71	70	2.72	2.70	95	0.032	100	100	38.9	0.69	314	72	71	66	0.061	0.03	9.20
20	3.158	3.146		0.16	0.16	1.35	1.13	0.34	72	72	70	2.80	2.70	96	0.033	98	98	38.1	0.73	317	72	71	66	0.061	0.02	9.97
21	3.319	3.305		0.16	0.16	1.32	1.13	0.34	72	72	70	2.76	2.70	95	0.032	101	100	38.0	0.11	315	73	71	66	0.061	0.01	10.20
22	3.480	3.464		0.16	0.16	1.32	1.13	0.34	72	72	70	2.75	2.70	96	0.031	103	102	37.9	0.08	315	73	71	66	0.060	0.04	9.47
23	3.641	3.622		0.16	0.16	1.32	1.13	0.34	72	72	70	2.76	2.70	96	0.032	101	100	37.9	0.04	313	73	71	67	0.061	0.08	8.79
24	3.802	3.781		0.16	0.16	1.32	1.13	0.34	72	72	70	2.77	2.70	96	0.034	98	97	37.4	0.49	312	73	71	67	0.060	0.11	8.42
25	3.964	3.939		0.16	0.16	1.32	1.13	0.34	73	72	70	2.77	2.70	96	0.033	100	98	37.2	0.20	312	73	71	67	0.060	0.09	8.56
26	4.125	4.098		0.16	0.16	1.30	1.15	0.34	73	73	70	2.74	2.70	95	0.031	102	102	36.9	0.36	313	73	71	66	0.060	0.07	8.64
27	4.284	4.259		0.16	0.16	1.30	1.15	0.34	73	73	70	2.74	2.70	96	0.030	103	105	36.6	0.29	313	73	72	67	0.061	0.01	10.02

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(%)
28	4.444	4.418		0.16	0.16	1.30	1.15	0.34	73	73	70	2.75	2.70	95	0.032	100	100	35.9	0.63	312	73	72	67	0.060	0.02	9.73
29	4.604	4.578		0.16	0.16	1.30	1.15	0.34	73	73	70	2.74	2.70	95	0.032	100	101	35.6	0.38	312	73	72	67	0.060	0.01	10.01
30	4.765	4.739		0.16	0.16	1.30	1.15	0.34	73	73	70	2.75	2.70	94	0.031	102	103	35.1	0.44	312	73	72	66	0.060	0.01	10.33
31	4.925	4.899		0.16	0.16	1.30	1.14	0.34	74	73	70	2.74	2.70	94	0.031	102	102	35.3	-0.23	311	73	72	67	0.060	0.01	10.21
32	5.085	5.059		0.16	0.16	1.30	1.15	0.34	74	73	70	2.74	2.70	95	0.031	102	102	35.1	0.25	316	73	72	67	0.059	0.01	10.00
33	5.245	5.220		0.16	0.16	1.30	1.15	0.34	74	74	70	2.75	2.70	95	0.033	98	100	34.6	0.47	316	73	72	66	0.060	0.00	11.37
34	5.406	5.379		0.16	0.16	1.30	1.15	0.34	74	74	70	2.75	2.70	95	0.031	102	101	34.4	0.19	314	73	72	67	0.059	0.00	10.37
35	5.567	5.540		0.16	0.16	1.30	1.15	0.34	74	74	70	2.74	2.70	94	0.031	102	103	33.9	0.51	312	73	72	67	0.059	0.00	10.29
36	5.727	5.701		0.16	0.16	1.30	1.15	0.34	74	74	70	2.74	2.70	94	0.032	100	101	33.6	0.29	310	73	72	66	0.060	0.00	10.43
37	5.887	5.860		0.16	0.16	1.30	1.15	0.34	74	74	70	2.74	2.70	94	0.032	100	100	33.0	0.61	308	73	72	66	0.058	0.00	10.44
38	6.048	6.020		0.16	0.16	1.30	1.15	0.34	74	74	70	2.75	2.70	93	0.032	100	100	32.3	0.69	307	73	72	67	0.059	0.00	10.59
39	6.208	6.181		0.16	0.16	1.31	1.15	0.34	75	74	70	2.73	2.70	92	0.030	103	104	31.9	0.47	305	73	72	67	0.058	0.00	10.50
40	6.370	6.342		0.16	0.16	1.30	1.15	0.34	75	75	70	2.75	2.70	92	0.032	101	101	31.7	0.12	304	73	72	67	0.059	0.00	10.68
41	6.530	6.502		0.16	0.16	1.30	1.15	0.34	75	75	70	2.75	2.70	92	0.032	100	100	31.9	-0.16	301	73	72	67	0.058	0.00	10.65
42	6.690	6.662		0.16	0.16	1.30	1.15	0.34	75	75	70	2.75	2.70	91	0.033	98	98	31.6	0.29	299	73	72	67	0.058	0.00	10.57
43	6.851	6.823		0.16	0.16	1.30	1.15	0.34	75	75	70	2.74	2.70	91	0.031	102	102	31.5	0.06	298	73	72	67	0.058	0.00	10.33
44	7.011	6.983		0.16	0.16	1.30	1.15	0.34	75	75	70	2.74	2.70	91	0.032	99	100	31.1	0.43	297	73	72	67	0.058	0.00	10.17
45	7.173	7.144		0.16	0.16	1.31	1.15	0.34	75	75	70	2.76	2.70	91	0.031	102	102	30.4	0.71	296	73	72	67	0.058	0.00	10.11
46	7.334	7.305		0.16	0.16	1.30	1.15	0.34	75	75	70	2.75	2.70	91	0.033	99	99	29.9	0.48	294	73	72	67	0.058	0.00	9.93
47	7.495	7.465		0.16	0.16	1.30	1.15	0.34	76	75	70	2.74	2.70	90	0.031	101	101	29.7	0.20	294	73	72	67	0.057	0.00	10.06
48	7.655	7.626		0.16	0.16	1.30	1.15	0.34	76	75	70	2.74	2.70	90	0.032	99	100	29.7	0.00	291	73	72	67	0.056	0.00	9.98
49	7.816	7.788		0.16	0.16	1.30	1.15	0.34	76	76	70	2.75	2.70	89	0.032	100	101	29.5	0.25	292	73	72	67	0.057	0.01	9.87
50	7.977	7.948		0.16	0.16	1.31	1.15	0.34	76	76	70	2.75	2.70	90	0.032	100	100	29.3	0.19	292	73	72	67	0.057	0.00	9.96
51	8.140	8.108		0.16	0.16	1.31	1.16	0.34	76	76	70	2.75	2.70	90	0.031	103	101	28.6	0.71	291	73	72	67	0.057	0.00	9.81
52	8.301	8.270		0.16	0.16	1.31	1.16	0.34	76	76	70	2.75	2.70	90	0.032	100	101	28.8	-0.23	292	73	72	67	0.057	0.01	9.58
53	8.462	8.431		0.16	0.16	1.31	1.15	0.34	76	76	70	2.76	2.70	90	0.032	100	100	27.9	0.90	292	73	72	66	0.057	0.02	9.37
54	8.623	8.592		0.16	0.16	1.31	1.15	0.34	76	76	70	2.76	2.70	90	0.031	101	102	28.1	-0.15	292	73	72	66	0.057	0.03	9.14
55	8.785	8.753		0.16	0.16	1.31	1.15	0.34	76	76	70	2.75	2.70	90	0.033	99	99	27.9	0.16	290	73	72	67	0.056	0.04	9.07
56	8.947	8.915		0.16	0.16	1.31	1.16	0.34	76	76	70	2.75	2.70	89	0.032	100	101	27.0	0.87	286	73	72	67	0.057	0.05	8.68
57	9.108	9.075		0.16	0.16	1.31	1.15	0.34	76	76	70	2.77	2.70	89	0.032	100	100	27.5	-0.48	288	73	72	67	0.056	0.03	8.88
58	9.271	9.236		0.16	0.16	1.31	1.16	0.34	77	76	70	2.75	2.70	90	0.032	101	100	27.0	0.54	289	73	72	67	0.056	0.03	9.74
59	9.432	9.397		0.16	0.16	1.31	1.16	0.34	77	76	70	2.76	2.70	89	0.032	100	100	26.4	0.57	288	73	71	67	0.057	0.02	9.52
60	9.594	9.559		0.16	0.16	1.31	1.15	0.34	77	77	70	2.76	2.70	89	0.033	99	99	26.2	0.22	288	73	71	67	0.056	0.06	9.66
61	9.752	9.719		0.16	0.16	1.33	1.15	0.34	77	77	70	3.18	2.70	89	0.034	95	96	26.3	-0.11	288	68	71	67	0.056	0.06	9.65
62	9.914	9.880		0.16	0.16	1.30	1.11	0.34	77	77	70	3.15	2.70	89	0.032	100	100	25.7	0.61	289	69	71	67	0.056	0.10	9.41
63	10.076	10.039		0.16	0.16	1.31	1.12	0.34	77	77	70	3.15	2.70	90	0.032	100	99	25.5	0.21	290	69	71	67	0.057	0.19	8.81
64	10.237	10.198		0.16	0.16	1.28	1.12	0.34	77	77	70	3.12	2.70	90	0.032	100	99	25.5	-0.02	289	69	71	67	0.056	0.22	8.55
65	10.398	10.357		0.16	0.16	1.30	1.14	0.34	77	77	70	3.15	2.70	90	0.029	105	104	25.2	0.28	290	69	71	67	0.057	0.25	8.43
66	10.559	10.518		0.16	0.16	1.29	1.13	0.34	77	77	70	3.12	2.70	90	0.033	98	99	24.5	0.65	290	69	71	67	0.057	0.28	8.30
67	10.719	10.677		0.16	0.16	1.30	1.13	0.34	77	77	70	3.14	2.70	90	0.033	97	97	24.8	-0.22	289	70	71	67	0.057	0.32	8.12
68	10.880	10.836		0.16	0.16	1.29	1.13	0.34	77	77	70	3.12	2.70	91	0.033	98	97	24.5	0.23	289	70	71	67	0.057	0.31	7.95
69	11.042	10.997		0.16	0.16	1.29	1.13	0.34	77	77	70	3.13	2.70	91	0.032	100	100	23.7	0.84	289	70	71	67	0.057	0.34	7.80
70	11.202	11.156		0.16	0.16	1.29	1.13	0.34	77	77	70	3.14	2.70	91	0.032	99	99	24.3	-0.63	289	70	71	67	0.057	0.37	7.50
71	11.363	11.316		0.16	0.16	1.29	1.13	0.34	77	77	70	3.14	2.70	92	0.030	103	103	23.3	1.06	290	70	71	67	0.057	0.41	7.36
72	11.523	11.476		0.16	0.16	1.29	1.13	0.34	77	77	70	3.13	2.70	92	0.031	101	101	23.4	-0.09	291	70	71	67	0.056	0.44	7.21

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(%)
73	11.684	11.635		0.16	0.16	1.29	1.13	0.34	77	77	70	3.13	2.70	93	0.034	97	96	22.7	0.65	292	71	71	67	0.057	0.48	7.11
74	11.845	11.795		0.16	0.16	1.30	1.13	0.34	78	77	70	3.13	2.70	94	0.031	101	101	22.9	-0.17	294	71	72	67	0.058	0.48	7.05
75	12.006	11.955		0.16	0.16	1.29	1.13	0.34	78	77	70	3.14	2.70	94	0.031	101	101	22.1	0.77	295	71	72	67	0.058	0.48	6.94
76	12.167	12.115		0.16	0.16	1.28	1.13	0.34	78	77	70	3.14	2.70	95	0.032	100	100	22.0	0.12	297	71	72	67	0.058	0.46	6.96
77	12.327	12.274		0.16	0.16	1.29	1.13	0.34	78	77	70	3.13	2.70	96	0.032	99	99	21.6	0.34	299	71	72	67	0.059	0.43	6.89
78	12.487	12.434		0.16	0.16	1.29	1.12	0.34	78	78	70	3.15	2.70	97	0.032	99	100	21.6	0.08	303	71	72	67	0.058	0.41	7.01
79	12.648	12.594		0.16	0.16	1.29	1.13	0.34	78	78	70	3.15	2.70	97	0.031	102	101	21.4	0.15	305	72	72	67	0.058	0.41	7.45
80	12.809	12.754		0.16	0.16	1.29	1.13	0.34	78	78	70	3.14	2.70	98	0.032	100	100	20.5	0.95	308	72	72	67	0.059	0.39	7.65
81	12.969	12.913		0.16	0.16	1.28	1.13	0.34	78	78	70	3.16	2.70	99	0.029	105	104	20.9	-0.44	321	72	72	67	0.061	0.40	7.86
82	13.129	13.073		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	98	0.031	101	102	19.8	1.09	323	72	72	67	0.060	0.00	11.87
83	13.289	13.233		0.16	0.16	1.29	1.13	0.34	78	78	70	3.14	2.70	99	0.032	100	100	20.1	-0.29	323	72	72	67	0.059	0.00	10.54
84	13.450	13.392		0.16	0.16	1.30	1.13	0.34	78	78	70	3.15	2.70	99	0.032	100	99	19.4	0.68	324	72	72	67	0.059	0.00	10.30
85	13.611	13.551		0.16	0.16	1.29	1.13	0.34	78	78	70	3.14	2.70	98	0.031	102	101	18.7	0.76	323	72	72	67	0.061	0.00	10.15
86	13.772	13.711		0.16	0.16	1.28	1.12	0.34	78	78	70	3.15	2.70	98	0.032	100	100	18.9	-0.23	321	72	72	67	0.060	0.00	10.08
87	13.932	13.871		0.16	0.16	1.28	1.13	0.34	78	78	70	3.15	2.70	97	0.032	99	100	17.8	1.08	320	73	72	67	0.060	0.00	10.15
88	14.092	14.030		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	97	0.030	103	103	17.9	-0.10	319	73	72	67	0.059	0.00	10.76
89	14.252	14.190		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	96	0.033	98	98	17.7	0.18	317	73	72	67	0.059	0.00	10.51
90	14.414	14.349		0.16	0.16	1.29	1.12	0.34	78	78	70	3.14	2.70	95	0.033	99	98	17.2	0.58	314	73	72	67	0.059	0.00	10.49
91	14.574	14.509		0.16	0.16	1.28	1.13	0.34	78	78	70	3.15	2.70	95	0.031	101	101	16.8	0.34	313	73	72	67	0.059	0.00	10.45
92	14.734	14.669		0.16	0.16	1.28	1.13	0.34	78	78	70	3.15	2.70	94	0.032	99	100	16.8	0.01	310	73	72	67	0.059	0.00	10.55
93	14.894	14.828		0.16	0.16	1.29	1.12	0.34	78	78	70	3.15	2.70	93	0.031	101	100	16.4	0.43	307	73	72	67	0.058	0.00	10.58
94	15.055	14.988		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	92	0.031	101	101	15.5	0.85	304	73	72	67	0.058	0.00	10.60
95	15.216	15.148		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	92	0.033	98	98	15.3	0.23	301	73	72	67	0.057	0.00	10.44
96	15.377	15.307		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	92	0.032	100	99	15.0	0.30	300	73	72	67	0.057	0.00	10.21
97	15.537	15.467		0.16	0.16	1.28	1.13	0.34	78	78	70	3.16	2.70	92	0.031	101	101	14.9	0.15	298	73	72	67	0.058	0.00	9.81
98	15.698	15.628		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	91	0.032	100	100	14.3	0.51	297	73	72	67	0.057	0.01	9.62
99	15.858	15.787		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	91	0.032	99	99	14.0	0.34	296	73	72	67	0.057	0.02	9.54
100	16.019	15.946		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	91	0.032	100	99	13.7	0.31	295	73	72	67	0.057	0.02	9.46
101	16.180	16.107		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	91	0.033	98	98	13.6	0.05	294	73	72	67	0.056	0.02	9.55
102	16.341	16.266		0.16	0.16	1.28	1.13	0.34	78	78	70	3.16	2.70	91	0.032	100	99	13.4	0.27	294	73	72	67	0.056	0.02	9.47
103	16.501	16.426		0.16	0.16	1.29	1.13	0.34	78	78	70	3.16	2.70	91	0.031	100	101	13.3	0.03	293	73	72	67	0.056	0.02	9.31
104	16.662	16.586		0.16	0.16	1.29	1.13	0.34	78	78	70	3.15	2.70	91	0.030	103	103	13.1	0.21	293	73	72	67	0.056	0.03	9.20
105	16.822	16.745		0.16	0.16	1.29	1.13	0.34	78	78	70	3.15	2.70	91	0.032	99	99	12.7	0.44	294	73	72	67	0.057	0.03	9.27
106	16.984	16.905		0.16	0.16	1.29	1.13	0.34	79	78	70	3.15	2.70	91	0.031	102	101	12.3	0.38	295	73	72	67	0.057	0.01	9.78
107	17.145	17.065		0.16	0.16	1.28	1.13	0.34	78	78	70	3.16	2.70	91	0.032	100	99	11.8	0.54	295	73	72	67	0.056	0.00	9.89
108	17.305	17.225		0.16	0.16	1.29	1.13	0.34	79	78	70	3.16	2.70	91	0.032	99	99	11.4	0.36	295	73	72	67	0.057	0.00	9.87
109	17.465	17.384		0.16	0.16	1.29	1.13	0.34	79	78	70	3.16	2.70	91	0.032	99	99	11.7	-0.28	295	73	72	67	0.056	0.00	10.04
110	17.626	17.545		0.16	0.16	1.29	1.13	0.34	79	78	70	3.15	2.70	90	0.032	99	100	11.8	-0.12	293	73	72	67	0.056	0.00	10.04
111	17.787	17.704		0.16	0.16	1.28	1.12	0.34	79	78	70	3.14	2.70	90	0.030	103	102	10.9	0.92	293	73	72	67	0.057	0.00	9.97
112	17.948	17.863		0.16	0.16	1.29	1.13	0.34	79	78	70	3.16	2.70	90	0.031	101	100	10.2	0.71	293	73	72	67	0.055	0.00	9.91
113	18.108	18.024		0.16	0.16	1.28	1.12	0.34	79	78	70	3.16	2.70	90	0.032	99	100	10.4	-0.20	292	73	72	67	0.056	0.00	9.66
114	18.269	18.183		0.16	0.16	1.29	1.12	0.34	79	78	70	3.15	2.70	90	0.033	98	97	9.8	0.61	291	72	72	67	0.055	0.00	9.71
115	18.430	18.343		0.16	0.16	1.30	1.13	0.34	79	78	70	3.16	2.70	90	0.030	103	103	9.7	0.06	289	72	72	67	0.056	0.01	9.67
116	18.591	18.504		0.16	0.16	1.29	1.13	0.34	79	78	70	3.17	2.70	90	0.032	99	100	9.5	0.27	290	72	72	67	0.055	0.01	9.78
117	18.752	18.663		0.16	0.16	1.29	1.13	0.34	79	78	70	3.17	2.70	90	0.031	101	100	9.2	0.30	290	72	72	67	0.056	0.00	9.75

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(%)
118	18.913	18.823		0.16	0.16	1.28	1.13	0.34	79	78	70	3.14	2.70	90	0.032	99	99	9.1	0.07	289	73	72	67	0.055	0.00	9.44
119	19.073	18.983		0.16	0.16	1.29	1.13	0.34	79	78	70	3.15	2.70	90	0.031	100	101	9.0	0.13	289	73	72	67	0.055	0.00	9.49
120	19.234	19.143		0.16	0.16	1.29	1.12	0.34	79	78	70	3.14	2.70	89	0.033	98	98	8.1	0.85	290	72	72	67	0.056	0.00	9.80
121	19.394	19.302		0.16	0.16	1.29	1.13	0.34	79	78	70	3.16	2.70	89	0.031	100	100	8.1	-0.02	288	72	72	67	0.055	0.00	10.07
122	19.556	19.463		0.16	0.16	1.29	1.13	0.34	79	78	70	3.16	2.70	89	0.033	98	98	7.8	0.29	288	72	72	67	0.055	0.00	9.84
123	19.717	19.623		0.16	0.16	1.29	1.13	0.34	79	78	70	3.15	2.70	89	0.032	99	99	7.3	0.50	287	72	72	67	0.055	0.00	9.56
124	19.877	19.782		0.16	0.16	1.29	1.13	0.34	79	78	70	3.16	2.70	88	0.032	98	98	7.0	0.31	285	72	72	67	0.054	0.00	9.50
125	20.038	19.943		0.16	0.16	1.29	1.13	0.34	79	78	70	3.16	2.70	89	0.032	99	100	7.0	0.02	287	72	72	67	0.055	0.00	10.50
126	20.199	20.102		0.16	0.16	1.29	1.13	0.34	79	78	70	3.15	2.70	88	0.032	99	98	6.8	0.23	283	72	72	67	0.054	0.00	9.82
127	20.360	20.262		0.16	0.16	1.30	1.12	0.34	79	78	70	3.15	2.70	87	0.031	101	101	6.5	0.32	280	72	72	67	0.054	0.00	10.09
128	20.521	20.423		0.16	0.16	1.29	1.13	0.34	79	78	70	3.17	2.70	87	0.032	99	100	6.3	0.19	278	72	71	67	0.054	0.00	10.22
129	20.682	20.582		0.16	0.16	1.29	1.12	0.34	79	79	70	3.14	2.70	87	0.031	101	100	5.8	0.43	278	72	71	67	0.054	0.00	9.89
130	20.843	20.742		0.16	0.16	1.29	1.12	0.34	79	78	70	3.15	2.70	87	0.031	101	101	5.6	0.29	276	72	71	67	0.054	0.00	9.87
131	21.003	20.903		0.16	0.16	1.29	1.13	0.34	79	78	70	3.16	2.70	87	0.032	98	100	5.4	0.12	276	72	71	67	0.054	0.00	9.72
132	21.164	21.062		0.16	0.16	1.29	1.12	0.34	79	78	70	3.16	2.70	87	0.031	101	100	4.9	0.56	275	72	71	67	0.053	0.00	9.48
133	21.326	21.222		0.16	0.16	1.30	1.13	0.34	79	79	70	3.15	2.70	87	0.032	100	99	4.9	-0.03	276	72	71	67	0.054	0.00	9.30
134	21.487	21.383		0.16	0.16	1.29	1.13	0.34	79	79	70	3.16	2.70	87	0.031	101	101	4.9	0.01	276	72	71	67	0.054	0.01	9.29
135	21.647	21.542		0.16	0.16	1.29	1.12	0.34	79	79	70	3.16	2.70	88	0.032	98	98	4.9	-0.05	277	72	71	67	0.054	0.01	9.16
136	21.808	21.702		0.16	0.16	1.29	1.13	0.34	79	79	70	3.14	2.70	88	0.030	102	102	4.7	0.29	278	72	71	67	0.054	0.01	9.07
137	21.969	21.863		0.16	0.16	1.29	1.12	0.34	79	79	70	3.16	2.70	88	0.032	99	100	4.8	-0.18	277	72	71	67	0.054	0.01	8.96
138	22.130	22.022		0.16	0.16	1.30	1.13	0.34	79	79	70	3.15	2.70	87	0.031	101	100	4.3	0.58	277	72	71	67	0.054	0.02	9.10
139	22.292	22.182		0.16	0.16	1.29	1.12	0.34	79	79	70	3.16	2.70	87	0.033	98	97	3.9	0.36	275	72	71	67	0.053	0.00	9.58
140	22.452	22.343		0.16	0.16	1.29	1.13	0.34	79	79	70	3.16	2.70	87	0.032	98	99	3.7	0.18	275	72	71	67	0.053	0.00	9.48
141	22.613	22.502		0.16	0.16	1.29	1.13	0.34	79	79	70	3.15	2.70	88	0.030	102	102	2.9	0.78	276	72	71	67	0.054	0.00	9.43
142	22.773	22.662		0.16	0.16	1.29	1.12	0.34	79	79	70	3.15	2.70	88	0.032	98	99	3.0	-0.02	278	72	71	67	0.054	0.01	9.25
143	22.935	22.823		0.16	0.16	1.29	1.12	0.34	79	79	70	3.15	2.70	89	0.032	100	100	3.2	-0.22	283	72	71	67	0.055	0.01	9.00
144	23.096	22.982		0.16	0.16	1.29	1.12	0.34	79	79	70	3.16	2.70	90	0.032	99	98	2.9	0.30	287	72	71	67	0.055	0.02	8.86
145	23.257	23.142		0.16	0.16	1.29	1.13	0.34	79	79	70	3.16	2.70	90	0.030	103	102	2.5	0.35	290	72	71	67	0.056	0.02	8.96
146	23.418	23.302		0.16	0.16	1.29	1.13	0.34	79	79	70	3.16	2.70	90	0.032	99	99	1.8	0.70	292	72	71	67	0.056	0.01	9.03
147	23.579	23.462		0.16	0.16	1.29	1.13	0.34	79	79	70	3.17	2.70	90	0.031	101	101	1.8	0.04	292	72	71	67	0.056	0.01	9.09
148	23.739	23.622		0.16	0.16	1.29	1.12	0.34	79	79	70	3.16	2.70	90	0.031	100	101	1.9	-0.12	292	72	71	67	0.055	0.00	9.29
149	23.900	23.782		0.16	0.16	1.29	1.12	0.34	79	79	70	3.15	2.70	91	0.031	101	101	1.5	0.36	297	72	71	67	0.057	0.01	9.44
150	24.062	23.942		0.16	0.16	1.29	1.12	0.34	79	79	70	3.17	2.70	92	0.030	103	103	1.1	0.42	298	72	71	67	0.056	0.03	8.87
151	24.223	24.101		0.16	0.16	1.29	1.13	0.34	79	79	70	3.15	2.70	92	0.032	99	99	0.7	0.39	300	72	71	67	0.057	0.04	8.65
152	24.383	24.262		0.16	0.16	1.29	1.13	0.34	79	79	70	3.16	2.70	93	0.032	99	100	0.9	-0.16	303	72	72	67	0.056	0.11	8.41
153	24.544	24.422		0.16	0.16	1.29	1.12	0.34	79	79	70	3.16	2.70	93	0.032	100	99	0.2	0.70	304	72	72	67	0.057	0.13	8.24
154	24.705	24.581		0.16	0.16	1.29	1.13	0.34	79	79	70	3.16	2.70	94	0.030	103	102	0.1	0.15	304	72	72	67	0.057	0.18	7.98
155	24.866	24.742	33.080	0.16	0.16	1.29	1.13	0.34	79	79	70	3.16	2.70	94	0.030	103	103	0.0	0.05	307	73	72	67	0.058	0.26	7.67
	24.866	24.742	33.080			1.29	1.13	0.34	76	76	70			92	0.032						72.06	71.38		0.057	0.06	9.41

Hydronic Heating Appliances - Test Method ASTM E2618-13 with PTS
Water Test Data

Run: 1

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Test Date: 12/16/2021
Technician: TT / KM
Beginning Clock Time: 12;06
Recording Interval: 1 min.
Total Sampling Time: 155 min.

Boiler Dry Weight (lbs): 1471.6
Boiler Water Weight (lbs): 274.5
Tank Weight (lbs): 736
Tank Water Weight (lbs): 3145
Initial Average Tank Temp (°F): 120.8
Final Average Tank Temp (°F): 118.1
Initial Average Heater Temp (°F 165.4
Final Average Heater Temp (°F 165.7

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
0	4.26	59	105	46	1.0012	8.3327	35.458	1632	105	119	15	121	121	193	138
1	4.26	59	105	47	1.0012	8.3327	35.457	1651	104	120	15	121	121	192	138
2	4.25	59	106	47	1.0012	8.3327	35.455	1657	105	119	15	121	121	191	138
3	4.25	59	104	46	1.0012	8.3327	35.446	1615	105	118	13	120	121	191	139
4	4.25	59	104	45	1.0012	8.3327	35.451	1604	105	118	13	120	121	191	139
5	4.25	59	105	46	1.0012	8.3327	35.449	1627	105	117	12	120	121	190	138
6	4.26	59	104	45	1.0012	8.3327	35.464	1590	105	117	12	120	121	190	139
7	4.26	59	104	45	1.0012	8.3327	35.465	1598	105	117	12	120	121	190	139
8	4.26	59	104	45	1.0012	8.3328	35.477	1613	105	118	14	120	121	191	139
9	4.26	59	105	46	1.0012	8.3328	35.469	1645	105	119	14	120	120	191	139
10	4.19	59	106	47	1.0012	8.3328	34.941	1651	105	119	14	120	120	192	138
11	4.21	59	106	47	1.0012	8.3328	35.065	1650	105	119	14	120	120	193	139
12	4.26	59	106	47	1.0012	8.3328	35.480	1666	105	119	14	120	120	193	139
13	4.26	59	106	47	1.0012	8.3328	35.479	1672	105	120	15	120	120	194	139
14	4.26	59	106	47	1.0012	8.3328	35.470	1677	105	120	15	120	120	194	139
15	4.26	59	106	47	1.0012	8.3328	35.462	1679	105	118	13	120	120	194	139
16	4.26	59	106	47	1.0012	8.3328	35.466	1674	105	120	15	120	120	194	139
17	4.26	59	106	47	1.0012	8.3329	35.476	1679	105	120	15	120	120	194	139
18	4.26	59	106	47	1.0012	8.3329	35.466	1682	105	120	15	121	120	194	139
19	4.26	59	106	47	1.0012	8.3329	35.457	1682	105	120	15	120	120	194	139
20	4.26	59	106	47	1.0012	8.3329	35.480	1682	105	119	14	120	120	194	139
21	4.26	59	106	47	1.0012	8.3329	35.489	1662	105	118	14	120	120	194	139
22	4.17	59	106	47	1.0012	8.3329	34.786	1634	105	119	14	120	120	194	139
23	4.27	59	105	46	1.0012	8.3329	35.557	1643	105	119	14	120	120	194	139
24	4.26	59	105	46	1.0012	8.3329	35.535	1644	105	119	14	120	120	194	139
25	4.26	59	105	46	1.0012	8.3329	35.530	1640	105	119	14	120	120	194	139
26	4.26	59	105	47	1.0012	8.3329	35.497	1656	105	120	15	120	120	194	139
27	4.27	59	106	47	1.0012	8.3330	35.543	1677	105	120	15	120	120	194	139
28	4.10	59	107	49	1.0012	8.3330	34.169	1659	105	120	15	120	120	194	139
29	4.26	59	106	47	1.0012	8.3330	35.502	1682	105	120	15	120	120	194	139
30	4.26	59	106	47	1.0012	8.3330	35.497	1679	105	120	15	120	120	194	139
31	4.26	59	106	47	1.0012	8.3330	35.499	1679	105	119	14	120	120	195	139
32	4.26	59	105	47	1.0012	8.3330	35.469	1653	105	119	14	120	120	195	139
33	4.26	59	105	47	1.0012	8.3330	35.465	1653	105	119	14	120	120	195	139
34	4.26	59	106	47	1.0012	8.3330	35.467	1675	105	120	15	120	120	195	139
35	4.26	59	106	47	1.0012	8.3330	35.473	1682	105	120	15	120	120	195	139
36	4.25	59	106	47	1.0012	8.3330	35.454	1683	105	120	15	120	120	195	139
37	4.26	59	106	48	1.0012	8.3331	35.461	1689	105	120	15	120	120	195	139
38	4.26	59	106	48	1.0012	8.3331	35.477	1690	105	120	15	120	120	195	139
39	4.25	59	106	48	1.0012	8.3331	35.443	1690	105	120	15	120	120	195	139
40	4.25	58	106	48	1.0012	8.3331	35.455	1692	105	120	15	120	120	195	139
41	4.25	58	106	48	1.0012	8.3331	35.438	1684	105	119	14	120	120	196	139
42	4.25	58	105	47	1.0012	8.3331	35.441	1650	105	119	14	120	120	196	139
43	4.25	58	106	47	1.0012	8.3331	35.444	1673	105	120	15	120	120	195	139
44	4.26	58	106	48	1.0012	8.3331	35.472	1688	105	120	15	120	120	195	139

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
45	4.25	58	106	48	1.0012	8.3331	35.429	1689	105	120	15	120	120	195	139
46	4.26	58	106	48	1.0012	8.3331	35.463	1689	105	120	15	120	120	195	139
47	4.25	58	106	48	1.0012	8.3331	35.452	1686	105	120	15	120	120	194	139
48	4.26	58	105	47	1.0012	8.3331	35.481	1657	105	118	14	120	120	195	139
49	4.26	58	105	47	1.0012	8.3332	35.489	1664	105	119	15	120	120	194	139
50	4.26	58	106	47	1.0012	8.3332	35.492	1675	105	119	15	120	120	193	139
51	4.26	58	104	46	1.0012	8.3332	35.498	1623	104	115	11	119	120	194	139
52	4.26	58	102	44	1.0012	8.3332	35.498	1561	105	114	9	118	120	194	139
53	4.26	58	103	44	1.0012	8.3332	35.509	1567	105	117	13	119	120	194	140
54	4.26	58	104	45	1.0012	8.3332	35.541	1609	105	117	12	119	120	194	139
55	4.26	58	105	46	1.0012	8.3332	35.519	1637	105	119	14	120	120	193	139
56	4.26	58	105	47	1.0012	8.3332	35.474	1659	105	119	14	120	120	193	139
57	4.27	58	105	47	1.0012	8.3332	35.558	1669	105	119	14	120	120	194	139
58	4.26	58	105	47	1.0012	8.3332	35.514	1670	105	119	14	120	120	194	139
59	4.26	58	105	47	1.0012	8.3332	35.467	1668	105	119	14	120	120	194	139
60	4.26	58	106	47	1.0012	8.3332	35.461	1670	105	119	14	120	120	194	139
61	4.26	58	105	47	1.0012	8.3332	35.526	1672	105	119	14	120	120	193	139
62	4.26	58	103	44	1.0012	8.3332	35.495	1574	105	115	10	118	120	195	139
63	4.26	58	102	43	1.0012	8.3332	35.495	1539	105	115	11	118	120	195	139
64	4.26	58	103	44	1.0012	8.3332	35.480	1576	105	117	12	119	120	194	139
65	4.26	58	104	45	1.0012	8.3332	35.459	1609	105	118	13	119	119	193	139
66	4.26	58	104	46	1.0012	8.3333	35.487	1634	105	118	14	119	119	193	139
67	4.26	58	105	46	1.0012	8.3333	35.476	1647	105	119	14	119	119	193	139
68	4.24	58	105	47	1.0012	8.3333	35.349	1652	105	119	14	119	119	193	139
69	4.26	58	105	47	1.0012	8.3333	35.478	1657	105	119	14	119	119	193	139
70	4.26	58	105	47	1.0012	8.3333	35.522	1659	105	119	14	119	119	193	139
71	4.25	58	105	46	1.0012	8.3333	35.407	1636	105	117	13	119	119	194	138
72	4.26	58	104	46	1.0012	8.3333	35.478	1619	105	118	13	119	119	193	139
73	4.25	58	104	46	1.0012	8.3333	35.429	1625	105	118	13	119	119	192	139
74	4.25	58	103	45	1.0012	8.3333	35.440	1602	105	117	12	119	119	192	139
75	4.25	58	104	45	1.0012	8.3333	35.438	1605	105	115	11	119	119	192	138
76	4.25	58	102	44	1.0012	8.3333	35.416	1559	104	115	11	118	119	193	139
77	4.25	58	103	45	1.0012	8.3334	35.422	1587	105	116	11	118	119	192	139
78	4.25	58	103	45	1.0012	8.3334	35.450	1601	105	116	12	118	119	192	139
79	4.25	58	104	45	1.0012	8.3334	35.416	1609	105	117	12	118	119	192	139
80	4.25	58	104	46	1.0012	8.3334	35.430	1621	105	117	12	118	119	192	139
81	4.25	58	104	46	1.0012	8.3334	35.439	1634	105	118	13	119	119	193	139
82	4.25	58	105	47	1.0012	8.3334	35.414	1654	105	118	13	119	119	193	139
83	4.25	58	105	47	1.0012	8.3334	35.436	1664	105	118	14	119	119	194	139
84	4.25	58	105	47	1.0012	8.3334	35.414	1667	105	118	14	119	119	194	139
85	4.25	58	105	47	1.0012	8.3334	35.444	1669	105	119	14	119	119	195	139
86	4.18	58	106	48	1.0012	8.3334	34.833	1665	105	119	14	119	119	196	139
87	4.26	58	106	47	1.0012	8.3334	35.493	1683	105	119	14	119	119	196	139
88	4.25	58	106	48	1.0012	8.3334	35.455	1689	105	119	15	119	119	197	139
89	4.26	58	106	48	1.0012	8.3335	35.480	1694	105	119	14	119	119	197	139
90	4.25	58	106	48	1.0012	8.3335	35.446	1696	105	119	15	119	119	198	139
91	4.26	58	106	48	1.0012	8.3335	35.467	1699	105	119	14	119	119	198	140
92	4.25	58	106	48	1.0012	8.3335	35.418	1697	105	120	15	119	119	198	139
93	4.25	58	106	48	1.0012	8.3335	35.425	1697	105	119	15	119	119	198	139
94	4.25	58	106	48	1.0012	8.3335	35.426	1697	105	119	14	119	119	197	139
95	4.25	58	106	48	1.0012	8.3335	35.422	1685	105	119	14	119	119	196	139
96	4.25	58	105	47	1.0012	8.3335	35.430	1655	105	118	13	119	119	197	139
97	4.25	58	105	47	1.0012	8.3335	35.431	1674	105	119	14	119	119	197	139
98	4.25	58	106	48	1.0012	8.3335	35.393	1690	105	118	13	119	119	197	139
99	4.25	58	105	47	1.0012	8.3336	35.422	1657	105	118	13	119	119	197	139
100	4.25	58	105	47	1.0012	8.3336	35.399	1677	105	119	14	119	119	196	139
101	4.25	58	106	48	1.0012	8.3336	35.397	1688	105	119	14	119	119	196	139

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
102	4.25	58	105	47	1.0012	8.3336	35.409	1660	105	118	13	119	119	196	139
103	4.25	58	105	47	1.0012	8.3336	35.412	1655	105	118	14	119	119	195	139
104	4.25	58	105	47	1.0012	8.3336	35.384	1673	105	119	14	119	119	194	138
105	4.25	58	103	45	1.0012	8.3336	35.416	1607	104	115	11	118	119	197	140
106	4.25	58	104	46	1.0012	8.3336	35.420	1622	104	117	12	118	119	196	140
107	4.25	58	104	46	1.0012	8.3336	35.413	1617	105	117	12	118	119	196	139
108	4.25	58	104	46	1.0012	8.3336	35.459	1623	105	115	10	118	119	195	139
109	4.26	58	104	46	1.0012	8.3336	35.483	1628	105	118	14	119	119	195	139
110	4.25	58	105	47	1.0012	8.3336	35.422	1665	105	118	14	119	119	195	139
111	4.26	58	105	47	1.0012	8.3336	35.463	1676	105	118	14	119	119	195	139
112	4.25	58	105	47	1.0012	8.3336	35.446	1675	105	119	14	119	119	195	139
113	4.25	58	105	47	1.0012	8.3336	35.442	1676	105	119	14	119	119	195	139
114	4.25	58	105	47	1.0012	8.3336	35.454	1676	105	119	14	119	119	195	139
115	4.25	58	105	47	1.0012	8.3337	35.443	1677	105	119	14	119	119	195	139
116	4.25	58	105	47	1.0012	8.3337	35.422	1675	105	116	12	119	119	194	139
117	4.26	58	103	45	1.0012	8.3337	35.464	1598	104	116	12	118	119	197	139
118	4.19	58	103	45	1.0012	8.3337	34.889	1564	105	117	12	118	119	196	138
119	4.19	58	102	44	1.0012	8.3337	34.945	1535	104	114	10	118	119	197	139
120	4.25	58	103	45	1.0012	8.3337	35.380	1586	104	115	10	117	119	195	140
121	4.26	58	103	45	1.0012	8.3337	35.495	1611	104	118	14	118	118	195	139
122	4.26	58	104	47	1.0012	8.3337	35.494	1653	104	118	14	119	118	195	139
123	4.25	58	105	47	1.0012	8.3337	35.457	1668	105	118	14	119	118	195	139
124	4.26	58	105	47	1.0012	8.3337	35.499	1675	104	117	13	118	118	196	139
125	4.26	58	105	47	1.0012	8.3337	35.491	1675	105	119	14	119	118	196	139
126	4.25	58	105	47	1.0012	8.3338	35.442	1679	105	119	14	119	118	196	139
127	4.26	58	105	47	1.0012	8.3338	35.498	1685	105	119	14	119	118	196	139
128	4.26	58	105	47	1.0012	8.3338	35.484	1681	104	119	14	119	118	196	139
129	4.26	58	105	47	1.0012	8.3338	35.475	1667	104	117	13	118	118	196	139
130	4.26	58	104	47	1.0012	8.3338	35.491	1655	104	118	14	119	118	195	139
131	4.26	58	105	47	1.0012	8.3338	35.472	1667	105	114	9	117	118	194	139
132	4.26	58	102	44	1.0012	8.3338	35.491	1570	104	115	11	118	118	196	139
133	4.26	58	103	45	1.0012	8.3338	35.478	1604	104	116	12	118	118	195	139
134	4.26	58	104	46	1.0012	8.3338	35.495	1632	104	117	13	118	118	194	139
135	4.26	58	104	47	1.0012	8.3338	35.472	1650	104	118	13	118	118	194	139
136	4.26	58	105	47	1.0012	8.3338	35.489	1661	105	118	13	118	118	194	139
137	4.18	58	105	47	1.0012	8.3339	34.804	1652	104	118	14	119	118	194	139
138	4.25	58	105	47	1.0012	8.3339	35.398	1662	104	118	14	118	118	193	139
139	4.25	58	105	47	1.0012	8.3339	35.398	1660	104	118	13	118	118	193	138
140	4.25	58	105	47	1.0012	8.3339	35.389	1657	104	116	12	118	118	193	139
141	4.24	58	104	46	1.0012	8.3339	35.376	1621	104	116	12	118	118	193	139
142	4.24	58	104	46	1.0012	8.3339	35.377	1625	104	117	13	118	118	192	139
143	4.25	57.8	104.0	46	1.0012	8.3339	35.430	1637	104	117	12	118	118	192	138
144	4.16	57.8	103.9	46	1.0012	8.3339	34.667	1601	105	116	12	118	118	192	139
145	4.23	57.8	103.6	46	1.0012	8.3339	35.235	1614	104	117	12	118	118	192	139
146	4.26	57.7	103.7	46	1.0012	8.3339	35.499	1630	104	117	13	118	118	191	139
147	4.26	57.7	104.0	46	1.0012	8.3339	35.492	1641	104	117	13	118	118	191	138
148	4.26	57.7	104.1	46	1.0012	8.3339	35.479	1644	104	117	13	118	118	192	138
149	4.26	57.7	104.1	46	1.0012	8.3339	35.485	1647	104	117	13	118	118	192	138
150	4.26	57.7	104.1	46	1.0012	8.3339	35.479	1646	104	117	13	118	118	192	139
151	4.25	57.7	104.1	46	1.0012	8.3339	35.459	1646	104	116	12	118	118	193	139
152	4.26	57.7	103.9	46	1.0012	8.3339	35.484	1638	104	117	13	118	118	193	139
153	4.26	57.7	104.1	46	1.0012	8.3339	35.478	1648	104	117	13	118	118	193	139
154	4.26	57.7	104.2	46	1.0012	8.3340	35.466	1649	104	117	13	118	118	193	138
155	4.25	57.7	104.2	47	1.0012	8.3340	35.457	1650	104	117	13	118	118	193	138
	4.25	58.26	104.8	46.6	1.0012	8.3334	35.4203	257284.4	104.7	118.1	13.4	119.2	119.3	194.1	138.8

Flow Meter Calibration Check

Manufacturer: Froling Date: 6/13/2022
Appliance: S3 Turbo 30 Run Number: 1
Project Number: 0456WB009E

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)	Accuracy, %
1.003	59.3014	15.2	999.103	8.338	35.3	4.221	4.231	Preburn	100.2%
1.012	58.3821	14.7	999.180	8.339	35.7	4.231	4.258	99	100.6%
1.014	57.6714	14.3	999.237	8.339	35.6	4.210	4.250	189	100.9%

Test Method ASTM E2515-11
Lab Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run #: 1
Date: 6/13/22

Equipment Numbers:

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	E701'	121.3	120.9	0.4
C. Rear filter catch	Filter	E703'	121.0	121.1	-0.1
D. Probe catch*	Probe	15	114341.0	114340.8	0.2
E. Filter seals catch*	Seals	S345	3326.2	3325.5	0.7

Sub-Total | Total Particulate, mg: | 1.2

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	E704'	121.7	120.8	0.9
C. Rear filter catch	Filter	E705'	120.7	121.1	-0.4
D. Probe catch*	Probe	81	111861.3	111861.3	0.0
E. Filter seals catch*	Seals	S346	3278.8	3278.0	0.8

Sub-Total | Total Particulate, mg: | 1.3

Train 1 Aggregate | Total Particulate, mg: | **2.5**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	E706'	121.0	120.6	0.4
B. Rear filter catch	Filter	E707'	121.8	121.5	0.3
C. Probe catch*	Probe	75	117637.7	117637.7	0.0
D. Filter seals catch*	Seals	S347	3280.1	3278.4	1.7

Total Particulate, mg: | 2.4

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter	E708'	121.4	121.4	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 E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 1

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/13/2022

Test Crew: T. Tong K. Morgan

OMNI Equipment ID numbers: 00637, 00709, 00283A

ASTM E2515 Lab Sheet

Assembled By:

Tony Tong

Date/Time in Dessicator:

06/13/2022, 15:40

	Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
Date/Time:	06/15/22 15:40	06/20/22 9:20	06/21/22 10:45		
R/H %:	22.7	18.6	16.0		
Temp:	72.1	70.8	72.1		
200 mg Audit:	200.0	200.1	200.1		
2 g Audit:	2000.3	2000.3	2000.3		
100 g Audit:	99998.0	99998.0	99998.0		
Initials:	TT	TT	TT		

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A (First Hour)	Front Filter	E701	120.9	121.5	121.3			
	Rear Filter	E703	121.1	121.1	121.0			
	Probe	15	114340.8	114341.2	114341.0			
	O-Ring Set	S845	3325.5	3326.4	3326.2			
A (Remainder)	Front Filter	E704	120.8	121.6	121.7			
	Rear Filter	E705	121.1	120.7	120.7			
	Probe	81	111861.3	111861.3	111861.3			
	O-Ring Set	S346	3278.0	3279.2	3278.9	3278.8		
B	Front Filter	E706	120.6	120.9	121.0			
	Rear Filter	E707	121.5	121.8	121.8			
	Probe	75	117637.7	117637.8	117637.7			
	O-Ring Set	S347	3278.4	3280.3	3280.1			
BG	Filter	E708	121.4	121.3	121.4			

Technician Signature: Tony Tong Date: 06/28/22

Tare Sheet: (check one) Probes_____ 47mm Filters✓ 100mm Filters_____ O-Ring Pair_____

Prepared By: Tony Tong Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 00283A 1 200mg

Placed in Dessicator: Date: 05/10/22 Time: 10:38 ID #	Date: 06/08/22 Time: 16:30 RH %: 16.5 T (°F): 75.7 Audit: 200.1	Date: 06/09/22 Time: 17:40 RH %: 21.6 T (°F): 71.3 Audit: TT	Date: 06/13/22 Time: 16:20 RH %: 14.3 T (°F): 71.4 Audit: 200.0	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
E701	120.9	120.9			06/13/22	0456WB009E	1
E702	121.0	121.3	121.2		06/14/22	0456WB009E	2
E703	121.0	121.1			06/13/2022	0456WB009E	1
E704	120.7	120.8			↓	↓	↓
E705	121.0	121.1					
E706	120.5	120.6					
E707	121.5	121.5					
E708	121.3	121.4					
E709	121.4	121.4			06/14/22	0456WB009E	2
E710	120.5	120.6			↓	↓	↓
E711	121.3	121.5					
E712	120.8	120.9					
E713	121.2	121.1					
E714	121.2	121.0					
E715	120.9	121.0			06/15/22	0456WB009E	3
E716	120.5	120.7			↓	↓	↓
E717	121.2	121.1					
E718	121.4	121.3					
E719	122.2	122.5	122.3				
E720	120.6	120.7					
	Initials: TT	Initials: TT	Initials: TT	Initials:			

Final Technician Signature: Tony Tong Date: 06/13/22 Evaluator signature: L.A. Moya

Tare Sheet: (check one) **Probes** ✓ **47mm Filters** ____ **100mm Filters** ____ **O-Ring Pair** ____

Prepared By: Tony Tong Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 00283A 1 1000g

ID #	Placed in Dessicator: Date: 06/08/22 Time: 15:30	Date: 06-10-22 Time: 1300 RH %: 20.0 T (°F): 71.7 Audit: 99997.9	Date: 06/13/22 Time: 7:30 RH %: 7.4 T (°F): 68.0 Audit: 99997.8	Date: 06/14/22 Time: 24.4 RH %: 71.9 T (°F): 71.6 Audit: 99998.0	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
15		114341.0	114340.8			06/13/22	0456WB009E	1
70		116834.6	116833.5	116833.4		06/16/22	0456WB009E	4
73		117066.2	117065.6	117065.8		06/15/22	0456WB009E	3
75		117637.9	117637.7			06/13/22	0456WB009E	1
76		116961.0	116960.5	116960.7		06/15/22	0456WB009E	3
78		117459.6	117459.2	117459.1		06/16/22	0456WB009E	4
81		111861.5	111861.3			06/13/22	0456WB009E	1
3		114770.9	116011.5	116011.2		Not used		
OES3		116011.8	114770.3	114770.4		↓		
4		114856.7	114856.6			06/14/22	0456WB009E	2
OES4		114148.5	114147.7	114147.7		06/16/22	0456WB009E	4
11		114186.1	114185.9	114185.7				
13		114321.8	114321.6			06/14/22	0456WB009E	2
14		114547.6	114547.6			↓	↓	↓
17		114562.5	114562.1	114561.9		06/15/22	0456WB009E	3
30		114327.4	114327.4			Not used		
65		117079.4	117079.1	117079.4		↓		
32		114743.2	114743.2					
		Initials: RD	Initials: TT	Initials: TT	Initials:			

Final Technician Signature: Tony Tong Date: 06/14/22 Evaluator signature: John J. Morgan

Tare Sheet: (check one) **Probes**____ **47mm Filters**____ **100mm Filters**____ **O-Ring Pair** ✓

Prepared By: Tony Tang Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 002834 1.5g

Placed in Dessicator: Date: 25/09/22 Time: 9:30	Date: 06/08/22 Time: 15:30 RH %: 18.8 T (°F): 75.3	Date: 06-10-22 Time: 1324 RH %: 20.0 T (°F): 73.0	Date: 06/13/22 Time: 7:30 RH %: 7.4 T (°F): 68.0	Date: 06/16/22 Time: 7:20 RH %: 18.6 T (°F): 71.7	Date Used	Project Number	Run No.
ID #	Audit: 5000.0	Audit: 5000.2	Audit: 4999.9	Audit: 4999.9			
S345	3325.4	3325.5 ✓			06/13/22	0456WB009E	1
S346	3277.7	3278.0	3278.0		↓	↓	↓
S347	3278.2	3278.4 ✓			↓	↓	↓
S348	3356.7	3356.9 ✓			06/14/22	0456WB009E	2
S349	4088.7	4088.9 ✓			↓	↓	↓
S350	3375.4	3375.5 ✓			↓	↓	↓
S351	3227.6	3227.8 ✓			06/15/22	0456WB009E	3
S352	3311.8	3312.0 ✓			↓	↓	↓
S353	3358.3	3358.5 ✓			↓	↓	↓
S354	4117.5	4117.5 ✓			06/16/22	0456WB009E	4
S355	3340.0	3340.2 ✓			↓	↓	↓
S356	3374.3	3374.5 ✓			↓	↓	↓
S357	4078.2	4078.4 ✓			Not used		
S358	3497.5	3498.3	3497.9	3497.7	↓		
S359					Not used		
S360					↓		
S361					↓		
S362					↓		
S363					↓		
S364					↓		
	Initials: TT	Initials: FO	Initials: TT	Initials: TT			

Final Technician Signature: Tony Tang Date: 06/16/2022 Evaluator signature: M. Morgan

Run 2 (Category I)

Hydronic Heating Appliances - Test Method ASTM E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run: 2
Test Date: June 14, 2022

Burn Rate	**5.76 kg/hr dry**
Average Tunnel Temperature	91 degrees F
Average Gas Velocity in Dilution Tunnel - vs	7.4 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	19908 dscf/hour
Average Delta p	0.030 inches H20
Average Delta H	1.28 inches H20
Total Time of Test	178 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**4.76** g/hr **0.54** g/kg
Complete Run:	**3.11** g/hr **0.54** g/kg **0.10** lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	28.50 cubic feet	28.52 cubic feet	45.12 cubic feet
Average Gas Meter Temperature	77 degrees F	77 degrees F	70 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	28.5 dscf	28.5 dscf	46.0 dscf
Total Particulates - mn	4.5 mg	4.4 mg	0 mg
Particulate Concentration (dry-standard)	0.000158 grams/dscf	0.000154 grams/dscf	0.000000 grams/dscf
Particulate Emissions	9.33 grams	9.12 grams	
Particulate Emission Rate	3.15 grams/hour	3.07 grams/hour	
Difference from Average	0.11 grams	0.11 grams	
Emissisons Factor	0.55 g/kg	0.53 g/kg	

Results Are Acceptable

AVERAGE

Total Sample Volume - Vm	28.51 cubic feet
Average Gas Meter Temperature	77 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	28.5 dscf
Train Precesion 7.5%	**1.17 grams**
Train Precision 0.5g/kg	0.01 grams/kg
Particulate Concentration (dry-standard)	0.00016 grams/dscf
Particulate Emissions	9.22 grams
7.5% of the average particulate emissions	0.69 grams

ADDITIONAL ACCEPTANCE CRITERIA

PTS Water Temperature >120 °F at Start of Test	**Acceptable**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	9.57 cubic feet
Average Gas Meter Temperature	74 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	9.62 dscf
Total Particulates - mn	2.3 mg
Particulate Concentration (dry-standard)	0.00024 grams/dscf
Particulate Emissions	4.76 grams
Burn Rate	8.76 (dry kg/hr)

Method ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Comments:	

Parameters:

Run Number:	2
Test Date:	6/14/22
Total Fuel Weight (lb):	45.6
Average Moisture of Fuel (% dry):	20.97
Average Moisture of Fuel (% wet):	17.33
Average Temperature of Appliance Water at Start of Test (°F):	119.4
Average Temperature of Appliance Water at End of Test (°F):	177.9
Average Thermopile Reading (°F):	84.8
Average Load Side Liquid Flow Rate (gal/min):	0.314
Time Interval (min):	178
Burn Rate (kg/hr):	5.76
Emissions (g):	9.22
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

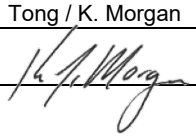
Calculations:

$Q_{in\ gross}$ (HHV, Btu):	314348
$Q_{in\ net}$ (HHV, Btu):	293948
Net HHV Heat Input Rate (Btu/hr):	99084
$Q_{in\ gross}$ (LHV, Btu):	291978
$Q_{in\ net}$ (LHV, Btu):	271578
Net LHV Heat Input Rate (Btu/hr):	91543
Appliance Water Specific Heat (Btu/lb°F):	1.001
Tank Water Specific Heat (Btu/lb°F):	1.001
Q_{unit} (Btu):	24666
Q_{Load} (Btu):	38559
$Q_{Storage}$ (Btu):	135785
Total Heat Output (Btu):	199010
Total Heat Output Rate (Btu/hr):	67082
Total Particulate Emissions (g):	9.22
Time Interval (hr):	3.0
Load Output Rate (Btu/hr):	12997
Emissions Factor(g/kg):	0.54
Total Particulate Emissions Rate (g/MJ):	0.044
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.102**
Total Particulate Emissions (g/hr):	3.11
Delivered Efficiency, HHV (%):	67.7
First Hour Emissions Factor (g/kg):	0.54
First Hour Emissions Rate (g/hr):	4.76

Flue Loss Efficiency

Manufacturer: Froling GmbH
Model: S3 Turbo 30
Date: 06/14/22
Run: 2
Control #: 2448
Test Duration: 178
Output Category: I

Technicians: T. Tong / K. Morgan



Test Results in Accordance with CSA B415.1-10

	HHV Basis	LHV Basis
Overall Efficiency	76.4%	81.7%
Combustion Efficiency	97.2%	97.2%
Heat Transfer Efficiency	79%	84.1%

Output Rate (kJ/h)	88,000	83,477	**(Btu/h)**
Burn Rate (kg/h)	5.77	12.71	**(lb/h)**
Input (kJ/h)	115,153	109,235	**(Btu/h)**

Test Load Weight (dry kg)	17.10	37.70	**dry lb**
MC wet (%)	17.33		
MC dry (%)	20.96		
Particulate (g)	9.22		
CO (g)	799		
Test Duration (h)	2.97		

Emissions	**Particulate**	**CO**
g/MJ Output	0.04	3.06
g/kg Dry Fuel	0.54	46.71
g/h	3.11	269.30
lb/MM Btu Output	0.08	7.11

Air/Fuel Ratio (A/F)	14.56

VERSION: **2.4** **4/15/2010**

OMNI-Test Laboratories, Inc. **ASTM E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 2

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/14/2022

Test Crew: T. Tong K. Morgan

OMNI Equipment ID numbers: 00335, 00336, 00594, 00356

Wood Heater Run Notes

Air Control Settings

Primary:

Primary air setting is adjusted by function monitored induced draft fan.

Secondary: Automatic

Tertiary/Pilot:

Fan: Automatic speed controlled induced draft fan

Preburn Notes

Time	Notes
8:52	started to draw heat from thermal storage tank at target load
9:58	started sampling when temperature of thermal tank dropped to 123°F

Test Notes

Sketch test fuel configuration:

See fuel load photos in the ~~test~~ report

Start up procedures & Timeline:

Bypass: N/A

Fuel loaded by: 2 minutes (lighting)

Door closed at: 2 minutes

Primary air: Automatic

Notes:

Time	Notes
9:58	loading fuel charge, ~~starting test~~
10:58	first hour filters change
12:28	stirred the charcoal
12:56	~~test~~ ended

Technician Signature: Tony Tong Date: 06/14/22

ASTM E2780 Wood Heater Run Sheets

Client: Froling GmbH Project Number: 0456WB009E Run Number: 2
Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/14/2022
Test Crew: T. TONG K. MORGAN
OMNI Equipment ID numbers: 00594, 00335, 00336, 00410, 00716, 00322, 00255, 00677

Wood Heater Supplemental Data

Start Time: 9:58
Stop Time: 12:56

Booth #: 3

Stack Gas Leak Check:
Initial: good Final: good

Sample Train Leak Check:
A: 0.000 @ 16.96 Hg A, 0.000 @ 16.46 Hg
B: 0.000 @ 16.96 Hg

Calibrations: Span Gas CO_2: 16.94 % CO: 4.32 %

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	8:30	8:33	13:08	13:10
CO_2	0.00	17.00	0.00	16.92
CO	0.00	4.32	0.00	4.30

Air Velocity (ft/min): Initial: <50 Final: <50
Scale Audit (lbs): Initial: 10 Final: 10
Pitot Tube Leak Test: Initial: good Final: good
Stack Diameter (in): 6
Induced Draft: 0.001
% Smoke Capture: 100
Flue Pipe Cleaned Prior to First Test in Series:
Date: 12/16/21 Initials: KM

	Initial	Middle	Ending
P_b (in/Hg)	30.24	30.25	30.24
RH (%)	55	52	49
Ambient (°F)	66	67	69

Tunnel Traverse

Microtector Reading		dP (in H_2O)		T(°F)	
1	7	0.010	.010	74	74
2	8	0.012	.012		
3	9	0.014	.016		
4	10	.014	.016		
5	11	.010	.012		
6	12	.010	.010	↓	↓
Center:					
		0.030		72	

Tunnel Static Pressure (in H_2O):	
Beginning of Test	End of Test
−0.251	−0.246

Background Filter Volume: 45,118 ft^3

Technician Signature: Tony Tong Date: 06/16/2022

342,500 108,000 342500 125,000
234,500 157,182 ~~321,00~~ 32,182

Froling 0456WB009E RUN 2 (CAT 1) 6-14-22 3.5

Cal Check: 12.0 = 12.0, 22.0 = 22.0

Project# 0456WB009E Date 6-14-22

Client FROLING Tracking# 2448

Test Fuel Load (60%) Model S3 TURBO 30 Initials LC

	Pc No	Weight, lb	L x W x h	Moisture
8.5	1	8.5	16 x 7 x 4.5	20.4, 24.9, 22.4, 19.5, 19.4
18.1	2	9.6	16 x ~~5~~ 6.5 x ~~6~~ 7.0	24.8, 24.9, 19.7, 19.2, 23.4
25.3	3	7.2	16 x 5.5 x 5.5	19.3, 19.6, 19.2, 18.9, 19.8
~~27.4~~	Kindling	2.6 lb	16 x 1 x 2	same log 11.8, 8.9, 12.4, 11.6, 13.0

Remainder (Goal = ~~45 lb - 4.3 startup = 25.3 of 60%~~ = 13.4)

~~33.8~~ 31	4	5.7	16 x 5 x 6	19.4, 23.1, 19.3, 22.6, 21.4
35.9	5	4.9	16 x 6 x 3	20.7, 22.0, 21.6, 19.0, 22.4
15 ~~40.3~~	6	4.4	16 x 5.5 x 4.5	22.7, 24.6, 23.2, 23.8, 22.8

<40.3>

Start-up ~~[illegible]~~ = 10% of 44 = 4.4

43.2	log 1	23.4, 22.0, 22.8, 22.0, 23.2	→ 3 2" pc's totaling 1.6 ~~2.9 lb~~
45.8	log 2	21.4, 22.6, 24.4, 23.8, 20.2	3 2" pc's @ 2.6

395,600 - 37,500
231,560 pts

K.L. Morgy 6-14-22

126,540

Main 60%	25.3
Main, Remainder	15.0
Start-up	4.2
	44.5
Kindling	2.6
Cord Band	0.2
	47.3
~~Δ = 1.0 lb~~	
-0.34 lb of hot Remainder	Coals: 1.7
	47.0

Flow - Pre-test

137.25 sec 7.6 lb

T 63-65

Mid test: T = 149 - 151 6.5 lb 146.31 s

End test: T = 267 - 270 6.6 lb, 189.81 s

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

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Run #:	2
Test Date:	June 14, 2022

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Maple, Black 7 x 4.5 x 16"	8.5	20.4	24.9	22.4	19.5	19.4
Maple, Black 6.5 x 7 x 16"	9.6	24.8	24.9	19.7	19.2	23.4
Maple, Black 5.5 x 5.5 x 16"	7.2	19.3	19.6	19.2	18.9	19.8
Maple, Black 5 x 6 x 16"	5.7	19.4	23.1	19.3	22.6	21.4
Maple, Black 6 x 3 x 16"	4.9	20.7	22	21.6	19	22.4
Maple, Black 5.5 x 4.5 x 16"	4.4	22.7	24.6	23.2	23.8	22.8
Maple, Black 10 x (1 x 2 x 16") Kindling	2.6	11.8	8.9	12.4	11.6	13
Maple, Black 2x (2 x 2 x 16") Start-up	1.6	23.4	22	22.8	22	23.2
Maple, Black 2 x (2 x 2 x 16") Statrt-up	2.6	21.4	22.6	24.4	23.8	20.2
Card Board	0.2					
Left Over Coals	1.7					

Weight of Main Fuel Load (with Start-up pieces), lb.	44.5
Weight of Kindling Fuel (Plus Cardboard), lb	2.8
Gross Fuel Weight, lb	47.3
Net Fuel Weight (Gross Fuel Weight minus remaining Coals), lb:	45.6
Total (Combined) Moisture of Load, % db:	**20.97**
Average Kindling Moisture, % db	11.54
Average Main Fuel Moisture, % db:	21.745

Equipment Numbers:

Hydronic Heating Appliances - Test Method ASTM E2618-13
Pre-Burn Data

Manufacturer: Froling
Model: S3 Turbo 30
Tracking No.: 2448
Project No.: 0456WB009E
Run: 2
Test Date: June 14, 2022

Load Average
12531.41 Btu / hr

Appliance				LOAD										PTS				
Time, Min	Supply (T1)	Return (T2)	ΔT	Load IN, °F (T3)	Load OUT, °F (T4)	Flow Hz	Water Flow, GPM	Cpi	ΔT	Mass Flow Rate, lb/min	Btu/Min	**Btu/Hr**	Fuel Weight, LB	PTS TOP (T7)	PTS Bottom (T9)	PTS Mid (T8)	PTS ΔT	Boiler Return
17	129.0	125.8	3.2	66.560	126.222	88.092	0.420	1.001	59.662	3.495	208.8	**12526.29**	46.78	127.9	129.0	128.6	1.2	129.9133
18	128.8	125.9	2.9	66.505	126.328	88.000	0.419	1.001	59.824	3.491	209.1	**12546.61**	46.81	128.0	129.1	128.5	1.1	129.6877
19	128.7	125.8	2.9	66.358	126.357	87.938	0.419	1.001	60.000	3.489	209.6	**12574.40**	46.81	127.9	129.1	128.3	1.2	129.3567
20	128.6	125.8	2.8	66.082	126.264	87.871	0.419	1.001	60.181	3.486	210.0	**12602.94**	46.85	127.8	128.9	128.2	1.1	129.1065
21	128.2	125.6	2.6	65.679	126.145	87.892	0.419	1.001	60.466	3.487	211.1	**12666.32**	46.81	127.7	128.8	126.6	1.1	128.7043
22	127.8	125.6	2.2	65.184	126.089	88.204	0.420	1.001	60.905	3.500	213.4	**12806.59**	46.97	127.7	128.6	126.6	0.9	128.3933
23	127.6	125.5	2.1	64.682	126.015	85.449	0.407	1.001	61.333	3.386	207.9	**12476.20**	47.11	127.6	128.6	126.4	1.0	128.1063
24	127.3	125.4	1.8	64.229	125.952	84.770	0.403	1.001	61.723	3.358	207.5	**12451.64**	47.09	127.3	128.3	126.2	1.0	127.8614
25	127.0	125.3	1.7	63.840	125.804	84.828	0.403	1.001	61.964	3.361	208.5	**12509.87**	47.00	127.4	128.5	126.2	1.1	127.609
26	126.8	125.3	1.5	63.500	125.796	84.872	0.404	1.001	62.295	3.363	209.7	**12584.15**	50.36	127.4	128.3	126.0	0.9	127.4652
27	126.5	125.2	1.4	63.252	125.698	84.839	0.404	1.001	62.446	3.362	210.2	**12609.91**	48.81	127.2	128.3	126.0	1.0	127.3211
28	126.1	125.1	1.1	63.073	125.596	83.622	0.397	1.001	62.523	3.311	207.3	**12435.99**	46.87	127.2	128.2	125.9	0.9	127.0367
29	126.0	125.0	0.9	62.917	125.564	82.835	0.394	1.001	62.647	3.279	205.6	**12337.99**	46.78	127.2	128.1	125.9	1.0	126.8889
30	125.7	124.9	0.8	62.807	125.410	85.478	0.407	1.001	62.602	3.388	212.4	**12741.85**	47.20	127.0	128.0	125.7	1.0	126.7506
31	125.3	124.8	0.5	62.733	125.356	85.344	0.406	1.001	62.624	3.383	212.1	**12725.43**	46.89	127.0	128.0	125.6	1.0	126.6474
32	125.3	124.8	0.6	62.668	125.314	85.271	0.406	1.001	62.646	3.380	212.0	**12718.76**	46.77	126.7	127.9	125.6	1.2	126.5069
33	124.9	124.6	0.3	62.626	125.173	85.206	0.405	1.001	62.547	3.377	211.5	**12688.53**	46.92	126.7	127.7	125.5	1.0	126.343
34	124.7	124.6	0.2	62.593	125.094	85.090	0.405	1.001	62.501	3.372	211.0	**12661.23**	46.86	126.7	127.6	125.5	0.9	126.3379
35	124.6	124.5	0.0	62.572	125.052	85.145	0.405	1.001	62.481	3.375	211.1	**12665.68**	47.16	126.7	127.7	125.4	1.0	126.1159
36	124.4	124.4	0.0	62.551	124.982	85.110	0.405	1.001	62.431	3.373	210.8	**12650.14**	46.68	126.6	127.5	125.1	0.9	126.0524
37	124.3	124.3	0.0	62.525	124.881	84.988	0.404	1.001	62.357	3.368	210.3	**12616.18**	46.94	126.5	127.5	125.0	1.0	125.9086
38	124.1	124.2	-0.1	62.501	124.816	84.893	0.404	1.001	62.315	3.364	209.9	**12593.07**	47.01	126.5	127.5	124.9	1.0	125.8561
39	124.0	124.0	0.0	62.482	124.757	84.906	0.404	1.001	62.275	3.365	209.8	**12587.01**	47.04	126.4	127.4	124.9	1.0	125.5276
40	123.7	123.6	0.0	62.463	124.702	84.283	0.401	1.001	62.239	3.339	208.1	**12483.06**	51.25	126.3	127.3	124.9	0.9	124.9468
41	123.2	123.6	-0.4	62.461	124.626	84.397	0.401	1.001	62.165	3.344	208.1	**12485.91**	51.14	126.1	127.1	124.8	1.0	124.2327
42	123.1	123.1	0.0	62.443	124.443	85.095	0.405	1.001	62.000	3.373	209.3	**12560.65**	46.67	126.0	127.1	124.7	1.1	123.7242
43	122.7	122.7	0.0	62.423	124.388	85.038	0.405	1.001	61.965	3.370	209.1	**12544.85**	56.88	126.0	127.0	124.6	1.0	123.4241
44	122.6	122.7	-0.1	62.400	124.284	84.986	0.404	1.001	61.883	3.368	208.7	**12520.43**	50.49	125.8	126.9	124.9	1.0	123.1813
45	122.4	122.3	0.1	62.380	124.216	84.946	0.404	1.001	61.835	3.366	208.4	**12504.48**	46.73	125.9	126.9	124.8	1.0	122.7947
46	122.0	121.9	0.1	62.365	124.176	84.966	0.404	1.001	61.811	3.367	208.4	**12502.63**	46.77	125.8	126.8	124.8	0.9	122.5438
47	121.6	121.8	-0.1	62.340	124.115	84.887	0.404	1.001	61.775	3.364	208.1	**12483.35**	46.87	125.8	126.7	124.7	0.9	122.268
48	121.6	121.9	-0.2	62.311	123.996	84.912	0.404	1.001	61.685	3.365	207.8	**12468.94**	46.87	125.7	126.7	124.4	0.9	122.0403
49	121.4	121.1	0.3	62.284	123.984	84.889	0.404	1.001	61.700	3.364	207.8	**12468.60**	46.80	125.6	126.5	124.4	0.9	121.8391
50	121.7	121.0	0.6	62.248	123.911	84.867	0.404	1.001	61.663	3.363	207.6	**12457.72**	46.86	125.5	126.4	124.4	0.9	121.5944
51	121.1	120.9	0.1	62.195	123.760	84.896	0.404	1.001	61.565	3.364	207.4	**12442.47**	51.14	125.5	126.4	124.4	1.0	121.4081
52	121.1	120.5	0.6	62.137	123.701	84.825	0.403	1.001	61.564	3.361	207.2	**12431.37**	48.92	125.4	126.3	124.2	0.9	121.1807

53	120.7	120.2	0.5	62.072	123.644	84.869	0.404	1.001	61.572	3.363	207.3	**12439.91**	50.35	125.3	126.3	124.6	1.0	120.9111
54	118.6	121.9	-3.3	61.978	123.564	84.948	0.404	1.001	61.586	3.367	207.6	**12455.03**	46.90	125.2	126.1	124.3	0.9	124.1296
55	116.8	121.7	-4.9	61.883	123.485	84.829	0.403	1.001	61.601	3.362	207.3	**12439.95**	46.72	125.1	126.1	124.3	1.0	124.6683
56	117.2	122.1	-4.9	61.785	123.429	84.814	0.403	1.001	61.644	3.361	207.4	**12446.41**	46.98	125.1	126.1	124.2	1.0	124.6138
57	119.9	122.3	-2.4	61.709	123.338	84.790	0.403	1.001	61.630	3.360	207.3	**12439.93**	46.84	125.1	126.0	124.1	0.9	124.3384
58	121.3	122.5	-1.2	61.612	123.274	84.758	0.403	1.001	61.661	3.359	207.4	**12441.61**	46.84	124.8	125.9	123.9	1.1	123.9581
59	122.0	122.5	-0.5	61.531	123.186	84.830	0.403	1.001	61.655	3.362	207.5	**12451.41**	46.98	124.8	125.7	123.9	0.9	123.7899
60	122.1	122.5	-0.4	61.458	123.091	84.844	0.404	1.001	61.633	3.363	207.5	**12449.35**	47.00	124.7	125.7	123.8	1.0	123.658
61	122.3	122.4	-0.1	61.400	123.002	84.775	0.403	1.001	61.601	3.360	207.2	**12432.39**	46.91	124.7	125.6	123.8	1.0	123.4435
62	122.3	122.4	0.0	61.336	122.943	84.753	0.403	1.001	61.607	3.359	207.2	**12430.26**	46.98	124.6	125.6	123.6	1.0	123.2284
63	122.3	122.3	0.0	61.293	122.883	84.224	0.400	1.001	61.590	3.337	205.8	**12345.67**	46.90	124.5	125.5	123.5	1.0	123.0454
64	122.1	122.3	-0.2	61.263	122.831	83.726	0.398	1.001	61.569	3.316	204.4	**12264.99**	46.85	124.5	125.4	123.2	0.9	122.7996
65	121.8	122.2	-0.4	61.209	122.789	84.823	0.403	1.001	61.580	3.362	207.3	**12435.66**	46.97	124.4	125.3	123.2	0.9	122.6092
66	121.6	121.9	-0.3	61.178	122.655	84.838	0.404	1.001	61.476	3.362	207.0	**12417.30**	46.84	124.4	125.3	123.2	0.9	122.2466
67	121.2	121.7	-0.4	61.155	122.585	84.814	0.403	1.001	61.429	3.361	206.7	**12404.10**	47.84	124.3	125.3	122.9	1.0	121.5053
68	121.2	121.2	0.0	61.147	122.565	84.781	0.403	1.001	61.418	3.360	206.6	**12396.75**	51.12	124.2	125.2	123.1	1.0	120.6554
69	120.2	121.6	-1.5	61.145	122.448	84.596	0.402	1.001	61.302	3.352	205.8	**12345.10**	46.82	124.2	125.1	123.0	0.9	122.184
70	119.5	121.7	-2.2	61.140	122.377	84.926	0.404	1.001	61.237	3.366	206.4	**12382.31**	47.01	124.1	125.0	122.9	0.9	122.1444
71	119.8	121.7	-1.9	61.126	122.272	84.401	0.401	1.001	61.147	3.344	204.7	**12284.05**	46.86	124.0	124.9	122.9	0.9	122.0615
72	120.1	121.6	-1.5	61.125	122.214	84.708	0.403	1.001	61.089	3.357	205.3	**12319.15**	46.98	123.9	124.8	122.7	0.9	121.8151
73	120.3	121.5	-1.2	61.142	122.108	87.937	0.419	1.001	60.966	3.491	213.1	**12785.67**	46.76	123.8	124.7	122.7	0.9	121.588
74	120.5	121.4	-0.9	61.157	121.927	88.881	0.424	1.001	60.770	3.530	214.8	**12887.66**	46.73	123.6	124.6	122.5	1.0	121.4401
75	120.5	121.3	-0.8	61.177	121.871	88.855	0.424	1.001	60.694	3.529	214.5	**12867.55**	47.01	123.6	124.6	122.4	1.0	121.4114
76	120.2	121.2	-1.0	61.203	121.783	88.876	0.424	1.001	60.580	3.530	214.1	**12846.48**	46.87	123.6	124.5	122.4	0.9	121.3539
77	120.2	121.2	-1.0	61.240	121.708	88.880	0.424	1.001	60.468	3.530	213.7	**12823.34**	47.00	123.5	124.5	122.4	1.0	121.2364
78	120.0	121.1	-1.1	61.283	121.622	86.583	0.412	1.001	60.339	3.435	207.5	**12449.96**	46.89	123.3	124.3	122.4	1.0	121.2072
79	120.0	121.0	-1.1	61.320	121.592	86.937	0.414	1.001	60.273	3.450	208.2	**12489.48**	47.11	123.3	124.1	122.1	0.8	121.0975
80	119.7	120.9	-1.2	61.362	121.475	88.837	0.423	1.001	60.113	3.528	212.4	**12741.32**	47.12	123.2	124.2	122.1	1.0	120.9877
81	119.5	120.6	-1.1	61.409	121.374	88.665	0.423	1.001	59.965	3.521	211.4	**12684.15**	47.08	123.1	124.1	122.5	0.9	120.7928
82	119.5	120.4	-0.9	61.458	121.209	86.692	0.413	1.001	59.751	3.439	205.7	**12344.63**	47.03	123.1	124.0	122.2	1.0	120.1129

Hydronic Heating Appliances - Test Method ASTM E2515-11

Emissions Sampling Data

Run: 2

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Test Date: June 14, 2022
Technician: TT / KM
Beginning Clock Time: 09:58
Recording Interval: 1 min.
Total Sampling Time: 178 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	0.010	0.012	0.014	0.014	0.010	0.010	0.010	0.012	0.016	0.016	0.012	0.010	0.030	"H2O
Initial Temp.	74	74	74	74	74	74	74	74	74	74	74	74	72	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: 12/16/2021

V_{strav} 7.29 ft/sec
V_{scent} 11.46 ft/sec
F_p 0.635

	(1)	(2)	(amb)	
Meter Box Y Factor:	1.003	1.003	1.011	
Barometric Pressure:	Begin	Middle	End	Average
	30.24	30.25	30.24	30.24 "Hg

PM Control Module: 335, 336
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: -0.248 "H2O
Pitot Tube Cp: 0.99

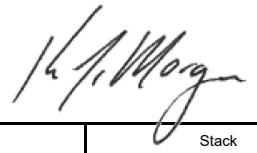
Tunnel Velocity: 7.42 ft/sec.
Intial Tunnel Flow: 335.9 scfm
Average Tunnel Flow: 331.8 scfm
Tunnel Area: 0.785 ft2

Post-Test Leak Check (1): 0.000 cfm @ -16 in. Hg
Post-Test Leak Check (2): 0.000 cfm @ -17 in. Hg
Fuel Moisture (dry basis %): 20.97
Total Particulate (1): 4.5
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			1.03	0.97	0.34	71	70	70	2.48	1.90	67	0.032			45.6		88	67	66	66	0.016	0.01	8.81
1	0.156	0.168		0.16	0.17	1.33	1.39	0.34	71	70	70	2.70	2.00	77	0.030	97	105	45.4	0.21	152	67	67	66	0.037	0.00	0.47
2	0.314	0.346		0.16	0.18	1.24	1.38	0.34	71	70	70	2.58	2.00	80	0.029	101	113	45.4	0.04	188	67	67	65	0.041	0.18	3.58
3	0.470	0.521		0.16	0.18	1.24	1.34	0.34	71	70	70	2.60	2.00	84	0.029	100	112	44.6	0.79	224	68	68	65	0.046	0.14	5.21
4	0.627	0.678		0.16	0.16	1.28	1.07	0.34	71	70	70	2.66	1.70	87	0.030	99	99	44.4	0.17	244	68	68	66	0.048	0.03	7.95
5	0.786	0.834		0.16	0.16	1.30	1.07	0.34	71	70	70	2.70	1.70	90	0.029	102	100	43.8	0.60	264	69	68	66	0.051	0.03	8.44
6	0.946	0.993		0.16	0.16	1.30	1.10	0.34	71	70	70	2.71	1.70	92	0.030	101	101	43.5	0.28	278	69	69	66	0.052	0.01	10.11
7	1.105	1.151		0.16	0.16	1.30	1.10	0.34	71	70	70	2.69	1.70	94	0.029	103	102	43.0	0.55	288	70	69	66	0.052	0.00	10.38
8	1.265	1.310		0.16	0.16	1.29	1.10	0.34	71	70	70	2.69	1.70	95	0.029	103	103	42.3	0.69	297	70	70	66	0.054	0.00	10.73
9	1.424	1.467		0.16	0.16	1.28	1.09	0.34	71	71	70	2.67	1.70	97	0.029	103	101	41.6	0.64	302	71	70	66	0.054	0.00	11.03
10	1.582	1.624		0.16	0.16	1.28	1.09	0.34	71	71	70	2.68	1.70	98	0.030	101	100	40.8	0.80	307	71	70	66	0.055	0.00	10.75
11	1.741	1.781		0.16	0.16	1.29	1.06	0.34	71	71	70	2.69	1.70	98	0.029	103	102	40.7	0.08	309	72	71	66	0.056	0.00	10.90
12	1.901	1.937		0.16	0.16	1.28	1.07	0.34	71	71	70	2.68	1.80	98	0.029	104	101	40.2	0.52	309	72	71	66	0.056	0.01	10.50
13	2.059	2.093		0.16	0.16	1.28	1.06	0.34	71	71	70	2.68	1.80	97	0.030	101	99	39.5	0.72	305	72	71	66	0.056	0.00	10.70
14	2.217	2.248		0.16	0.16	1.28	1.06	0.34	71	71	70	2.69	1.80	95	0.028	104	102	39.0	0.49	302	72	71	66	0.054	0.01	10.46
15	2.377	2.404		0.16	0.16	1.28	1.06	0.34	71	71	70	2.69	1.80	96	0.029	103	101	38.4	0.64	304	72	71	66	0.055	0.02	10.97
16	2.535	2.560		0.16	0.16	1.27	1.12	0.34	72	71	70	2.69	1.80	98	0.031	99	98	38.3	0.03	311	72	71	66	0.054	0.01	10.63
17	2.693	2.718		0.16	0.16	1.28	1.11	0.34	72	72	70	2.68	1.80	99	0.029	102	102	37.8	0.52	314	73	72	66	0.055	0.01	10.30
18	2.851	2.876		0.16	0.16	1.29	1.09	0.34	72	72	70	2.71	1.80	99	0.031	99	99	37.1	0.77	314	73	71	66	0.055	0.01	10.09
19	3.011	3.036		0.16	0.16	1.29	1.10	0.34	72	72	70	2.69	1.80	99	0.028	105	105	36.8	0.22	315	73	71	66	0.055	0.01	9.45
20	3.171	3.194		0.16	0.16	1.28	1.10	0.34	72	72	70	2.71	1.80	100	0.030	102	100	36.5	0.36	316	73	71	66	0.056	0.03	9.10
21	3.329	3.352		0.16	0.16	1.29	1.10	0.34	72	72	70	2.70	1.80	100	0.030	101	100	36.2	0.32	315	73	71	66	0.054	0.05	8.83
22	3.489	3.512		0.16	0.16	1.28	1.10	0.34	72	72	70	2.71	1.80	100	0.030	102	102	35.4	0.75	314	73	71	66	0.055	0.07	8.18
23	3.649	3.670		0.16	0.16	1.29	1.10	0.34	73	72	70	2.70	1.80	100	0.030	102	100	35.8	-0.39	313	73	71	66	0.054	0.08	8.02
24	3.808	3.829		0.16	0.16	1.28	1.10	0.34	73	73	70	2.72	1.80	101	0.030	101	101	35.0	0.77	312	73	72	66	0.055	0.11	8.01
25	3.967	3.988		0.16	0.16	1.29	1.10	0.34	73	73	70	2.71	1.80	101	0.030	101	101	34.4	0.63	314	73	72	66	0.055	0.21	8.15
26	4.127	4.146		0.16	0.16	1.29	1.10	0.34	73	73	70	2.70	1.80	101	0.030	102	100	34.4	-0.02	315	73	72	66	0.055	0.11	8.62
27	4.287	4.306		0.16	0.16	1.28	1.10	0.34	73	73	70	2.71	1.80	101	0.030	102	102	33.8	0.62	314	73	72	66	0.055	0.18	8.20

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(%)
28	4.446	4.464		0.16	0.16	1.29	1.10	0.34	73	73	70	2.71	1.80	101	0.031	100	99	33.2	0.58	314	73	72	67	0.055	0.18	8.04
29	4.605	4.622		0.16	0.16	1.28	1.10	0.34	73	73	70	2.71	1.80	101	0.032	98	97	32.6	0.65	314	73	72	66	0.056	0.18	7.97
30	4.765	4.782		0.16	0.16	1.29	1.10	0.34	74	74	70	2.70	1.80	101	0.030	102	101	32.9	-0.31	313	73	72	66	0.055	0.20	7.82
31	4.925	4.939		0.16	0.16	1.28	1.10	0.34	74	74	70	2.70	1.90	101	0.029	103	101	32.2	0.65	311	73	72	67	0.056	0.22	7.54
32	5.084	5.099		0.16	0.16	1.28	1.10	0.34	74	74	70	2.72	1.90	101	0.031	99	100	31.9	0.28	310	73	72	67	0.054	0.25	7.38
33	5.243	5.257		0.16	0.16	1.29	1.09	0.34	74	74	70	2.72	1.80	101	0.031	99	99	31.7	0.27	308	73	72	67	0.054	0.33	7.39
34	5.403	5.416		0.16	0.16	1.28	1.10	0.34	74	74	70	2.71	1.90	101	0.031	100	99	31.0	0.66	307	74	72	67	0.054	0.33	7.01
35	5.563	5.575		0.16	0.16	1.29	1.10	0.34	74	74	70	2.71	1.90	101	0.030	102	101	30.8	0.22	306	73	72	67	0.054	0.40	6.67
36	5.723	5.733		0.16	0.16	1.28	1.09	0.34	74	74	70	2.71	1.80	101	0.031	100	99	30.1	0.69	307	74	72	67	0.055	0.35	6.63
37	5.882	5.892		0.16	0.16	1.29	1.10	0.34	75	74	70	2.72	1.90	101	0.030	101	101	29.7	0.37	306	74	72	66	0.054	0.30	6.82
38	6.042	6.051		0.16	0.16	1.28	1.09	0.34	75	75	70	2.71	1.80	101	0.030	101	101	29.8	-0.11	304	73	72	67	0.054	0.33	6.49
39	6.201	6.209		0.16	0.16	1.29	1.10	0.34	75	75	70	2.72	1.90	101	0.030	101	100	29.2	0.64	302	74	72	67	0.053	0.27	6.33
40	6.362	6.369		0.16	0.16	1.28	1.09	0.34	75	75	70	2.72	1.80	101	0.030	102	101	28.8	0.41	300	74	72	67	0.054	0.36	6.01
41	6.522	6.527		0.16	0.16	1.28	1.10	0.34	75	75	70	2.72	1.90	101	0.030	101	100	28.8	-0.01	303	74	72	67	0.054	0.43	6.03
42	6.681	6.686		0.16	0.16	1.28	1.09	0.34	75	75	70	2.72	1.80	101	0.029	102	102	28.4	0.37	306	74	72	67	0.054	0.37	6.55
43	6.841	6.846		0.16	0.16	1.29	1.10	0.34	75	75	70	2.72	1.90	101	0.030	101	101	28.2	0.25	305	74	72	67	0.054	0.24	7.16
44	7.001	7.004		0.16	0.16	1.29	1.10	0.34	75	75	70	2.71	1.90	101	0.029	103	102	27.4	0.82	307	74	72	67	0.054	0.33	6.56
45	7.161	7.163		0.16	0.16	1.28	1.10	0.34	76	75	70	2.71	1.90	101	0.030	101	101	27.1	0.22	306	74	72	67	0.055	0.22	6.84
46	7.321	7.323		0.16	0.16	1.28	1.09	0.34	76	76	70	2.73	1.90	101	0.028	105	105	26.7	0.39	306	74	72	67	0.055	0.27	6.72
47	7.481	7.481		0.16	0.16	1.29	1.10	0.34	76	76	70	2.72	1.90	99	0.029	103	101	26.9	-0.14	302	74	72	67	0.054	0.30	6.53
48	7.641	7.641		0.16	0.16	1.29	1.10	0.34	76	76	70	2.72	1.90	98	0.030	101	101	26.2	0.70	302	74	72	67	0.055	0.26	7.76
49	7.802	7.799		0.16	0.16	1.29	1.09	0.34	76	76	70	2.71	1.90	97	0.031	100	98	25.7	0.51	301	74	72	67	0.054	0.25	7.77
50	7.962	7.958		0.16	0.16	1.28	1.10	0.34	76	76	70	2.72	1.90	97	0.031	99	98	25.7	-0.01	301	74	72	67	0.054	0.31	7.55
51	8.121	8.119		0.16	0.16	1.29	1.10	0.34	76	76	70	2.72	1.90	97	0.030	100	101	24.8	0.86	301	74	72	67	0.055	0.36	7.40
52	8.281	8.277		0.16	0.16	1.29	1.09	0.34	76	76	70	2.71	1.90	98	0.030	101	100	24.5	0.30	302	74	72	67	0.054	0.37	7.12
53	8.441	8.436		0.16	0.16	1.29	1.10	0.34	76	76	70	2.71	1.80	98	0.030	101	100	24.2	0.30	302	74	72	67	0.054	0.35	7.08
54	8.603	8.596		0.16	0.16	1.27	1.10	0.34	77	76	70	2.71	1.90	98	0.031	100	99	23.8	0.42	303	74	72	67	0.054	0.38	7.09
55	8.763	8.755		0.16	0.16	1.28	1.10	0.34	77	76	70	2.71	1.80	98	0.029	102	102	23.8	0.00	303	74	72	67	0.055	0.34	7.41
56	8.922	8.914		0.16	0.16	1.28	1.10	0.34	77	76	70	2.72	1.90	98	0.031	99	99	23.4	0.41	303	74	72	67	0.055	0.35	7.22
57	9.083	9.074		0.16	0.16	1.29	1.10	0.34	77	77	70	2.71	1.90	98	0.030	101	101	22.8	0.57	302	74	73	67	0.054	0.38	6.71
58	9.243	9.233		0.16	0.16	1.29	1.10	0.34	77	77	70	2.71	1.80	98	0.029	102	102	22.8	0.01	302	74	73	67	0.054	0.39	6.37
59	9.405	9.393		0.16	0.16	1.28	1.10	0.34	77	77	70	2.71	1.80	98	0.031	100	99	22.3	0.54	302	75	73	67	0.055	0.37	6.36
60	9.565	9.553		0.16	0.16	1.28	1.10	0.34	77	77	70	2.71	1.90	99	0.030	101	101	22.2	0.07	302	75	73	67	0.055	0.37	6.47
61	9.723	9.712		0.16	0.16	1.28	1.10	0.34	77	77	70	3.07	1.80	98	0.031	98	98	21.4	0.84	302	69	73	67	0.055	0.41	6.70
62	9.883	9.872		0.16	0.16	1.28	1.09	0.34	77	77	70	3.08	1.90	99	0.030	101	101	21.1	0.30	303	69	73	67	0.056	0.39	6.80
63	10.044	10.031		0.16	0.16	1.28	1.10	0.34	77	77	70	3.08	1.90	98	0.028	105	104	20.8	0.24	303	70	73	67	0.054	0.38	6.75
64	10.204	10.190		0.16	0.16	1.28	1.11	0.34	77	77	70	3.08	1.90	98	0.031	99	98	20.5	0.30	302	70	73	67	0.055	0.37	6.75
65	10.363	10.350		0.16	0.16	1.28	1.10	0.34	77	77	70	3.08	1.90	97	0.030	100	101	20.3	0.29	299	70	73	67	0.055	0.34	6.87
66	10.523	10.510		0.16	0.16	1.28	1.10	0.34	77	77	70	3.08	1.80	97	0.029	102	102	20.3	-0.07	299	70	73	67	0.055	0.27	7.40
67	10.683	10.669		0.16	0.16	1.28	1.11	0.34	77	77	70	3.08	1.80	97	0.029	102	102	19.8	0.53	300	70	73	67	0.055	0.20	7.60
68	10.844	10.830		0.16	0.16	1.28	1.11	0.34	78	77	70	3.07	1.80	97	0.031	99	100	19.0	0.80	299	71	73	67	0.054	0.32	7.30
69	11.004	10.989		0.16	0.16	1.27	1.10	0.34	78	77	70	3.07	1.80	97	0.032	97	97	19.0	-0.05	300	71	73	67	0.055	0.38	7.04
70	11.164	11.149		0.16	0.16	1.27	1.11	0.34	78	77	70	3.06	1.80	97	0.031	99	99	18.9	0.11	300	71	73	67	0.054	0.24	7.29
71	11.324	11.309		0.16	0.16	1.28	1.11	0.34	78	77	70	3.08	1.80	97	0.030	100	101	18.5	0.40	300	71	73	67	0.055	0.28	7.07
72	11.484	11.469		0.16	0.16	1.28	1.11	0.34	78	77	70	3.06	1.80	97	0.032	97	97	18.1	0.41	299	71	73	67	0.055	0.34	6.87

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(%)
73	11.645	11.628		0.16	0.16	1.28	1.11	0.34	78	78	70	3.07	1.80	97	0.032	98	97	17.6	0.52	297	71	73	67	0.055	0.37	6.28
74	11.805	11.789		0.16	0.16	1.28	1.10	0.34	78	78	70	3.07	1.80	96	0.031	99	99	17.5	0.10	298	71	73	67	0.054	0.38	6.32
75	11.965	11.949		0.16	0.16	1.28	1.10	0.34	78	78	70	3.07	1.80	96	0.030	100	100	17.5	0.00	297	72	73	67	0.054	0.31	6.56
76	12.125	12.109		0.16	0.16	1.28	1.11	0.34	78	78	70	3.06	1.80	97	0.031	99	99	17.1	0.38	296	72	73	67	0.054	0.36	6.17
77	12.286	12.270		0.16	0.16	1.29	1.11	0.34	78	78	70	3.07	1.80	96	0.030	101	101	16.9	0.23	296	72	73	67	0.054	0.35	5.93
78	12.447	12.430		0.16	0.16	1.28	1.11	0.34	78	78	70	3.08	1.80	96	0.030	101	100	16.6	0.30	300	72	73	67	0.054	0.29	6.08
79	12.607	12.589		0.16	0.16	1.28	1.11	0.34	78	78	70	3.08	1.80	97	0.030	100	100	15.6	1.02	303	72	73	67	0.055	0.38	7.00
80	12.767	12.750		0.16	0.16	1.28	1.11	0.34	78	78	70	3.08	1.80	98	0.031	99	99	15.9	-0.34	307	72	73	67	0.056	0.35	7.36
81	12.927	12.910		0.16	0.16	1.28	1.10	0.34	78	78	70	3.08	1.80	98	0.032	97	97	15.1	0.76	307	72	73	67	0.054	0.36	7.46
82	13.087	13.070		0.16	0.16	1.29	1.11	0.34	78	78	70	3.08	1.80	98	0.029	102	102	14.8	0.33	309	72	73	67	0.055	0.30	7.63
83	13.248	13.230		0.16	0.16	1.28	1.11	0.34	78	78	70	3.07	1.80	98	0.030	101	100	14.5	0.35	308	72	73	67	0.054	0.31	7.66
84	13.408	13.391		0.16	0.16	1.28	1.11	0.34	78	78	70	3.08	1.80	98	0.031	99	99	14.3	0.19	307	73	73	67	0.055	0.31	7.57
85	13.568	13.551		0.16	0.16	1.28	1.11	0.34	78	78	70	3.07	1.80	98	0.030	101	100	14.2	0.06	307	73	73	68	0.054	0.36	7.44
86	13.729	13.711		0.16	0.16	1.29	1.11	0.34	78	78	70	3.06	1.80	97	0.031	99	99	13.5	0.72	307	73	73	67	0.054	0.34	7.43
87	13.889	13.872		0.16	0.16	1.29	1.11	0.34	78	78	70	3.07	1.80	97	0.032	97	98	13.4	0.11	307	73	73	67	0.054	0.34	7.44
88	14.050	14.032		0.16	0.16	1.29	1.11	0.34	78	78	70	3.07	1.80	97	0.030	101	100	12.8	0.56	307	73	73	67	0.054	0.26	7.53
89	14.211	14.193		0.16	0.16	1.28	1.12	0.34	78	78	70	3.07	1.80	97	0.031	99	99	12.8	0.07	307	73	73	67	0.055	0.28	7.56
90	14.371	14.354		0.16	0.16	1.28	1.11	0.34	78	78	70	3.06	1.80	97	0.030	100	101	12.6	0.15	307	73	73	67	0.055	0.18	7.69
91	14.531	14.514		0.16	0.16	1.29	1.11	0.34	79	78	70	3.07	1.80	96	0.030	100	100	11.7	0.94	306	73	73	67	0.053	0.21	7.58
92	14.692	14.674		0.16	0.16	1.29	1.12	0.34	79	78	70	3.07	1.80	97	0.030	101	100	11.4	0.32	308	73	73	68	0.053	0.23	7.44
93	14.853	14.836		0.16	0.16	1.28	1.12	0.34	79	78	70	3.06	1.80	97	0.032	98	98	11.4	-0.05	311	73	73	68	0.054	0.03	8.78
94	15.013	14.996		0.16	0.16	1.28	1.11	0.34	79	78	70	3.07	1.80	95	0.030	100	100	10.8	0.65	306	73	73	68	0.053	0.01	8.81
95	15.174	15.157		0.16	0.16	1.29	1.11	0.34	79	78	70	3.07	1.80	94	0.032	97	98	10.7	0.02	302	73	73	68	0.052	0.01	9.22
96	15.334	15.317		0.16	0.16	1.29	1.12	0.34	79	78	70	3.06	1.80	94	0.030	100	100	10.2	0.54	300	73	73	68	0.053	0.01	9.03
97	15.495	15.478		0.16	0.16	1.29	1.12	0.34	79	78	70	3.06	1.80	93	0.030	101	101	10.1	0.13	297	73	73	68	0.052	0.02	8.77
98	15.656	15.639		0.16	0.16	1.28	1.11	0.34	79	78	70	3.07	1.80	93	0.030	101	101	9.9	0.18	295	73	73	68	0.052	0.04	8.41
99	15.817	15.800		0.16	0.16	1.29	1.12	0.34	79	78	70	3.05	1.80	92	0.030	100	101	9.8	0.14	293	73	73	68	0.050	0.06	8.23
100	15.977	15.962		0.16	0.16	1.29	1.11	0.34	79	78	70	3.06	1.80	92	0.030	100	101	9.0	0.73	290	73	73	68	0.051	0.12	7.79
101	16.138	16.123		0.16	0.16	1.28	1.12	0.34	79	78	70	3.06	1.80	92	0.029	102	102	9.2	-0.14	288	73	73	68	0.050	0.22	7.34
102	16.299	16.284		0.16	0.16	1.29	1.12	0.34	79	78	70	3.06	1.80	92	0.030	100	101	8.8	0.35	286	73	73	68	0.051	0.38	6.79
103	16.460	16.445		0.16	0.16	1.29	1.12	0.34	79	78	70	3.05	1.80	91	0.029	102	102	8.4	0.39	283	73	73	68	0.050	0.50	6.26
104	16.621	16.607		0.16	0.16	1.29	1.12	0.34	79	79	70	3.06	1.80	91	0.029	102	103	8.3	0.18	280	73	73	68	0.050	0.57	5.81
105	16.782	16.768		0.16	0.16	1.28	1.12	0.34	79	79	70	3.06	1.80	91	0.029	102	102	7.7	0.60	277	73	73	68	0.049	0.55	5.57
106	16.942	16.929		0.16	0.16	1.29	1.12	0.34	79	79	70	3.06	1.80	91	0.030	100	100	8.0	-0.37	274	73	73	68	0.049	0.52	5.30
107	17.103	17.091		0.16	0.16	1.29	1.12	0.34	79	79	70	3.06	1.80	90	0.030	100	101	7.8	0.24	272	73	73	68	0.048	0.50	5.03
108	17.264	17.253		0.16	0.16	1.29	1.12	0.34	79	79	70	3.05	1.80	90	0.030	100	101	7.9	-0.11	270	73	72	68	0.048	0.48	4.85
109	17.426	17.414		0.16	0.16	1.29	1.12	0.34	79	79	70	3.07	1.80	90	0.030	101	100	7.2	0.72	268	73	72	68	0.047	0.49	4.72
110	17.586	17.575		0.16	0.16	1.29	1.13	0.34	79	79	70	3.06	1.80	90	0.029	101	102	7.4	-0.24	265	73	72	68	0.048	0.48	4.54
111	17.747	17.737		0.16	0.16	1.28	1.12	0.34	79	79	70	3.06	1.80	90	0.030	100	101	7.0	0.43	263	73	72	68	0.047	0.47	4.43
112	17.907	17.899		0.16	0.16	1.28	1.12	0.34	79	79	70	3.06	1.80	89	0.029	101	102	7.0	-0.06	264	73	72	68	0.047	0.47	4.37
113	18.068	18.060		0.16	0.16	1.29	1.12	0.34	79	79	70	3.06	1.80	88	0.030	100	100	6.5	0.56	266	73	72	68	0.047	0.25	6.73
114	18.229	18.221		0.16	0.16	1.29	1.13	0.34	79	79	70	3.05	1.80	87	0.030	100	100	6.4	0.11	263	73	72	68	0.047	0.16	6.77
115	18.390	18.384		0.16	0.16	1.29	1.12	0.34	79	79	70	3.06	1.80	87	0.030	100	101	6.2	0.19	261	73	72	68	0.047	0.15	6.98
116	18.551	18.545		0.16	0.16	1.28	1.12	0.34	79	79	70	3.05	1.80	87	0.030	100	100	6.1	0.12	262	73	72	68	0.047	0.18	6.73
117	18.712	18.706		0.16	0.16	1.29	1.12	0.34	79	79	70	3.06	1.80	87	0.030	100	100	6.1	-0.02	261	73	72	68	0.047	0.26	6.53



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(%)
118	18.872	18.868		0.16	0.16	1.29	1.12	0.34	79	79	70	3.07	1.80	86	0.031	98	99	5.7	0.36	259	72	72	68	0.046	0.30	6.34
119	19.033	19.030		0.16	0.16	1.29	1.13	0.34	79	79	70	3.07	1.80	86	0.031	98	99	5.7	-0.02	256	72	72	68	0.046	0.36	6.08
120	19.195	19.192		0.16	0.16	1.29	1.12	0.34	79	79	70	3.05	1.80	85	0.031	99	99	5.6	0.12	253	72	72	68	0.046	0.43	5.90
121	19.356	19.353		0.16	0.16	1.28	1.12	0.34	79	79	70	3.05	1.80	85	0.030	100	100	5.3	0.37	250	72	72	68	0.045	0.54	5.66
122	19.516	19.514		0.16	0.16	1.29	1.13	0.34	79	79	70	3.05	1.80	85	0.030	99	100	5.5	-0.21	248	72	72	68	0.045	0.57	5.51
123	19.677	19.677		0.16	0.16	1.28	1.12	0.34	79	79	70	3.05	1.80	84	0.030	100	101	5.3	0.15	246	72	72	67	0.045	0.55	5.53
124	19.838	19.838		0.16	0.16	1.29	1.13	0.34	79	79	70	3.05	1.80	84	0.031	98	98	4.8	0.55	242	72	72	67	0.044	0.57	5.35
125	19.999	19.999		0.16	0.16	1.29	1.13	0.34	79	79	70	3.06	1.80	83	0.030	100	100	4.6	0.20	239	72	72	68	0.044	0.58	5.16
126	20.161	20.161		0.16	0.16	1.29	1.12	0.34	79	79	70	3.05	1.80	83	0.031	99	99	4.6	-0.06	238	72	72	68	0.043	0.57	5.05
127	20.322	20.323		0.16	0.16	1.28	1.12	0.34	79	79	70	3.06	1.80	83	0.029	101	102	4.8	-0.15	235	72	72	68	0.042	0.52	5.24
128	20.482	20.485		0.16	0.16	1.29	1.12	0.34	79	79	70	3.05	1.80	82	0.030	99	100	4.7	0.04	233	72	72	68	0.042	0.45	5.40
129	20.643	20.646		0.16	0.16	1.29	1.13	0.34	79	79	70	3.05	1.80	82	0.029	101	101	4.1	0.63	230	72	71	68	0.041	0.49	5.26
130	20.804	20.808		0.16	0.16	1.29	1.13	0.34	79	79	70	3.05	1.80	82	0.030	100	100	4.0	0.10	228	72	71	68	0.041	0.49	5.14
131	20.966	20.971		0.16	0.16	1.29	1.12	0.34	80	79	70	3.05	1.80	82	0.030	100	101	4.0	-0.04	226	72	71	68	0.041	0.53	4.86
132	21.127	21.132		0.16	0.16	1.28	1.13	0.34	80	79	70	3.07	1.80	81	0.029	101	101	3.8	0.23	224	72	71	68	0.040	0.51	4.80
133	21.288	21.293		0.16	0.16	1.28	1.13	0.34	80	79	70	3.06	1.80	81	0.030	99	99	3.8	-0.02	223	72	71	68	0.039	0.50	4.69
134	21.449	21.455		0.16	0.16	1.28	1.13	0.34	80	79	70	3.05	1.80	81	0.031	98	98	3.9	-0.03	221	72	71	68	0.039	0.52	4.89
135	21.609	21.618		0.16	0.16	1.29	1.12	0.34	80	79	70	3.05	1.80	80	0.031	97	99	3.8	0.05	219	72	71	68	0.039	0.52	4.92
136	21.771	21.779		0.16	0.16	1.29	1.12	0.34	80	79	70	3.06	1.80	80	0.031	98	98	3.6	0.20	218	72	71	68	0.040	0.51	4.91
137	21.932	21.941		0.16	0.16	1.29	1.13	0.34	80	79	70	3.05	1.80	80	0.029	101	102	3.6	0.06	217	72	71	68	0.039	0.49	5.06
138	22.093	22.103		0.16	0.16	1.29	1.13	0.34	80	79	70	3.05	1.80	80	0.028	103	103	3.0	0.55	217	72	71	68	0.038	0.44	5.82
139	22.255	22.265		0.16	0.16	1.28	1.13	0.34	80	79	70	3.06	1.80	80	0.029	102	102	2.8	0.23	217	72	71	68	0.038	0.49	5.66
140	22.415	22.426		0.16	0.16	1.28	1.12	0.34	80	79	70	3.05	1.80	80	0.029	100	101	3.1	-0.33	216	72	71	68	0.038	0.52	5.49
141	22.576	22.588		0.16	0.16	1.28	1.12	0.34	80	79	70	3.06	1.80	80	0.029	101	102	2.6	0.48	216	72	71	68	0.039	0.52	5.95
142	22.737	22.750		0.16	0.16	1.29	1.13	0.34	80	79	70	3.05	1.80	80	0.031	98	98	3.0	-0.36	215	71	71	68	0.039	0.51	5.61
143	22.899	22.912		0.16	0.16	1.29	1.12	0.34	80	79	70	3.05	1.80	80	0.029	102	102	2.5	0.45	215	71	71	68	0.039	0.43	5.58
144	23.060	23.073		0.16	0.16	1.29	1.13	0.34	80	79	70	3.05	1.80	80	0.031	98	98	2.9	-0.41	215	71	71	68	0.039	0.43	5.53
145	23.220	23.235		0.16	0.16	1.27	1.10	0.34	80	79	70	3.03	1.80	80	0.030	99	100	2.7	0.25	214	71	71	68	0.039	0.42	5.37
146	23.379	23.396		0.16	0.16	1.27	1.11	0.34	80	79	70	3.02	1.80	80	0.030	98	99	2.4	0.32	213	71	71	68	0.038	0.46	5.24
147	23.540	23.555		0.16	0.16	1.27	1.10	0.34	80	79	70	3.02	1.80	80	0.030	99	98	2.2	0.17	213	71	71	68	0.038	0.48	4.99
148	23.701	23.715		0.16	0.16	1.26	1.10	0.34	80	79	70	3.03	1.80	80	0.029	101	100	2.1	0.07	212	71	71	68	0.039	0.48	4.90
149	23.861	23.876		0.16	0.16	1.26	1.11	0.34	80	79	70	3.02	1.80	80	0.030	99	99	2.3	-0.20	212	71	71	68	0.038	0.48	4.92
150	24.020	24.036		0.16	0.16	1.27	1.10	0.34	80	79	70	3.03	1.80	81	0.031	96	97	2.4	-0.04	215	71	71	68	0.087	0.48	4.77
151	24.180	24.195		0.16	0.16	1.27	1.10	0.34	80	79	70	3.03	1.80	90	0.030	99	99	2.5	-0.08	232	72	71	68	0.041	0.50	4.76
152	24.340	24.356		0.16	0.16	1.27	1.10	0.34	80	79	70	3.04	1.80	83	0.030	99	100	2.2	0.30	228	72	71	68	0.040	0.04	6.35
153	24.500	24.517		0.16	0.16	1.27	1.10	0.34	80	79	70	3.03	1.80	81	0.030	99	99	1.6	0.51	222	72	71	68	0.038	0.26	6.74
154	24.660	24.676		0.16	0.16	1.26	1.10	0.34	80	79	70	3.03	1.80	80	0.029	100	100	1.6	0.05	220	71	71	68	0.038	0.21	7.70
155	24.820	24.837		0.16	0.16	1.27	1.10	0.34	80	80	70	3.03	1.80	80	0.031	97	97	1.5	0.11	219	71	71	68	0.039	0.25	7.60
156	24.980	24.997		0.16	0.16	1.27	1.10	0.34	80	80		3.03	1.80	80	0.030	99	98	1.7	-0.17	218	71	71	68	0.038	0.41	7.26
157	25.140	25.157		0.16	0.16	1.27	1.10	0.34	80	80		3.03	1.80	80	0.030	99	98	1.4	0.22	217	71	71	68	0.038	0.58	6.57
158	25.301	25.317		0.16	0.16	1.27	1.11	0.34	80	80		3.03	1.80	80	0.030	99	98	1.2	0.27	216	71	71	67	0.038	0.67	6.28
159	25.460	25.479		0.16	0.16	1.27	1.10	0.34	80	80		3.02	1.80	79	0.030	98	100	1.3	-0.13	216	71	71	67	0.038	0.71	6.00
160	25.620	25.638		0.16	0.16	1.27	1.10	0.34	80	80		3.02	1.80	79	0.030	98	98	1.4	-0.10	215	71	71	67	0.038	0.75	5.84
161	25.780	25.799		0.16	0.16	1.27	1.11	0.34	80	80		3.01	1.80	79	0.030	98	99	1.1	0.25	214	71	71	68	0.038	0.79	5.72
162	25.941	25.960		0.16	0.16	1.26	1.10	0.34	80	80		3.03	1.80	79	0.030	99	99	1.5	-0.31	213	71	71	68	0.038	0.80	5.52

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(%)
163	26.101	26.119		0.16	0.16	1.27	1.10	0.34	80	80		3.03	1.80	79	0.030	98	98	0.9	0.58	212	71	71	68	0.037	0.80	5.37
164	26.261	26.280		0.16	0.16	1.26	1.11	0.34	80	80		3.01	1.80	79	0.032	95	96	0.7	0.16	211	71	71	68	0.038	0.78	5.25
165	26.421	26.441		0.16	0.16	1.27	1.10	0.34	80	80		3.03	1.80	79	0.032	95	96	1.0	-0.28	211	71	71	68	0.038	0.77	5.16
166	26.581	26.601		0.16	0.16	1.28	1.10	0.34	80	80		3.02	1.80	79	0.030	98	98	0.6	0.43	211	71	71	68	0.037	0.74	5.01
167	26.742	26.761		0.16	0.16	1.27	1.10	0.34	80	80		3.01	1.80	79	0.030	99	98	0.9	-0.38	210	71	71	68	0.038	0.74	4.91
168	26.902	26.921		0.16	0.16	1.26	1.10	0.34	80	80		3.03	1.80	79	0.030	98	98	0.4	0.57	210	71	71	68	0.038	0.76	4.78
169	27.061	27.081		0.16	0.16	1.27	1.10	0.34	80	80		3.03	1.80	79	0.030	98	98	0.5	-0.15	210	71	71	68	0.038	0.73	4.56
170	27.222	27.241		0.16	0.16	1.27	1.10	0.34	80	80		3.02	1.80	80	0.031	98	97	0.7	-0.14	210	71	71	68	0.038	0.67	4.39
171	27.382	27.402		0.16	0.16	1.27	1.11	0.34	80	80		3.02	1.80	80	0.031	97	97	0.2	0.51	210	71	71	68	0.038	0.63	4.29
172	27.542	27.562		0.16	0.16	1.27	1.10	0.34	80	80		3.04	1.80	80	0.031	97	97	0.3	-0.19	209	71	71	68	0.037	0.60	4.23
173	27.702	27.722		0.16	0.16	1.27	1.10	0.34	80	80		3.03	1.80	80	0.030	99	98	0.3	0.04	209	71	71	68	0.037	0.56	4.21
174	27.862	27.883		0.16	0.16	1.27	1.11	0.34	80	80		3.03	1.80	80	0.031	97	97	0.5	-0.20	209	71	71	68	0.037	0.56	4.19
175	28.022	28.043		0.16	0.16	1.27	1.10	0.34	80	80		3.02	1.80	80	0.031	97	97	0.4	0.14	208	71	71	68	0.037	0.58	4.12
176	28.183	28.203		0.16	0.16	1.27	1.11	0.34	80	80		3.03	1.80	80	0.030	99	98	0.1	0.26	209	71	71	68	0.037	0.58	4.07
177	28.343	28.363		0.16	0.16	1.26	1.11	0.34	80	80		3.03	1.80	80	0.030	99	98	0.1	0.04	209	71	71	68	0.037	0.57	3.98
178	28.503	28.524	45.118	0.16	0.16	1.26	1.10	0.34	80	80		3.02	1.80	80	0.030	99	99	0.0	0.07	209	71	71	68	0.037	0.52	3.84
	28.503	28.524	45.118			1.28	1.11	0.34	77	77	70			91	0.030						72.07	71.72		0.048	0.34	6.69

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

Run: 2

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Test Date: 12/16/2021

Technician: TT / KM
Beginning Clock Time: 09:58
Recording Interval: 1 min.
Total Sampling Time: 178 min.

Boiler Dry Weight (lbs): 1471.6
Boiler Water Weight (lbs): 274.5
Tank Weight (lbs): 736
Tank Water Weight (lbs): 3145

Initial Average Tank Temp (°F) 123.4
Final Average Tank Temp (°F): 165.6
Initial Average Heater Temp (°F 119.4
Final Average Heater Temp (°F 177.9

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Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
0	0.42	62	121	60	1.0012	8.3300	3.532	211	121	121	0	123	124	119	120
1	0.42	62	121	60	1.0012	8.3299	3.533	211	121	121	0	123	124	119	119
2	0.42	62	121	59	1.0012	8.3299	3.537	210	121	121	0	123	124	119	119
3	0.42	62	121	59	1.0012	8.3298	3.533	210	121	121	0	123	124	119	118
4	0.42	62	121	59	1.0012	8.3297	3.533	209	121	121	0	123	124	119	119
5	0.42	62	121	59	1.0012	8.3296	3.529	209	121	121	0	121	124	118	120
6	0.42	62	121	59	1.0012	8.3295	3.532	209	121	121	0	121	124	118	122
7	0.42	62	121	59	1.0012	8.3294	3.531	208	121	121	0	121	123	118	125
8	0.42	62	121	59	1.0012	8.3293	3.533	208	121	120	0	121	123	118	127
9	0.42	62	121	59	1.0012	8.3292	3.529	207	120	120	0	121	123	118	130
10	0.42	62	121	58	1.0012	8.3291	3.530	206	120	120	0	121	123	118	133
11	0.42	62	121	58	1.0012	8.3290	3.528	205	120	120	0	121	123	117	137
12	0.43	62	120	58	1.0012	8.3289	3.618	210	120	120	0	120	123	117	130
13	0.44	63	120	58	1.0012	8.3288	3.648	210	120	121	1	122	123	151	140
14	0.44	63	122	59	1.0012	8.3287	3.642	216	120	123	2	123	122	157	140
15	0.44	63	123	60	1.0012	8.3286	3.647	219	121	123	2	124	123	161	140
16	0.42	63	124	61	1.0012	8.3285	3.538	217	121	125	4	125	123	163	140
17	0.42	63	125	62	1.0012	8.3285	3.490	218	122	126	4	126	123	166	140
18	0.40	63	126	63	1.0012	8.3284	3.366	211	122	126	4	126	123	169	141
19	0.42	63	126	63	1.0012	8.3283	3.482	220	122	128	6	128	123	170	141
20	0.42	63	128	65	1.0012	8.3282	3.482	227	123	129	7	130	123	172	141
21	0.41	63	130	66	1.0012	8.3282	3.393	225	123	130	7	130	123	174	141
22	0.40	63	130	67	1.0012	8.3281	3.348	225	123	131	7	131	123	176	141
23	0.38	63	131	68	1.0012	8.3281	3.167	214	124	131	8	132	123	177	141
24	0.38	63	131	68	1.0012	8.3280	3.132	214	124	132	8	132	123	179	141
25	0.38	63	132	69	1.0012	8.3280	3.127	215	124	132	8	133	123	180	141
26	0.37	63	132	69	1.0012	8.3279	3.069	212	124	132	8	133	123	181	141
27	0.35	63	133	69	1.0012	8.3279	2.933	203	124	133	9	133	123	182	141
28	0.36	63	133	70	1.0012	8.3279	2.982	208	124	133	9	134	123	182	141
29	0.38	63	133	70	1.0012	8.3279	3.152	220	124	133	9	134	123	183	142
30	0.39	63	133	70	1.0012	8.3278	3.212	225	124	133	9	134	123	183	141
31	0.39	64	133	70	1.0012	8.3278	3.213	224	124	133	9	133	123	184	141
32	0.35	64	133	70	1.0012	8.3278	2.954	206	124	134	9	134	123	184	142
33	0.35	64	134	70	1.0012	8.3278	2.928	206	125	134	9	134	123	184	142
34	0.35	64	134	70	1.0012	8.3278	2.929	206	124	133	9	134	123	184	141
35	0.35	64	133	70	1.0012	8.3277	2.920	204	124	133	8	134	123	185	141
36	0.37	64	133	69	1.0012	8.3277	3.052	212	124	134	9	134	123	185	142
37	0.37	64	134	70	1.0012	8.3277	3.066	215	125	134	9	134	123	185	142
38	0.37	64	134	70	1.0012	8.3277	3.064	216	125	134	9	134	123	186	142
39	0.37	64	134	70	1.0012	8.3277	3.060	215	125	134	9	134	123	186	142
40	0.37	64	134	70	1.0012	8.3277	3.059	215	125	133	8	134	124	186	141
41	0.37	64	133	70	1.0012	8.3277	3.059	214	125	133	8	134	124	186	141
42	0.35	64	133	70	1.0012	8.3277	2.954	206	125	134	9	135	124	186	142

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
43	0.35	64	134	71	1.0012	8.3276	2.948	208	126	135	9	135	124	186	142
44	0.37	64	135	71	1.0012	8.3276	3.040	216	126	135	9	136	125	186	142
45	0.37	64	135	72	1.0012	8.3276	3.051	218	126	135	9	136	125	186	142
46	0.37	64	136	72	1.0012	8.3276	3.050	219	127	136	9	136	126	187	142
47	0.35	64	136	72	1.0012	8.3276	2.942	212	127	136	9	137	127	187	143
48	0.35	64	136	73	1.0012	8.3276	2.892	210	128	136	8	137	127	187	142
49	0.35	64	137	73	1.0012	8.3276	2.893	211	129	137	8	137	128	188	143
50	0.34	64	137	74	1.0012	8.3275	2.858	211	129	139	10	140	129	187	143
51	0.35	64	139	75	1.0012	8.3275	2.899	218	130	140	10	140	129	187	143
52	0.34	64	140	76	1.0012	8.3275	2.827	215	131	141	10	141	130	187	144
53	0.35	64	140	77	1.0012	8.3274	2.884	221	131	141	10	142	130	187	144
54	0.35	64	141	77	1.0012	8.3274	2.906	225	132	142	10	142	131	187	144
55	0.33	64	141	78	1.0012	8.3274	2.782	216	132	142	9	142	131	187	145
56	0.33	64	141	77	1.0012	8.3273	2.737	212	132	142	9	143	131	187	144
57	0.33	64	142	78	1.0012	8.3273	2.735	213	133	142	9	143	132	187	144
58	0.33	64	142	78	1.0012	8.3273	2.725	212	133	142	9	142	132	187	144
59	0.33	64	142	78	1.0012	8.3272	2.728	212	133	142	9	143	132	187	143
60	0.33	64	142	78	1.0012	8.3272	2.731	213	133	143	10	143	132	188	145
61	0.33	64	143	78	1.0012	8.3272	2.729	214	133	143	10	143	132	188	145
62	0.33	64	143	79	1.0012	8.3271	2.727	215	134	143	10	144	132	187	145
63	0.33	64	143	79	1.0012	8.3271	2.719	216	134	144	10	144	133	187	145
64	0.32	64	144	80	1.0012	8.3271	2.660	212	134	144	10	145	133	187	145
65	0.32	64	144	80	1.0012	8.3271	2.641	211	134	144	10	145	133	187	145
66	0.32	64	144	80	1.0012	8.3271	2.641	212	135	144	10	145	133	187	145
67	0.31	64	144	80	1.0012	8.3271	2.551	205	135	145	10	145	133	187	145
68	0.32	64	145	80	1.0012	8.3270	2.691	216	135	145	10	145	134	187	145
69	0.32	64	145	81	1.0012	8.3270	2.655	214	135	145	10	146	134	187	145
70	0.32	64	145	81	1.0012	8.3270	2.656	214	135	145	10	146	134	187	145
71	0.32	64	145	81	1.0012	8.3270	2.644	214	136	145	10	146	134	188	145
72	0.32	64	145	81	1.0012	8.3270	2.647	215	136	145	9	145	134	189	144
73	0.32	64	145	81	1.0012	8.3270	2.656	214	136	145	9	146	135	189	144
74	0.32	64	145	81	1.0012	8.3270	2.650	214	136	146	10	146	135	189	145
75	0.31	64	146	82	1.0012	8.3270	2.609	213	137	146	9	147	136	189	144
76	0.32	64	146	82	1.0012	8.3270	2.649	217	137	146	9	147	136	190	144
77	0.31	64	146	82	1.0012	8.3270	2.553	210	138	146	9	146	137	190	145
78	0.30	64	146	82	1.0012	8.3270	2.467	203	138	145	7	146	137	191	142

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
79	0.30	64	146	82	1.0012	8.3270	2.470	201	138	145	7	146	138	192	142
80	0.31	64	146	82	1.0012	8.3270	2.567	210	139	146	7	147	138	192	142
81	0.31	64	146	82	1.0012	8.3270	2.581	211	139	148	9	147	139	195	145
82	0.31	64	148	83	1.0012	8.3270	2.586	215	140	147	7	147	139	196	142
83	0.31	64	147	83	1.0012	8.3269	2.578	214	140	151	10	151	140	194	147
84	0.31	64	150	86	1.0012	8.3269	2.580	222	141	151	10	152	140	195	147
85	0.31	64	151	87	1.0012	8.3269	2.584	224	141	150	9	151	140	198	143
86	0.31	64	151	87	1.0012	8.3269	2.582	224	142	152	10	153	141	197	146
87	0.29	64	152	88	1.0012	8.3269	2.417	212	142	153	10	154	141	198	147
88	0.29	64	152	88	1.0012	8.3269	2.390	210	143	154	11	152	142	198	148
89	0.29	64	153	89	1.0012	8.3269	2.385	213	144	155	11	155	142	198	148
90	0.29	64	154	90	1.0012	8.3269	2.384	214	144	155	11	156	143	199	148
91	0.29	64	155	91	1.0012	8.3269	2.380	216	144	155	11	156	143	199	147
92	0.29	64	155	91	1.0012	8.3269	2.377	216	144	155	11	156	143	199	148
93	0.28	64	155	91	1.0012	8.3268	2.371	216	145	155	11	156	143	199	147
94	0.28	64	155	91	1.0012	8.3268	2.370	215	145	156	11	156	143	199	148
95	0.28	64	155	91	1.0012	8.3268	2.366	215	145	156	11	156	144	199	148
96	0.29	64	155	91	1.0012	8.3268	2.375	216	145	156	11	157	144	199	149
97	0.29	64	156	91	1.0012	8.3268	2.380	218	146	157	11	157	144	198	149
98	0.28	64	156	92	1.0012	8.3268	2.363	217	146	157	11	158	144	199	150
99	0.28	64	157	92	1.0012	8.3268	2.361	218	146	157	11	158	145	198	150
100	0.29	64	157	93	1.0012	8.3268	2.382	220	146	157	11	158	145	198	150
101	0.29	64	157	93	1.0012	8.3267	2.377	220	146	157	11	158	145	197	150
102	0.29	64	157	93	1.0012	8.3267	2.395	222	146	157	10	157	145	197	149
103	0.29	64	156	92	1.0012	8.3267	2.377	219	146	156	10	157	145	197	148
104	0.29	64	156	92	1.0012	8.3267	2.377	218	146	157	10	157	146	197	149
105	0.28	64	156	92	1.0012	8.3267	2.373	218	147	157	10	157	146	197	149
106	0.28	64	157	92	1.0012	8.3267	2.368	218	147	156	9	157	146	197	148
107	0.28	64	156	92	1.0012	8.3268	2.373	217	147	156	9	157	147	198	147
108	0.29	64	156	91	1.0012	8.3267	2.375	217	148	157	9	157	147	199	147
109	0.29	64	156	92	1.0012	8.3267	2.384	219	148	157	9	157	148	199	148
110	0.29	64	157	92	1.0012	8.3267	2.374	219	148	157	9	158	148	199	148
111	0.29	64	157	92	1.0012	8.3267	2.379	220	149	157	9	158	149	199	148
112	0.29	64	157	93	1.0012	8.3267	2.377	220	149	158	9	158	149	198	149
113	0.28	65	157	93	1.0012	8.3267	2.367	219	149	158	9	158	149	198	149
114	0.29	65	157	93	1.0012	8.3267	2.379	221	150	158	8	159	150	198	149
115	0.29	64	158	93	1.0012	8.3267	2.379	222	150	157	7	158	151	199	149
116	0.29	65	157	93	1.0012	8.3267	2.376	221	151	157	7	158	152	199	149
117	0.29	65	157	93	1.0012	8.3267	2.378	221	151	159	7	159	152	199	150
118	0.28	65	158	93	1.0012	8.3267	2.367	221	152	158	7	159	153	199	150
119	0.28	65	158	94	1.0012	8.3267	2.366	222	152	159	7	159	153	198	151
120	0.27	65	159	94	1.0012	8.3267	2.263	213	153	160	8	161	154	197	152
121	0.28	65	160	96	1.0012	8.3267	2.328	222	154	161	8	162	154	198	152
122	0.28	65	161	96	1.0012	8.3267	2.329	224	154	162	8	162	155	198	153
123	0.27	65	161	97	1.0012	8.3267	2.248	217	154	162	8	163	155	198	154
124	0.26	65	162	97	1.0012	8.3267	2.169	211	155	163	8	163	155	198	154
125	0.27	65	162	98	1.0012	8.3267	2.240	218	155	163	8	164	155	198	155
126	0.27	65	163	98	1.0012	8.3267	2.216	218	156	163	8	164	156	198	155
127	0.27	65	163	98	1.0012	8.3267	2.225	219	156	163	8	164	156	198	155
128	0.27	65	163	98	1.0012	8.3266	2.220	218	156	163	8	164	156	198	155
129	0.27	65	163	98	1.0012	8.3266	2.209	217	156	163	8	164	156	197	155
130	0.27	65	163	98	1.0012	8.3267	2.212	217	156	162	6	162	156	197	155
131	0.27	65	162	97	1.0012	8.3267	2.212	215	156	162	6	162	156	198	154
132	0.27	65	161	97	1.0012	8.3266	2.207	213	156	161	6	162	156	198	154
133	0.27	65	161	97	1.0012	8.3266	2.209	213	156	161	6	162	156	197	154

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
134	0.26	65	161	96	1.0012	8.3267	2.206	213	156	162	6	162	157	197	154
135	0.27	65	161	97	1.0012	8.3267	2.288	221	156	162	6	162	157	197	154
136	0.28	65	161	97	1.0012	8.3267	2.346	227	156	162	6	162	157	197	154
137	0.28	65	161	97	1.0012	8.3267	2.341	226	156	162	6	162	157	198	154
138	0.28	65	161	97	1.0012	8.3267	2.341	227	156	162	6	162	157	198	154
139	0.28	65	162	97	1.0012	8.3267	2.336	227	156	163	7	164	157	197	155
140	0.28	65	163	98	1.0012	8.3267	2.308	227	157	164	7	164	157	197	156
141	0.28	65	163	99	1.0012	8.3267	2.300	227	157	164	7	165	158	197	156
142	0.28	65	164	99	1.0012	8.3267	2.317	229	157	164	7	165	158	197	156
143	0.28	64.5	163.6	99	1.0012	8.3267	2.316	230	157	163	6	164	158	197	156
144	0.26	64.5	163.5	99	1.0012	8.3267	2.157	214	158	163	6	164	158	197	156
145	0.26	64.5	162.9	98	1.0012	8.3267	2.126	209	158	163	6	164	159	197	156
146	0.25	64.5	162.8	98	1.0012	8.3267	2.118	208	158	163	6	164	159	197	156
147	0.25	64.5	162.8	98	1.0012	8.3267	2.118	208	158	164	5	164	159	197	156
148	0.25	64.5	163.0	98	1.0012	8.3267	2.117	208	159	164	5	164	160	197	157
149	0.25	64.5	163.3	99	1.0012	8.3267	2.114	209	159	164	5	165	160	196	157
150	0.25	64.5	163.6	99	1.0012	8.3267	2.111	209	159	164	5	165	161	196	157
151	0.25	64.5	164.1	100	1.0012	8.3267	2.104	209	160	166	6	166	161	195	158
152	0.26	64.5	165.8	101	1.0012	8.3267	2.141	217	160	168	7	168	161	194	160
153	0.27	64.5	166.8	102	1.0012	8.3267	2.232	228	161	168	7	169	161	194	161
154	0.27	64.5	167.2	103	1.0012	8.3267	2.241	230	161	168	7	168	161	194	161
155	0.25	64.5	167.2	103	1.0012	8.3267	2.062	212	161	168	7	169	161	193	161
156	0.24	64.6	167.6	103	1.0012	8.3266	2.010	207	161	168	7	168	162	193	161
157	0.24	64.6	167.2	103	1.0012	8.3266	1.986	204	161	168	7	168	162	193	161
158	0.25	64.6	167.4	103	1.0012	8.3266	2.091	215	161	168	7	168	162	192	161
159	0.26	64.6	166.5	102	1.0012	8.3266	2.124	217	161	168	7	168	162	193	160
160	0.26	64.5	166.3	102	1.0012	8.3267	2.124	216	161	166	5	167	162	193	160
161	0.25	64.5	166.5	102	1.0012	8.3267	2.121	216	161	168	6	168	162	192	161
162	0.26	64.5	167.0	102	1.0012	8.3267	2.124	218	162	169	7	169	162	192	161
163	0.25	64.5	167.6	103	1.0012	8.3267	2.118	218	162	168	7	169	162	192	162
164	0.25	64.5	168.0	103	1.0012	8.3267	2.118	219	162	169	7	169	163	192	162
165	0.25	64.5	168.0	104	1.0012	8.3267	2.116	219	162	169	7	169	163	192	162
166	0.25	64.5	168.0	103	1.0012	8.3267	2.113	219	162	167	5	168	163	193	161
167	0.25	64.5	167.0	102	1.0012	8.3267	2.116	217	162	168	6	169	163	193	162
168	0.25	64.5	166.7	102	1.0012	8.3267	2.114	216	162	166	4	167	163	193	160
169	0.25	64.6	166.0	101	1.0012	8.3266	2.117	215	162	166	4	167	163	193	160
170	0.25	64.6	166.0	101	1.0012	8.3266	2.112	214	162	167	5	167	163	193	161
171	0.25	64.6	166.8	102	1.0012	8.3266	2.103	215	162	167	5	168	163	193	161
172	0.25	64.6	166.7	102	1.0012	8.3266	2.103	215	162	168	6	168	163	193	162
173	0.25	64.6	167.6	103	1.0012	8.3266	2.100	216	163	169	6	168	164	193	162
174	0.25	64.6	167.7	103	1.0012	8.3266	2.100	216	163	169	6	169	164	192	162
175	0.25	64.6	167.7	103	1.0012	8.3266	2.099	216	163	169	6	170	164	192	163
176	0.25	64.6	168.1	103	1.0012	8.3266	2.097	217	163	169	6	168	165	194	162
177	0.25	64.6	167.8	103	1.0012	8.3265	2.099	217	164	168	4	168	165	193	162
178	0.25	64.7	167.4	103	1.0012	8.3265	2.100	216	164	168	4	169	166	193	162
	0.31	64.01	148.8	84.8	1.0012	8.3272	2.6175	38558.6	141.9	149.2	7.3	149.7	141.9	185.7	147.5
Elapsed Time	Water Flow Rate, Gal / Min.	HE In, °F	HE Out, °F	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F	HE Out, °F	Delta-T	Top, °F	Bottom, °F		

Flow Meter Calibration Check

Manufacturer: Froling Date: 6/14/2022
Appliance: S3 Turbo 30 Run Number: 2
Project Number: 0456WB009E

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)	Accuracy, %
2.288	61.5	16.4	998.908	8.336	7.6	0.399	0.401	Preburn	100.6%
2.439	64.1	17.8	998.655	8.334	6.5	0.320	0.317	66	99.2%
3.160	64.7	18.2	998.594	8.334	6.6	0.251	0.251	184	100.2%

Test Method ASTM E2515-11
Lab Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run #: 2
Date: 6/14/22

Equipment Numbers:

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	E702'	122.8	121.2	1.6
C. Rear filter catch	Filter	E709'	120.4	121.4	-1.0
D. Probe catch*	Probe	4	114856.7	114856.6	0.1
E. Filter seals catch*	Seals	S348	3358.5	3356.9	1.6

Sub-Total Total Particulate, mg: 2.3

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	E710'	121.4	120.6	0.8
C. Rear filter catch	Filter	E711'	119.6	121.5	-1.9
D. Probe catch*	Probe	13	114321.6	114321.6	0.0
E. Filter seals catch*	Seals	S349	4092.2	4088.9	3.3

Sub-Total Total Particulate, mg: 2.2

Train 1 Aggregate Total Particulate, mg: **4.5**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	E712'	124.3	120.9	3.4
B. Rear filter catch	Filter	E713'	121.8	121.1	0.7
C. Probe catch*	Probe	14	114547.8	114547.6	0.2
D. Filter seals catch*	Seals	S350	3375.6	3375.5	0.1

Total Particulate, mg: 4.4

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter	E714'	121.0	121.0	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 E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 2

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/14/2022

Test Crew: T. TONG

OMNI Equipment ID numbers: 00637, 00709, 00283A

ASTM E2515 Lab Sheet

Assembled By:

Tony Tong

Date/Time in Dessicator:

06/14/22, 13:20

	Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
Date/Time:	06/15/22 15:45	06/20/22 9:20	06/21/22 10:45		
R/H %:	22.7	18.6	16.0		
Temp:	72.1	70.8	72.1		
200 mg Audit:	200.0	200.1	200.1		
2 g Audit:	2000.3	2000.3	2000.3		
100 g Audit:	99998.0	99998.0	99998.0		
Initials:	TT	TT	TT		

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A (First Hour)	Front Filter	E702	121.2	122.7	122.8			
	Rear Filter	E709	121.4	120.6	120.4			
	Probe	4	114856.6	114856.8	114856.7			
	O-Ring Set	S348	3356.9	3359.2	3358.6	3358.5		
A (Remainder)	Front Filter	E710	120.6	121.5	121.4			
	Rear Filter	E711	121.5	119.8	119.6			
	Probe	13	114321.6	114321.7	114321.6			
	O-Ring Set	S349	4088.9	4092.8	4092.3	4092.2		
B	Front Filter	E712	120.9	124.3	124.3			
	Rear Filter	E713	121.1	121.8	121.8			
	Probe	14	114547.6	114548.2	114547.8			
	O-Ring Set	S350	3375.5	3376.3	3375.8	3375.6		
BG	Filter	E714	121.0	121.1	121.0			

Technician Signature: Tony Tong Date: 06/28/22

Tare Sheet: (check one) Probes_____ 47mm Filters✓ 100mm Filters_____ O-Ring Pair_____

Prepared By: Tony Tong Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 00283A 1 200mg

Placed in Dessicator: Date: 05/10/22 Time: 10:38 ID #	Date: 06/08/22 Time: 16:30 RH %: 16.5 T (°F): 75.7 Audit: 200.1	Date: 06/09/22 Time: 17:40 RH %: 21.6 T (°F): 71.3 Audit: TT	Date: 06/13/22 Time: 16:20 RH %: 14.3 T (°F): 71.4 Audit: 200.0	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
E701	120.9	120.9 ✓			06/13/22	0456WB009E	1
E702	121.0	121.3 ✓	121.2 ✓		06/14/22	0456WB009E	2
E703	121.0	121.1 ✓			06/13/2022	0456WB009E	1
E704	120.7	120.8 ✓			↓	↓	↓
E705	121.0	121.1 ✓					
E706	120.5	120.6 ✓					
E707	121.5	121.5 ✓					
E708	121.3	121.4 ✓					
E709	121.4	121.4 ✓			06/14/22	0456WB009E	2
E710	120.5	120.6 ✓			↓	↓	↓
E711	121.3	121.5 ✓					
E712	120.8	120.9 ✓					
E713	121.2	121.1 ✓					
E714	121.2	121.0 ✓					
E715	120.9	121.0 ✓			06/15/22	0456WB009E	3
E716	120.5	120.7 ✓					
E717	121.2	121.1 ✓					
E718	121.4	121.3 ✓					
E719	122.2	122.5 ✓	122.3 ✓				
E720	120.6	120.7 ✓			↓	↓	↓
	Initials: TT	Initials: TT	Initials: TT	Initials:			

Final Technician Signature: Tony Tong Date: 06/13/22 Evaluator signature: L.A. Moya

Tare Sheet: (check one) **Probes** ✓ **47mm Filters** ____ **100mm Filters** ____ **O-Ring Pair** ____

Prepared By: Tony Tong Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 00283A 1 1000g

Placed in Dessicator: Date: 06/08/22 Time: 15:30 ID #	Date: 06-6-22 Time: 1300 RH %: 20.0 T (°F): 71.7 Audit: 99997.9	Date: 06/13/22 Time: 7:30 RH %: 7.4 T (°F): 68.0 Audit: 99997.8	Date: 06/14/22 Time: 24.4 RH %: 71.9 T (°F): 71.6 Audit: 99998.0	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
15	114341.0	114340.8			06/13/22	0456WB009E	1
70	116834.6	116833.5	116833.4		06/16/22	0456WB009E	4
73	117066.2	117065.6	117065.8		06/15/22	0456WB009E	3
75	117637.9	117637.7			06/13/22	0456WB009E	1
76	116961.0	116960.5	116960.7		06/15/22	0456WB009E	3
78	117459.6	117459.2	117459.1		06/16/22	0456WB009E	4
81	111861.5	111861.3			06/13/22	0456WB009E	1
3	114770.9	116011.5	116011.2		Not used		
OES3	116011.8	114770.3	114770.4		↓		
4	114856.7	114856.6			06/14/22	0456WB009E	2
OES4	114148.5	114147.7	114147.7		06/16/22	0456WB009E	4
11	114186.1	114185.9	114185.7				
13	114321.8	114321.6			06/14/22	0456WB009E	2
14	114547.6	114547.6			↓	↓	↓
17	114562.5	114562.1	114561.9		06/15/22	0456WB009E	3
30	114327.4	114327.4			Not used		
65	117079.4	117079.1	117079.4		↓		
32	114743.2	114743.2					
	Initials: TT	Initials: TT	Initials: TT	Initials:			

Final Technician Signature: Tony Tong Date: 06/14/22 Evaluator signature: [signature]

Tare Sheet: (check one) **Probes**____ **47mm Filters**____ **100mm Filters**____ **O-Ring Pair** ✓

Prepared By: Tony Tang Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 002834 1.5g

Placed in Dessicator: Date: 25/09/22 Time: 9:30	Date: 06/08/22 Time: 15:30 RH %: 18.8 T (°F): 75.3	Date: 06-10-22 Time: 1324 RH %: 20.0 T (°F): 73.0	Date: 06/13/22 Time: 7:30 RH %: 7.4 T (°F): 68.0	Date: 06/16/22 Time: 7:20 RH %: 18.6 T (°F): 71.7	Date Used	Project Number	Run No.
ID #	Audit: 5000.0	Audit: 5000.2	Audit: 4999.9	Audit: 4999.9			
S345	3325.4	3325.5 ✓			06/13/22	0456WB009E	1
S346	3277.7	3278.0	3278.0		↓	↓	↓
S347	3278.2	3278.4 ✓			↓	↓	↓
S348	3356.7	3356.9 ✓			06/14/22	0456WB009E	2
S349	4088.7	4088.9 ✓			↓	↓	↓
S350	3375.4	3375.5 ✓			↓	↓	↓
S351	3227.6	3227.8 ✓			06/15/22	0456WB009E	3
S352	3311.8	3312.0 ✓			↓	↓	↓
S353	3358.3	3358.5 ✓			↓	↓	↓
S354	4117.5	4117.5 ✓			06/16/22	0456WB009E	4
S355	3340.0	3340.2 ✓			↓	↓	↓
S356	3374.3	3374.5 ✓			↓	↓	↓
S357	4078.2	4078.4 ✓			Not used		
S358	3497.5	3498.3	3497.9	3497.7	↓		
S359					Not used		
S360					↓		
S361					↓		
S362					↓		
S363					↓		
S364					↓		
	Initials: TT	Initials: TT	Initials: TT	Initials: TT			

Final Technician Signature: Tony Tang Date: 06/16/2022 Evaluator signature: M. Morgan

Run 3 (Category II)

Hydronic Heating Appliances - Test Methods ASTM E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run: 3
Test Date: June 15, 2022

Burn Rate	**5.43 kg/hr dry**
Average Tunnel Temperature	91 degrees F
Average Gas Velocity in Dilution Tunnel - vs	8.7 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	23233 dscf/hour
Average Delta p	0.029 inches H20
Average Delta H	1.26 inches H20
Total Time of Test	194 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**6.33** g/hr
	0.66 g/kg
Complete Run:	**3.76** g/hr
	0.69 g/kg
	0.13 lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	31.11 cubic feet	31.08 cubic feet	48.61 cubic feet
Average Gas Meter Temperature	80 degrees F	80 degrees F	71 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	30.6 dscf	30.6 dscf	48.9 dscf
Total Particulates - mn	4.6 mg	5.3 mg	0 mg
Particulate Concentration (dry-standard)	0.000150 grams/dscf	0.000173 grams/dscf	0.000000 grams/dscf
Particulate Emissions	11.29 grams	13.02 grams	
Particulate Emission Rate	3.49 grams/hour	4.03 grams/hour	
Difference from Average	0.86 grams	0.86 grams	
Emissisons Factor	0.64 g/kg	0.74 g/kg	
	Results Are Acceptable		

AVERAGE

Total Sample Volume - Vm	31.10 cubic feet
Average Gas Meter Temperature	80 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	30.6 dscf
Train Precesion 7.5%	**7.10 grams**
Train Precision 0.5g/kg	0.10 grams/kg
Particulate Concentration (dry-standard)	0.00016 grams/dscf
Particulate Emissions	12.16 grams
7.5% of the average particulate emissions	0.91 grams

ADDITIONAL ACCEPTANCE CRITERIA

PTS Water Temperature >120 °F at Start of Test	**Acceptable**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	9.63 cubic feet
Average Gas Meter Temperature	77 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	9.54 dscf
Total Particulates - mn	2.6 mg
Particulate Concentration (dry-standard)	0.00027 grams/dscf
Particulate Emissions	6.33 grams
Burn Rate	9.54 (dry kg/hr)

Method ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Comments:	

Parameters:

Run Number:	3
Test Date:	6/15/22
Total Fuel Weight (lb):	46.6
Average Moisture of Fuel (% dry):	20.39
Average Moisture of Fuel (% wet):	16.94
Average Temperature of Appliance Water at Start of Test (°F):	108.9
Average Temperature of Appliance Water at End of Test (°F):	178.4
Average Thermopile Reading (°F):	108.9
Average Load Side Liquid Flow Rate (gal/min):	0.4
Time Interval (min):	194
Burn Rate (kg/hr):	5.43
Emissions (g):	12.16
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

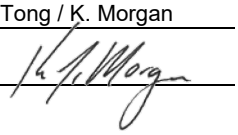
Calculations:

HHV Heat Input (Btu):	332886
Net HHV Heat Input (Btu):	310086
Net HHV Heat Input Rate (Btu/hr):	95903
LHV Heat Input (Btu):	309197
Net LHV Heat Input (Btu):	286397
Net LHV Heat Input Rate (Btu/hr):	88576
Appliance Water Specific Heat (Btu/lb°F):	1.001
Tank Water Specific Heat (Btu/lb°F):	1.001
Q_{unit} (Btu):	29359
Q_{Load} (Btu):	62565
$Q_{Storage}$ (Btu):	120479
Total Heat Output (Btu):	212403
Total Heat Output Rate (Btu/hr):	65692
Total Particulate Emissions (g):	12.16
Time Interval (hr):	3.2
Load Output Rate (Btu/hr):	19350
Emissions Factor(g/kg):	0.69
Total Particulate Emissions Rate (g/MJ):	0.054
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.126**
Total Particulate Emissions (g/hr):	3.76
Delivered Efficiency, HHV (%):	**68.5**
First Hour Emissions Factor (g/kg):	0.66
First Hour Emissions Rate (g/hr):	6.33

Stack Loss Efficiency

Manufacturer: Froling GmbH
Model: S3 Turbo 30
Date: 06/15/22
Run: 3
Control #: 2448
Test Duration: 194
Output Category: II

Technicians: T. Tong / K. Morgan



Test Results in Accordance with CSA B415.1-10

	HHV Basis	LHV Basis
Overall Efficiency	73.8%	78.9%
Combustion Efficiency	99.5%	99.5%
Heat Transfer Efficiency	74%	79.3%

Output Rate (kJ/h)	80,017	75,905	**(Btu/h)**
Burn Rate (kg/h)	5.43	11.97	**(lb/h)**
Input (kJ/h)	108,482	102,907	**(Btu/h)**

Test Load Weight (dry kg)	17.56	38.71	**dry lb**
MC wet (%)	16.94		
MC dry (%)	20.39		
Particulate (g)	12.16		
CO (g)	480		
Test Duration (h)	3.23		

Emissions	Particulate	CO
g/MJ Output	0.05	1.85
g/kg Dry Fuel	0.69	27.33
g/h	3.76	148.42
lb/MM Btu Output	0.11	4.31

Air/Fuel Ratio (A/F)	15.61

VERSION: **2.4** **4/15/2010**

OMNI-Test Laboratories, Inc. **ASTM E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 3

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/15/2022

Test Crew: T. TONG K. MORGAN

OMNI Equipment ID numbers: ~~00637, 00709, 00284~~ 00335, 00336, 00594, 00356

Wood Heater Run Notes

Air Control Settings

Primary: Primary air setting is adjusted by automatic induced draft fan

Secondary: Automatic

Tertiary/Pilot:

Fan: Automatic induced draft fan

Preburn Notes

Time	Notes
8:38	Drawing heat from PTS at Target load
10:47	Temperature of PTS dropped to 129 F

Test Notes

Sketch test fuel configuration:

See fuel load photos in test report

Start up procedures & Timeline:

Bypass: N/A
Fuel loaded by: 2 minutes (lighting)
Door closed at: 2 minutes
Primary air: Automatic

Notes:

Time	Notes
10:47	Testing started
11:47	First hour filters change
13:28	Repositioned unburned fuel
14:01	Testing ended

Technician Signature: Tony Tong Date: 06/15/22

OMNI-Test Laboratories, Inc. **ASTM E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 3

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/15/2022

Test Crew: T. TONG K. MORGAN

OMNI Equipment ID numbers: 00594, 00335, 00336, 00440, 00716, 00322, 00255, 00677

Wood Heater Supplemental Data

Start Time: 10:47 Booth #: 3

Stop Time: 14:01

Stack Gas Leak Check:

Initial: ~~good~~ Final: good

Sample Train Leak Check:

A: 0.000 @ 16.30 "Hg A1 0.000 @ 16.30 "Hg

B: 0.000 @ 15.10 "Hg

Calibrations: Span Gas CO_2: 16.94 % CO: 4.32 %

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	10:22	10:25	14:18	14:21
CO_2	0.00	16.93	0.00	16.92
CO	0.00	4.31	0.00	4.30

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

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

Pitot Tube Leak Test: Initial: ~~good~~ Final: good

Stack Diameter (in): 6

Induced Draft: 0.001

% Smoke Capture: 100

Flue Pipe Cleaned Prior to First Test in Series:

Date: 12/16/21 Initials: KM

	Initial	Middle	Ending
P_b (in/Hg)	29.98		29.93
RH (%)	49		48
Ambient (°F)	70		72

Tunnel Traverse

Microtector Reading	dP (in H_2O)	T(°F)
1 .016	7 0.010	85 84
2 .020	8 0.016	
3 .022	9 0.020	
4 .024	10 0.020	
5 .016	11 0.020	
6 .008	12 0.012	
Center:		
	0.029	86

Background Filter Volume: 48.610 ft^3

Tunnel Static Pressure (in H_2O):	
Beginning of Test	End of Test
-0.257	-0.240

Technician Signature: Tony Tong Date: 06/15/22

25 - 50
23,000 - 46,000 34,500 18742

16 - 24
14,700 - 22,050
18,400

Froling 0456WB009E Run 3 Cat II 6-15-22

TEST Fuel (60% Main Load) Cal Check: 12.0 = 12.0, 22.0 = 22.0

		PC	Weight	L x W x h	moisture
~~7.9~~	7.9	1	7.9	16 x 7 x 4 1/2	25.2, 22.4, 23.1, 19.8, 24.2
~~14.8~~		~~2~~	~~6.9~~	~~16 x 5 x 5 1/2~~	~~20.1, 19.0, 23.5, 23.8, 21.2~~
~~23.2~~	16.3	3	8.4	16 x 6 x 6	19.4, 20.2, 19.5, 20.1, 19.8
25		2	8.7	16 x 7 x 4	20.9, 22.1, 18.8, 20.2, 21.4

TEST Fuel Remainder (Less 10% for start-up)

31.9	4	6.9	16 x 5 x 5 1/2	20.1, 19.0, 23.5, 23.8, 21.2
37.5	5	5.6	16 x 7 x 3	19.7, 20.4, 21.2, 19.6, 22.4
41.5	6	4.0	16 x 5 x 3	19.6, 20.1, 19.2, 18.9, 20.0

START-UP

~~45.3~~ ~~45.8~~ PC 1 → 22.1, 19.6, 20.2, 21.2, 19.8 → 4 @ 3.8 lb
~~3 pcs~~ total ~~2.3 lb~~

Project# 0456WB009E Date 6-15-22
Client Froling Tracking# 24488
Model 33 TURBO 30 Initials ~~JL~~ JC

Kindling

3.0 PC 1 → 11.4, 13.2, 12.8, 12.0, 11.8 → ~~10 pcs @ 3.0 lb~~ 10 pc's @ 3.0 lb total JC

Card Board = 0.2 lb

+ 0.2 Card board
48.5 total

Pre-burn Water Flow
T 200 - 202 7.0 lb 91.78 ~~151.78~~ sec JC

Mid-test Flow Check
~~T 290 - 293~~ T 306 - 309 129.33 sec, 7.7 lb

END-TEST Flow Check
T 410 - 413 132.14 s, 7.2 lb

Remaining Coals: 1.9 lb

K. Morgan
6-15-22

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

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Run #:	3
Test Date:	June 15, 2022

Cordwood Fuel Type	Wet Weight (lb)	% Moisture					
Maple, Black 7 x 4.5 x 16"	7.9	25.2	22.4	23.1	19.8	24.2	181.2
Maple, Black 6 x 6 x 16"	8.4	19.4	20.2	19.5	20.1	19.8	166.3
Maple, Black 7 x 4x 16"	8.7	20.9	22.1	18.8	20.2	21.4	179.9
Maple, Black 5 x 5.5 x 16"	6.9	20.1	19	23.5	23.8	21.2	148.5
Maple, Black 7 x 3 x 16"	5.6	19.7	20.4	21.2	19.6	22.4	115.7
Maple, Black 5 x 3 x 16"	4	19.6	20.1	19.2	18.9	20	78.2
Maple, Black 4 x (2 x 2 x 16") Start-up	3.8	22.1	19.6	20.2	21.2	19.8	78.2
Maple, Black 10 x (1 x 2 x 16") Kindling	3	11.4	13.2	12.8	12	11.8	36.7
Card Board	0.2						
Left Over Coals	1.9						

41.5

Weight of Main Fuel Load (with Start-up pieces), lb.	45.3
Weight of Kindling Fuel (Plus Cardboard), lb	3.2
Gross Fuel Weight, lb	48.5
Net Fuel Weight (Gross Fuel Weight minus remaining Coals), lb:	46.6
Total Moisture of Load (%):	**20.39**
Average Kindling Moisture, % db	12.24
Average Main Fuel Moisture, % db	20.82

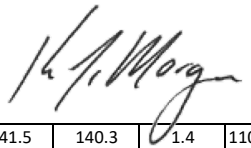
Equipment Numbers:

Hydronic Heating Appliances - Test Method ASTM E2618-13
Pre-Burn Data

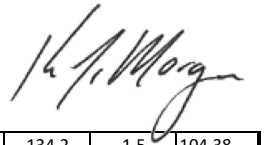
Manufacturer: Froling
Model: S3 Turbo 30
Tracking No.: 2448
Project No.: 0456WB009E
Run: 3
Test Date: June 15, 2022

Load Average
18117.22 Btu / hr

Appliance				LOAD										PTS				
Time, Min	Supply (T1)	Return (T2)	ΔT	Load IN, °F (T3)	Load OUT, °F (T4)	Flow Hz	Water Flow, GPM	Cpi	ΔT	Mass Flow Rate, lb/min	Btu/Min	**Btu/Hr**	Fuel Weight, LB	PTS TOP (T7)	PTS Bottom (T9)	PTS Mid (T8)	PTS ΔT	Boiler Return
83	113.8	140.6	-26.8	63.334	140.143	101.873	0.488	1.001	76.809	4.069	312.9	**18773.35**	0.19	144.2	146.0	144.6	1.8	115.2999
84	113.8	141.0	-27.2	63.217	140.812	99.662	0.477	1.001	77.595	3.977	309.0	**18537.71**	0.17	144.1	145.8	144.6	1.6	115.2796
85	114.0	141.0	-27.0	62.938	140.864	99.622	0.477	1.001	77.925	3.976	310.2	**18609.58**	0.17	144.1	145.8	144.4	1.7	115.2515
86	114.8	140.8	-26.0	62.791	140.803	95.793	0.458	1.001	78.012	3.817	298.1	**17885.50**	0.16	144.0	145.6	144.3	1.6	115.191
87	126.0	140.4	-14.4	62.730	140.886	94.452	0.451	1.001	78.156	3.761	294.3	**17657.44**	0.19	144.0	145.4	144.2	1.4	114.7673
88	127.3	139.8	-12.5	62.735	140.915	94.291	0.451	1.001	78.180	3.754	293.9	**17631.28**	0.20	143.8	145.1	144.0	1.4	113.7615
89	128.9	139.6	-10.7	62.779	140.790	95.411	0.456	1.001	78.011	3.801	296.9	**17811.19**	0.18	143.6	144.9	144.0	1.3	113.2671
90	129.8	139.2	-9.4	62.848	140.571	100.007	0.479	1.001	77.723	3.992	310.6	**18636.19**	4.07	143.5	144.9	143.8	1.5	112.9217
91	116.7	140.0	-23.4	62.941	140.383	99.927	0.479	1.001	77.442	3.988	309.2	**18553.04**	0.19	143.4	144.8	143.7	1.4	115.0345
92	113.7	139.7	-26.0	63.031	140.182	99.872	0.478	1.001	77.151	3.986	307.9	**18472.63**	0.18	143.1	144.7	143.5	1.6	115.0217
93	113.2	139.4	-26.2	63.119	140.043	96.322	0.461	1.001	76.924	3.838	295.6	**17736.98**	0.18	143.2	144.7	143.4	1.6	114.9831
94	113.3	139.5	-26.2	63.181	140.027	99.840	0.478	1.001	76.845	3.984	306.5	**18392.91**	0.17	143.0	144.6	143.2	1.5	114.9469
95	113.5	139.5	-26.0	63.235	139.848	97.665	0.467	1.001	76.613	3.894	298.7	**17921.71**	0.19	143.0	144.5	143.1	1.6	114.9801
96	113.3	139.5	-26.2	63.281	139.738	101.538	0.487	1.001	76.457	4.055	310.4	**18623.60**	0.17	142.8	144.5	143.1	1.6	114.977
97	113.8	139.4	-25.6	63.319	139.575	103.254	0.495	1.001	76.257	4.126	315.0	**18900.97**	0.19	142.5	144.1	143.0	1.7	114.9714
98	113.8	139.2	-25.3	63.370	139.302	103.282	0.495	1.001	75.932	4.127	313.8	**18825.66**	0.18	142.2	143.9	142.9	1.7	114.9668
99	113.7	139.0	-25.3	63.443	139.073	103.308	0.496	1.001	75.630	4.128	312.6	**18755.42**	0.19	142.3	144.0	142.6	1.7	114.9725
100	113.6	138.9	-25.3	63.539	139.052	103.172	0.495	1.001	75.513	4.123	311.7	**18700.89**	0.17	142.2	143.8	142.5	1.6	114.9751
101	114.1	138.8	-24.7	63.645	138.994	103.167	0.495	1.001	75.349	4.122	311.0	**18658.90**	0.18	142.1	143.7	142.3	1.6	114.9673
102	114.0	138.7	-24.7	63.754	138.876	103.159	0.495	1.001	75.122	4.122	310.0	**18600.79**	4.38	142.0	143.5	142.2	1.6	114.9743
103	122.5	138.3	-15.8	63.877	138.808	102.973	0.494	1.001	74.932	4.114	308.6	**18518.63**	0.18	141.9	143.5	142.1	1.6	114.678
104	126.4	138.0	-11.6	63.982	138.797	102.995	0.494	1.001	74.815	4.115	308.2	**18493.77**	0.19	141.8	143.3	142.0	1.5	113.963
105	128.2	137.7	-9.4	64.092	138.735	102.985	0.494	1.001	74.644	4.115	307.5	**18449.26**	0.18	141.7	143.3	141.9	1.6	113.3646
106	128.5	137.4	-8.9	64.210	138.672	103.000	0.494	1.001	74.461	4.115	306.8	**18406.58**	0.16	141.5	143.0	141.8	1.5	113.0279
107	129.6	136.8	-7.3	64.320	138.471	102.963	0.494	1.001	74.151	4.114	305.4	**18322.77**	0.18	141.4	142.8	141.7	1.5	112.7505
108	128.7	136.6	-8.0	64.422	138.344	102.942	0.494	1.001	73.921	4.113	304.4	**18262.07**	0.20	141.3	142.8	141.6	1.5	112.4502
109	129.5	136.5	-7.0	64.517	138.276	102.904	0.494	1.001	73.759	4.111	303.6	**18214.77**	0.16	141.3	142.7	141.5	1.4	112.2521
110	131.0	136.5	-5.5	64.610	138.193	102.834	0.493	1.001	73.583	4.108	302.6	**18158.16**	0.19	141.1	142.5	141.4	1.4	112.0388
111	129.9	135.8	-6.0	64.691	138.038	102.891	0.493	1.001	73.348	4.110	301.8	**18110.40**	0.19	141.0	142.5	141.2	1.4	111.8008
112	129.5	135.4	-5.9	64.769	137.965	102.889	0.493	1.001	73.195	4.110	301.2	**18072.08**	0.19	140.9	142.4	140.9	1.5	111.5867
113	129.4	134.6	-5.2	64.832	137.878	102.724	0.493	1.001	73.046	4.103	300.1	**18004.87**	0.18	140.8	142.3	140.9	1.4	111.3634
114	129.9	134.6	-4.7	64.887	137.768	102.761	0.493	1.001	72.881	4.105	299.5	**17970.88**	0.16	140.6	142.1	140.8	1.5	111.1687
115	129.1	134.4	-5.3	64.929	137.649	102.694	0.492	1.001	72.720	4.102	298.6	**17918.95**	0.18	140.6	142.1	140.7	1.4	110.985
116	128.7	134.4	-5.6	64.960	137.594	102.638	0.492	1.001	72.634	4.100	298.1	**17887.76**	0.18	140.5	141.9	140.7	1.4	110.7907
117	129.2	133.8	-4.6	64.983	137.440	102.722	0.493	1.001	72.457	4.103	297.7	**17859.06**	0.18	140.1	141.6	140.4	1.6	110.5964
118	129.1	133.6	-4.5	65.001	137.219	102.611	0.492	1.001	72.219	4.099	296.3	**17780.31**	0.20	140.2	141.7	140.4	1.5	110.408
119	129.3	132.9	-3.6	65.004	137.170	102.679	0.492	1.001	72.166	4.101	296.3	**17779.79**	0.20	140.0	141.5	140.4	1.4	110.2916



120	129.3	133.2	-3.9	65.001	137.061	102.635	0.492	1.001	72.060	4.100	295.8	**17745.54**	0.17	140.0	141.5	140.3	1.4	110.1209
121	128.8	133.0	-4.2	64.994	137.010	102.690	0.492	1.001	72.017	4.102	295.7	**17744.79**	0.18	139.8	141.3	140.1	1.5	109.9406
122	128.9	132.3	-3.4	64.985	136.911	102.667	0.492	1.001	71.926	4.101	295.3	**17718.49**	0.18	139.7	141.2	140.1	1.5	109.7721
123	129.1	132.5	-3.4	64.963	136.824	104.023	0.499	1.001	71.861	4.157	299.1	**17945.48**	0.18	139.6	141.1	139.9	1.4	109.6266
124	128.5	131.9	-3.4	64.925	136.648	105.432	0.506	1.001	71.722	4.216	302.7	**18162.80**	0.17	139.5	140.9	139.6	1.5	109.4683
125	129.5	132.0	-2.5	64.873	136.478	105.884	0.508	1.001	71.605	4.235	303.6	**18214.08**	0.19	139.3	140.8	139.6	1.5	109.3489
126	128.4	132.0	-3.6	64.823	136.344	105.707	0.508	1.001	71.521	4.227	302.7	**18161.22**	0.17	139.2	140.7	139.5	1.5	109.1869
127	129.0	131.3	-2.3	64.751	136.192	105.926	0.509	1.001	71.442	4.236	303.0	**18180.18**	0.18	139.2	140.7	139.4	1.5	109.077
128	128.7	131.6	-2.9	64.682	136.123	105.907	0.509	1.001	71.441	4.236	303.0	**18177.02**	0.15	138.9	140.5	139.3	1.6	108.9372
129	128.7	131.5	-2.8	64.605	135.993	105.934	0.509	1.001	71.388	4.237	302.8	**18168.33**	0.17	138.9	140.4	139.1	1.4	108.8154
130	128.3	130.9	-2.5	64.523	135.875	105.835	0.508	1.001	71.353	4.233	302.4	**18141.93**	0.19	138.8	140.3	139.1	1.5	108.6561
131	127.9	130.6	-2.7	64.446	135.771	105.851	0.508	1.001	71.325	4.233	302.3	**18138.00**	0.19	138.6	140.1	139.0	1.5	108.5736
132	127.7	130.1	-2.4	64.364	135.669	105.787	0.508	1.001	71.305	4.231	302.0	**18121.75**	0.18	138.5	140.0	138.9	1.5	108.4508
133	127.9	130.2	-2.3	64.292	135.559	104.612	0.502	1.001	71.267	4.182	298.4	**17903.44**	0.17	138.4	139.8	138.8	1.5	108.3199
134	127.6	130.4	-2.8	64.214	135.389	106.080	0.509	1.001	71.175	4.243	302.3	**18140.86**	0.19	138.2	139.8	138.7	1.6	108.1693
135	127.1	130.2	-3.1	64.148	135.316	106.038	0.509	1.001	71.168	4.241	302.2	**18131.90**	0.17	138.2	139.6	138.5	1.4	108.0518
136	127.3	129.6	-2.3	64.094	135.224	105.969	0.509	1.001	71.131	4.238	301.8	**18110.40**	0.18	138.1	139.5	138.5	1.4	107.9513
137	127.6	129.2	-1.5	64.056	135.108	105.918	0.509	1.001	71.052	4.236	301.4	**18081.55**	0.18	138.0	139.4	138.3	1.5	107.8117
138	127.6	129.7	-2.1	64.014	134.979	105.923	0.509	1.001	70.965	4.237	301.0	**18060.12**	0.17	137.8	139.3	138.0	1.5	107.7132
139	127.3	129.8	-2.5	63.992	134.909	105.879	0.508	1.001	70.917	4.235	300.7	**18040.33**	0.19	137.9	139.3	137.9	1.4	107.6016
140	127.1	128.9	-1.8	63.975	134.843	105.807	0.508	1.001	70.868	4.232	300.3	**18015.06**	0.19	137.7	139.2	137.8	1.5	107.4817
141	126.6	129.6	-3.0	63.971	134.749	105.793	0.508	1.001	70.779	4.231	299.8	**17989.94**	0.17	137.6	139.0	137.8	1.4	107.3663
142	127.6	128.6	-1.1	63.972	134.577	105.722	0.508	1.001	70.605	4.228	298.9	**17933.27**	0.21	137.4	138.9	137.7	1.5	107.2672
143	126.1	129.0	-2.9	63.989	134.468	105.896	0.508	1.001	70.479	4.235	298.9	**17931.86**	0.16	137.3	138.8	137.5	1.4	107.1698
144	127.7	127.8	-0.1	64.007	134.378	105.965	0.509	1.001	70.371	4.238	298.6	**17916.34**	0.16	137.2	138.6	137.5	1.4	107.0402
145	126.9	128.1	-1.2	64.029	134.238	105.849	0.508	1.001	70.209	4.233	297.6	**17854.68**	0.18	137.0	138.4	137.4	1.4	106.9648
146	126.7	128.0	-1.3	64.059	134.109	105.821	0.508	1.001	70.050	4.232	296.8	**17809.41**	0.14	137.0	138.4	137.2	1.4	106.7671
147	126.0	128.1	-2.1	64.086	134.053	105.755	0.508	1.001	69.967	4.230	296.3	**17776.70**	0.19	136.9	138.3	137.1	1.4	106.7449
148	126.3	127.9	-1.6	64.117	133.978	105.711	0.508	1.001	69.862	4.228	295.7	**17742.26**	0.18	136.8	138.2	137.0	1.4	106.6563
149	126.6	128.0	-1.4	64.158	133.943	105.040	0.504	1.001	69.785	4.200	293.4	**17606.00**	0.18	136.6	138.1	137.0	1.5	106.5466
150	126.7	127.7	-1.1	64.202	133.732	106.274	0.510	1.001	69.530	4.251	295.9	**17755.39**	0.18	136.3	137.7	136.8	1.4	106.362
151	126.7	127.2	-0.4	64.214	133.485	109.708	0.527	1.001	69.270	4.394	304.7	**18282.23**	0.18	136.3	137.8	136.6	1.4	106.2913
152	126.5	127.2	-0.7	64.247	133.326	108.571	0.522	1.001	69.079	4.346	300.6	**18035.93**	0.18	136.3	137.8	136.5	1.5	106.2162
153	126.4	127.3	-0.9	64.278	133.299	115.440	0.556	1.001	69.020	4.632	320.0	**19202.86**	0.19	136.2	137.6	136.5	1.5	106.0855
154	125.9	127.1	-1.2	64.311	133.103	114.846	0.553	1.001	68.792	4.607	317.3	**19037.44**	0.19	136.0	137.6	136.3	1.5	105.9705
155	125.4	127.1	-1.7	64.331	132.972	114.730	0.552	1.001	68.641	4.602	316.3	**18975.59**	0.18	135.8	137.4	136.2	1.6	105.8592
156	124.9	127.0	-2.1	64.349	132.873	114.652	0.552	1.001	68.525	4.599	315.5	**18930.11**	0.16	135.7	137.2	136.1	1.5	105.7843
157	125.5	127.1	-1.6	64.368	132.732	114.699	0.552	1.001	68.364	4.601	314.9	**18893.64**	0.16	135.6	137.1	135.8	1.6	105.682
158	125.6	126.5	-0.9	64.388	132.599	114.661	0.552	1.001	68.212	4.599	314.1	**18844.99**	0.20	135.4	136.9	135.7	1.5	105.6349
159	125.1	126.2	-1.2	64.403	132.479	114.684	0.552	1.001	68.076	4.600	313.5	**18811.35**	0.21	135.4	136.9	135.6	1.5	105.5257
160	124.3	126.3	-2.0	64.410	132.415	114.608	0.552	1.001	68.005	4.597	313.0	**18778.92**	0.18	135.4	136.9	135.5	1.5	105.4038
161	124.5	126.3	-1.8	64.412	132.388	114.643	0.552	1.001	67.976	4.598	312.9	**18776.82**	0.17	135.3	136.6	135.4	1.4	105.3207
162	124.5	125.8	-1.3	64.409	132.226	114.720	0.552	1.001	67.817	4.602	312.4	**18745.89**	0.16	135.1	136.6	135.3	1.5	105.1886
163	124.5	125.7	-1.2	64.407	132.139	114.660	0.552	1.001	67.732	4.599	311.9	**18712.24**	0.21	135.1	136.6	135.2	1.5	105.1466
164	124.1	125.9	-1.8	64.402	132.076	114.673	0.552	1.001	67.674	4.600	311.6	**18698.45**	0.16	134.9	136.4	135.2	1.4	105.0334
165	123.8	125.5	-1.7	64.393	131.909	114.622	0.552	1.001	67.516	4.598	310.8	**18646.41**	0.19	134.7	136.2	135.1	1.4	104.9349
166	124.0	124.6	-0.6	64.381	131.777	114.689	0.552	1.001	67.397	4.600	310.4	**18624.63**	0.19	134.5	136.0	135.0	1.5	104.8787
167	124.0	125.1	-1.1	64.364	131.638	114.634	0.552	1.001	67.273	4.598	309.7	**18581.35**	0.18	134.5	136.0	134.8	1.4	104.8061
168	124.5	125.2	-0.8	64.349	131.564	114.704	0.552	1.001	67.215	4.601	309.6	**18577.01**	0.19	134.4	135.9	134.8	1.4	104.7156
169	123.9	124.9	-1.0	64.332	131.412	114.672	0.552	1.001	67.080	4.600	308.9	**18534.55**	0.20	134.2	135.7	134.7	1.5	104.5987
170	123.7	124.9	-1.1	64.300	131.219	114.720	0.552	1.001	66.919	4.602	308.3	**18498.09**	0.18	134.2	135.7	134.4	1.5	104.5973
171	124.3	124.3	0.1	64.271	131.227	114.757	0.553	1.001	66.956	4.603	308.6	**18514.41**	0.18	134.1	135.5	134.3	1.4	104.4636



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174	123.2	124.6	-1.5	64.208	130.893	114.773	0.553	1.001	66.685	4.604	307.4	**18442.35**	0.17	133.7	135.2	134.0	1.4	104.2146
175	123.7	123.4	0.3	64.193	130.827	113.938	0.549	1.001	66.634	4.569	304.8	**18289.33**	0.20	133.6	135.1	133.9	1.5	104.1476
176	123.7	123.7	0.0	64.183	130.760	114.977	0.554	1.001	66.577	4.612	307.4	**18446.31**	0.19	133.5	135.0	133.9	1.5	104.0596
177	123.1	123.7	-0.6	64.172	130.645	114.913	0.553	1.001	66.473	4.610	306.8	**18406.92**	0.18	133.4	134.8	133.8	1.4	103.9517
178	122.9	123.1	-0.2	64.164	130.503	114.921	0.553	1.001	66.339	4.610	306.2	**18371.27**	0.17	133.4	134.8	133.7	1.4	103.9162
179	122.5	123.4	-0.9	64.156	130.432	114.804	0.553	1.001	66.276	4.605	305.6	**18334.40**	0.16	133.2	134.6	133.6	1.4	103.8365
180	123.2	122.5	0.7	64.148	130.269	114.857	0.553	1.001	66.121	4.607	305.0	**18300.38**	0.18	133.0	134.5	133.5	1.4	103.7782
181	122.4	123.5	-1.1	64.149	130.165	114.674	0.552	1.001	66.016	4.600	304.0	**18241.31**	0.16	132.9	134.3	133.4	1.4	103.6691
182	122.7	123.0	-0.3	64.141	130.070	114.886	0.553	1.001	65.928	4.609	304.2	**18251.79**	0.22	132.9	134.3	133.1	1.4	103.6092
183	122.3	123.1	-0.8	64.130	130.035	114.832	0.553	1.001	65.905	4.606	303.9	**18236.63**	5.13	132.8	134.2	133.0	1.4	103.4821
184	122.3	123.4	-1.1	64.138	129.917	112.081	0.539	1.001	65.779	4.492	295.8	**17750.37**	109.00	132.7	134.1	132.8	1.4	103.4177
185	123.8	122.7	1.1	64.137	129.911	113.721	0.547	1.001	65.774	4.560	300.3	**18017.83**	2.83	132.5	133.9	132.8	1.4	103.3117
186	122.2	122.3	-0.2	64.142	129.713	114.882	0.553	1.001	65.572	4.608	302.5	**18152.49**	20.55	132.4	133.8	132.8	1.4	103.2544
187	121.7	123.0	-1.3	64.155	129.566	114.878	0.553	1.001	65.411	4.608	301.8	**18107.09**	32.52	132.3	133.7	132.5	1.4	103.0981
188	122.4	122.4	0.0	64.164	129.488	112.911	0.543	1.001	65.325	4.527	296.0	**17762.83**	49.31	132.2	133.6	132.4	1.3	102.9637
189	121.8	121.8	0.0	64.166	129.424	114.847	0.553	1.001	65.257	4.607	301.0	**18059.67**	48.66	132.1	133.6	132.4	1.4	102.844
190	123.1	122.4	0.7	64.171	129.342	114.798	0.553	1.001	65.170	4.605	300.5	**18027.64**	48.66	132.0	133.3	132.4	1.3	102.7366
191	122.6	122.7	-0.1	64.177	129.182	114.856	0.553	1.001	65.005	4.607	299.9	**17991.28**	48.63	131.9	133.3	132.3	1.4	102.5793
192	122.5	122.3	0.1	64.189	129.084	114.884	0.553	1.001	64.895	4.609	299.4	**17965.27**	48.64	131.9	133.2	132.1	1.4	102.464
193	121.7	121.6	0.2	64.209	129.028	114.145	0.550	1.001	64.820	4.578	297.1	**17824.91**	48.65	131.7	133.1	131.8	1.4	102.3508
194	121.0	122.2	-1.2	64.212	128.945	114.597	0.552	1.001	64.732	4.597	297.9	**17873.97**	48.66	131.7	133.0	131.7	1.4	102.2785
195	121.2	120.9	0.3	64.238	128.856	110.417	0.531	1.001	64.618	4.423	286.1	**17168.67**	48.67	131.5	132.9	131.6	1.4	102.159
196	121.8	121.8	-0.1	64.249	128.755	113.035	0.544	1.001	64.506	4.532	292.7	**17560.01**	48.68	131.3	132.7	131.6	1.4	102.0546
197	120.8	122.1	-1.4	64.264	128.569	112.970	0.544	1.001	64.305	4.529	291.6	**17494.79**	48.68	131.2	132.5	131.5	1.4	101.9349
198	120.9	121.2	-0.3	64.276	128.454	114.735	0.553	1.001	64.178	4.602	295.7	**17742.78**	48.62	131.2	132.5	131.3	1.4	101.8103
199	121.6	121.1	0.5	64.294	128.345	115.976	0.559	1.001	64.052	4.654	298.4	**17905.99**	48.63	131.0	132.4	131.3	1.4	101.7033
200	120.7	121.3	-0.6	64.309	128.195	117.050	0.564	1.001	63.885	4.698	300.5	**18030.47**	48.15	130.7	132.2	130.3	1.5	101.3778
201	120.6	120.6	0.0	64.314	127.963	116.889	0.563	1.001	63.648	4.692	299.0	**17938.02**	48.63	130.6	132.1	130.2	1.4	101.2531
202	120.4	120.4	-0.1	64.322	127.901	116.845	0.563	1.001	63.579	4.690	298.5	**17911.68**	48.32	130.6	132.0	130.1	1.4	101.1358
203	120.8	119.9	0.9	64.326	127.863	116.954	0.564	1.001	63.537	4.694	298.6	**17917.02**	48.60	130.6	132.0	129.9	1.4	101.0512
204	120.8	119.7	1.1	64.322	127.800	116.976	0.564	1.001	63.478	4.695	298.4	**17903.85**	48.57	130.4	131.8	129.8	1.4	100.9225
205	120.2	119.1	1.1	64.323	127.689	117.054	0.564	1.001	63.366	4.699	298.1	**17884.62**	48.80	130.2	131.6	129.7	1.4	100.8417
206	120.9	120.3	0.6	64.320	127.534	117.065	0.564	1.001	63.214	4.699	297.4	**17843.43**	48.42	130.1	131.5	129.7	1.3	100.7339
207	119.9	119.8	0.1	64.308	127.462	117.039	0.564	1.001	63.153	4.698	297.0	**17822.32**	48.56	130.4	131.5	129.7	1.1	100.7258
208	119.0	119.7	-0.7	64.297	124.160	117.143	0.565	1.001	59.863	4.702	281.8	**16909.22**	48.54	131.5	131.5	129.5	0.1	100.6518
209	118.5	118.7	-0.2	64.282	117.877	117.173	0.565	1.001	53.595	4.703	252.4	**15142.86**	48.53	131.4	131.4	129.5	0.0	100.5077
210	117.7	117.6	0.0	64.271	112.514	116.968	0.564	1.001	48.243	4.695	226.8	**13606.09**	48.77	122.9	131.4	129.2	8.4	100.4683
211	116.9	117.2	-0.3	64.246	123.479	115.745	0.558	1.001	59.233	4.644	275.4	**16524.99**	48.65	126.6	131.3	129.2	4.8	100.3516

Hydronic Heating Appliances - Test Method ASTM E2515-11

Emissions Sampling Data

Run: 3

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Test Date: June 15, 2022
Technician: TT / KM
Beginning Clock Time: 10:47
Recording Interval: 1 min.
Total Sampling Time: 194 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	0.016	0.020	0.022	0.024	0.016	0.008	0.010	0.016	0.020	0.020	0.020	0.012	0.029	"H2O
Initial Temp.	85	85	85	85	85	85	84	84	84	84	84	84	86	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: 12/16/2021

V_{strav} 8.67 ft/sec
V_{scent} 11.47 ft/sec
F_p 0.756

	(1)	(2)	(amb)	
Meter Box Y Factor:	1.003	1.003	1.011	
Barometric Pressure:	Begin	Middle	End	Average
	29.98		29.93	29.96 "Hg

PM Control Module: 335, 336
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: -0.248 "H2O
Pitot Tube Cp: 0.99

Tunnel Velocity: 8.75 ft/sec.
Intial Tunnel Flow: 388.6 scfm
Average Tunnel Flow: 387.2 scfm
Tunnel Area: 0.785 ft2

Post-Test Leak Check (1): 0.000 cfm @ -16 in. Hg
Post-Test Leak Check (2): 0.000 cfm @ -15 in. Hg
Fuel Moisture (dry basis %): 20.39
Total Particulate (1): 4.6
Total Particulate (2): 5.3

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			1.23	1.38	0.34	74	74	71	2.84	2.20	70	0.029			46.6		90	70	70	70	0.018	0.00	0.07
1	0.141	0.151		0.14	0.15	1.28	1.10	0.34	74	74	71	2.69	1.80	79	0.027	92	98	46.5	0.12	135	70	70	70	0.028	0.00	0.06
2	0.302	0.311		0.16	0.16	1.35	1.10	0.34	74	74	71	2.80	1.80	81	0.030	99	99	46.1	0.38	164	71	70	70	0.035	0.27	1.95
3	0.466	0.471		0.16	0.16	1.35	1.08	0.34	74	74	71	2.79	1.80	83	0.029	103	101	45.9	0.24	188	71	70	70	0.037	0.16	3.92
4	0.630	0.630		0.16	0.16	1.34	1.09	0.34	74	74	71	2.79	1.80	86	0.029	103	100	45.2	0.62	209	71	71	70	0.040	0.25	5.11
5	0.794	0.789		0.16	0.16	1.34	1.08	0.34	74	74	71	2.78	1.80	88	0.030	102	99	45.0	0.24	225	72	71	70	0.041	0.25	6.27
6	0.958	0.947		0.16	0.16	1.33	1.08	0.34	74	74	71	2.78	1.80	90	0.029	104	100	44.4	0.65	238	72	71	70	0.044	0.17	7.24
7	1.121	1.105		0.16	0.16	1.32	1.07	0.34	74	74	71	2.78	1.80	91	0.030	102	98	44.1	0.26	251	72	72	70	0.046	0.12	7.94
8	1.284	1.263		0.16	0.16	1.33	1.07	0.34	74	74	71	2.78	1.80	95	0.029	104	101	43.1	0.96	269	73	72	70	0.047	0.06	8.84
9	1.446	1.420		0.16	0.16	1.32	1.07	0.34	74	74	71	2.77	1.80	97	0.030	101	98	42.7	0.48	282	73	73	70	0.049	0.03	9.60
10	1.608	1.579		0.16	0.16	1.32	1.07	0.34	74	74	71	2.77	1.80	99	0.027	107	105	41.9	0.71	292	74	73	70	0.049	0.03	9.88
11	1.767	1.735		0.16	0.16	1.27	1.08	0.34	74	74	71	2.70	1.80	100	0.027	105	103	41.6	0.36	296	74	73	70	0.049	0.02	10.17
12	1.926	1.895		0.16	0.16	1.29	1.10	0.34	75	74	71	2.72	1.90	100	0.031	98	99	41.2	0.41	300	74	73	70	0.049	0.02	9.71
13	2.088	2.055		0.16	0.16	1.28	1.09	0.34	75	74	71	2.74	1.90	101	0.026	109	108	40.4	0.76	302	75	74	69	0.050	0.04	9.84
14	2.248	2.214		0.16	0.16	1.28	1.09	0.34	75	75	71	2.72	1.90	101	0.029	102	101	39.9	0.54	305	75	74	69	0.050	0.08	9.64
15	2.408	2.373		0.16	0.16	1.28	1.09	0.34	75	75	71	2.72	1.90	101	0.029	102	101	39.4	0.47	306	75	74	69	0.051	0.04	9.80
16	2.568	2.533		0.16	0.16	1.28	1.08	0.34	75	75	71	2.72	1.90	101	0.043	84	84	38.9	0.47	308	75	74	69	0.050	0.03	9.47
17	2.728	2.692		0.16	0.16	1.29	1.09	0.34	75	75	71	2.72	1.90	101	0.029	102	101	38.6	0.35	310	76	74	69	0.051	0.03	9.49
18	2.889	2.852		0.16	0.16	1.28	1.09	0.34	75	75	71	2.74	1.90	101	0.029	103	102	38.0	0.57	311	76	74	69	0.051	0.01	9.80
19	3.049	3.011		0.16	0.16	1.28	1.08	0.34	75	75	71	2.74	1.90	102	0.028	104	103	37.6	0.39	312	76	74	69	0.051	0.01	9.39
20	3.209	3.170		0.16	0.16	1.28	1.08	0.34	76	75	71	2.73	1.90	101	0.029	102	101	37.1	0.57	311	76	74	69	0.051	0.01	9.13
21	3.369	3.329		0.16	0.16	1.28	1.08	0.34	76	76	71	2.72	1.90	102	0.028	104	103	36.8	0.27	312	76	74	69	0.050	0.01	8.91
22	3.530	3.488		0.16	0.16	1.28	1.08	0.34	76	76	71	2.72	1.90	102	0.029	103	101	36.5	0.26	311	76	74	69	0.051	0.06	8.29
23	3.690	3.647		0.16	0.16	1.28	1.08	0.34	76	76	71	2.72	1.90	102	0.029	102	101	36.1	0.45	311	76	74	69	0.051	0.05	7.88
24	3.850	3.807		0.16	0.16	1.28	1.09	0.34	76	76	71	2.72	1.90	103	0.028	104	104	35.7	0.36	310	76	74	70	0.050	0.07	7.60
25	4.010	3.967		0.16	0.16	1.28	1.09	0.34	76	76	71	2.72	1.90	103	0.028	104	104	35.4	0.29	311	76	74	70	0.050	0.08	7.38
26	4.171	4.126		0.16	0.16	1.28	1.09	0.34	76	76	71	2.73	1.90	103	0.028	105	103	34.8	0.59	310	76	74	70	0.050	0.07	7.20
27	4.332	4.287		0.16	0.16	1.28	1.09	0.34	77	76	71	2.73	1.90	103	0.028	104	105	34.6	0.21	310	76	74	69	0.050	0.08	6.94

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(%)
28	4.492	4.446		0.16	0.16	1.28	1.09	0.34	77	77	71	2.74	1.90	103	0.028	104	103	34.6	0.05	310	76	74	69	0.051	0.10	6.78
29	4.652	4.606		0.16	0.16	1.28	1.09	0.34	77	77	71	2.72	1.90	103	0.027	106	106	34.0	0.61	313	76	74	69	0.050	0.08	6.74
30	4.813	4.767		0.16	0.16	1.28	1.09	0.34	77	77	71	2.73	1.90	104	0.029	103	103	33.6	0.42	313	76	74	69	0.051	0.05	6.91
31	4.973	4.926		0.16	0.16	1.28	1.09	0.34	77	77	71	2.73	1.90	103	0.029	102	101	33.0	0.54	312	76	75	70	0.051	0.06	7.47
32	5.134	5.086		0.16	0.16	1.28	1.09	0.34	77	77	71	2.72	1.90	103	0.029	103	102	32.7	0.34	312	76	75	70	0.051	0.09	7.37
33	5.295	5.247		0.16	0.16	1.28	1.09	0.34	77	77	71	2.74	1.90	104	0.028	104	104	32.5	0.13	313	76	75	70	0.050	0.12	7.21
34	5.455	5.406		0.16	0.16	1.27	1.09	0.34	78	77	71	2.73	1.90	104	0.030	100	100	32.0	0.55	314	77	75	70	0.050	0.10	7.30
35	5.616	5.567		0.16	0.16	1.28	1.09	0.34	78	77	71	2.73	1.90	105	0.028	104	105	31.7	0.31	313	77	75	69	0.050	0.11	7.27
36	5.776	5.728		0.16	0.16	1.28	1.09	0.34	78	78	71	2.74	1.90	104	0.030	100	101	31.1	0.56	314	77	75	70	0.050	0.16	6.96
37	5.937	5.887		0.16	0.16	1.28	1.09	0.34	78	78	71	2.73	1.90	104	0.028	104	103	30.6	0.47	314	77	75	70	0.051	0.13	7.10
38	6.099	6.047		0.16	0.16	1.28	1.09	0.34	78	78	71	2.72	1.90	104	0.029	103	102	30.4	0.29	314	77	75	70	0.051	0.15	6.87
39	6.259	6.208		0.16	0.16	1.27	1.09	0.34	78	78	71	2.73	1.90	105	0.029	102	103	30.2	0.19	313	77	75	70	0.051	0.17	6.91
40	6.420	6.368		0.16	0.16	1.28	1.09	0.34	78	78	71	2.73	1.90	105	0.030	101	100	29.8	0.37	313	77	76	70	0.051	0.18	6.84
41	6.580	6.528		0.16	0.16	1.28	1.09	0.34	78	78	71	2.74	1.90	105	0.028	104	104	29.3	0.47	312	77	76	70	0.051	0.19	6.76
42	6.741	6.689		0.16	0.16	1.27	1.09	0.34	78	78	71	2.72	1.90	105	0.028	104	104	28.9	0.47	314	77	76	70	0.051	0.21	6.56
43	6.903	6.849		0.16	0.16	1.28	1.08	0.34	79	78	71	2.74	1.90	105	0.030	101	100	28.5	0.41	317	77	76	70	0.052	0.23	6.84
44	7.064	7.009		0.16	0.16	1.28	1.09	0.34	79	78	71	2.73	1.90	106	0.031	99	99	28.2	0.22	317	77	76	70	0.051	0.15	7.61
45	7.224	7.169		0.16	0.16	1.26	1.09	0.34	79	79	71	2.72	1.90	105	0.030	100	100	27.5	0.70	319	77	76	70	0.051	0.28	7.30
46	7.383	7.330		0.16	0.16	1.26	1.09	0.34	79	79	71	2.72	1.90	105	0.030	99	101	27.4	0.15	319	78	76	70	0.051	0.25	7.39
47	7.544	7.490		0.16	0.16	1.27	1.09	0.34	79	79	71	2.72	1.90	106	0.029	102	102	26.8	0.56	318	78	76	70	0.051	0.25	7.40
48	7.704	7.650		0.16	0.16	1.26	1.09	0.34	79	79	71	2.71	1.90	105	0.029	102	102	26.6	0.22	318	78	76	70	0.051	0.26	7.37
49	7.865	7.811		0.16	0.16	1.27	1.09	0.34	79	79	71	2.71	1.90	106	0.028	104	104	26.1	0.54	323	78	76	70	0.052	0.31	7.36
50	8.024	7.971		0.16	0.16	1.27	1.09	0.34	79	79	71	2.71	1.90	106	0.030	99	100	25.2	0.81	324	78	76	70	0.052	0.12	8.23
51	8.184	8.132		0.16	0.16	1.26	1.09	0.34	79	79	71	2.72	1.90	106	0.028	104	104	24.7	0.50	325	78	76	70	0.053	0.06	8.37
52	8.344	8.293		0.16	0.16	1.27	1.09	0.34	79	79	71	2.71	1.90	105	0.029	102	102	24.5	0.26	326	78	76	70	0.052	0.06	8.46
53	8.506	8.452		0.16	0.16	1.27	1.09	0.34	80	79	71	2.72	1.90	106	0.031	100	98	23.7	0.76	328	78	76	70	0.052	0.06	8.51
54	8.666	8.613		0.16	0.16	1.26	1.09	0.34	80	79	71	2.72	1.90	105	0.030	100	101	23.8	-0.03	330	78	76	70	0.052	0.03	9.03
55	8.825	8.774		0.16	0.16	1.26	1.09	0.34	80	79	71	2.72	1.90	105	0.028	103	104	23.3	0.50	330	78	76	70	0.052	0.03	9.05
56	8.985	8.933		0.16	0.16	1.26	1.09	0.34	80	79	71	2.73	1.90	105	0.028	103	103	22.6	0.66	330	78	76	70	0.052	0.02	8.98
57	9.146	9.093		0.16	0.16	1.26	1.09	0.34	80	79	71	2.71	1.90	105	0.029	102	102	22.2	0.40	329	78	76	70	0.052	0.02	8.78
58	9.307	9.254		0.16	0.16	1.26	1.09	0.34	80	80	71	2.72	1.90	105	0.029	102	102	21.8	0.39	331	78	76	70	0.052	0.01	8.69
59	9.467	9.415		0.16	0.16	1.27	1.08	0.34	80	80	71	2.73	1.90	105	0.028	103	104	21.4	0.41	331	78	76	70	0.052	0.01	9.09
60	9.627	9.574		0.16	0.16	1.26	1.09	0.34	80	80	71	2.71	1.90	105	0.028	103	103	21.3	0.13	329	78	76	70	0.052	0.01	8.98
61	9.783	9.735		0.16	0.16	1.19	1.09	0.34	80	80	71	2.95	1.90	104	0.028	101	104	20.9	0.37	328	72	76	70	0.052	0.01	8.73
62	9.944	9.896		0.16	0.16	1.26	1.09	0.34	80	80	71	3.08	1.90	104	0.029	102	102	20.3	0.55	327	73	76	70	0.053	0.02	8.54
63	10.104	10.056		0.16	0.16	1.26	1.09	0.34	80	80	71	3.09	1.90	104	0.028	103	103	20.2	0.12	326	73	77	70	0.052	0.02	8.49
64	10.263	10.216		0.16	0.16	1.26	1.09	0.34	80	80	71	3.09	1.90	103	0.030	99	100	19.7	0.51	325	73	77	70	0.052	0.01	8.78
65	10.423	10.377		0.16	0.16	1.26	1.09	0.34	80	80	71	3.07	1.90	103	0.029	101	102	19.6	0.13	323	73	77	70	0.051	0.01	8.80
66	10.584	10.537		0.16	0.16	1.27	1.09	0.34	80	80	71	3.07	1.90	102	0.030	100	100	19.0	0.54	321	73	77	70	0.052	0.02	8.60
67	10.745	10.698		0.16	0.16	1.27	1.09	0.34	80	80	71	3.08	1.90	102	0.029	102	102	18.8	0.27	319	74	76	70	0.051	0.02	8.41
68	10.906	10.859		0.16	0.16	1.26	1.09	0.34	80	80	71	3.07	1.90	101	0.029	102	102	18.1	0.67	317	74	76	70	0.050	0.03	8.29
69	11.066	11.020		0.16	0.16	1.26	1.09	0.34	80	80	71	3.08	1.90	100	0.029	101	102	17.9	0.23	314	74	76	70	0.050	0.04	8.16
70	11.226	11.180		0.16	0.16	1.27	1.09	0.34	81	80	71	3.08	1.90	99	0.031	97	98	17.5	0.41	311	74	76	70	0.049	0.03	8.35
71	11.386	11.341		0.16	0.16	1.27	1.09	0.34	81	80	71	3.08	1.90	99	0.031	97	98	17.5	-0.05	310	74	76	70	0.050	0.05	8.41
72	11.548	11.503		0.16	0.16	1.27	1.09	0.34	81	80	71	3.07	1.90	98	0.029	102	102	17.1	0.41	308	74	76	70	0.049	0.04	8.36

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(%)
73	11.709	11.663		0.16	0.16	1.26	1.10	0.34	81	80	71	3.07	1.90	98	0.029	101	101	16.5	0.56	306	74	76	70	0.049	0.04	8.16
74	11.868	11.824		0.16	0.16	1.26	1.10	0.34	81	80	71	3.07	1.90	97	0.030	98	100	16.3	0.28	304	74	76	70	0.048	0.04	7.99
75	12.029	11.986		0.16	0.16	1.27	1.10	0.34	81	80	71	3.06	1.90	97	0.029	101	102	16.1	0.15	302	75	76	69	0.049	0.04	7.99
76	12.189	12.147		0.16	0.16	1.27	1.09	0.34	81	81	71	3.08	1.90	97	0.028	102	103	15.9	0.22	300	75	76	70	0.048	0.04	8.02
77	12.351	12.308		0.16	0.16	1.27	1.10	0.34	81	81	71	3.06	1.90	97	0.028	104	103	15.5	0.34	299	75	76	70	0.049	0.06	7.95
78	12.512	12.470		0.16	0.16	1.27	1.10	0.34	81	81	71	3.08	1.90	96	0.029	101	102	15.0	0.50	297	75	76	70	0.047	0.06	7.80
79	12.672	12.632		0.16	0.16	1.27	1.10	0.34	81	81	71	3.06	1.90	95	0.028	102	104	15.0	0.03	294	75	76	70	0.047	0.08	7.68
80	12.833	12.793		0.16	0.16	1.26	1.10	0.34	81	81	71	3.07	1.90	95	0.029	101	101	14.8	0.25	294	75	76	70	0.047	0.09	7.64
81	12.994	12.954		0.16	0.16	1.27	1.10	0.34	81	81	71	3.06	1.90	95	0.029	101	101	14.6	0.18	292	75	76	70	0.048	0.06	7.79
82	13.155	13.116		0.16	0.16	1.27	1.10	0.34	81	81	71	3.08	1.90	94	0.028	103	103	14.5	0.11	290	75	76	70	0.047	0.02	8.13
83	13.316	13.278		0.16	0.16	1.27	1.10	0.34	81	81	71	3.06	1.90	93	0.029	101	102	13.8	0.71	286	75	76	70	0.046	0.04	8.07
84	13.477	13.439		0.16	0.16	1.27	1.10	0.34	81	81	71	3.06	1.90	93	0.029	101	101	13.7	0.04	284	75	76	70	0.047	0.02	8.46
85	13.637	13.601		0.16	0.16	1.26	1.11	0.34	81	81	71	3.07	1.90	92	0.030	98	100	13.4	0.31	282	75	76	70	0.046	0.02	8.67
86	13.797	13.763		0.16	0.16	1.27	1.10	0.34	81	81	71	3.06	1.90	92	0.030	98	100	13.3	0.16	280	75	76	70	0.046	0.01	8.52
87	13.958	13.925		0.16	0.16	1.27	1.10	0.34	81	81	71	3.06	1.90	92	0.030	99	100	12.9	0.32	279	75	75	70	0.046	0.01	8.74
88	14.120	14.087		0.16	0.16	1.26	1.10	0.34	81	81	71	3.08	1.90	91	0.031	98	98	12.5	0.46	277	75	75	70	0.046	0.00	8.78
89	14.281	14.248		0.16	0.16	1.27	1.11	0.34	81	81	71	3.07	1.90	91	0.028	102	103	12.0	0.46	275	75	75	70	0.044	0.00	8.65
90	14.442	14.411		0.16	0.16	1.26	1.11	0.34	81	81	71	3.06	1.90	90	0.031	97	99	12.0	0.07	273	75	75	70	0.044	0.00	8.48
91	14.602	14.573		0.16	0.16	1.26	1.10	0.34	81	81	71	3.07	1.80	90	0.031	97	98	12.0	-0.07	271	75	75	70	0.044	0.01	8.26
92	14.763	14.734		0.16	0.16	1.27	1.11	0.34	81	81	71	3.07	1.90	90	0.031	97	97	11.7	0.35	269	75	75	70	0.044	0.02	8.15
93	14.924	14.896		0.16	0.16	1.27	1.11	0.34	81	81	71	3.06	1.90	89	0.030	99	99	11.4	0.24	267	75	75	70	0.044	0.02	7.94
94	15.086	15.059		0.16	0.16	1.27	1.11	0.34	82	81	71	3.06	1.80	89	0.029	101	102	11.2	0.27	265	75	75	70	0.043	0.03	7.96
95	15.247	15.221		0.16	0.16	1.26	1.10	0.34	82	81	71	3.06	1.80	89	0.031	97	98	11.2	-0.07	264	75	75	70	0.042	0.02	7.74
96	15.407	15.382		0.16	0.16	1.27	1.06	0.34	82	81	71	3.06	1.80	88	0.029	100	100	10.7	0.48	261	75	75	70	0.043	0.03	7.49
97	15.568	15.542		0.16	0.16	1.26	1.08	0.34	82	81	71	3.07	1.80	88	0.029	100	100	10.8	-0.02	260	75	75	70	0.043	0.03	7.24
98	15.729	15.703		0.16	0.16	1.27	1.07	0.34	82	81	71	3.07	1.80	88	0.029	100	100	10.5	0.30	258	75	75	70	0.042	0.01	7.39
99	15.890	15.862		0.16	0.16	1.27	1.07	0.34	82	81	71	3.06	1.80	87	0.030	98	97	10.1	0.32	256	75	75	70	0.042	0.01	7.55
100	16.052	16.022		0.16	0.16	1.27	1.08	0.34	82	81	71	3.07	1.80	87	0.029	101	100	9.9	0.26	255	75	75	70	0.040	0.01	7.45
101	16.213	16.183		0.16	0.16	1.26	1.07	0.34	82	81	71	3.07	1.80	86	0.028	102	102	9.8	0.07	252	75	75	70	0.041	0.01	7.44
102	16.373	16.342		0.16	0.16	1.26	1.08	0.34	82	81	71	3.07	1.80	86	0.028	101	101	10.0	-0.23	250	75	74	70	0.041	0.06	6.82
103	16.534	16.502		0.16	0.16	1.26	1.08	0.34	82	81	71	3.07	1.80	86	0.030	98	98	9.7	0.31	248	75	74	70	0.040	0.09	6.50
104	16.695	16.663		0.16	0.16	1.26	1.07	0.34	82	81	71	3.06	1.80	86	0.029	100	100	9.3	0.46	246	75	74	70	0.040	0.15	6.25
105	16.857	16.823		0.16	0.16	1.26	1.07	0.34	82	81	71	3.06	1.80	85	0.031	97	96	9.2	0.05	242	75	74	70	0.040	0.23	5.96
106	17.018	16.982		0.16	0.16	1.27	1.08	0.34	82	81	71	3.06	1.80	85	0.030	98	97	9.1	0.10	240	75	74	70	0.040	0.34	5.72
107	17.179	17.143		0.16	0.16	1.26	1.08	0.34	82	81	71	3.07	1.80	84	0.029	100	100	8.9	0.26	238	74	74	70	0.039	0.27	5.78
108	17.340	17.303		0.16	0.16	1.27	1.07	0.34	82	82	71	3.05	1.80	84	0.030	98	98	8.6	0.30	235	74	74	70	0.039	0.34	5.63
109	17.501	17.462		0.16	0.16	1.27	1.08	0.34	82	82	71	3.06	1.80	83	0.029	100	99	8.4	0.14	231	74	74	70	0.039	0.43	5.36
110	17.662	17.623		0.16	0.16	1.27	1.07	0.34	82	81	71	3.05	1.80	83	0.031	97	97	8.4	-0.03	229	74	74	70	0.038	0.49	5.14
111	17.824	17.783		0.16	0.16	1.27	1.07	0.34	82	82	71	3.05	1.80	83	0.028	102	101	8.4	0.07	226	74	74	69	0.038	0.53	4.95
112	17.985	17.943		0.16	0.16	1.26	1.08	0.34	82	82	71	3.06	1.80	83	0.028	102	101	7.8	0.54	225	74	74	70	0.037	0.54	4.73
113	18.146	18.104		0.16	0.16	1.24	1.08	0.34	82	82	71	3.03	1.80	83	0.029	100	100	7.9	-0.10	227	74	74	70	0.037	0.52	4.54
114	18.306	18.264		0.16	0.16	1.24	1.07	0.34	82	82	71	3.03	1.80	83	0.030	97	98	7.6	0.30	227	74	74	69	0.037	0.10	6.15
115	18.466	18.423		0.16	0.16	1.25	1.08	0.34	82	82	71	3.03	1.80	83	0.030	97	97	7.7	-0.05	227	74	74	70	0.038	0.06	6.27
116	18.626	18.584		0.16	0.16	1.25	1.08	0.34	82	82	71	3.02	1.80	83	0.029	99	100	7.3	0.39	227	74	74	70	0.037	0.07	6.39
117	18.786	18.744		0.16	0.16	1.24	1.07	0.34	82	82	71	3.02	1.80	83	0.029	99	99	7.3	-0.03	227	74	74	70	0.038	0.10	6.27

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(%)
118	18.946	18.903		0.16	0.16	1.24	1.07	0.34	82	82	71	3.02	1.80	83	0.030	97	97	7.1	0.21	226	74	73	70	0.037	0.13	6.18
119	19.105	19.064		0.16	0.16	1.25	1.08	0.34	82	82	71	3.02	1.80	83	0.030	97	98	7.3	-0.18	226	74	74	70	0.037	0.15	6.07
120	19.265	19.224		0.16	0.16	1.24	1.07	0.34	82	82	71	3.02	1.80	82	0.028	101	101	7.2	0.13	225	74	73	70	0.037	0.14	6.08
121	19.426	19.384		0.16	0.16	1.24	1.08	0.34	82	82	71	3.03	1.80	82	0.030	98	97	7.1	0.04	225	74	73	70	0.037	0.18	5.90
122	19.586	19.544		0.16	0.16	1.24	1.08	0.34	82	82	71	3.03	1.80	82	0.030	97	97	6.9	0.24	224	74	73	70	0.037	0.22	5.85
123	19.745	19.704		0.16	0.16	1.25	1.07	0.34	82	82	71	3.03	1.80	82	0.029	98	99	6.7	0.19	224	74	73	70	0.037	0.28	5.72
124	19.905	19.864		0.16	0.16	1.25	1.07	0.34	82	82	71	3.03	1.80	82	0.030	97	97	6.6	0.06	223	74	73	70	0.037	0.34	5.40
125	20.066	20.024		0.16	0.16	1.25	1.08	0.34	82	82	71	3.02	1.80	82	0.030	98	97	6.3	0.35	222	74	73	70	0.037	0.37	5.31
126	20.226	20.185		0.16	0.16	1.25	1.07	0.34	82	82	71	3.03	1.80	82	0.030	97	98	6.5	-0.18	222	74	73	70	0.037	0.37	5.16
127	20.385	20.344		0.16	0.16	1.24	1.07	0.34	82	82	71	3.02	1.80	82	0.030	97	97	6.0	0.47	222	74	73	70	0.037	0.38	5.06
128	20.545	20.504		0.16	0.16	1.24	1.07	0.34	82	82	71	3.02	1.80	82	0.029	99	99	6.1	-0.14	221	74	73	70	0.037	0.43	4.95
129	20.705	20.665		0.16	0.16	1.25	1.07	0.34	82	82	71	3.04	1.80	82	0.030	97	98	5.9	0.19	220	74	73	70	0.036	0.50	4.69
130	20.866	20.825		0.16	0.16	1.25	1.08	0.34	82	82	71	3.03	1.80	82	0.030	98	97	5.7	0.28	219	74	73	70	0.036	0.48	4.46
131	21.025	20.985		0.16	0.16	1.24	1.08	0.34	82	82	71	3.02	1.80	82	0.028	100	101	5.9	-0.19	218	74	73	70	0.036	0.47	4.24
132	21.185	21.146		0.16	0.16	1.24	1.08	0.34	82	82	71	3.02	1.80	82	0.030	97	98	5.5	0.35	217	74	73	70	0.036	0.46	4.10
133	21.345	21.305		0.16	0.16	1.25	1.07	0.34	82	82	71	3.02	1.80	82	0.030	97	97	5.3	0.25	216	74	73	70	0.036	0.44	3.90
134	21.505	21.465		0.16	0.16	1.25	1.08	0.34	82	82	71	3.02	1.80	82	0.028	101	101	5.3	-0.01	215	73	73	70	0.036	0.43	3.81
135	21.666	21.626		0.16	0.16	1.24	1.08	0.34	82	82	71	3.03	1.80	82	0.029	100	100	5.3	0.00	214	73	73	70	0.035	0.42	3.68
136	21.825	21.786		0.16	0.16	1.24	1.08	0.34	82	82	71	3.03	1.80	82	0.029	98	99	5.2	0.09	213	74	73	70	0.035	0.40	3.58
137	21.985	21.946		0.16	0.16	1.25	1.07	0.34	82	82	71	3.03	1.80	82	0.030	97	97	5.1	0.10	212	74	73	71	0.035	0.39	3.48
138	22.145	22.107		0.16	0.16	1.25	1.07	0.34	82	82	71	3.02	1.80	82	0.029	99	100	3.5	1.63	211	74	73	71	0.035	0.37	3.30
139	22.306	22.267		0.16	0.16	1.25	1.07	0.34	82	82	71	3.04	1.80	82	0.030	98	97	5.1	-1.59	211	74	73	70	0.035	0.37	3.26
140	22.466	22.427		0.16	0.16	1.25	1.08	0.34	82	82	71	3.03	1.80	82	0.028	101	101	4.6	0.47	210	74	73	71	0.035	0.36	3.20
141	22.625	22.588		0.16	0.16	1.24	1.08	0.34	82	82	71	3.02	1.80	82	0.028	100	101	4.6	-0.05	210	73	73	71	0.034	0.36	3.12
142	22.785	22.748		0.16	0.16	1.25	1.08	0.34	82	82	71	3.04	1.80	82	0.029	99	99	4.4	0.27	210	73	73	71	0.034	0.36	3.09
143	22.945	22.908		0.16	0.16	1.25	1.08	0.34	82	82	71	3.04	1.80	82	0.029	99	99	4.5	-0.17	210	74	73	71	0.035	0.40	3.39
144	23.106	23.068		0.16	0.16	1.24	1.08	0.34	82	82	71	3.03	1.80	82	0.030	98	97	4.4	0.08	210	74	73	70	0.035	0.37	3.55
145	23.266	23.229		0.16	0.16	1.24	1.07	0.34	82	82	71	3.04	1.80	82	0.030	97	98	4.2	0.21	210	74	73	70	0.034	0.35	3.50
146	23.425	23.389		0.16	0.16	1.24	1.08	0.34	82	82	71	3.04	1.80	82	0.029	98	99	4.3	-0.08	209	74	73	70	0.034	0.34	3.46
147	23.585	23.549		0.16	0.16	1.25	1.08	0.34	82	82	71	3.04	1.80	82	0.030	97	97	4.1	0.19	209	74	73	70	0.034	0.33	3.43
148	23.746	23.710		0.16	0.16	1.25	1.08	0.34	82	82	71	3.04	1.80	81	0.030	98	98	4.2	-0.05	209	73	73	71	0.034	0.32	3.43
149	23.906	23.870		0.16	0.16	1.25	1.07	0.34	82	82	71	3.04	1.80	81	0.030	97	97	4.1	0.05	209	74	73	70	0.034	0.32	3.43
150	24.066	24.030		0.16	0.16	1.25	1.08	0.34	83	82	71	3.03	1.80	81	0.029	99	99	3.8	0.28	210	74	73	71	0.034	0.33	3.45
151	24.225	24.192		0.16	0.16	1.25	1.07	0.34	83	82	71	3.02	1.80	82	0.028	100	102	3.6	0.25	210	74	73	70	0.035	0.31	3.88
152	24.385	24.351		0.16	0.16	1.24	1.07	0.34	83	82	71	3.02	1.80	82	0.027	102	102	3.7	-0.07	210	74	73	71	0.034	0.30	3.87
153	24.546	24.511		0.16	0.16	1.25	1.08	0.34	83	82	71	3.04	1.80	82	0.030	98	97	3.4	0.32	210	74	73	70	0.034	0.30	3.80
154	24.706	24.673		0.16	0.16	1.25	1.07	0.34	83	82	71	3.03	1.80	81	0.030	97	99	3.5	-0.16	211	74	73	70	0.034	0.30	3.75
155	24.865	24.832		0.16	0.16	1.24	1.08	0.34	83	82	71	3.02	1.80	82	0.029	98	98	3.3	0.24	211	74	73	70	0.035	0.31	3.95
156	25.025	24.992		0.16	0.16	1.25	1.08	0.34	83	82	71	3.03	1.80	81	0.029	99	99	3.2	0.08	212	74	73	71	0.034	0.31	4.28
157	25.185	25.153		0.16	0.16	1.25	1.08	0.34	83	82	71	3.04	1.80	82	0.030	97	98	3.2	0.04	212	74	73	71	0.034	0.31	4.25
158	25.346	25.314		0.16	0.16	1.24	1.07	0.34	83	82	71	3.02	1.80	82	0.029	100	100	3.0	0.17	212	74	73	71	0.035	0.30	4.20
159	25.506	25.473		0.16	0.16	1.24	1.08	0.34	83	82	71	3.03	1.80	82	0.030	97	97	3.0	-0.03	212	74	73	71	0.035	0.30	4.16
160	25.665	25.634		0.16	0.16	1.24	1.08	0.34	83	82	71	3.02	1.80	82	0.029	98	100	3.1	-0.07	211	74	73	71	0.034	0.30	4.08
161	25.825	25.794		0.16	0.16	1.25	1.07	0.34	83	82	71	3.04	1.80	82	0.030	97	97	2.8	0.31	212	74	73	71	0.034	0.30	4.00
162	25.986	25.954		0.16	0.16	1.23	1.07	0.34	83	82	71	3.04	1.80	100	0.028	103	103	2.4	0.40	221	74	73	71	0.090	0.32	3.92

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(%)
163	26.146	26.114		0.16	0.16	1.24	1.08	0.34	83	82	71	3.03	1.80	88	0.027	103	103	2.4	-0.05	239	74	73	70	0.038	0.35	3.79
164	26.305	26.275		0.16	0.16	1.25	1.08	0.34	83	82	71	3.04	1.80	85	0.030	97	98	2.4	0.08	239	74	73	71	0.037	0.13	3.34
165	26.465	26.435		0.16	0.16	1.25	1.07	0.34	83	82	71	3.04	1.80	84	0.032	94	95	2.0	0.31	236	74	73	71	0.036	0.00	6.49
166	26.625	26.595		0.16	0.16	1.25	1.08	0.34	83	82	71	3.04	1.80	84	0.027	103	103	1.6	0.45	233	74	73	71	0.036	0.00	6.22
167	26.786	26.756		0.16	0.16	1.24	1.08	0.34	83	82	71	3.04	1.80	83	0.030	98	98	1.9	-0.34	230	74	73	71	0.035	0.00	6.46
168	26.946	26.915		0.16	0.16	1.24	1.08	0.34	83	83	71	3.03	1.80	83	0.029	99	98	1.6	0.34	227	74	73	71	0.035	0.00	6.68
169	27.105	27.076		0.16	0.16	1.24	1.07	0.34	83	83	71	3.02	1.80	83	0.028	100	101	1.3	0.31	225	74	73	71	0.035	0.00	6.89
170	27.265	27.236		0.16	0.16	1.25	1.08	0.34	83	83	71	3.04	1.80	83	0.029	99	99	1.3	0.01	224	74	73	71	0.035	0.01	6.76
171	27.425	27.396		0.16	0.16	1.25	1.08	0.34	83	83	71	3.03	1.80	82	0.028	101	101	1.3	-0.08	222	74	73	71	0.035	0.02	6.50
172	27.586	27.556		0.16	0.16	1.25	1.08	0.34	83	83	71	3.03	1.80	82	0.030	98	97	1.1	0.24	221	74	73	71	0.035	0.07	6.25
173	27.745	27.717		0.16	0.16	1.24	1.08	0.34	83	83	71	3.04	1.80	82	0.028	100	101	1.2	-0.12	220	74	73	71	0.035	0.16	6.02
174	27.905	27.877		0.16	0.16	1.24	1.08	0.34	83	83	71	3.04	1.80	82	0.029	99	99	0.9	0.28	219	74	73	71	0.034	0.23	5.85
175	28.065	28.037		0.16	0.16	1.25	1.08	0.34	83	83	71	3.03	1.80	82	0.030	97	97	1.0	-0.01	218	74	73	71	0.034	0.33	5.41
176	28.226	28.198		0.16	0.16	1.25	1.08	0.34	83	83	71	3.02	1.80	82	0.029	100	100	0.9	0.04	216	74	73	71	0.034	0.48	5.02
177	28.386	28.358		0.16	0.16	1.24	1.07	0.34	83	83	71	3.03	1.80	82	0.029	99	99	0.5	0.37	215	74	73	71	0.034	0.52	4.71
178	28.545	28.518		0.16	0.16	1.24	1.07	0.34	83	83	71	3.03	1.80	82	0.029	98	99	0.5	0.02	214	74	73	71	0.034	0.53	4.44
179	28.705	28.679		0.16	0.16	1.25	1.08	0.34	83	83	71	3.02	1.80	82	0.029	99	100	0.7	-0.21	213	74	73	71	0.033	0.53	4.27
180	28.866	28.840		0.16	0.16	1.24	1.07	0.34	83	83	71	3.02	1.80	82	0.030	98	98	0.7	0.07	212	74	73	71	0.034	0.53	4.10
181	29.027	29.000		0.16	0.16	1.25	1.08	0.34	83	83	71	3.03	1.80	82	0.030	98	97	0.3	0.32	211	74	73	71	0.034	0.51	3.92
182	29.186	29.160		0.16	0.16	1.24	1.08	0.34	83	83	71	3.03	1.80	82	0.030	97	97	0.4	-0.04	210	74	73	71	0.033	0.51	3.78
183	29.346	29.321		0.16	0.16	1.24	1.07	0.34	83	83	71	3.04	1.80	82	0.029	99	100	0.4	-0.03	210	74	73	71	0.033	0.47	3.68
184	29.506	29.481		0.16	0.16	1.25	1.08	0.34	83	83	71	3.04	1.80	82	0.030	97	97	0.5	-0.11	210	74	73	71	0.034	0.49	3.69
185	29.666	29.641		0.16	0.16	1.25	1.08	0.34	83	83	71	3.03	1.80	82	0.029	99	99	0.1	0.44	211	74	73	71	0.034	0.50	3.72
186	29.827	29.802		0.16	0.16	1.25	1.08	0.34	83	83	71	3.02	1.80	82	0.028	101	101	0.2	-0.12	210	74	74	71	0.034	0.47	3.56
187	29.986	29.962		0.16	0.16	1.25	1.08	0.34	83	83	71	3.04	1.80	82	0.029	98	99	0.1	0.13	210	74	73	71	0.034	0.42	3.45
188	30.146	30.122		0.16	0.16	1.25	1.08	0.34	83	83	71	3.03	1.80	82	0.030	97	97	0.1	0.02	210	74	74	71	0.033	0.39	3.34
189	30.306	30.283		0.16	0.16	1.24	1.07	0.34	83	83	71	3.02	1.80	82	0.028	101	101	0.1	-0.02	209	74	74	71	0.033	0.37	3.37
190	30.467	30.443		0.16	0.16	1.24	1.08	0.34	83	83	71	3.03	1.80	82	0.029	100	99	0.1	0.00	209	74	74	71	0.033	0.36	3.36
191	30.627	30.603		0.16	0.16	1.24	1.08	0.34	83	83	71	3.03	1.80	82	0.029	99	99	0.1	0.00	208	74	74	71	0.033	0.34	3.23
192	30.787	30.764		0.16	0.16	1.24	1.08	0.34	83	83	71	3.03	1.80	82	0.030	97	98	0.1	0.00	208	74	74	71	0.033	0.35	3.08
193	30.947	30.925		0.16	0.16	1.25	1.07	0.34	83	83	71	3.02	1.80	82	0.030	97	98	0.1	0.00	207	74	74	71	0.033	0.34	2.99
194	31.107	31.084	48.610	0.16	0.16	1.25	1.08	0.34	83	83	71	3.02	1.80	82	0.029	99	98	0.0	0.10	208	74	74	71	0.033	0.33	2.94
	31.107	31.084	48.610			1.26	1.08	0.34	80	80	71			91	0.029						74.66	74.11		0.042	0.19	6.29

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

Run: 3

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Test Date: 6/15/2022

Technician: TT / KM
Beginning Clock Time: 10:47
Recording Interval: 1 min.
Total Sampling Time: 194 min.

Boiler Dry Weight (lbs): 1471.6
Boiler Water Weight (lbs): 274.5
Tank Weight (lbs): 736
Tank Water Weight (lbs): 3145

Initial Average Tank Temp (°F) 130.4
Final Average Tank Temp (°F): 167.8
Initial Average Heater Temp (°F 108.9
Final Average Heater Temp (°F 178.4

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
0	0.56	64	126	62	1.0012	8.3270	4.652	289	127	126	0	127	130	117	100
1	0.56	64	127	62	1.0012	8.3270	4.661	291	127	126	0	127	131	118	100
2	0.58	64	127	63	1.0012	8.3270	4.851	303	127	126	0	127	131	119	101
3	0.59	64	127	62	1.0012	8.3271	4.926	308	127	126	0	127	131	118	102
4	0.59	64	127	62	1.0012	8.3271	4.931	308	126	126	0	127	130	119	104
5	0.59	64	126	62	1.0012	8.3271	4.930	307	126	126	0	127	130	118	107
6	0.59	64	126	62	1.0012	8.3271	4.937	307	126	126	0	127	130	119	109
7	0.59	64	126	62	1.0012	8.3272	4.936	307	126	126	0	126	130	118	111
8	0.59	64	126	62	1.0012	8.3272	4.939	306	126	126	0	126	130	119	114
9	0.59	64	126	62	1.0012	8.3272	4.939	306	126	126	0	126	130	118	117
10	0.59	64	126	62	1.0012	8.3272	4.937	305	126	126	0	126	130	118	120
11	0.59	64	126	62	1.0012	8.3272	4.943	305	126	125	0	126	130	119	123
12	0.61	64	126	62	1.0012	8.3272	5.114	315	125	125	0	126	129	118	126
13	0.62	64	125	61	1.0012	8.3272	5.121	315	125	125	0	126	129	119	130
14	0.60	64	125	61	1.0012	8.3272	5.026	308	125	125	0	126	129	117	133
15	0.60	64	125	61	1.0012	8.3272	5.021	308	125	125	0	125	129	118	137
16	0.60	64	125	61	1.0012	8.3272	5.022	307	125	125	0	125	129	137	141
17	0.60	64	126	62	1.0012	8.3272	5.022	310	125	127	2	127	129	155	141
18	0.60	64	127	63	1.0012	8.3272	5.011	318	126	128	2	128	129	160	140
19	0.60	64	129	65	1.0012	8.3272	4.991	324	126	130	4	130	129	163	141
20	0.60	64	130	66	1.0012	8.3272	4.967	327	126	130	4	131	129	166	141
21	0.58	64	130	66	1.0012	8.3271	4.851	321	127	130	3	131	129	168	141
22	0.56	64	131	67	1.0012	8.3271	4.676	313	127	133	6	133	129	170	142
23	0.56	64	133	69	1.0012	8.3271	4.652	321	128	134	7	135	129	172	142
24	0.54	64	134	70	1.0012	8.3271	4.486	314	128	135	7	135	129	174	142
25	0.54	64	135	71	1.0012	8.3271	4.471	316	128	135	7	136	129	176	142
26	0.54	64	136	71	1.0012	8.3270	4.467	319	128	136	8	136	129	177	143
27	0.53	64	136	72	1.0012	8.3270	4.388	315	128	136	8	137	129	178	142
28	0.52	64	136	72	1.0012	8.3270	4.371	315	129	136	8	137	129	179	143
29	0.52	64	137	72	1.0012	8.3270	4.370	317	129	137	8	137	129	180	143
30	0.52	64	137	72	1.0012	8.3269	4.352	315	129	137	9	138	129	181	142
31	0.52	64	137	73	1.0012	8.3269	4.356	318	129	138	9	138	129	182	142
32	0.52	64	138	73	1.0012	8.3269	4.359	320	129	138	9	138	129	182	142
33	0.50	64	138	73	1.0012	8.3269	4.152	305	129	138	9	139	129	183	143
34	0.49	64	138	74	1.0012	8.3269	4.050	300	129	138	9	139	129	184	142
35	0.49	64	138	74	1.0012	8.3269	4.105	304	129	139	9	139	129	184	143
36	0.50	64	139	74	1.0012	8.3268	4.169	310	129	139	9	139	129	185	142
37	0.50	64	139	74	1.0012	8.3268	4.152	309	129	138	9	139	129	185	142
38	0.50	64	139	74	1.0012	8.3268	4.155	308	129	139	10	140	129	185	143
39	0.49	64	139	75	1.0012	8.3268	4.071	304	130	139	10	140	129	185	143
40	0.50	64	139	75	1.0012	8.3268	4.122	309	130	139	9	140	129	186	143
41	0.50	64	139	75	1.0012	8.3268	4.134	309	130	139	9	140	129	186	143
42	0.50	64	139	75	1.0012	8.3268	4.125	308	130	139	9	139	129	186	142

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
43	0.50	64	139	75	1.0012	8.3268	4.125	308	130	139	9	139	129	187	142
44	0.49	64	139	75	1.0012	8.3268	4.116	307	130	140	10	140	130	187	143
45	0.50	64	140	75	1.0012	8.3268	4.131	312	130	140	10	141	130	187	143
46	0.50	64	140	76	1.0012	8.3268	4.159	315	131	140	10	141	130	188	143
47	0.50	64	140	76	1.0012	8.3269	4.165	317	131	139	9	141	130	188	143
48	0.50	64	141	77	1.0012	8.3269	4.137	317	131	141	10	142	131	188	144
49	0.50	64	142	77	1.0012	8.3269	4.171	323	132	142	10	143	131	189	144
50	0.49	64	142	78	1.0012	8.3269	4.101	319	132	142	10	143	132	189	145
51	0.49	64	143	78	1.0012	8.3269	4.094	320	133	143	10	144	132	189	144
52	0.48	64	143	79	1.0012	8.3269	3.973	313	133	143	10	144	133	190	144
53	0.48	64	144	79	1.0012	8.3269	3.959	314	134	144	10	145	134	190	145
54	0.46	64	144	80	1.0012	8.3269	3.792	303	134	145	11	145	134	191	145
55	0.48	64	145	80	1.0012	8.3269	3.979	320	135	145	11	146	134	191	145
56	0.47	64	145	81	1.0012	8.3269	3.940	319	135	145	10	146	135	192	145
57	0.46	64	146	82	1.0012	8.3269	3.856	314	136	146	11	147	135	192	146
58	0.46	64	147	82	1.0012	8.3269	3.837	316	136	147	11	148	136	193	146
59	0.46	64	147	83	1.0012	8.3269	3.837	318	137	148	11	148	136	193	146
60	0.45	64	147	83	1.0012	8.3269	3.777	314	137	148	11	149	136	194	146
61	0.45	64	148	84	1.0012	8.3269	3.767	316	137	148	11	149	137	195	146
62	0.45	64	149	84	1.0012	8.3269	3.764	317	138	149	11	150	137	195	146
63	0.45	64	149	85	1.0012	8.3269	3.760	318	138	149	11	150	137	196	146
64	0.44	64	149	85	1.0012	8.3269	3.663	311	138	150	11	150	137	197	146
65	0.44	64	150	85	1.0012	8.3269	3.638	310	139	150	11	151	138	197	146
66	0.44	64	150	86	1.0012	8.3269	3.629	311	139	151	12	151	138	197	147
67	0.44	64	151	86	1.0012	8.3269	3.627	313	139	151	12	152	138	197	147
68	0.44	64	151	86	1.0012	8.3268	3.630	314	139	151	12	152	138	197	147
69	0.44	64	151	87	1.0012	8.3268	3.628	314	140	151	12	152	138	198	147
70	0.43	64	151	87	1.0012	8.3268	3.556	309	140	151	11	152	139	198	145
71	0.43	64	151	87	1.0012	8.3268	3.621	314	140	152	12	152	139	198	147
72	0.43	64	152	87	1.0012	8.3268	3.612	315	140	152	12	153	139	197	147
73	0.43	64	152	88	1.0012	8.3268	3.619	317	141	152	12	153	140	197	147
74	0.43	64	152	88	1.0012	8.3267	3.610	317	141	152	11	153	140	197	147
75	0.43	64	152	88	1.0012	8.3267	3.608	316	141	152	11	153	140	198	146
76	0.43	64	152	88	1.0012	8.3267	3.605	316	141	153	11	153	141	197	147
77	0.43	64	153	88	1.0012	8.3267	3.608	318	142	153	11	154	141	196	148
78	0.43	64	153	88	1.0012	8.3267	3.616	320	142	153	11	153	141	196	146
79	0.43	64	153	88	1.0012	8.3267	3.612	319	142	153	10	153	142	195	146
80	0.43	64	153	88	1.0012	8.3267	3.610	318	143	151	9	152	142	195	144
81	0.43	64	152	87	1.0012	8.3267	3.607	314	143	151	9	152	143	197	143
82	0.43	64	152	87	1.0012	8.3267	3.607	314	143	153	10	154	143	196	146

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
83	0.43	64	152	88	1.0012	8.3267	3.597	316	143	154	11	154	144	197	148
84	0.43	65	153	89	1.0012	8.3267	3.597	320	145	155	11	156	145	196	149
85	0.43	65	155	90	1.0012	8.3267	3.599	325	145	156	11	156	145	197	148
86	0.43	65	155	91	1.0012	8.3267	3.600	327	145	156	11	157	146	197	149
87	0.43	65	156	92	1.0012	8.3267	3.595	329	146	157	11	157	146	197	150
88	0.43	65	157	92	1.0012	8.3266	3.598	331	147	157	11	158	146	197	150
89	0.43	65	157	92	1.0012	8.3266	3.604	333	147	158	11	158	147	197	150
90	0.43	65	157	93	1.0012	8.3266	3.604	334	147	157	9	157	147	198	148
91	0.43	65	156	92	1.0012	8.3266	3.603	330	147	155	7	156	148	198	148
92	0.43	65	156	91	1.0012	8.3266	3.597	328	148	156	8	157	148	198	149
93	0.43	65	156	92	1.0012	8.3266	3.598	330	148	156	9	157	149	198	148
94	0.43	65	157	92	1.0012	8.3266	3.595	332	148	158	10	159	149	198	150
95	0.43	65	158	93	1.0012	8.3266	3.594	336	149	159	10	160	150	197	151
96	0.43	65	159	94	1.0012	8.3266	3.544	334	150	160	10	160	150	197	152
97	0.40	65	160	95	1.0012	8.3265	3.320	315	150	161	10	161	150	197	153
98	0.39	65	160	95	1.0012	8.3265	3.286	314	151	161	10	161	151	197	153
99	0.40	65	160	96	1.0012	8.3265	3.290	315	151	158	7	159	151	197	151
100	0.40	65	160	95	1.0012	8.3265	3.294	313	151	159	8	159	151	198	150
101	0.40	65	158	94	1.0012	8.3265	3.292	309	151	159	8	159	151	198	150
102	0.39	65	158	94	1.0012	8.3265	3.287	308	151	159	8	159	151	198	150
103	0.39	65	158	93	1.0012	8.3265	3.287	307	151	157	7	158	151	199	149
104	0.39	65	157	92	1.0012	8.3264	3.283	304	151	159	8	159	152	198	150
105	0.39	65	159	94	1.0012	8.3264	3.265	307	151	160	9	160	152	198	150
106	0.39	65	159	95	1.0012	8.3264	3.281	310	151	160	9	161	152	198	151
107	0.39	65	160	95	1.0012	8.3264	3.283	312	152	161	9	161	152	198	151
108	0.39	65	160	95	1.0012	8.3264	3.216	307	152	162	10	162	153	198	153
109	0.39	65	161	97	1.0012	8.3264	3.273	316	153	162	9	163	153	197	154
110	0.39	65	162	97	1.0012	8.3264	3.271	318	153	161	8	162	154	198	153
111	0.39	65	161	96	1.0012	8.3264	3.270	313	153	160	8	161	154	198	152
112	0.39	65	160	96	1.0012	8.3264	3.254	311	153	161	8	161	154	198	152
113	0.39	65	160	96	1.0012	8.3264	3.287	314	153	161	8	161	155	197	152
114	0.39	65	160	95	1.0012	8.3264	3.269	312	153	160	6	160	155	198	152
115	0.39	65	159	95	1.0012	8.3263	3.274	309	153	160	6	160	155	198	152
116	0.39	65	160	95	1.0012	8.3263	3.269	310	154	160	6	160	155	197	152
117	0.39	65	159	95	1.0012	8.3263	3.267	309	154	160	6	160	156	197	152
118	0.40	65	159	95	1.0012	8.3263	3.358	318	154	160	6	160	156	197	152
119	0.40	65	160	95	1.0012	8.3263	3.335	316	154	160	6	161	156	197	152
120	0.40	65	160	95	1.0012	8.3263	3.316	315	155	162	7	162	157	197	153
121	0.40	65	161	97	1.0012	8.3263	3.343	323	156	163	7	163	157	196	154
122	0.40	65	162	97	1.0012	8.3263	3.331	324	156	163	7	164	157	197	155
123	0.40	65	163	98	1.0012	8.3263	3.328	325	156	164	8	164	158	197	155
124	0.40	65	164	99	1.0012	8.3263	3.326	328	157	165	8	165	158	196	157
125	0.40	65	164	100	1.0012	8.3262	3.324	331	157	165	8	166	158	196	158
126	0.40	65	165	100	1.0012	8.3262	3.325	332	157	165	8	166	158	196	158
127	0.40	65	164	100	1.0012	8.3262	3.327	331	157	164	7	165	158	196	156
128	0.40	65	164	99	1.0012	8.3262	3.325	329	157	164	7	165	158	196	156
129	0.40	65	164	99	1.0012	8.3262	3.324	329	157	163	6	163	159	196	156
130	0.40	65	163	98	1.0012	8.3262	3.329	325	157	163	6	163	159	196	155
131	0.40	65	162	97	1.0012	8.3262	3.327	323	157	162	5	163	159	195	155
132	0.40	65	162	97	1.0012	8.3262	3.325	323	157	164	6	164	159	195	156
133	0.40	65	163	98	1.0012	8.3262	3.323	325	158	163	5	163	160	195	156
134	0.40	65	162	97	1.0012	8.3262	3.323	324	157	163	5	163	160	195	156
135	0.40	65	163	98	1.0012	8.3261	3.323	324	158	163	6	164	160	194	156
136	0.40	65	163	98	1.0012	8.3261	3.322	327	158	164	6	165	160	194	157
137	0.40	65	164	99	1.0012	8.3261	3.324	328	158	164	6	165	160	194	157

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
138	0.40	65	164	99	1.0012	8.3261	3.321	328	158	164	6	165	160	195	156
139	0.40	65	164	99	1.0012	8.3261	3.321	327	158	164	6	164	160	195	156
140	0.40	65	163	98	1.0012	8.3261	3.322	327	158	164	6	164	160	195	156
141	0.40	65	163	98	1.0012	8.3261	3.322	326	158	164	6	164	160	195	156
142	0.40	65	163	98	1.0012	8.3261	3.320	326	158	164	5	164	160	195	156
143	0.40	65.0	163.2	98	1.0012	8.3261	3.317	326	158	164	5	164	160	195	156
144	0.40	65.1	163.2	98	1.0012	8.3261	3.308	325	158	164	5	164	161	195	157
145	0.38	65.1	163.1	98	1.0012	8.3261	3.178	312	159	164	5	164	161	195	157
146	0.38	65.1	163.2	98	1.0012	8.3261	3.186	313	159	164	5	164	161	195	157
147	0.40	65.1	163.4	98	1.0012	8.3260	3.314	326	159	164	5	164	161	195	157
148	0.40	65.1	163.6	98	1.0012	8.3260	3.299	325	159	164	5	165	162	195	157
149	0.40	65.1	163.8	99	1.0012	8.3261	3.295	325	160	164	5	165	162	195	158
150	0.40	65.1	164.0	99	1.0012	8.3261	3.294	326	160	165	5	165	162	195	158
151	0.40	65.1	164.2	99	1.0012	8.3260	3.294	326	160	165	5	165	163	195	158
152	0.40	65.1	164.4	99	1.0012	8.3260	3.293	327	160	165	5	165	163	195	158
153	0.40	65.1	164.5	99	1.0012	8.3260	3.292	327	160	165	5	166	163	195	158
154	0.40	65.1	164.6	100	1.0012	8.3260	3.289	327	160	165	5	166	163	195	158
155	0.40	65.1	164.9	100	1.0012	8.3260	3.291	328	161	167	6	167	163	195	159
156	0.39	65.1	165.8	101	1.0012	8.3260	3.288	331	161	167	6	167	163	195	159
157	0.39	65.1	166.3	101	1.0012	8.3260	3.286	332	161	167	6	167	163	195	160
158	0.39	65.1	166.5	101	1.0012	8.3260	3.287	333	161	167	6	168	163	195	160
159	0.39	65.1	166.6	101	1.0012	8.3260	3.282	333	161	167	6	168	163	195	160
160	0.39	65.1	166.7	102	1.0012	8.3260	3.285	333	161	167	6	168	163	195	160
161	0.39	65.1	166.7	102	1.0012	8.3260	3.286	334	161	167	6	168	163	195	160
162	0.39	65.1	166.8	102	1.0012	8.3260	3.283	334	162	169	7	169	163	194	161
163	0.39	65.1	168.1	103	1.0012	8.3260	3.284	338	162	168	6	168	163	195	160
164	0.39	65.2	167.3	102	1.0012	8.3260	3.280	335	162	168	7	169	163	194	161
165	0.39	65.2	167.8	103	1.0012	8.3259	3.285	337	162	169	7	169	164	194	162
166	0.39	65.2	168.3	103	1.0012	8.3259	3.279	338	162	169	7	170	164	194	162
167	0.39	65.2	168.6	103	1.0012	8.3259	3.211	332	162	169	7	170	164	194	162
168	0.39	65.2	168.7	104	1.0012	8.3259	3.274	339	162	169	7	170	164	194	162
169	0.39	65.2	168.8	104	1.0012	8.3259	3.274	339	162	169	7	170	164	194	162
170	0.38	65.2	168.9	104	1.0012	8.3259	3.188	331	162	170	7	170	164	194	162
171	0.38	65.2	169.0	104	1.0012	8.3259	3.150	327	163	170	7	170	164	195	162
172	0.39	65.2	169.1	104	1.0012	8.3259	3.225	335	163	170	7	170	164	195	162
173	0.39	65.2	169.2	104	1.0012	8.3259	3.271	340	163	170	7	170	164	195	162
174	0.39	65.2	169.3	104	1.0012	8.3259	3.275	341	163	170	7	170	164	195	163
175	0.39	65.2	169.3	104	1.0012	8.3260	3.266	340	163	170	7	170	164	194	163
176	0.39	65.1	169.4	104	1.0012	8.3260	3.264	340	163	170	7	170	164	194	163
177	0.39	65.1	169.3	104	1.0012	8.3260	3.266	340	163	169	6	170	165	194	162
178	0.39	65.1	168.9	104	1.0012	8.3260	3.261	338	163	170	7	170	165	194	163
179	0.39	65.1	169.2	104	1.0012	8.3260	3.264	340	163	170	7	170	165	193	163
180	0.39	65.1	169.4	104	1.0012	8.3260	3.263	340	163	170	6	170	165	193	163
181	0.39	65.1	169.1	104	1.0012	8.3260	3.264	339	163	169	6	170	165	193	163
182	0.39	65.1	169.0	104	1.0012	8.3260	3.262	339	164	170	6	170	166	192	163
183	0.39	65.1	169.3	104	1.0012	8.3260	3.263	340	164	168	5	169	166	192	162
184	0.39	65.1	168.0	103	1.0012	8.3260	3.264	336	163	168	5	169	166	192	162
185	0.39	65.1	167.7	103	1.0012	8.3260	3.262	335	163	168	4	168	166	193	161
186	0.39	65.1	167.2	102	1.0012	8.3260	3.258	333	164	169	5	169	166	192	162
187	0.39	65.1	167.9	103	1.0012	8.3260	3.257	335	164	168	4	169	167	193	162
188	0.39	65.1	168.2	103	1.0012	8.3260	3.255	336	164	170	6	170	167	192	164
189	0.39	65.2	169.5	104	1.0012	8.3260	3.256	340	165	171	6	171	167	192	164
190	0.39	65.2	170.2	105	1.0012	8.3259	3.254	342	165	171	6	172	167	192	164
191	0.39	65.2	170.5	105	1.0012	8.3259	3.251	342	165	171	6	172	168	192	165
192	0.39	65.2	170.7	106	1.0012	8.3259	3.249	343	166	171	6	172	168	192	165

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
193	0.39	65.2	170.8	106	1.0012	8.3259	3.254	344	166	170	5	171	168	192	165
194	0.39	65.2	169.5	104	1.0012	8.3259	3.253	339	165	171	5	171	168	193	164
	0.45	64.67	153.2	88.5	1.0012	8.3265	3.7087	62564.8	146.4	153.6	7.1	154.1	147.6	186.0	148.8
Elapsed Time	Water Flow Rate, Gal / Min.	HE In, °F	HE Out, °F	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F	HE Out, °F	Delta-T	Top, °F	Bottom, °F		

Flow Meter Calibration Check

Manufacturer: Froling
Appliance: S3 Turbo 30
Project Number: 0456WB009E
Date: 6/15/2022
Run Number: 3

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)	Accuracy, %
1.530	64.3	17.9	998.635	8.334	7	0.549	0.547	Preburn	99.6%
2.156	64.5	18.1	998.615	8.334	7.7	0.429	0.432	78	100.8%
2.202	65.3	18.5	998.531	8.333	7.2	0.392	0.390	198	99.3%

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Test Method ASTM E2515-11
Lab Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run #: 3
Date: 6/15/22

Equipment Numbers:

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	E715'	122.7	121.0	1.7
C. Rear filter catch	Filter	E716'	119.9	120.7	-0.8
D. Probe catch*	Probe	17	114562.3	114561.9	0.4
E. Filter seals catch*	Seals	S351	3229.1	3227.8	1.3

Sub-Total Total Particulate, mg: 2.6

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	E717'	123.1	121.1	2.0
C. Rear filter catch	Filter	E718'	120.6	121.3	-0.7
D. Probe catch*	Probe	73	117065.8	117065.8	0.0
E. Filter seals catch*	Seals	S352	3312.7	3312.0	0.7

Sub-Total Total Particulate, mg: 2.0

Train 1 Aggregate Total Particulate, mg: **4.6**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	E719'	126.1	122.3	3.8
B. Rear filter catch	Filter	E720'	119.4	120.7	-1.3
C. Probe catch*	Probe	76	116961.1	116960.7	0.4
D. Filter seals catch*	Seals	S353	3360.9	3358.5	2.4

Total Particulate, mg: 5.3

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter	E721	121.3	121.3	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 E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 3

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/15/2022

Test Crew: T. Tong

OMNI Equipment ID numbers: 00637, 00709, 00283/4

ASTM E2515 Lab Sheet

Assembled By:

Tony Tong

Date/Time in Dessicator:

06/15/2022, 14:30

	Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
Date/Time:	06/20/22 9:20	06/21/22 10:45	06/23/22 7:40	06/23/22 14:45	
R/H %:	18.6	16.0	8.3	7.4	
Temp:	70.8	72.1	73.9	75.9	
200 mg Audit:	200.1	200.1	200.1	200.0	
2 g Audit:	2000.3	2000.3	2000.3	2000.4	
100 g Audit:	99998.0	99998.0	99998.0	99998.0	
Initials:	TT	TT	TT	TT	

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A (First Hour)	Front Filter	E715	121.0	122.7	122.7			
	Rear Filter	E716	120.7	120.0	119.9			
	Probe	17	116561.9	116562.4	116562.3			
	O-Ring Set	S351	3227.8	3229.2	3229.1			
A (Remainder)	Front Filter	E717	121.1	123.3	123.1			
	Rear Filter	E718	121.3	120.7	120.6			
	Probe	73	117065.8	117066.0	117065.8			
	O-Ring Set	S352	3312.0	3313.8	3313.3	3312.7	3312.7	
B	Front Filter	E719	122.3	126.1	126.1			
	Rear Filter	E720	120.7	119.5	119.4			
	Probe	76	116960.7	116961.2	116961.1			
	O-Ring Set	S353	3358.5	3361.1	3360.9			
BG	Filter	E721	121.3	121.4	121.3			

Technician Signature: Tony Tong Date: 06/28/22

Tare Sheet: (check one) **Probes**____ **47mm Filters** ✓ **100mm Filters**____ **O-Ring Pair**____

Prepared By: Tony Tong Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 00283A 1 200mg

Placed in Dessicator: Date: 05/10/22 Time: 10:38 ID #	Date: 06/08/22 Time: 16:30 RH %: 16.5 T (°F): 75.7 Audit: 200.1	Date: 06/09/22 Time: 17:40 RH %: 21.6 T (°F): 71.3 Audit: TT	Date: 06/13/22 Time: 16:20 RH %: 14.3 T (°F): 71.4 Audit: 200.0	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
E701	120.9	120.9			06/13/22	0456WB009E	1
E702	121.0	121.3	121.2		06/14/22	0456WB009E	2
E703	121.0	121.1			06/13/2022	0456WB009E	1
E704	120.7	120.8					
E705	121.0	121.1					
E706	120.5	120.6					
E707	121.5	121.5					
E708	121.3	121.4					
E709	121.4	121.4			06/14/22	0456WB009E	2
E710	120.5	120.6					
E711	121.3	121.5					
E712	120.8	120.9					
E713	121.2	121.1					
E714	121.2	121.0					
E715	120.9	121.0			06/15/22	0456WB009E	3
E716	120.5	120.7					
E717	121.2	121.1					
E718	121.4	121.3					
E719	122.2	122.5	122.3				
E720	120.6	120.7					
	Initials: TT	Initials: TT	Initials: TT	Initials:			

Final Technician Signature: Tony Tong Date: 06/13/22 Evaluator signature: L. A. Moya

Tare Sheet: (check one) **Probes** ✓ **47mm Filters** ____ **100mm Filters** ____ **O-Ring Pair** ____

Prepared By: Tony Tong Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 00283A 1 1000g

Placed in Dessicator: Date: 06/08/22 Time: 15:30 ID #	Date: 06-6-22 Time: 1300 RH %: 20.0 T (°F): 71.7 Audit: 99997.9	Date: 06/13/22 Time: 7:30 RH %: 7.4 T (°F): 68.0 Audit: 99997.8	Date: 06/14/22 Time: 24.4 RH %: 71.9 T (°F): 71.6 Audit: 99998.0	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
15	114341.0	114340.8			06/13/22	0456WB009E	1
70	116834.6	116833.5	116833.4		06/16/22	0456WB009E	4
73	117066.2	117065.6	117065.8		06/15/22	0456WB009E	3
75	117637.9	117637.7			06/13/22	0456WB009E	1
76	116961.0	116960.5	116960.7		06/15/22	0456WB009E	3
78	117459.6	117459.2	117459.1		06/16/22	0456WB009E	4
81	111861.5	111861.3			06/13/22	0456WB009E	1
3	114770.9	116011.5	116011.2		Not used		
OES3	116011.8	114770.3	114770.4		↓		
4	114856.7	114856.6			06/14/22	0456WB009E	2
OES4	114148.5	114147.7	114147.7		06/16/22	0456WB009E	4
11	114186.1	114185.9	114185.7				
13	114321.8	114321.6			06/14/22	0456WB009E	2
14	114547.6	114547.6			↓	↓	↓
17	114562.5	114562.1	114561.9		06/15/22	0456WB009E	3
30	114327.4	114327.4			Not used		
65	117079.4	117079.1	117079.4		↓		
32	114743.2	114743.2					
	Initials: TT	Initials: TT	Initials: TT	Initials:			

Final Technician Signature: Tony Tong Date: 06/14/22 Evaluator signature: [signature]

Tare Sheet: (check one) **Probes**____ **47mm Filters**____ **100mm Filters**____ **O-Ring Pair** ✓

Prepared By: Tony Tang Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 002834 1.5g

Placed in Dessicator: Date: 25/09/22 Time: 9:30	Date: 06/08/22 Time: 15:30 RH %: 18.8 T (°F): 75.3	Date: 06-10-22 Time: 1324 RH %: 20.0 T (°F): 73.0	Date: 06/13/22 Time: 7:30 RH %: 7.4 T (°F): 68.0	Date: 06/16/22 Time: 7:20 RH %: 18.6 T (°F): 71.7	Date Used	Project Number	Run No.
ID #	Audit: 5000.0	Audit: 5000.2	Audit: 4999.9	Audit: 4999.9			
S345	3325.4	3325.5 ✓			06/13/22	0456WB009E	1
S346	3277.7	3278.0	3278.0		↓	↓	↓
S347	3278.2	3278.4 ✓			↓	↓	↓
S348	3356.7	3356.9 ✓			06/14/22	0456WB009E	2
S349	4088.7	4088.9 ✓			↓	↓	↓
S350	3375.4	3375.5 ✓			↓	↓	↓
S351	3227.6	3227.8 ✓			06/15/22	0456WB009E	3
S352	3311.8	3312.0 ✓			↓	↓	↓
S353	3358.3	3358.5 ✓			↓	↓	↓
S354	4117.5	4117.5 ✓			06/16/22	0456WB009E	4
S355	3340.0	3340.2 ✓			↓	↓	↓
S356	3374.3	3374.5 ✓			↓	↓	↓
S357	4078.2	4078.4 ✓			Not used		
S358	3497.5	3498.3	3497.9	3497.7	↓		
S359					Not used		
S360					↓		
S361					↓		
S362					↓		
S363					↓		
S364					↓		
	Initials: TT	Initials: FO	Initials: TT	Initials: TT			

Final Technician Signature: Tony Tang Date: 06/16/2022 Evaluator signature: M. Morgan

Run 4 (Category III)

Hydronic Heating Appliances - Test Method ASTM E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run: 4
Test Date: June 16, 2022

Burn Rate	**5.26 kg/hr dry**
Average Tunnel Temperature	95 degrees F
Average Gas Velocity in Dilution Tunnel - vs	10.4 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	27484 dscf/hour
Average Delta p	0.028 inches H20
Average Delta H	1.25 inches H20
Total Time of Test	191 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**4.08** g/hr **0.65** g/kg
Complete Run:	**2.86** g/hr **0.54** g/kg **0.08** lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	30.72 cubic feet	30.49 cubic feet	44.35 cubic feet
Average Gas Meter Temperature	85 degrees F	85 degrees F	72 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	29.9 dscf	29.7 dscf	44.5 dscf
Total Particulates - mn	3.2 mg	3 mg	0 mg
Particulate Concentration (dry-standard)	0.000107 grams/dscf	0.000101 grams/dscf	0.000000 grams/dscf
Particulate Emissions	9.37 grams	8.85 grams	
Particulate Emission Rate	2.94 grams/hour	2.78 grams/hour	
Difference from Average	0.26 grams	0.26 grams	
Emissisons Factor	0.56 g/kg	0.53 g/kg	

Results Are Acceptable

AVERAGE

Total Sample Volume - Vm	30.60 cubic feet
Average Gas Meter Temperature	85 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	29.8 dscf
Train Precesion 7.5%	**2.83 grams**
Train Precision 0.5g/kg	0.03 grams/kg
Particulate Concentration (dry-standard)	0.00010 grams/dscf
Particulate Emissions	9.11 grams
7.5% of the average particulate emissions	0.68 grams

ADDITIONAL ACCEPTANCE CRITERIA

PTS Water Temperature >120 °F at Start of Test	**Acceptable**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	9.62 cubic feet
Average Gas Meter Temperature	81 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	9.44 dscf
Total Particulates - mn	1.4 mg
Particulate Concentration (dry-standard)	0.00015 grams/dscf
Particulate Emissions	4.08 grams
Burn Rate	6.26 (dry kg/hr)

Method ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Comments:	

Parameters:

Run Number:	4
Test Date:	6/16/22
Total Fuel Weight (lb):	44.9
Average Moisture of Fuel (% dry):	21.73
Average Moisture of Fuel (% wet):	17.85
Average Temperature of Appliance Water at Start of Test (°F):	167.5
Average Temperature of Appliance Water at End of Test (°F):	172.8
Average Thermopile Reading (°F):	103.8
Average Load Side Liquid Flow Rate (gal/min):	1.2
Time Interval (min):	191
Burn Rate (kg/hr):	5.26
Emissions (g):	9.11
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

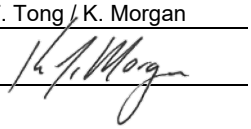
Calculations:

HHV Heat Input (Btu):	317223
Net HHV Heat Input (Btu):	317223
Net HHV Heat Input Rate (Btu/hr):	99651
LHV Heat Input (Btu):	294648
Net LHV Heat Input (Btu):	294648
Net LHV Heat Input Rate (Btu/hr):	92560
Appliance Water Specific Heat (Btu/lb°F):	1.001
Tank Water Specific Heat (Btu/lb°F):	1.001
Q_{unit} (Btu):	2213
Q_{Load} (Btu):	160441
$Q_{Storage}$ (Btu):	87502
Total Heat Output (Btu):	250156
Total Heat Output Rate (Btu/hr):	78583
Total Particulate Emissions (g):	9.11
Time Interval (hr):	3.2
Load Output Rate (Btu/hr):	50400
Emissions Factor(g/kg):	0.54
Total Particulate Emissions Rate (g/MJ):	0.035
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.080**
Total Particulate Emissions (g/hr):	2.86
Delivered Efficiency, HHV (%):	**78.9**
First Hour Emissions Factor (g/kg):	0.65
First Hour Emissions Rate (g/hr):	4.08

Stack Loss Efficiency

Manufacturer: Froling GmbH
Model: S3 Turbo 30
Date: 06/16/22
Run: 4
Control #: 2448
Test Duration: 191
Output Category: III

Technicians: T. Tong / K. Morgan



Test Results in Accordance with CSA B415.1-10

	HHV Basis	LHV Basis
Overall Efficiency	77.6%	83.0%
Combustion Efficiency	99.1%	99.1%
Heat Transfer Efficiency	78%	83.8%

Output Rate (kJ/h)	81,506	77,317	**(Btu/h)**
Burn Rate (kg/h)	5.26	11.59	**(lb/h)**
Input (kJ/h)	105,003	99,607	**(Btu/h)**

Test Load Weight (dry kg)	16.74	36.89	**dry lb**
MC wet (%)	17.85		
MC dry (%)	21.73		
Particulate (g)	9.11		
CO (g)	356		
Test Duration (h)	3.18		

Emissions	Particulate	CO
g/MJ Output	0.04	1.37
g/kg Dry Fuel	0.54	21.29
g/h	2.86	111.95
lb/MM Btu Output	0.08	3.19

Air/Fuel Ratio (A/F)	15.98

VERSION: **2.4** **4/15/2010**

OMNI-Test Laboratories, Inc. **ASTM E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 4

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/16/2022

Test Crew: T. Tong / K. Morgan

OMNI Equipment ID numbers: 00335, 00336, 00594, 00356

Wood Heater Run Notes

Air Control Settings

Primary:

Automatic Adjustment

Secondary: Automatic

Tertiary/Pilot:

Fan: Automatic speed controlled draft fan

Preburn Notes

Time	Notes
8:13	loading 40.0 lb of scrap fuel
9:56	scooped out residual fuel and zeroed scale
10:00	added 41.3 lb
10:46	heat output was set at target load with 24.16 lb of preburn fuel
11:47	added 16.2 lbs
14:00	added 28 lbs
15:07	Pre-burn ended at 6.3 lbs coal

Test Notes

Sketch test fuel configuration:

See fuel load photos in the test report

Start up procedures & Timeline:

Bypass: N/A

Fuel loaded by: 2 mins

Door closed at: 2 mins

Primary air: Automatic

Notes:

Time	Notes
15:07	Sampling started, 44.9 lbs test fuel loaded
16:07	First hour filters change
18:18	Test completed

Technician Signature: Tom Tong Date: 06/16/2022

OMNI-Test Laboratories, Inc. **ASTM E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 4

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/16/2022

Test Crew: T. Tong / K. Morgan

OMNI Equipment ID numbers: 00594, 00335, 00336, 00410, 00716, 00322, 00255, 00677

Wood Heater Supplemental Data

Start Time: 15:07

Stop Time: 18:18

Booth #: 3

Stack Gas Leak Check:

Initial: good Final: good

Sample Train Leak Check:

A: 0.000 @ 16.75 "Hg

B: 0.000 @ 16.75 "Hg

A, 0.000 @ 16.75 "Hg

Calibrations: Span Gas CO_2: 16.94 % CO: 4.32 %

	Pre Test		Post Test	
	Zero	Span	Zero	Span
Time	11:16	11:19	18:22	18:25
CO_2	0.00	16.95	0.00	16.84
CO	0.00	4.31	0.00	4.30

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

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

Pitot Tube Leak Test: Initial: good Final: good

Stack Diameter (in): 6

Induced Draft: 0.001 "H2O

% Smoke Capture: 100

Flue Pipe Cleaned Prior to First Test in Series:

Date: 12/16/21 Initials: KM

	Initial	Middle	Ending
P_b (in/Hg)	29.90	29.87	29.85
RH (%)	44	42	41
Ambient (°F)	73	75	76

Tunnel Traverse

Microtector Reading	dP (in H_2O)	T(°F)	
1 0,024	7 ,022	97	96
2 ,024	8 ,028		
3 ,028	9 ,032		
4 ,028	10 ,030		
5 ,026	11 ,028		
6 ,014	12 ,020	↓	↓
Center:			
	0,030	97	

Background Filter Volume: 44.350

Tunnel Static Pressure (in H_2O):	
Beginning of Test	End of Test
-0.245	-0.250

Technician Signature: Tony Tong Date: 06/16/22

C3; 4.5 - 8.9 25-50% → 23,000 - 46,000 34,500 Aim For 40K

Froling 0456WB009E Run 4 Cat III 6-16-22

Test Fuel (80% of Main) Cal Check=> 12.0=12.0, 22.0=22.0

	Pt	Weight	L x W x H	Moisture
9.2	1	9.2	16 x 5 x 7	22.8, 19.1, 22.7, 23.1, 19.5
16.9	2	7.7	16 x 6 x 6	19.6, 20.1, 19.8, 22.2, 22.1
25.3	3	8.4	16 x 7 x 4	24.8, 23.2, 20.2, 21.3, 24.2
32.9	4	7.6	16 x 6 x 7	24.3, 23.2, 23.8, 22.0, 23.4
	— 20% —			
38.9	5	6.0	16 x 4 x 6	22.8, 19.5, 23.1, 19.5, 22.7
44.9	6	6.0	16 x 6 x 4	22.3, 19.0, 18.9, 19.3, 21.2

— PREBURN 21.73% WB

1 -	20.0%	5.4
2 -	25.1	6.6
3 -	23.2	6.9
4 -	20.9	7.0
5 -	23.4	7.6
6 -	24.1	7.8

41.3 lb. All 16" Long

Added #7 24.6
Added #8 20.9 } 16.2 lb

Added #9 19.9 9.6 lb

Added #10 25.1
Added #11 19.7
Added #12 24.3 } 23.3 lb

#13 20.8 — 4.8 lb

28.1

Fire lit @ 7:50

- Fuel Added: 12.5 + 28.5 = 41 lb.
- Run on Max (No pts in Loop)

Pre-test	65.02 sec, 12.5 lb	T = 452 - 454
Mid-Test	68.11 sec, 11.6 lb	T = 536 - 538
Test-End	74.43 sec, 11.2 lb.	T = 637 - 639

Project# 0456WB009E Date 6-16-22

Client FROLING Tracking# 2448

Model T3 TURBO 30 Initials JK

6-16

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

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Run #:	4
Test Date:	June 16, 2022

Cordwood Fuel Type	Wet Weight (lb)	% Moisture				
Maple, Black 5 x 7 x 16"	9.2	22.8	19.1	22.7	23.1	19.5
Maple, Black 6 x 6 x 16"	7.7	19.6	20.1	19.8	22.2	22.1
Maple, Black 7 x 4 x 16"	8.4	24.8	23.2	20.2	21.3	24.2
Maple, Black 6 x 7 x 16"	7.6	24.3	23.2	23.8	22	23.4
Maple, Black 4 x 6 x 16"	6.0	22.8	19.5	23.1	19.5	22.7
Maple, Black 6 x 4 x 16"	6.0	22.3	19	18.9	19.3	21.2

Total Weight of Load (lb):	44.9
Total Moisture of Load (%):	21.73

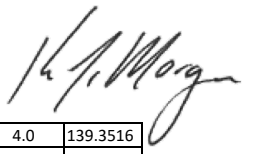
Equipment Numbers:

Hydronic Heating Appliances - Test Method ASTM E2618-13
Pre-Burn Data

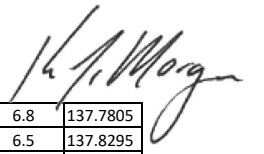
Manufacturer: Froling
Model: S3 Turbo 30
Tracking No.: 2448
Project No.: 0456WB009E
Run: 4
Test Date: June 16, 2022

Load Average (last 60 min)
46931.87 Btu / hr

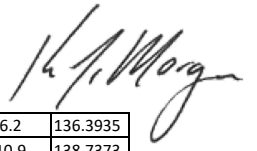
Appliance				LOAD										PTS					
Time, Min	Supply (T1)	Return (T2)	ΔT	Load IN, °F (T3)	Load OUT, °F (T4)	Flow Hz	Water Flow, GPM	Cpi	ΔT	Mass Flow Rate, lb/min	Btu/Min	**Btu/Hr**	Fuel Weight, LB	PTS TOP (T7)	PTS Bottom (T9)	PTS Mid (T8)	PTS ΔT	Boiler Return	
205	196.3	112.2	84.1	58.062	115.885	604.690	2.994	1.001	57.823	24.962	1445.1	**86706.33**	24.16	92.99	124.5	121.5	120.2	3.0	139.4235
206	196.8	114.0	82.8	58.164	122.735	445.139	2.199	1.001	64.571	18.333	1185.2	**71111.30**	23.92	99.26	126.9	121.5	120.2	5.4	140.0861
207	197.2	115.8	81.4	58.245	125.522	377.692	1.863	1.001	67.277	15.531	1046.1	**62765.52**	23.17	104.46	128.6	121.5	120.2	7.1	140.3059
208	197.3	116.3	81.1	58.352	127.063	367.676	1.813	1.001	68.710	15.114	1039.7	**62384.84**	23.54	105.97	129.1	121.5	120.2	7.6	140.3112
209	197.2	117.9	79.2	58.452	128.367	308.300	1.517	1.001	69.915	12.647	885.3	**53117.29**	22.97	111.22	130.6	121.5	120.1	9.2	140.9317
210	197.0	118.8	78.2	58.539	130.124	276.293	1.358	1.001	71.585	11.317	811.1	**48667.25**	22.57	113.78	131.4	121.5	120.1	9.9	141.1396
211	197.1	118.8	78.3	58.632	130.724	269.949	1.326	1.001	72.092	11.054	797.8	**47870.24**	22.57	114.61	130.6	121.5	120.1	9.1	140.7807
212	196.0	119.1	76.9	58.701	130.318	262.563	1.289	1.001	71.617	10.747	770.6	**46234.33**	22.28	114.76	131.5	121.5	120.1	10.0	141.0802
213	195.4	120.1	75.3	58.788	131.119	229.917	1.127	1.001	72.331	9.390	680.0	**40801.97**	21.84	117.82	132.3	121.5	120.1	10.8	141.2408
214	195.6	120.0	75.6	58.880	131.420	221.441	1.084	1.001	72.540	9.038	656.4	**39384.93**	21.55	118.20	131.5	121.5	120.1	10.0	140.8
215	194.9	120.1	74.8	58.962	131.233	221.528	1.085	1.001	72.272	9.042	654.2	**39254.66**	21.50	117.97	132.2	121.5	120.2	10.6	141.261
216	194.7	120.3	74.4	59.006	131.856	221.491	1.085	1.001	72.850	9.040	659.4	**39561.79**	21.44	118.70	132.5	121.5	120.3	11.0	141.2538
217	194.5	120.4	74.1	59.049	131.938	221.300	1.084	1.001	72.889	9.032	659.1	**39548.26**	21.10	118.95	132.5	121.5	120.5	11.0	141.2319
218	194.3	120.4	74.0	59.135	131.941	221.203	1.083	1.001	72.806	9.028	658.1	**39485.16**	20.69	118.82	132.4	121.5	120.8	10.9	141.1606
219	194.1	120.4	73.7	59.221	131.953	220.865	1.081	1.001	72.732	9.014	656.4	**39383.30**	20.26	119.00	132.4	121.5	121.2	10.9	141.283
220	193.7	120.3	73.4	59.295	131.957	222.648	1.090	1.001	72.661	9.088	661.1	**39667.78**	20.54	118.46	131.9	121.5	121.8	10.4	141.3555
221	195.5	119.3	76.1	59.357	130.514	229.554	1.125	1.001	71.157	9.375	667.9	**40072.43**	20.02	117.40	129.3	121.5	122.3	7.8	141.3467
222	194.8	119.1	75.8	59.396	130.047	229.794	1.126	1.001	70.651	9.385	663.8	**39829.66**	19.77	116.84	128.4	121.5	123.1	6.9	140.3731
223	194.6	118.8	75.8	59.431	128.538	229.796	1.126	1.001	69.107	9.385	649.3	**38959.52**	19.28	115.57	128.8	121.5	123.9	7.3	140.3497
224	193.9	119.1	74.7	59.488	128.145	229.947	1.127	1.001	68.656	9.391	645.5	**38730.88**	19.04	115.20	131.2	121.6	124.6	9.6	140.0978
225	195.4	118.6	76.8	59.506	128.328	229.572	1.125	1.001	68.822	9.375	646.0	**38759.85**	18.86	115.24	127.9	121.6	125.2	6.4	141.3546
226	195.6	119.4	76.2	59.496	130.364	229.848	1.126	1.001	70.868	9.387	666.0	**39960.80**	18.62	117.02	129.6	121.7	125.9	7.9	141.5251
227	194.1	120.1	74.0	59.572	130.746	229.975	1.127	1.001	71.173	9.392	669.3	**40155.37**	18.50	117.05	132.0	121.8	126.5	10.2	140.9463
228	194.4	119.9	74.5	59.569	131.271	244.224	1.198	1.001	71.702	9.984	716.7	**43003.24**	18.09	116.75	131.9	121.9	127.1	10.1	141.0737
229	194.4	120.0	74.4	59.601	131.381	244.003	1.197	1.001	71.780	9.975	716.8	**43010.12**	17.90	116.79	132.1	122.2	127.5	9.9	141.1341
230	194.5	120.2	74.3	59.624	131.478	267.019	1.311	1.001	71.853	10.931	786.3	**47180.67**	17.33	117.15	132.3	122.4	127.6	9.9	141.1425
231	195.0	115.0	80.0	59.574	124.897	476.081	2.353	1.001	65.323	19.615	1282.8	**76970.87**	17.13	100.91	127.5	122.8	127.7	4.7	140.2571
232	195.9	114.5	81.4	59.500	123.131	476.675	2.356	1.001	63.631	19.640	1251.2	**75072.09**	16.96	99.04	125.7	123.3	127.8	2.5	139.6311
233	194.4	114.9	79.5	59.438	122.588	479.738	2.372	1.001	63.150	19.767	1249.8	**74987.97**	16.32	98.21	127.3	124.1	127.9	3.2	139.6219
234	194.3	115.5	78.8	59.349	123.480	487.235	2.409	1.001	64.131	20.079	1289.2	**77353.68**	16.35	98.71	127.8	124.7	128.1	3.1	140.0961
235	194.5	116.1	78.5	59.319	124.054	488.044	2.413	1.001	64.735	20.113	1303.6	**78213.37**	15.99	98.75	128.4	125.4	128.1	2.9	140.3714
236	194.9	116.7	78.2	59.335	124.584	487.626	2.411	1.001	65.249	20.095	1312.8	**78765.75**	15.74	99.17	128.9	126.4	128.0	2.6	140.5555
237	195.2	117.4	77.8	59.331	125.231	487.978	2.413	1.001	65.900	20.110	1326.8	**79609.50**	15.54	99.30	129.7	127.1	127.9	2.6	140.5258
238	195.1	117.8	77.3	59.345	125.783	487.707	2.411	1.001	66.438	20.099	1336.9	**80213.70**	14.87	99.95	130.0	127.2	127.9	2.8	140.6664
239	194.9	113.3	81.6	59.305	113.202	823.027	4.083	1.001	53.897	34.028	1836.2	**110172.43**	14.92	84.36	126.2	128.5	127.9	2.3	139.2285
240	194.6	112.6	82.0	59.229	109.201	924.818	4.590	1.001	49.972	38.257	1914.1	**114844.61**	14.39	81.24	125.2	128.6	127.9	3.4	139.2183
241	194.3	112.5	81.8	59.239	108.931	926.860	4.600	1.001	49.692	38.342	1907.5	**114452.95**	14.52	81.01	124.6	128.9	127.9	4.3	139.8178
242	195.0	112.4	82.5	59.326	107.594	927.118	4.601	1.001	48.268	38.352	1853.4	**111203.32**	14.06	80.59	123.3	129.0	127.7	5.6	139.3958
243	195.8	112.4	83.4	59.403	107.774	928.724	4.609	1.001	48.371	38.419	1860.6	**111633.87**	14.01	80.74	124.3	128.5	127.5	4.1	139.4739



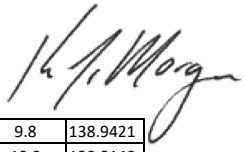
244	195.3	112.0	83.3	59.434	107.214	929.068	4.611	1.001	47.779	38.433	1838.5	**110308.95**	13.22	80.57	124.0	128.1	127.4	4.0	139.3516
245	195.1	112.3	82.8	59.447	107.864	929.513	4.613	1.001	48.417	38.451	1863.9	**111834.50**	12.91	80.57	124.5	128.1	127.1	3.6	138.9176
246	194.5	112.4	82.1	59.416	108.354	929.865	4.615	1.001	48.937	38.466	1884.7	**113079.53**	12.84	80.74	124.8	128.0	126.7	3.2	138.9165
247	194.7	112.0	82.6	59.371	107.961	929.970	4.616	1.001	48.591	38.470	1871.5	**112292.04**	12.53	80.73	124.7	127.5	126.7	2.7	139.4418
248	194.5	112.4	82.1	59.332	108.562	929.685	4.614	1.001	49.230	38.459	1895.6	**113734.14**	12.44	80.93	124.9	127.9	126.7	2.9	139.3702
249	194.5	112.1	82.4	59.317	108.600	929.702	4.614	1.001	49.282	38.460	1897.6	**113858.34**	12.43	80.98	124.7	127.4	126.7	2.6	139.3708
250	194.5	112.2	82.3	59.354	108.460	930.631	4.619	1.001	49.106	38.498	1892.7	**113563.99**	11.84	80.92	124.8	127.6	126.4	2.8	139.4147
251	194.4	111.9	82.5	59.202	108.485	930.713	4.619	1.001	49.283	38.502	1899.8	**113985.96**	12.03	80.76	124.7	127.2	126.2	2.6	139.3595
252	194.5	111.6	82.9	59.114	107.909	930.928	4.620	1.001	48.796	38.511	1881.4	**112886.04**	11.14	80.58	123.3	127.3	126.2	4.0	139.7435
253	194.7	105.2	89.5	59.092	111.689	931.224	4.622	1.001	52.597	38.524	2028.6	**121718.20**	11.00	95.30	115.7	127.4	126.2	11.7	139.274
254	194.8	104.8	90.0	58.945	110.230	930.524	4.618	1.001	51.286	38.495	1976.6	**118596.91**	10.69	94.62	115.9	126.9	125.9	11.0	138.8333
255	194.4	104.2	90.2	58.750	109.811	931.549	4.624	1.001	51.060	38.539	1970.2	**118209.04**	10.30	93.99	114.4	126.8	125.8	12.4	139.288
256	194.9	104.1	90.7	58.547	109.659	931.377	4.623	1.001	51.112	38.533	1971.8	**118309.72**	10.32	94.01	113.9	126.6	125.7	12.8	138.355
257	194.6	104.3	90.3	58.388	109.696	931.249	4.622	1.001	51.308	38.528	1979.2	**118750.52**	10.36	93.87	115.4	126.6	125.6	11.3	138.6097
258	193.9	104.9	89.1	58.289	111.046	930.481	4.618	1.001	52.757	38.497	2033.4	**122003.40**	9.73	94.66	116.6	126.1	125.4	9.5	138.1437
259	194.1	105.2	88.9	58.211	112.043	930.773	4.620	1.001	53.832	38.509	2075.5	**124529.57**	9.49	95.47	117.2	126.0	125.3	8.8	138.2537
260	194.2	105.2	88.9	58.130	112.107	932.068	4.626	1.001	53.976	38.563	2084.0	**125039.58**	9.68	95.46	117.2	125.9	125.0	8.7	138.3105
261	194.1	105.2	88.8	58.061	112.122	931.161	4.622	1.001	54.061	38.526	2085.2	**125113.90**	8.85	95.45	117.1	125.9	124.7	8.7	138.3583
262	193.9	105.2	88.8	58.019	112.070	931.308	4.622	1.001	54.051	38.532	2085.2	**125111.60**	8.61	95.40	117.1	125.8	124.4	8.7	138.0692
263	196.2	102.6	93.5	57.989	108.017	930.923	4.620	1.001	50.027	38.516	1929.2	**115750.80**	8.55	92.85	111.9	125.5	124.3	13.6	139.5952
264	196.2	102.5	93.7	57.978	107.392	907.547	4.504	1.001	49.414	37.545	1857.5	**111449.13**	8.36	92.61	112.1	125.4	124.1	13.3	138.8291
265	195.8	101.3	94.5	57.962	107.604	899.692	4.465	1.001	49.642	37.219	1849.8	**110989.32**	8.13	93.09	122.0	125.2	122.7	3.2	139.1327
266	193.6	100.8	92.8	57.958	107.068	942.015	4.676	1.001	49.110	38.977	1916.4	**114986.91**	23.98	92.63	121.9	124.9	122.8	3.0	138.5494
267	193.9	100.0	93.9	57.912	106.126	939.580	4.664	1.001	48.213	38.876	1876.6	**112595.71**	23.86	92.10	121.2	124.6	122.4	3.5	139.0841
268	193.2	100.0	93.3	57.876	105.717	940.565	4.668	1.001	47.841	38.917	1864.1	**111844.09**	23.50	91.55	121.3	124.6	122.2	3.3	138.8145
269	192.7	100.7	91.9	57.880	106.997	938.757	4.659	1.001	49.117	38.842	1910.1	**114606.21**	23.68	92.43	121.7	124.6	122.3	2.9	138.4719
270	192.6	100.8	91.8	57.893	107.462	938.466	4.658	1.001	49.569	38.830	1927.1	**115625.11**	22.75	92.88	121.3	124.3	122.1	2.9	138.1176
271	192.2	101.5	90.7	57.901	108.687	938.370	4.658	1.001	50.786	38.826	1974.2	**118451.03**	22.66	93.61	121.6	124.0	121.8	2.4	137.9255
272	192.3	101.8	90.5	57.885	109.310	938.588	4.659	1.001	51.424	38.835	1999.5	**119968.05**	22.47	94.06	121.7	124.0	121.8	2.3	138.3228
273	192.5	101.8	90.7	57.847	109.452	938.771	4.660	1.001	51.605	38.843	2006.9	**120413.71**	21.97	94.16	121.7	123.9	121.6	2.2	138.3372
274	192.5	101.8	90.7	57.813	109.412	937.661	4.654	1.001	51.599	38.797	2004.3	**120257.12**	22.02	94.15	121.6	123.8	121.5	2.1	138.3135
275	192.2	101.8	90.4	57.787	109.311	937.876	4.655	1.001	51.524	38.806	2001.8	**120109.43**	21.62	94.10	121.6	123.8	121.3	2.2	138.1355
276	192.0	102.7	89.3	57.781	109.158	939.427	4.663	1.001	51.377	38.871	1999.4	**119966.54**	20.92	93.32	113.7	123.5	122.3	9.8	137.509
277	191.8	102.3	89.5	57.777	108.263	938.280	4.657	1.001	50.486	38.823	1962.4	**117741.45**	20.73	92.78	113.2	123.4	122.1	10.2	137.984
278	190.9	102.1	88.8	57.783	108.358	938.037	4.656	1.001	50.575	38.813	1965.3	**117918.41**	20.62	92.83	112.7	123.1	122.0	10.4	137.7404
279	191.2	101.5	89.6	57.778	107.112	938.817	4.660	1.001	49.334	38.845	1918.7	**115121.44**	20.06	91.91	111.9	122.9	121.8	11.0	137.9506
280	190.6	101.6	89.0	57.771	107.388	938.531	4.658	1.001	49.617	38.833	1929.1	**115746.70**	19.88	92.15	112.3	122.8	121.6	10.5	137.9373
281	190.3	101.8	88.5	57.752	107.866	938.533	4.658	1.001	50.115	38.834	1948.5	**116907.95**	19.43	92.36	112.8	122.5	121.3	9.7	138.0481
282	190.4	102.1	88.3	57.738	108.282	938.648	4.659	1.001	50.544	38.838	1965.4	**117924.85**	28.75	92.69	113.3	122.4	121.2	9.0	137.7329
283	190.7	102.2	88.5	57.724	108.675	938.481	4.658	1.001	50.951	38.831	1980.9	**118852.73**	28.26	92.91	113.6	122.2	121.1	8.6	137.8505
284	190.8	100.7	90.0	57.725	108.461	938.787	4.660	1.001	50.736	38.844	1973.2	**118390.33**	28.41	93.38	120.2	122.2	120.0	2.1	137.7927
285	190.9	101.1	89.8	57.709	108.328	921.159	4.572	1.001	50.619	38.112	1931.5	**115890.36**	27.78	93.57	120.0	122.1	119.9	2.1	137.8888
286	191.0	100.7	90.3	57.713	108.223	933.971	4.636	1.001	50.510	38.644	1954.2	**117254.86**	27.37	93.38	120.0	122.0	120.0	2.0	137.808
287	190.9	100.6	90.4	57.720	108.032	940.205	4.667	1.001	50.311	38.903	1959.6	**117577.10**	27.41	93.21	119.9	121.9	119.8	2.0	137.8885
288	191.0	100.5	90.5	57.701	107.909	940.930	4.670	1.001	50.208	38.933	1957.1	**117425.42**	26.99	93.15	119.8	121.8	119.7	2.0	137.7601
289	191.0	100.5	90.5	57.700	107.880	941.044	4.671	1.001	50.180	38.938	1956.2	**117374.30**	26.28	93.00	119.5	121.7	119.6	2.2	137.891
290	191.0	100.4	90.6	57.691	107.865	940.950	4.670	1.001	50.174	38.934	1955.8	**117349.86**	26.04	93.12	119.6	121.6	119.4	2.0	137.7493
291	190.9	100.4	90.5	57.714	107.825	940.583	4.669	1.001	50.111	38.919	1952.6	**117156.36**	25.51	93.01	119.4	121.5	119.2	2.1	137.7274
292	191.0	100.4	90.6	57.713	107.792	940.003	4.666	1.001	50.080	38.895	1950.2	**117009.97**	25.46	93.02	119.1	121.3	119.0	2.2	137.7558
293	191.1	100.3	90.8	57.706	107.799	940.437	4.668	1.001	50.092	38.913	1951.6	**117094.71**	24.86	92.98	119.1	121.2	118.9	2.0	137.7753
294	191.5	100.3	91.2	57.694	107.763	940.684	4.669	1.001	50.069	38.923	1951.2	**117071.46**	24.82	93.03	119.1	121.1	118.9	1.9	137.8095
295	192.0	100.3	91.6	57.690	107.867	940.338	4.667	1.001	50.177	38.909	1954.7	**117280.97**	24.09	93.04	119.1	121.0	118.9	1.9	137.8909
296	192.3	100.3	91.9	57.683	107.952	939.150	4.661	1.001	50.269	38.859	1955.8	**117346.61**	23.96	93.14	119.1	120.9	118.7	1.8	137.9427
297	192.4	101.3	91.1	57.680	107.928	940.142	4.666	1.001	50.247	38.901	1957.0	**117420.14**	23.58	92.95	112.6	120.9	119.4	8.3	137.5461
298	192.9	101.6	91.3	57.686	108.136	940.420	4.668	1.001	50.450	38.912	1965.5	**117928.25**	22.42	92.64	113.4	120.7	119.3	7.3	137.5624



299	193.3	101.7	91.6	57.685	108.672	939.584	4.664	1.001	50.987	38.878	1984.6	**119078.15**	22.70	93.05	113.7	120.5	119.2	6.8	137.7805
300	193.7	101.7	92.1	57.688	108.795	940.049	4.666	1.001	51.107	38.897	1990.3	**119415.76**	21.88	93.13	113.8	120.3	119.1	6.5	137.8295
301	194.4	101.7	92.7	57.694	108.895	938.745	4.659	1.001	51.201	38.843	1991.2	**119469.42**	21.85	93.13	114.0	120.2	119.1	6.3	137.6475
302	194.9	101.7	93.2	57.690	108.848	940.768	4.669	1.001	51.157	38.927	1993.8	**119626.25**	21.45	93.04	114.0	120.1	118.9	6.1	137.7283
303	195.6	101.9	93.7	57.686	109.179	941.179	4.672	1.001	51.493	38.944	2007.7	**120463.94**	20.92	93.26	114.2	120.1	118.9	5.9	137.791
304	197.1	101.2	95.9	57.685	107.913	941.628	4.674	1.001	50.229	38.962	1959.4	**117562.47**	20.56	92.84	113.5	120.0	118.7	6.5	137.7439
305	196.8	101.9	94.9	57.689	109.346	941.888	4.675	1.001	51.657	38.973	2015.7	**120940.28**	20.06	93.45	114.5	119.9	118.7	5.4	137.7828
306	197.3	101.9	95.4	57.669	109.232	941.522	4.673	1.001	51.562	38.958	2011.2	**120671.03**	19.99	93.39	114.4	119.8	118.6	5.4	137.7995
307	197.4	102.0	95.4	57.680	109.587	941.527	4.673	1.001	51.907	38.958	2024.6	**121476.77**	19.46	93.49	114.7	119.8	118.5	5.1	137.7482
308	197.6	101.9	95.7	57.674	109.459	941.518	4.673	1.001	51.785	38.958	2019.8	**121190.96**	18.77	93.39	114.7	119.6	118.5	4.9	137.7974
309	198.1	102.1	96.0	57.675	109.792	940.258	4.667	1.001	52.118	38.906	2030.1	**121805.52**	18.53	93.80	114.9	119.6	118.4	4.7	137.842
310	198.8	101.9	96.9	57.682	109.735	940.872	4.670	1.001	52.053	38.931	2028.9	**121734.75**	18.21	93.78	114.4	119.6	118.3	5.2	138.0637
311	198.8	102.1	96.7	57.682	109.942	940.987	4.671	1.001	52.261	38.936	2037.2	**122234.92**	18.10	93.79	115.0	119.4	118.3	4.4	137.8462
312	199.2	102.1	97.1	57.693	110.045	940.257	4.667	1.001	52.352	38.905	2039.2	**122353.93**	17.52	93.96	115.1	119.3	118.2	4.2	137.7244
313	199.2	102.1	97.1	57.694	110.012	941.496	4.673	1.001	52.318	38.957	2040.6	**122436.01**	17.02	93.81	115.1	119.3	118.1	4.2	137.9503
314	199.3	102.1	97.2	57.702	110.046	941.367	4.672	1.001	52.344	38.951	2041.3	**122479.88**	17.50	93.77	115.1	119.1	117.8	3.9	137.8147
315	199.0	102.0	97.0	57.706	109.953	940.238	4.667	1.001	52.247	38.905	2035.1	**122104.54**	16.63	93.91	115.0	119.0	117.6	3.9	137.7622
316	198.9	102.0	96.9	57.704	109.916	940.748	4.669	1.001	52.213	38.926	2034.8	**122090.88**	15.82	93.84	115.0	119.1	117.7	4.1	137.6328
317	198.3	101.9	96.4	57.705	109.804	940.260	4.667	1.001	52.099	38.905	2029.4	**121762.06**	15.38	93.71	114.8	119.1	117.7	4.2	137.4162
318	196.1	101.4	94.6	57.708	109.042	940.847	4.670	1.001	51.334	38.930	2000.8	**120049.21**	15.51	93.30	113.9	119.0	117.5	5.2	137.4961
319	197.5	100.8	96.7	57.708	107.892	938.829	4.660	1.001	50.185	38.846	1951.8	**117108.76**	15.41	92.58	112.7	118.9	117.5	6.2	138.0782
320	197.6	101.4	96.2	57.712	108.862	939.795	4.665	1.001	51.150	38.886	1991.4	**119483.72**	14.96	93.12	114.1	118.8	117.6	4.7	137.5069
321	197.7	100.0	97.7	57.716	106.976	1034.151	5.135	1.001	49.260	42.806	2111.2	**126670.20**	14.28	91.05	113.0	118.7	117.7	5.7	137.0717
322	198.3	99.3	99.1	57.696	105.617	1039.681	5.162	1.001	47.921	43.036	2064.8	**123888.79**	14.06	90.14	111.9	118.6	117.3	6.8	137.1636
323	198.4	98.8	99.5	57.686	105.198	1040.330	5.166	1.001	47.512	43.063	2048.5	**122909.13**	14.09	89.88	111.1	118.5	117.3	7.3	137.7363
324	198.2	99.1	99.0	57.675	105.532	1039.869	5.163	1.001	47.857	43.044	2062.4	**123745.78**	13.69	89.99	111.3	118.4	117.2	7.1	136.8122
325	197.7	99.1	98.6	57.670	105.722	1041.176	5.170	1.001	48.053	43.099	2073.5	**124409.02**	13.29	90.14	111.8	118.1	117.2	6.3	137.0386
326	197.5	99.2	98.3	57.669	105.894	1041.529	5.172	1.001	48.225	43.113	2081.6	**124896.93**	13.30	90.13	112.1	118.2	117.1	6.1	137.4055
327	197.3	99.2	98.1	57.665	105.955	1043.875	5.183	1.001	48.290	43.211	2089.2	**125349.01**	13.27	90.32	112.1	118.1	117.0	6.1	136.9386
328	197.5	98.7	98.8	57.660	105.321	1043.612	5.182	1.001	47.662	43.200	2061.4	**123686.81**	12.62	89.73	111.0	118.0	116.8	7.0	137.3758
329	197.6	98.4	99.2	57.651	104.747	1043.158	5.180	1.001	47.096	43.181	2036.1	**122164.74**	12.22	89.42	110.3	117.8	116.5	7.5	136.8017
330	197.2	98.4	98.8	57.640	104.542	1043.507	5.182	1.001	46.902	43.196	2028.4	**121703.58**	11.62	89.31	110.8	117.9	116.5	7.1	137.5669
331	196.6	98.8	97.7	57.630	105.331	1043.592	5.182	1.001	47.701	43.199	2063.1	**123787.90**	11.47	89.77	111.5	117.8	116.5	6.3	137.4317
332	196.3	98.8	97.5	57.619	105.375	1044.366	5.186	1.001	47.757	43.231	2067.1	**124023.87**	11.59	89.90	111.4	117.5	116.5	6.1	137.0266
333	197.0	97.9	99.1	57.613	103.948	1044.043	5.184	1.001	46.335	43.218	2004.9	**120294.94**	11.45	88.92	109.6	117.4	116.3	7.8	137.2629
334	196.4	98.2	98.2	57.610	104.264	1042.215	5.175	1.001	46.654	43.142	2015.1	**120908.82**	10.34	89.10	110.5	117.3	116.2	6.9	137.2747
335	196.3	98.9	97.4	57.601	105.418	1033.471	5.131	1.001	47.818	42.779	2048.0	**122881.95**	10.63	90.04	111.3	117.3	116.1	5.9	137.3006
336	196.6	98.6	98.0	57.592	105.128	1045.745	5.193	1.001	47.536	43.289	2060.2	**123614.39**	9.84	89.62	111.2	117.1	116.1	5.9	137.2667
337	196.7	98.5	98.3	57.584	105.069	1046.689	5.197	1.001	47.485	43.328	2059.9	**123595.11**	10.21	89.53	111.1	117.0	116.0	5.9	137.411
338	197.1	98.6	98.5	57.570	105.161	1046.107	5.194	1.001	47.591	43.304	2063.4	**123801.14**	9.46	89.49	111.2	117.1	116.0	5.8	137.2487
339	197.6	98.3	99.3	57.571	104.711	1047.158	5.200	1.001	47.140	43.348	2045.9	**122752.18**	9.15	89.20	111.0	117.0	115.9	6.0	137.3199
340	197.6	98.5	99.1	57.571	105.089	1046.103	5.194	1.001	47.518	43.304	2060.2	**123610.47**	9.08	89.49	111.2	116.8	115.7	5.7	137.3787
341	197.7	98.5	99.2	57.574	105.144	1046.614	5.197	1.001	47.570	43.325	2063.4	**123806.10**	8.74	89.53	111.2	116.8	115.6	5.6	137.3635
342	197.6	98.5	99.2	57.572	105.173	1046.015	5.194	1.001	47.601	43.300	2063.6	**123817.31**	8.81	89.71	111.2	116.7	115.4	5.5	137.3498
343	197.6	98.4	99.1	57.568	105.142	1046.219	5.195	1.001	47.574	43.309	2062.8	**123770.20**	8.69	89.66	111.2	116.5	115.2	5.3	137.0681
344	197.8	98.1	99.7	57.568	104.814	1046.317	5.196	1.001	47.246	43.313	2048.8	**122927.72**	7.85	89.51	110.7	116.4	115.1	5.7	137.2515
345	198.1	97.5	100.6	57.573	103.797	1046.265	5.195	1.001	46.224	43.311	2004.4	**120263.40**	7.82	88.73	109.8	116.2	115.0	6.3	137.2725
346	198.8	97.6	101.2	57.577	103.714	1046.164	5.195	1.001	46.138	43.306	2000.4	**120026.88**	7.86	88.76	109.7	116.3	115.1	6.6	137.5781
347	198.1	98.0	100.1	57.581	104.585	1047.071	5.199	1.001	47.005	43.344	2039.8	**122389.40**	8.05	89.17	110.9	116.1	115.0	5.3	136.8798
348	197.7	98.2	99.5	57.584	104.933	1047.040	5.199	1.001	47.349	43.343	2054.7	**123282.47**	7.33	89.51	110.9	116.0	115.0	5.1	137.2831
349	197.3	98.0	99.3	57.590	104.768	1046.170	5.195	1.001	47.178	43.307	2045.6	**122734.37**	6.95	89.37	110.7	116.0	114.9	5.3	137.0687
350	197.0	97.9	99.1	57.593	104.587	1046.061	5.194	1.001	46.994	43.302	2037.4	**122243.52**	6.65	89.29	110.6	115.9	114.8	5.3	137.076
351	196.7	97.9	98.8	57.598	104.548	1045.564	5.192	1.001	46.949	43.281	2034.5	**122067.11**	6.52	89.24	110.6	115.9	114.7	5.3	137.0409
352	197.0	97.5	99.5	57.607	104.153	1040.573	5.167	1.001	46.546	43.074	2007.3	**120439.09**	6.46	89.05	109.4	115.9	114.6	6.5	137.1304
353	196.5	97.4	99.1	57.611	103.575	1042.905	5.179	1.001	45.964	43.171	1986.7	**119201.33**	6.09	88.53	109.6	115.7	114.5	6.1	137.0719



354	193.2	97.3	95.9	57.619	103.684	1046.553	5.197	1.001	46.066	43.322	1998.1	**119883.88**	6.21	88.76	109.2	115.5	114.3	6.2	136.3935
355	196.8	95.6	101.3	57.618	100.805	1041.329	5.171	1.001	43.188	43.105	1863.8	**111830.91**	5.91	87.10	104.6	115.5	114.3	10.9	138.7373
356	198.2	95.0	103.2	57.620	99.306	1045.860	5.193	1.001	41.686	43.293	1806.9	**108413.00**	5.56	85.73	105.2	115.4	114.2	10.2	137.9064
357	196.6	95.8	100.8	57.621	101.021	1047.241	5.200	1.001	43.400	43.351	1883.7	**113020.95**	5.31	86.85	107.0	115.2	114.0	8.2	137.4435
358	195.8	96.5	99.3	57.625	102.190	1046.367	5.196	1.001	44.565	43.314	1932.6	**115956.97**	5.94	87.68	108.3	115.0	113.9	6.8	137.0526
359	195.2	97.1	98.1	57.632	103.394	1035.369	5.141	1.001	45.762	42.858	1963.6	**117815.46**	4.89	88.44	109.4	114.9	113.8	5.6	137.0502
360	195.4	97.1	98.3	57.635	103.561	1046.867	5.198	1.001	45.926	43.335	1992.6	**119556.42**	5.22	88.59	109.5	114.8	113.8	5.4	137.0702
361	195.4	97.1	98.3	57.627	103.532	1047.180	5.200	1.001	45.905	43.348	1992.3	**119537.74**	4.81	88.52	109.4	114.8	113.7	5.4	136.9477
362	195.5	97.1	98.4	57.621	103.517	1044.238	5.185	1.001	45.895	43.226	1986.3	**119175.31**	4.79	88.60	109.4	114.7	113.7	5.2	137.1097
363	195.2	97.0	98.2	57.621	103.461	1046.101	5.194	1.001	45.839	43.303	1987.4	**119242.07**	4.44	88.49	109.3	114.7	113.6	5.3	136.8356
364	195.3	96.6	98.7	57.624	103.098	1046.346	5.196	1.001	45.474	43.314	1972.0	**118320.69**	4.68	88.45	108.2	114.5	113.5	6.4	136.7553
365	195.0	96.0	99.0	57.613	101.818	1045.083	5.189	1.001	44.205	43.261	1914.7	**114880.26**	4.40	87.41	107.6	114.4	113.3	6.8	137.1071
366	193.9	96.2	97.7	57.614	102.177	1045.138	5.190	1.001	44.563	43.263	1930.3	**115816.00**	4.00	87.71	108.1	114.3	113.1	6.2	136.861
367	194.3	95.5	98.9	57.610	100.971	1045.667	5.192	1.001	43.361	43.285	1879.1	**112748.67**	4.05	86.85	106.6	114.3	113.0	7.7	136.8812
368	193.6	95.6	98.0	57.618	101.176	1045.398	5.191	1.001	43.559	43.274	1887.2	**113234.21**	3.74	87.04	106.9	114.3	112.8	7.3	137.1701
369	194.0	95.2	98.7	57.614	100.831	1045.448	5.191	1.001	43.217	43.276	1872.5	**112351.33**	3.76	86.85	106.3	113.9	112.7	7.7	137.0965
370	194.0	95.0	99.1	57.612	100.229	1045.545	5.192	1.001	42.616	43.280	1846.7	**110799.66**	3.40	86.49	105.7	113.8	112.7	8.1	137.1416
371	193.7	95.0	98.6	57.606	100.350	1046.169	5.195	1.001	42.744	43.306	1853.3	**111198.08**	3.15	86.53	106.0	113.6	112.6	7.7	137.0562
372	193.3	95.5	97.9	57.619	101.103	1045.838	5.193	1.001	43.484	43.293	1884.8	**113087.58**	3.01	86.91	106.9	113.6	112.6	6.7	136.7225
373	192.9	95.8	97.1	57.627	101.876	1045.807	5.193	1.001	44.249	43.291	1917.9	**115073.62**	3.17	87.42	107.5	113.5	112.4	6.0	136.5259
374	193.0	96.0	97.0	57.644	102.220	1046.573	5.197	1.001	44.576	43.323	1933.5	**116009.18**	2.65	87.80	108.0	113.5	112.3	5.5	136.6373
375	193.3	96.7	96.6	57.644	102.910	1020.623	5.067	1.001	45.266	42.245	1914.5	**114872.35**	2.71	88.66	108.4	113.4	112.3	5.0	136.8946
376	194.2	95.8	98.3	57.660	102.482	1034.806	5.138	1.001	44.822	42.834	1922.2	**115333.51**	2.29	88.01	107.4	113.3	112.2	5.9	137.1157
377	194.0	96.0	98.0	57.661	102.243	1050.431	5.216	1.001	44.581	43.483	1940.9	**116451.20**	2.45	87.69	108.2	113.1	112.1	4.9	136.4683
378	194.2	96.1	98.2	57.610	102.449	1050.157	5.215	1.001	44.839	43.472	1951.6	**117094.81**	2.05	87.79	108.3	113.3	112.0	5.0	136.6358
379	194.6	96.2	98.5	57.603	102.564	1049.636	5.212	1.001	44.961	43.450	1955.9	**117354.69**	2.06	87.94	108.5	113.1	112.0	4.6	136.4871
380	194.8	95.9	98.9	57.626	102.216	1048.981	5.209	1.001	44.590	43.423	1938.5	**116312.71**	1.66	87.73	108.2	113.0	111.8	4.8	136.8337
381	194.9	96.0	98.9	57.646	102.570	1049.434	5.211	1.001	44.924	43.442	1953.9	**117234.44**	2.07	87.94	108.4	112.9	111.7	4.5	136.812
382	194.9	96.0	98.9	57.642	102.642	1047.348	5.201	1.001	45.000	43.355	1953.3	**117200.33**	1.78	87.98	108.5	112.7	111.7	4.3	136.559
383	194.6	96.0	98.6	57.628	102.503	1048.488	5.206	1.001	44.874	43.403	1950.0	**117000.04**	1.66	87.77	108.3	112.7	111.7	4.4	136.4377
384	194.3	95.9	98.4	57.611	102.412	1048.511	5.206	1.001	44.801	43.404	1946.9	**116811.06**	1.60	87.89	108.3	112.8	111.6	4.5	136.4831
385	194.0	95.6	98.4	57.608	102.136	1048.448	5.206	1.001	44.527	43.401	1934.9	**116091.22**	1.69	87.72	107.3	112.7	111.6	5.4	136.7328
386	194.1	94.8	99.3	57.618	100.480	1048.180	5.205	1.001	42.861	43.390	1862.0	**111718.03**	1.32	86.58	106.0	112.6	111.4	6.5	137.0444
387	192.8	94.9	97.9	57.620	100.694	1050.347	5.216	1.001	43.074	43.480	1875.1	**112505.38**	1.18	86.66	106.5	112.5	111.3	6.1	136.9184
388	193.0	94.1	98.9	57.629	99.381	1048.591	5.207	1.001	41.752	43.407	1814.5	**108871.03**	1.04	85.91	104.8	112.2	111.2	7.5	137.013
389	191.9	93.9	98.1	57.632	99.336	1048.985	5.209	1.001	41.704	43.423	1813.1	**108785.46**	1.36	85.90	103.6	112.3	111.2	8.7	137.7853
390	193.1	92.8	100.3	57.636	96.858	1049.391	5.211	1.001	39.222	43.440	1705.8	**102350.19**	0.78	84.28	102.1	112.2	111.0	10.1	137.8167
391	191.8	92.7	99.0	57.636	97.006	1048.393	5.206	1.001	39.370	43.399	1710.7	**102640.39**	0.65	84.26	102.2	112.0	110.9	9.8	137.2757
392	194.0	91.4	102.7	57.645	94.200	1049.482	5.211	1.001	36.555	43.444	1590.0	**95399.43**	0.97	82.43	99.6	111.8	110.8	12.2	138.5173
393	193.0	91.3	101.7	57.644	94.353	1048.291	5.205	1.001	36.708	43.394	1594.8	**95690.69**	0.96	82.69	99.1	111.6	110.6	12.5	138.9245
394	192.5	91.2	101.3	57.642	94.144	1049.644	5.212	1.001	36.501	43.451	1587.9	**95274.62**	0.22	82.39	99.1	111.3	110.4	12.3	138.5116
395	192.0	91.2	100.8	57.656	94.278	1048.512	5.206	1.001	36.622	43.403	1591.4	**95485.67**	-0.09	82.54	99.3	111.1	110.2	11.9	138.3338
396	191.3	91.3	100.0	57.664	94.461	1048.339	5.206	1.001	36.797	43.396	1598.8	**95925.81**	0.52	82.63	99.5	111.0	110.1	11.5	138.3164
397	190.7	91.4	99.4	57.667	94.785	1045.880	5.193	1.001	37.118	43.294	1608.9	**96534.91**	0.17	82.94	99.8	110.6	109.6	10.8	138.229
398	190.3	91.3	99.0	57.673	94.918	1048.219	5.205	1.001	37.245	43.391	1618.1	**97083.56**	1.82	82.96	100.0	110.6	109.5	10.6	138.0067
399	189.7	95.0	94.6	57.667	96.623	861.771	4.276	1.001	38.956	35.645	1390.2	**83413.58**	28.01	86.49	102.0	110.6	109.4	8.6	137.4856
400	189.5	103.6	85.9	57.788	108.612	391.903	1.934	1.001	50.825	16.122	820.4	**49222.13**	27.13	91.09	113.0	110.5	109.2	2.5	138.2535
401	189.5	104.7	84.8	57.920	112.022	376.698	1.858	1.001	54.102	15.490	839.0	**50342.03**	27.15	94.57	114.6	110.4	109.2	4.1	139.0278
402	189.3	105.1	84.2	58.039	113.099	375.306	1.851	1.001	55.060	15.432	850.7	**51041.52**	26.73	95.54	115.2	110.4	109.2	4.7	138.5724
403	189.7	105.1	84.6	58.167	113.727	362.158	1.786	1.001	55.560	14.885	828.0	**49681.43**	26.08	96.31	112.9	110.4	109.1	2.5	139.9582
404	189.0	105.1	83.9	58.274	112.756	354.367	1.747	1.001	54.482	14.561	794.3	**47656.80**	26.11	95.70	114.3	110.4	109.1	3.9	139.4143
405	188.5	105.6	82.9	58.366	113.950	350.311	1.727	1.001	55.585	14.393	801.0	**48058.46**	25.34	96.60	116.4	110.4	109.0	6.0	138.3116
406	188.9	106.6	82.3	58.461	115.558	318.363	1.567	1.001	57.096	13.065	746.9	**44812.39**	25.10	99.61	117.6	110.5	109.0	7.2	138.5796
407	189.8	107.7	82.1	58.572	117.418	280.668	1.380	1.001	58.846	11.499	677.5	**40649.25**	24.74	102.90	119.0	110.4	109.1	8.6	138.7925
408	190.8	108.0	82.8	58.660	118.788	291.298	1.433	1.001	60.128	11.941	718.8	**43129.38**	24.32	103.15	119.9	110.5	109.1	9.4	138.9281



409	192.1	108.1	84.1	58.727	119.257	297.849	1.465	1.001	60.530	12.213	740.1	**44407.00**	23.97	103.31	120.3	110.5	109.2	9.8	138.9421
410	193.1	108.2	84.9	58.802	119.561	299.170	1.472	1.001	60.759	12.267	746.3	**44775.22**	23.63	103.59	120.6	110.5	109.3	10.2	138.8148
411	194.1	108.3	85.8	58.885	119.934	299.003	1.471	1.001	61.049	12.260	749.4	**44962.61**	22.75	103.93	120.9	110.4	109.5	10.5	139.1108
412	194.8	108.3	86.5	58.986	119.748	298.880	1.470	1.001	60.762	12.255	745.5	**44732.43**	22.56	103.85	121.1	110.4	109.7	10.7	139.07
413	195.2	108.5	86.7	59.055	120.371	298.667	1.469	1.001	61.316	12.246	751.8	**45107.22**	22.37	104.46	121.3	110.4	109.9	10.9	139.1063
414	195.6	108.4	87.2	59.128	120.043	298.402	1.468	1.001	60.914	12.235	746.2	**44770.82**	21.98	103.91	121.4	110.4	110.2	11.0	138.9659
415	195.4	108.6	86.9	59.187	120.626	298.420	1.468	1.001	61.439	12.236	752.7	**45159.19**	21.72	104.55	121.5	110.4	110.5	11.1	139.0181
416	195.5	108.6	86.9	59.239	120.756	298.297	1.467	1.001	61.517	12.231	753.3	**45196.89**	20.98	104.61	121.5	110.4	110.9	11.1	139.0661
417	195.4	108.8	86.6	59.304	120.925	288.911	1.421	1.001	61.621	11.841	730.5	**43829.65**	20.84	105.17	121.7	110.4	111.3	11.2	139.0537
418	195.5	108.5	87.1	59.372	120.746	297.454	1.463	1.001	61.374	12.195	749.4	**44962.37**	20.13	104.83	120.9	110.4	111.7	10.5	138.7607
419	195.5	108.5	87.0	59.420	120.116	296.000	1.456	1.001	60.697	12.135	737.4	**44245.57**	19.95	104.42	121.5	110.4	112.1	11.1	138.4112
420	195.6	108.5	87.2	59.459	120.309	298.051	1.466	1.001	60.850	12.220	744.5	**44668.50**	19.75	104.38	121.1	110.5	112.7	10.6	139.3722
421	195.7	108.5	87.1	59.515	120.548	298.822	1.470	1.001	61.033	12.252	748.7	**44919.82**	19.40	104.53	121.1	110.6	113.2	10.5	139.1372
422	195.5	108.8	86.7	59.553	120.632	299.892	1.475	1.001	61.079	12.296	751.9	**45116.50**	18.80	104.60	121.7	110.7	113.8	11.0	139.0033
423	195.8	108.8	86.9	59.596	120.844	299.692	1.474	1.001	61.248	12.288	753.5	**45210.36**	18.69	104.80	121.7	110.9	114.5	10.8	139.2209
424	195.7	111.6	84.1	59.608	121.004	299.738	1.475	1.001	61.396	12.290	755.5	**45327.02**	18.08	111.39	122.8	111.1	115.1	11.7	139.5562
425	195.5	114.2	81.3	59.610	124.813	299.193	1.472	1.001	65.203	12.267	800.8	**48048.68**	17.97	116.68	125.8	111.2	115.6	14.5	140.2538
426	195.4	115.2	80.2	59.612	126.233	293.503	1.443	1.001	66.621	12.031	802.5	**48147.59**	17.23	118.25	126.8	111.1	116.1	15.7	140.3286
427	195.7	117.3	78.4	59.642	127.725	274.714	1.350	1.001	68.082	11.250	766.9	**46011.78**	17.17	120.94	128.3	111.4	116.4	16.9	140.5996
428	195.9	110.8	85.1	59.690	127.812	264.948	1.301	1.001	68.122	10.845	739.6	**44378.40**	16.73	107.56	124.2	111.8	116.6	12.3	139.1907
429	196.0	109.4	86.6	59.738	122.221	265.279	1.303	1.001	62.482	10.858	679.3	**40755.57**	16.56	100.78	121.9	112.2	116.9	9.8	138.7717
430	195.9	109.3	86.5	59.789	120.779	265.243	1.303	1.001	60.990	10.857	662.9	**39776.52**	15.77	99.74	121.6	112.6	117.2	9.0	138.7705
431	195.5	109.7	85.8	59.812	120.520	275.871	1.356	1.001	60.708	11.298	686.7	**41202.59**	15.61	98.48	123.0	113.1	117.4	9.9	138.8247
432	195.5	110.0	85.6	59.861	121.130	290.946	1.431	1.001	61.269	11.924	731.5	**43887.56**	15.35	97.68	123.2	113.7	117.6	9.5	139.036
433	195.7	110.3	85.4	59.958	121.466	293.479	1.443	1.001	61.508	12.029	740.8	**44447.38**	15.48	97.67	123.6	114.2	117.7	9.5	139.261
434	195.9	110.8	85.1	59.998	121.887	296.407	1.458	1.001	61.888	12.151	752.9	**45173.69**	14.57	97.83	124.1	115.0	117.9	9.1	139.4314
435	196.6	111.3	85.3	60.089	122.340	296.393	1.458	1.001	62.251	12.150	757.3	**45436.12**	14.62	97.95	124.3	115.7	118.0	8.6	139.8349
436	196.5	112.1	84.4	60.149	122.878	296.591	1.459	1.001	62.729	12.158	763.6	**45815.46**	14.11	98.35	125.4	116.2	118.5	9.2	139.4293
437	196.5	112.7	83.8	60.214	123.625	296.435	1.458	1.001	63.411	12.152	771.5	**46288.59**	13.37	98.77	126.0	117.1	119.1	8.9	139.6544
438	196.6	113.3	83.2	60.271	124.195	296.072	1.456	1.001	63.924	12.137	776.7	**46604.45**	13.67	99.16	126.6	117.6	119.7	8.9	139.704
439	196.4	113.8	82.6	60.316	124.658	296.031	1.456	1.001	64.341	12.135	781.7	**46901.97**	12.73	99.68	126.9	118.1	120.0	8.8	139.8095
440	196.4	115.0	81.3	60.369	124.988	295.705	1.454	1.001	64.619	12.121	784.2	**47051.69**	12.75	99.99	127.1	118.6	120.2	8.5	140.1133
441	196.1	113.8	82.3	60.407	123.079	295.805	1.455	1.001	62.672	12.125	760.8	**45649.64**	12.65	92.05	126.6	118.8	120.3	7.8	139.8994
442	195.5	114.3	81.2	60.444	123.199	295.589	1.454	1.001	62.755	12.116	761.3	**45676.18**	12.06	92.33	127.5	119.0	120.5	8.5	140.0856
443	195.2	114.7	80.5	60.492	123.383	295.994	1.456	1.001	62.891	12.133	764.0	**45837.96**	11.78	91.13	127.9	119.1	120.7	8.8	140.1763
444	195.1	114.7	80.5	60.526	123.255	296.298	1.457	1.001	62.729	12.146	762.8	**45767.40**	11.87	90.55	127.7	119.4	121.0	8.3	139.69
445	195.4	114.7	80.7	60.574	123.274	287.557	1.414	1.001	62.701	11.783	739.6	**44378.94**	11.51	91.13	127.0	119.5	121.2	7.5	140.7577
446	195.1	115.2	79.9	60.605	123.340	282.960	1.391	1.001	62.736	11.592	728.1	**43684.09**	11.07	91.63	127.7	120.0	121.6	7.7	140.283
447	194.9	115.7	79.2	60.621	123.893	282.428	1.388	1.001	63.272	11.569	732.9	**43973.39**	10.85	91.60	128.8	120.6	121.9	8.2	140.2322
448	195.0	116.3	78.7	60.642	124.602	282.598	1.389	1.001	63.960	11.576	741.3	**44478.26**	10.47	92.19	129.2	121.0	122.2	8.2	140.5995
449	195.0	116.6	78.4	60.660	124.986	282.610	1.389	1.001	64.326	11.577	745.6	**44735.17**	10.05	92.50	129.6	121.3	122.6	8.3	140.7594
450	195.4	116.7	78.7	60.695	125.302	282.378	1.388	1.001	64.607	11.567	748.2	**44892.48**	10.12	92.52	128.9	121.6	122.9	7.3	140.9629
451	195.1	117.1	78.1	60.703	125.335	281.970	1.386	1.001	64.633	11.550	747.4	**44844.72**	9.57	92.64	129.6	121.9	123.2	7.7	140.9587
452	195.4	117.0	78.4	60.739	125.385	281.395	1.383	1.001	64.646	11.526	746.0	**44760.99**	9.68	92.72	128.9	122.1	123.5	6.8	140.6421
453	195.1	117.3	77.7	60.753	125.079	281.372	1.383	1.001	64.327	11.525	742.3	**44536.24**	9.01	92.80	129.5	122.4	123.8	7.1	140.7356
454	194.5	117.6	76.9	60.785	125.584	281.450	1.383	1.001	64.799	11.529	747.9	**44875.34**	8.60	92.78	130.4	122.5	124.0	7.9	140.9576
455	194.2	118.0	76.2	60.842	126.209	281.184	1.382	1.001	65.367	11.517	753.8	**45225.10**	8.34	92.87	130.7	122.9	124.3	7.8	140.8242
456	194.3	118.3	76.0	60.875	126.522	281.167	1.382	1.001	65.647	11.517	756.9	**45415.90**	8.72	93.35	131.0	123.1	124.6	7.9	140.8839
457	194.5	118.4	76.1	60.902	126.784	281.307	1.383	1.001	65.882	11.522	760.0	**45601.63**	8.31	93.22	130.8	123.3	124.8	7.5	140.9827
458	194.8	107.8	87.0	60.949	130.221	280.718	1.380	1.001	69.272	11.498	797.4	**47846.02**	8.10	100.92	125.6	123.1	123.9	2.5	140.181
459	194.6	120.4	74.2	60.978	149.824	278.442	1.368	1.001	88.845	11.403	1014.3	**60860.27**	7.80	116.03	124.6	122.2	124.0	2.3	140.8467
460	194.7	127.7	66.9	61.022	158.492	277.147	1.362	1.001	97.471	11.350	1107.6	**66453.65**	7.16	122.06	123.3	123.7	124.1	0.4	143.375
461	194.1	133.9	60.3	61.070	163.311	275.784	1.355	1.001	102.241	11.293	1156.0	**69357.88**	7.43	126.07	123.7	124.4	124.2	0.7	145.0153
462	194.2	138.2	56.0	61.112	168.741	274.834	1.350	1.001	107.629	11.253	1212.6	**72757.53**	6.46	128.55	124.1	124.6	124.3	0.5	145.8495
463	194.1	124.3	69.8	61.158	168.812	274.475	1.349	1.001	107.655	11.238	1211.3	**72677.91**	6.30	120.49	137.1	125.1	125.6	12.1	141.3736

Hydronic Heating Appliances - Test Method ASTM E2515-11

Emissions Sampling Data

Run: 4

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Test Date: June 16, 2022
Technician: TT / KM
Beginning Clock Time: 15:07
Recording Interval: 1 min.
Total Sampling Time: 191 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	0.024	0.024	0.028	0.028	0.026	0.014	0.022	0.028	0.032	0.030	0.028	0.020	0.030	"H2O
Initial Temp.	97	97	97	97	97	97	96	96	96	96	96	96	97	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: 12/16/2021

V_{strav} 10.78 ft/sec
V_{scent} 11.80 ft/sec
F_p 0.914

	(1)	(2)	(amb)	
Meter Box Y Factor:	1.003	1.003	1.011	
Barometric Pressure:	Begin	Middle	End	Average
	29.90	29.87	29.85	29.87 "Hg

PM Control Module: 335, 336
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: -0.248 "H2O
Pitot Tube Cp: 0.99

Tunnel Velocity: 10.45 ft/sec.
Intial Tunnel Flow: 471.7 scfm
Average Tunnel Flow: 458.1 scfm
Tunnel Area: 0.785398 ft2

Post-Test Leak Check (1): 0.000 cfm @ -17 in. Hg
Post-Test Leak Check (2): 0.000 cfm @ -16 in. Hg
Fuel Moisture (dry basis %): 21.73
Total Particulate (1): 3.2
Total Particulate (2): 3.0

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			0.99	1.02	0.34	77	77	72	2.60	1.80	96	0.029			44.9		285	74	74	74	0.043	0.00	7.59
1	0.153	0.151		0.15	0.15	1.25	1.09	0.34	77	77	72	2.71	1.80	113	0.029	97	96	44.3	0.56	276	77	75	75	0.043	0.01	7.21
2	0.312	0.311		0.16	0.16	1.25	1.09	0.34	77	77	72	2.69	1.80	98	0.030	98	99	44.9	-0.56	278	77	75	74	0.043	0.00	8.92
3	0.471	0.471		0.16	0.16	1.26	1.08	0.34	77	77	72	2.69	1.80	95	0.029	99	100	44.5	0.37	275	77	75	74	0.043	0.00	7.70
4	0.631	0.630		0.16	0.16	1.25	1.08	0.34	77	77	72	2.67	1.80	94	0.029	100	100	43.6	0.92	272	77	76	74	0.042	0.00	7.65
5	0.789	0.790		0.16	0.16	1.24	1.08	0.34	77	77	72	2.67	1.80	94	0.029	98	100	43.6	-0.03	270	77	76	74	0.043	0.00	7.79
6	0.947	0.949		0.16	0.16	1.24	1.07	0.34	77	77	72	2.67	1.80	94	0.029	98	100	43.2	0.48	272	77	76	74	0.043	0.00	8.33
7	1.106	1.108		0.16	0.16	1.24	1.07	0.34	77	77	72	2.65	1.80	94	0.027	103	103	43.2	-0.01	275	77	76	74	0.043	0.00	8.86
8	1.265	1.266		0.16	0.16	1.24	1.08	0.34	78	77	72	2.65	1.80	94	0.026	104	105	42.4	0.76	273	78	76	74	0.042	0.00	8.35
9	1.423	1.426		0.16	0.16	1.24	1.06	0.34	78	78	72	2.64	1.80	94	0.030	96	98	42.5	-0.09	274	78	76	74	0.042	0.00	8.49
10	1.581	1.584		0.16	0.16	1.23	1.07	0.34	78	78	72	2.64	1.80	94	0.025	106	106	42.3	0.17	274	78	76	74	0.043	0.00	8.72
11	1.740	1.743		0.16	0.16	1.23	1.06	0.34	78	78	72	2.65	1.80	94	0.029	99	99	42.3	0.06	275	78	76	74	0.043	0.00	8.50
12	1.898	1.901		0.16	0.16	1.23	1.06	0.34	78	78	72	2.64	1.80	94	0.029	98	99	41.1	1.19	275	78	77	74	0.042	0.00	8.51
13	2.055	2.059		0.16	0.16	1.23	1.06	0.34	78	78	72	2.65	1.80	94	0.030	96	97	41.3	-0.24	275	78	77	74	0.042	0.00	8.44
14	2.213	2.218		0.16	0.16	1.23	1.06	0.34	78	78	72	2.64	1.80	94	0.024	108	109	41.3	0.05	275	78	77	74	0.043	0.00	8.42
15	2.371	2.376		0.16	0.16	1.22	1.06	0.34	78	78	72	2.64	1.80	94	0.027	102	102	41.1	0.19	275	78	77	74	0.043	0.00	8.50
16	2.529	2.535		0.16	0.16	1.23	1.05	0.34	79	78	72	2.63	1.80	94	0.029	98	99	40.3	0.73	275	78	77	74	0.042	0.00	8.21
17	2.686	2.693		0.16	0.16	1.23	1.06	0.34	79	79	72	2.64	1.80	94	0.028	99	100	40.6	-0.29	274	78	77	74	0.042	0.00	8.11
18	2.845	2.851		0.16	0.16	1.22	1.06	0.34	79	79	72	2.65	1.80	94	0.028	100	100	39.9	0.68	276	79	77	74	0.043	0.00	8.19
19	3.002	3.010		0.16	0.16	1.23	1.06	0.34	79	79	72	2.64	1.80	94	0.028	99	101	39.3	0.69	277	79	77	74	0.043	0.00	8.33
20	3.163	3.168		0.16	0.16	1.30	1.06	0.34	79	79	72	2.74	1.80	95	0.028	102	101	39.4	-0.17	278	79	77	74	0.043	0.00	8.27
21	3.326	3.327		0.16	0.16	1.30	1.07	0.34	79	79	72	2.73	1.80	95	0.028	103	101	39.3	0.17	281	79	77	74	0.043	0.00	8.23
22	3.488	3.486		0.16	0.16	1.30	1.06	0.34	80	79	72	2.73	1.80	95	0.028	102	101	38.6	0.64	283	79	77	74	0.044	0.00	8.35
23	3.651	3.644		0.16	0.16	1.29	1.06	0.34	80	80	72	2.75	1.80	95	0.029	101	99	38.4	0.18	283	79	78	74	0.044	0.00	8.46
24	3.814	3.804		0.16	0.16	1.30	1.06	0.34	80	80	72	2.73	1.80	96	0.030	99	98	38.6	-0.21	285	79	78	74	0.044	0.00	8.62
25	3.976	3.962		0.16	0.16	1.30	1.06	0.34	80	80	72	2.74	1.80	96	0.027	104	102	37.9	0.71	288	79	78	74	0.044	0.00	8.82
26	4.138	4.120		0.16	0.16	1.29	1.06	0.34	80	80	72	2.74	1.80	97	0.027	104	102	37.2	0.77	289	79	78	74	0.044	0.00	8.69
27	4.299	4.280		0.16	0.16	1.27	1.07	0.34	80	80	72	2.69	1.80	96	0.029	100	100	37.0	0.17	289	79	78	74	0.044	0.00	8.39

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(%)
28	4.459	4.439		0.16	0.16	1.27	1.07	0.34	80	80	72	2.69	1.80	96	0.028	101	101	36.8	0.19	288	79	78	74	0.044	0.00	8.14
29	4.620	4.598		0.16	0.16	1.27	1.07	0.34	81	81	72	2.71	1.80	96	0.027	103	103	36.9	-0.09	288	80	78	74	0.043	0.00	8.08
30	4.782	4.758		0.16	0.16	1.27	1.06	0.34	81	81	72	2.69	1.80	96	0.028	102	101	36.2	0.72	287	80	78	74	0.044	0.00	8.05
31	4.943	4.917		0.16	0.16	1.27	1.07	0.34	81	81	72	2.70	1.80	96	0.030	98	97	36.1	0.10	288	80	78	74	0.044	0.00	8.28
32	5.103	5.077		0.16	0.16	1.27	1.07	0.34	81	81	72	2.71	1.80	96	0.028	101	101	35.5	0.61	289	80	78	74	0.044	0.00	8.02
33	5.264	5.236		0.16	0.16	1.26	1.06	0.34	81	81	72	2.70	1.80	97	0.028	101	101	35.8	-0.32	289	80	78	74	0.044	0.00	8.09
34	5.425	5.395		0.16	0.16	1.27	1.07	0.34	81	81	72	2.71	1.80	97	0.028	101	101	35.1	0.70	290	80	78	74	0.045	0.00	8.13
35	5.587	5.556		0.16	0.16	1.27	1.07	0.34	82	82	72	2.70	1.80	97	0.028	102	102	35.3	-0.17	292	80	78	74	0.045	0.00	8.05
36	5.748	5.714		0.16	0.16	1.27	1.07	0.34	82	82	72	2.70	1.80	97	0.028	101	100	34.3	0.95	292	80	78	74	0.044	0.00	7.85
37	5.909	5.874		0.16	0.16	1.26	1.07	0.34	82	82	72	2.70	1.80	98	0.027	103	103	34.7	-0.38	294	80	78	74	0.046	0.00	7.60
38	6.070	6.034		0.16	0.16	1.27	1.07	0.34	82	82	72	2.70	1.80	98	0.027	103	103	34.0	0.74	294	80	79	74	0.045	0.00	7.41
39	6.231	6.192		0.16	0.16	1.27	1.07	0.34	82	82	72	2.70	1.90	98	0.028	101	100	33.6	0.36	295	80	79	74	0.045	0.01	7.19
40	6.392	6.352		0.16	0.16	1.26	1.06	0.34	82	82	72	2.70	1.80	98	0.028	101	101	33.7	-0.09	294	80	79	74	0.045	0.02	7.06
41	6.553	6.512		0.16	0.16	1.27	1.07	0.34	82	82	72	2.70	1.90	98	0.028	101	101	32.9	0.84	295	80	79	75	0.045	0.02	6.83
42	6.715	6.671		0.16	0.16	1.27	1.07	0.34	83	83	72	2.71	1.90	99	0.028	102	101	32.6	0.22	296	80	79	74	0.045	0.02	6.70
43	6.876	6.830		0.16	0.16	1.26	1.07	0.34	83	83	72	2.72	1.90	99	0.028	101	101	32.3	0.37	296	80	79	74	0.045	0.01	6.85
44	7.037	6.991		0.16	0.16	1.27	1.07	0.34	83	83	72	2.71	1.80	99	0.028	101	102	32.4	-0.17	297	80	79	74	0.046	0.02	6.90
45	7.198	7.150		0.16	0.16	1.27	1.06	0.34	83	83	72	2.72	1.90	99	0.029	99	99	32.0	0.45	298	80	79	74	0.046	0.06	6.70
46	7.359	7.309		0.16	0.16	1.27	1.07	0.34	83	83	72	2.71	1.90	100	0.030	98	97	32.1	-0.06	299	81	79	74	0.046	0.10	6.57
47	7.521	7.469		0.16	0.16	1.27	1.06	0.34	83	83	72	2.70	1.80	100	0.028	102	101	31.6	0.45	300	81	79	74	0.045	0.08	6.59
48	7.683	7.628		0.16	0.16	1.27	1.06	0.34	83	83	72	2.70	1.90	100	0.030	99	97	31.7	-0.08	300	81	79	74	0.046	0.14	6.49
49	7.844	7.788		0.16	0.16	1.26	1.07	0.34	83	83	72	2.70	1.80	101	0.028	101	102	31.2	0.47	301	81	79	74	0.046	0.13	6.66
50	8.005	7.948		0.16	0.16	1.27	1.07	0.34	83	83	72	2.70	1.90	101	0.028	101	102	30.3	0.92	302	81	79	74	0.046	0.11	6.80
51	8.166	8.107		0.16	0.16	1.26	1.07	0.34	84	84	72	2.71	1.90	101	0.027	103	103	30.2	0.09	302	81	79	74	0.045	0.03	6.92
52	8.327	8.267		0.16	0.16	1.26	1.07	0.34	84	84	72	2.70	1.80	101	0.029	99	100	29.9	0.31	303	81	79	74	0.046	0.02	6.96
53	8.489	8.427		0.16	0.16	1.26	1.06	0.34	84	84	72	2.71	1.90	101	0.030	98	98	29.3	0.62	304	81	79	75	0.046	0.01	6.91
54	8.650	8.586		0.16	0.16	1.26	1.07	0.34	84	84	72	2.70	1.90	102	0.028	101	101	29.3	-0.08	305	81	79	74	0.046	0.01	6.86
55	8.811	8.746		0.16	0.16	1.26	1.07	0.34	84	84	72	2.70	1.90	102	0.028	101	101	29.5	-0.16	305	81	80	74	0.047	0.02	6.68
56	8.972	8.906		0.16	0.16	1.26	1.06	0.34	84	84	72	2.71	1.90	101	0.028	101	101	28.9	0.65	306	81	80	73	0.047	0.02	6.59
57	9.133	9.065		0.16	0.16	1.26	1.07	0.34	84	84	72	2.70	1.90	102	0.029	100	99	28.3	0.55	307	81	80	73	0.047	0.02	6.48
58	9.294	9.226		0.16	0.16	1.27	1.07	0.34	84	84	72	2.70	1.90	102	0.027	103	104	28.3	0.03	307	81	80	73	0.046	0.02	6.60
59	9.455	9.386		0.16	0.16	1.27	1.07	0.34	84	84	72	2.71	1.90	102	0.028	101	101	27.7	0.62	307	81	80	74	0.046	0.04	6.57
60	9.618	9.544		0.16	0.16	1.26	1.07	0.34	84	84	72	2.71	1.90	102	0.028	103	100	28.1	-0.44	307	81	80	74	0.046	0.07	6.40
61	9.778	9.705		0.16	0.16	1.28	1.06	0.34	84	84	72	3.13	1.90	102	0.027	103	104	27.1	1.00	307	76	80	74	0.046	0.06	6.55
62	9.941	9.865		0.16	0.16	1.28	1.07	0.34	84	85	72	3.11	1.90	101	0.028	103	101	27.5	-0.45	306	76	80	74	0.045	0.08	6.55
63	10.103	10.024		0.16	0.16	1.29	1.07	0.34	84	85	72	3.11	1.90	101	0.027	104	102	26.5	1.07	304	77	80	74	0.046	0.16	6.39
64	10.266	10.185		0.16	0.16	1.28	1.07	0.34	85	85	72	3.11	1.90	101	0.030	99	98	27.0	-0.49	303	77	80	74	0.046	0.19	6.15
65	10.429	10.344		0.16	0.16	1.28	1.06	0.34	85	85	72	3.12	1.90	101	0.027	104	102	26.0	1.00	302	77	80	74	0.046	0.17	6.11
66	10.592	10.504		0.16	0.16	1.29	1.07	0.34	85	85	72	3.11	1.90	101	0.028	102	101	26.2	-0.23	300	77	80	74	0.045	0.25	5.93
67	10.753	10.664		0.16	0.16	1.27	1.07	0.34	85	85	72	3.09	1.90	101	0.028	101	101	25.8	0.37	298	77	80	74	0.046	0.31	5.76
68	10.916	10.824		0.16	0.16	1.26	1.07	0.34	85	85	72	3.07	1.90	101	0.026	106	105	25.0	0.83	297	77	80	74	0.045	0.37	5.61
69	11.077	10.984		0.16	0.16	1.26	1.07	0.34	85	85	72	3.08	1.90	101	0.028	101	101	25.0	0.00	296	78	80	74	0.045	0.46	5.50
70	11.237	11.144		0.16	0.16	1.25	1.07	0.34	85	85	72	3.08	1.90	100	0.029	99	99	25.0	0.03	297	78	80	74	0.044	0.39	5.74
71	11.398	11.304		0.16	0.16	1.25	1.06	0.34	85	85	72	3.08	1.90	100	0.028	101	101	24.8	0.15	294	78	80	74	0.045	0.11	6.31
72	11.560	11.463		0.16	0.16	1.26	1.07	0.34	85	85	72	3.08	1.90	100	0.028	102	100	24.6	0.19	293	78	80	74	0.044	0.46	5.67

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(%)
73	11.721	11.624		0.16	0.16	1.26	1.07	0.34	85	85	72	3.07	1.90	100	0.029	99	100	23.7	0.91	293	78	80	74	0.045	0.39	5.72
74	11.883	11.784		0.16	0.16	1.26	1.06	0.34	85	85	72	3.08	1.90	100	0.028	102	101	24.3	-0.61	292	78	80	74	0.044	0.28	5.85
75	12.043	11.943		0.16	0.16	1.26	1.07	0.34	85	85	72	3.07	1.90	100	0.029	99	99	23.2	1.11	291	78	80	74	0.044	0.28	5.87
76	12.204	12.104		0.16	0.16	1.25	1.07	0.34	85	85	72	3.07	1.90	99	0.028	101	102	22.8	0.38	290	79	80	74	0.044	0.33	5.81
77	12.365	12.264		0.16	0.16	1.25	1.06	0.34	85	85	72	3.08	1.90	99	0.028	101	101	23.0	-0.18	288	79	80	74	0.044	0.37	5.63
78	12.526	12.423		0.16	0.16	1.26	1.07	0.34	85	85	72	3.07	1.90	99	0.029	99	99	23.1	-0.12	285	79	80	74	0.043	0.33	5.81
79	12.687	12.584		0.16	0.16	1.26	1.07	0.34	85	85	72	3.08	1.90	98	0.027	103	103	22.2	0.96	285	79	80	74	0.043	0.47	5.66
80	12.849	12.744		0.16	0.16	1.26	1.06	0.34	85	85	72	3.07	1.90	98	0.029	100	99	22.2	0.00	285	79	80	74	0.043	0.24	6.13
81	13.010	12.903		0.16	0.16	1.25	1.07	0.34	85	85	72	3.07	1.90	98	0.028	101	100	21.6	0.52	286	79	80	74	0.043	0.04	6.40
82	13.170	13.064		0.16	0.16	1.25	1.07	0.34	86	86	72	3.08	1.90	98	0.028	100	101	21.5	0.15	287	79	80	75	0.044	0.03	6.42
83	13.331	13.224		0.16	0.16	1.25	1.06	0.34	86	86	72	3.07	1.90	99	0.027	103	103	21.5	0.01	289	79	80	75	0.044	0.03	6.42
84	13.492	13.383		0.16	0.16	1.26	1.06	0.34	86	86	72	3.08	1.90	98	0.029	99	98	21.0	0.43	288	79	80	75	0.043	0.05	6.24
85	13.654	13.543		0.16	0.16	1.26	1.07	0.34	86	86	72	3.08	1.90	100	0.028	101	101	21.1	-0.01	296	79	80	75	0.044	0.06	6.64
86	13.815	13.704		0.16	0.16	1.26	1.06	0.34	86	86	72	3.07	1.90	99	0.029	99	100	20.6	0.45	294	79	80	75	0.043	0.00	6.84
87	13.976	13.863		0.16	0.16	1.25	1.07	0.34	86	86	72	3.08	1.90	98	0.028	101	100	20.2	0.44	291	80	80	75	0.043	0.00	6.75
88	14.137	14.023		0.16	0.16	1.25	1.07	0.34	86	86	72	3.08	1.90	98	0.028	101	101	19.9	0.21	289	80	80	75	0.043	0.00	6.90
89	14.297	14.184		0.16	0.16	1.26	1.07	0.34	86	86	72	3.08	1.90	98	0.028	100	101	20.0	-0.08	289	80	80	75	0.043	0.00	7.08
90	14.459	14.343		0.16	0.16	1.25	1.06	0.34	86	86	72	3.07	1.90	98	0.030	98	97	19.2	0.85	289	80	80	75	0.043	0.00	7.23
91	14.620	14.503		0.16	0.16	1.25	1.07	0.34	86	86	72	3.07	1.90	98	0.028	101	101	19.3	-0.08	287	80	80	75	0.043	0.00	7.28
92	14.782	14.664		0.16	0.16	1.26	1.07	0.34	86	86	72	3.09	1.90	97	0.029	99	100	18.9	0.38	284	80	80	75	0.042	0.00	7.27
93	14.943	14.823		0.16	0.16	1.25	1.07	0.34	86	86	72	3.08	1.90	96	0.029	99	98	18.9	-0.01	282	80	80	75	0.042	0.00	7.22
94	15.103	14.983		0.16	0.16	1.25	1.07	0.34	86	86	72	3.07	1.90	96	0.028	100	101	18.4	0.51	281	80	80	75	0.042	0.00	7.11
95	15.264	15.144		0.16	0.16	1.26	1.07	0.34	86	86	72	3.08	1.90	96	0.029	99	99	17.9	0.53	279	80	80	75	0.042	0.00	7.12
96	15.425	15.303		0.16	0.16	1.25	1.07	0.34	86	86	72	3.08	1.90	96	0.028	100	100	17.8	0.06	278	80	80	75	0.041	0.00	7.21
97	15.587	15.463		0.16	0.16	1.25	1.07	0.34	86	86	72	3.08	1.90	96	0.028	101	101	17.8	0.02	277	80	80	75	0.042	0.00	6.98
98	15.749	15.624		0.16	0.16	1.25	1.07	0.34	86	86	72	3.08	1.90	95	0.027	103	103	17.3	0.46	275	80	80	75	0.041	0.00	6.82
99	15.910	15.783		0.16	0.16	1.25	1.07	0.34	86	86	72	3.08	1.90	95	0.029	99	98	17.2	0.17	274	80	80	75	0.040	0.00	6.88
100	16.070	15.943		0.16	0.16	1.25	1.07	0.34	86	86	72	3.07	1.90	95	0.028	100	100	16.8	0.31	272	80	80	75	0.040	0.00	6.75
101	16.231	16.104		0.16	0.16	1.26	1.07	0.34	86	86	72	3.07	1.90	94	0.029	99	99	16.8	0.05	271	80	80	75	0.040	0.00	6.50
102	16.392	16.264		0.16	0.16	1.26	1.06	0.34	86	86	72	3.07	1.90	94	0.028	100	100	16.6	0.18	269	80	80	75	0.040	0.00	6.44
103	16.554	16.423		0.16	0.16	1.25	1.07	0.34	86	86	72	3.08	1.90	94	0.028	101	100	16.1	0.53	268	80	80	75	0.040	0.00	6.58
104	16.716	16.584		0.16	0.16	1.26	1.06	0.34	87	86	72	3.08	1.90	94	0.028	101	101	15.8	0.33	267	80	80	75	0.040	0.00	6.63
105	16.877	16.744		0.16	0.16	1.25	1.07	0.34	87	87	72	3.08	1.90	94	0.030	97	97	15.5	0.24	267	80	80	75	0.040	0.00	6.86
106	17.038	16.904		0.16	0.16	1.25	1.07	0.34	87	87	72	3.07	1.90	93	0.029	98	98	15.3	0.23	265	80	80	75	0.039	0.00	6.88
107	17.198	17.064		0.16	0.16	1.26	1.06	0.34	87	87	72	3.08	1.90	93	0.028	99	100	15.3	-0.02	263	80	80	75	0.039	0.00	6.94
108	17.360	17.224		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	93	0.028	101	100	15.2	0.11	263	80	80	75	0.039	0.00	7.12
109	17.522	17.384		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	93	0.028	101	100	15.0	0.17	262	80	80	75	0.039	0.00	6.79
110	17.683	17.545		0.16	0.16	1.26	1.06	0.34	87	87	72	3.07	1.90	93	0.029	98	99	14.8	0.19	262	80	80	75	0.039	0.00	6.56
111	17.844	17.704		0.16	0.16	1.25	1.06	0.34	87	87	72	3.08	1.90	93	0.028	100	99	14.7	0.12	262	80	80	75	0.039	0.00	6.40
112	18.005	17.864		0.16	0.16	1.25	1.07	0.34	87	87	72	3.08	1.90	93	0.029	98	98	14.3	0.43	261	80	80	75	0.039	0.00	6.27
113	18.166	18.025		0.16	0.16	1.26	1.06	0.34	87	87	72	3.07	1.90	93	0.029	98	99	14.2	0.12	261	80	80	75	0.039	0.01	6.13
114	18.327	18.184		0.16	0.16	1.25	1.07	0.34	87	87	72	3.06	1.90	93	0.030	97	96	13.6	0.54	260	80	80	75	0.039	0.01	6.28
115	18.489	18.344		0.16	0.16	1.26	1.06	0.34	87	87	72	3.07	1.90	93	0.029	99	98	13.6	0.03	260	80	80	75	0.039	0.01	6.23
116	18.651	18.505		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	93	0.029	99	99	13.5	0.13	263	80	80	75	0.039	0.00	6.73
117	18.812	18.664		0.16	0.16	1.25	1.06	0.34	87	87	72	3.08	1.90	93	0.028	100	99	13.4	0.07	261	80	80	75	0.039	0.00	6.70

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(%)
118	18.973	18.824		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	93	0.028	100	100	13.0	0.41	260	80	80	75	0.038	0.00	6.79
119	19.134	18.985		0.16	0.16	1.26	1.07	0.34	87	87	72	3.07	1.90	93	0.028	100	101	12.8	0.15	259	80	80	75	0.038	0.00	6.90
120	19.295	19.144		0.16	0.16	1.25	1.06	0.34	87	87	72	3.09	1.90	93	0.028	100	99	12.2	0.64	259	80	80	75	0.039	0.00	6.87
121	19.457	19.304		0.16	0.16	1.26	1.07	0.34	87	87	72	3.08	1.90	93	0.027	102	102	12.0	0.21	259	80	80	75	0.039	0.00	6.88
122	19.618	19.465		0.16	0.16	1.25	1.07	0.34	87	87	72	3.09	1.90	92	0.028	100	101	12.1	-0.14	259	80	80	75	0.039	0.00	6.68
123	19.780	19.624		0.16	0.16	1.25	1.06	0.34	87	87	72	3.08	1.90	92	0.028	101	99	12.0	0.15	258	80	80	75	0.038	0.00	6.51
124	19.940	19.784		0.16	0.16	1.25	1.07	0.34	87	87	72	3.09	1.90	92	0.029	98	98	11.4	0.54	258	80	80	75	0.038	0.00	6.42
125	20.101	19.944		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	92	0.029	98	98	11.4	0.04	257	80	80	75	0.039	0.00	6.25
126	20.262	20.104		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	92	0.029	98	98	11.3	0.06	256	80	79	75	0.039	0.00	6.22
127	20.424	20.264		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	92	0.029	99	98	10.8	0.48	255	80	79	75	0.038	0.00	6.14
128	20.585	20.424		0.16	0.16	1.25	1.07	0.34	87	87	72	3.06	1.90	92	0.028	100	100	10.7	0.19	255	80	80	75	0.039	0.01	5.99
129	20.746	20.584		0.16	0.16	1.24	1.06	0.34	87	87	72	3.06	1.90	92	0.028	100	100	11.3	-0.59	255	80	80	75	0.038	0.01	5.95
130	20.907	20.743		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	92	0.026	104	103	10.4	0.89	255	80	80	76	0.038	0.03	5.99
131	21.067	20.904		0.16	0.16	1.25	1.06	0.34	87	87	72	3.06	1.90	92	0.029	98	99	10.0	0.33	254	80	79	75	0.038	0.04	5.87
132	21.228	21.064		0.16	0.16	1.25	1.06	0.34	87	87	72	3.06	1.90	92	0.029	98	98	9.9	0.13	254	80	79	75	0.038	0.04	5.80
133	21.390	21.224		0.16	0.16	1.25	1.07	0.34	87	87	72	3.06	1.90	92	0.030	97	97	9.6	0.35	253	80	79	75	0.038	0.03	5.70
134	21.551	21.384		0.16	0.16	1.25	1.06	0.34	87	87	72	3.06	1.90	92	0.028	100	100	9.7	-0.13	253	80	79	75	0.037	0.04	5.51
135	21.712	21.544		0.16	0.16	1.24	1.06	0.34	87	87	72	3.06	1.90	92	0.029	98	98	9.5	0.22	252	80	79	75	0.037	0.03	5.59
136	21.873	21.703		0.16	0.16	1.24	1.06	0.34	87	87	72	3.06	1.90	92	0.027	102	101	9.3	0.14	252	80	79	75	0.038	0.04	5.47
137	22.034	21.864		0.16	0.16	1.25	1.06	0.34	87	87	72	3.08	1.90	92	0.027	102	102	9.0	0.35	252	80	79	75	0.038	0.05	5.38
138	22.195	22.024		0.16	0.16	1.25	1.06	0.34	87	87	72	3.06	1.90	92	0.029	98	98	9.0	-0.02	251	80	79	75	0.038	0.06	5.34
139	22.357	22.183		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	92	0.028	101	99	8.1	0.93	251	80	79	76	0.037	0.08	5.27
140	22.517	22.343		0.16	0.16	1.25	1.06	0.34	87	87	72	3.08	1.90	92	0.028	99	100	8.8	-0.72	251	80	79	75	0.037	0.06	5.41
141	22.678	22.504		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	93	0.028	100	101	8.3	0.50	255	80	79	75	0.038	0.04	5.50
142	22.839	22.663		0.16	0.16	1.25	1.06	0.34	87	87	72	3.08	1.90	92	0.029	98	98	7.9	0.37	255	80	79	76	0.038	0.00	5.91
143	23.000	22.823		0.16	0.16	1.25	1.06	0.34	87	87	72	3.07	1.90	92	0.028	100	100	8.0	-0.06	253	80	79	75	0.038	0.00	5.92
144	23.161	22.983		0.16	0.16	1.25	1.06	0.34	87	87	72	3.06	1.90	91	0.028	100	100	7.9	0.10	251	80	79	75	0.037	0.00	6.05
145	23.323	23.142		0.16	0.16	1.24	1.06	0.34	87	87	72	3.08	1.90	91	0.028	100	99	7.6	0.30	249	80	79	76	0.036	0.00	6.04
146	23.484	23.303		0.16	0.16	1.25	1.06	0.34	87	87	72	3.08	1.90	91	0.027	102	102	7.2	0.33	247	80	79	76	0.036	0.00	6.15
147	23.644	23.463		0.16	0.16	1.24	1.06	0.34	88	87	72	3.07	1.90	91	0.028	99	100	7.2	-0.02	245	80	79	76	0.036	0.01	5.91
148	23.805	23.622		0.16	0.16	1.25	1.06	0.34	88	87	72	3.08	1.90	91	0.027	101	101	7.2	0.05	245	80	79	76	0.036	0.01	5.89
149	23.966	23.782		0.16	0.16	1.25	1.06	0.34	88	88	72	3.08	1.90	91	0.029	98	98	6.8	0.38	245	80	79	75	0.036	0.03	5.82
150	24.127	23.942		0.16	0.16	1.25	1.06	0.34	88	88	72	3.08	1.90	91	0.027	101	102	6.3	0.51	244	80	79	75	0.036	0.04	5.63
151	24.289	24.101		0.16	0.16	1.24	1.06	0.34	88	88	72	3.08	1.90	91	0.029	98	97	6.3	-0.03	244	80	79	75	0.036	0.03	5.61
152	24.449	24.262		0.16	0.16	1.24	1.06	0.34	88	88	72	3.07	1.90	91	0.030	96	97	6.5	-0.16	243	80	79	75	0.036	0.03	5.54
153	24.610	24.421		0.16	0.16	1.24	1.05	0.34	88	88	72	3.06	1.90	90	0.027	101	101	5.8	0.71	243	80	79	75	0.035	0.06	5.38
154	24.771	24.580		0.16	0.16	1.24	1.06	0.34	88	88	72	3.07	1.90	90	0.027	101	101	5.8	0.00	243	80	79	75	0.036	0.07	5.11
155	24.932	24.741		0.16	0.16	1.25	1.06	0.34	88	88	72	3.08	1.90	91	0.030	96	97	5.5	0.32	243	80	79	75	0.037	0.07	4.97
156	25.094	24.901		0.16	0.16	1.25	1.06	0.34	88	88	72	3.06	1.90	91	0.029	98	98	5.9	-0.38	243	79	79	76	0.036	0.08	4.84
157	25.254	25.060		0.16	0.16	1.24	1.06	0.34	88	88	72	3.08	1.90	91	0.029	97	97	5.0	0.85	242	80	79	76	0.036	0.09	4.73
158	25.415	25.220		0.16	0.16	1.24	1.06	0.34	88	88	72	3.07	1.90	90	0.028	100	100	5.1	-0.07	242	79	79	75	0.036	0.11	4.62
159	25.576	25.380		0.16	0.16	1.25	1.06	0.34	88	88	72	3.07	1.90	90	0.028	100	100	5.4	-0.33	242	79	79	75	0.036	0.13	4.59
160	25.737	25.539		0.16	0.16	1.24	1.06	0.34	88	88	72	3.08	1.90	90	0.028	100	99	5.0	0.44	241	79	79	76	0.036	0.15	4.46
161	25.898	25.700		0.16	0.16	1.25	1.06	0.34	88	88	72	3.07	1.90	90	0.029	98	99	4.5	0.42	241	80	79	75	0.035	0.18	4.27
162	26.060	25.859		0.16	0.16	1.24	1.05	0.34	88	88	72	3.08	1.90	90	0.027	102	101	4.4	0.16	240	79	79	76	0.036	0.21	4.09

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(%)
163	26.221	26.018		0.16	0.16	1.25	1.06	0.34	88	88	72	3.08	1.90	91	0.029	98	97	4.3	0.07	240	79	79	76	0.036	0.23	4.02
164	26.381	26.179		0.16	0.16	1.24	1.05	0.34	88	88	72	3.07	1.90	91	0.029	97	99	4.0	0.35	239	79	79	75	0.036	0.34	3.82
165	26.542	26.338		0.16	0.16	1.24	1.06	0.34	88	88	72	3.08	1.90	91	0.029	98	97	3.6	0.31	239	79	79	75	0.036	0.37	3.68
166	26.703	26.498		0.16	0.16	1.25	1.06	0.34	88	88	72	3.07	1.90	91	0.028	100	100	3.8	-0.15	239	79	79	75	0.036	0.35	3.49
167	26.864	26.658		0.16	0.16	1.24	1.06	0.34	88	88	72	3.09	1.90	91	0.028	100	100	4.0	-0.22	239	79	79	76	0.036	0.33	3.44
168	27.026	26.817		0.16	0.16	1.24	1.06	0.34	88	88	72	3.07	1.90	91	0.028	100	99	3.9	0.15	240	79	79	76	0.036	0.32	3.38
169	27.187	26.976		0.16	0.16	1.24	1.06	0.34	88	88	72	3.09	1.90	91	0.028	100	99	3.8	0.11	239	79	79	75	0.036	0.33	3.28
170	27.347	27.137		0.16	0.16	1.24	1.05	0.34	88	88	72	3.07	1.90	91	0.027	101	102	3.4	0.38	239	79	79	75	0.036	0.32	3.23
171	27.508	27.296		0.16	0.16	1.24	1.05	0.34	88	88	72	3.08	1.90	91	0.028	100	99	3.4	-0.05	239	79	79	75	0.036	0.35	3.32
172	27.669	27.455		0.16	0.16	1.24	1.06	0.34	88	88	72	3.09	1.90	91	0.028	100	99	2.9	0.52	240	79	79	76	0.036	0.34	3.25
173	27.830	27.615		0.16	0.16	1.24	1.05	0.34	88	88	72	3.09	1.90	91	0.028	100	100	3.1	-0.20	241	80	79	75	0.036	0.33	3.27
174	27.991	27.774		0.16	0.16	1.24	1.05	0.34	88	88	72	3.09	1.90	91	0.030	96	96	3.3	-0.15	241	79	79	75	0.036	0.30	3.24
175	28.152	27.934		0.16	0.16	1.24	1.06	0.34	88	88	72	3.08	1.90	91	0.027	101	102	2.8	0.49	241	79	79	74	0.036	0.26	3.27
176	28.312	28.094		0.16	0.16	1.24	1.05	0.34	88	88	72	3.07	1.90	91	0.029	97	98	2.4	0.37	241	79	79	74	0.036	0.27	3.21
177	28.473	28.253		0.16	0.16	1.24	1.05	0.34	88	88	72	3.06	1.90	91	0.028	100	99	2.3	0.13	242	79	79	74	0.036	0.28	3.21
178	28.633	28.412		0.16	0.16	1.24	1.05	0.34	88	88	72	3.07	1.90	91	0.028	99	99	2.3	-0.08	242	79	79	74	0.036	0.24	3.23
179	28.794	28.572		0.16	0.16	1.23	1.05	0.34	88	88	72	3.06	1.90	91	0.027	101	102	2.2	0.14	242	79	79	75	0.036	0.22	3.12
180	28.954	28.731		0.16	0.16	1.23	1.05	0.34	88	88	72	3.08	1.90	91	0.030	96	96	2.0	0.22	242	79	79	75	0.036	0.23	3.03
181	29.114	28.891		0.16	0.16	1.23	1.05	0.34	88	88	72	3.08	1.90	91	0.028	99	100	1.8	0.16	242	79	79	75	0.036	0.24	2.86
182	29.275	29.051		0.16	0.16	1.23	1.05	0.34	88	88	72	3.08	1.90	91	0.029	98	98	1.5	0.34	241	79	79	75	0.036	0.27	2.86
183	29.435	29.209		0.16	0.16	1.23	1.06	0.34	88	88	72	3.07	1.90	91	0.029	97	97	1.5	0.01	241	79	79	75	0.036	0.26	2.73
184	29.596	29.370		0.16	0.16	1.24	1.06	0.34	88	88	72	3.07	1.90	91	0.028	100	100	1.3	0.18	240	79	79	75	0.036	0.26	2.70
185	29.757	29.530		0.16	0.16	1.23	1.05	0.34	88	88	72	3.06	1.90	92	0.028	100	100	1.3	-0.04	240	79	79	75	0.036	0.25	2.62
186	29.917	29.689		0.16	0.16	1.23	1.06	0.34	88	88	72	3.07	1.90	92	0.027	101	101	1.2	0.13	241	79	79	75	0.036	0.25	2.57
187	30.077	29.849		0.16	0.16	1.24	1.06	0.34	88	88	72	3.05	1.90	92	0.028	99	100	1.3	-0.07	242	79	79	75	0.036	0.24	2.54
188	30.238	30.009		0.16	0.16	1.23	1.06	0.34	88	88	72	3.06	1.90	92	0.030	96	96	0.9	0.35	243	79	79	75	0.036	0.28	2.68
189	30.399	30.169		0.16	0.16	1.23	1.06	0.34	88	88	72	3.06	1.90	92	0.029	98	98	0.7	0.19	243	79	79	75	0.036	0.30	2.77
190	30.560	30.329		0.16	0.16	1.24	1.06	0.34	88	88	72	3.05	1.90	92	0.028	100	100	0.0	0.70	243	79	79	75	0.036	0.30	2.79
191	30.720	30.489	44.350	0.16	0.16	1.23	1.05	0.34	88	88	72	3.06	1.90	92	0.028	99	100	0.0	0.06	243	79	79	76	0.037	0.28	2.69
	30.720	30.489	44.350			1.25	1.06	0.34	85	85	72			95	0.028						79.34	78.98		0.041	0.09	6.16

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

Run: 4

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Test Date: 6/16/2022
Technician: TT / KM
Beginning Clock Time: 15:07
Recording Interval: 1 min.
Total Sampling Time: 191 min.

Boiler Dry Weight (lbs): 1471.6
Boiler Water Weight (lbs): 274.5
Tank Weight (lbs): 736
Tank Water Weight (lbs): 3145
Initial Average Tank Temp (°F): 130.1
Final Average Tank Temp (°F): 157.3
Initial Average Heater Temp (°F 167.5
Final Average Heater Temp (°F 172.8

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
0	1.37	61	138	77	1.0012	8.3303	11.393	872	121	134	13	135	126	194	141
1	1.38	61	131	70	1.0012	8.3303	11.469	807	120	133	13	134	125	194	140
2	1.35	61	130	69	1.0012	8.3303	11.255	774	120	133	13	134	126	194	140
3	1.27	61	131	69	1.0012	8.3302	10.609	735	121	134	13	134	126	193	141
4	1.27	61	131	70	1.0012	8.3302	10.559	735	121	134	13	134	127	193	141
5	1.27	61	131	69	1.0012	8.3302	10.543	730	121	133	12	133	127	193	141
6	1.28	61	129	68	1.0012	8.3301	10.666	722	121	130	9	131	127	194	140
7	1.38	61	128	66	1.0012	8.3301	11.494	761	121	130	9	130	127	194	139
8	1.43	61	126	65	1.0012	8.3302	11.904	775	121	130	9	131	127	195	140
9	1.47	61	126	65	1.0012	8.3301	12.238	790	121	129	9	130	127	194	139
10	1.48	61	126	65	1.0012	8.3301	12.345	802	121	130	9	131	127	193	140
11	1.48	61	126	65	1.0012	8.3301	12.367	805	121	133	13	134	127	193	141
12	1.48	61	128	67	1.0012	8.3301	12.356	826	121	134	13	134	127	193	141
13	1.48	61	129	67	1.0012	8.3301	12.367	832	121	134	13	134	127	193	141
14	1.48	61	129	67	1.0012	8.3301	12.354	834	121	134	13	134	127	193	141
15	1.48	61	129	68	1.0012	8.3301	12.357	834	121	134	13	134	127	193	141
16	1.46	61	129	68	1.0012	8.3301	12.127	822	121	134	13	134	127	193	141
17	1.47	61	129	68	1.0012	8.3301	12.244	829	121	131	10	134	127	192	140
18	1.49	61	127	66	1.0012	8.3301	12.379	812	121	131	10	131	128	194	140
19	1.49	61	127	65	1.0012	8.3301	12.382	807	122	133	11	133	129	193	140
20	1.49	61	128	66	1.0012	8.3301	12.392	822	123	132	9	132	130	193	140
21	1.49	61	127	66	1.0012	8.3301	12.396	819	123	134	11	134	130	192	140
22	1.49	61	129	67	1.0012	8.3301	12.400	832	123	135	11	135	131	192	141
23	1.49	61	129	68	1.0012	8.3301	12.402	844	124	135	12	136	131	192	141
24	1.49	61	130	69	1.0012	8.3302	12.380	854	124	136	12	137	131	192	142
25	1.49	61	131	70	1.0012	8.3302	12.397	864	124	136	12	137	131	193	142
26	1.49	61	131	70	1.0012	8.3302	12.387	867	124	137	12	137	131	193	142
27	1.48	61	132	70	1.0012	8.3302	12.307	865	124	137	12	137	131	193	142
28	1.43	61	132	71	1.0012	8.3302	11.904	844	125	137	12	138	131	193	143
29	1.43	61	132	71	1.0012	8.3302	11.920	848	125	137	12	138	132	193	143
30	1.41	61	133	71	1.0012	8.3302	11.716	837	125	137	12	138	132	192	143
31	1.38	61	133	72	1.0012	8.3301	11.517	825	125	137	11	137	132	193	142
32	1.38	61	133	72	1.0012	8.3301	11.495	822	126	137	12	138	132	192	142
33	1.38	61	133	72	1.0012	8.3301	11.486	826	126	138	12	138	132	192	142
34	1.38	61	134	72	1.0012	8.3300	11.488	831	126	138	12	139	132	192	142
35	1.38	62	134	73	1.0012	8.3300	11.479	833	126	138	12	139	132	192	142
36	1.34	62	134	73	1.0012	8.3300	11.144	812	126	138	12	139	132	193	142
37	1.35	62	135	73	1.0012	8.3299	11.222	822	126	138	11	139	132	193	141
38	1.38	62	134	73	1.0012	8.3299	11.474	834	126	138	12	139	133	193	142
39	1.38	62	135	73	1.0012	8.3299	11.468	837	126	139	12	139	133	193	143
40	1.38	62	135	73	1.0012	8.3299	11.464	837	126	139	12	139	133	193	142
41	1.38	62	135	73	1.0012	8.3298	11.474	839	127	139	12	140	133	193	143
42	1.38	62	135	73	1.0012	8.3298	11.458	841	127	139	12	140	133	193	143
43	1.38	62	135	74	1.0012	8.3298	11.461	843	127	139	12	140	134	193	143
44	1.38	62	135	74	1.0012	8.3299	11.461	846	127	140	12	140	134	194	143

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
45	1.38	62	136	74	1.0012	8.3300	11.472	850	128	140	12	141	135	193	143
46	1.35	61	136	75	1.0012	8.3300	11.205	835	128	140	12	141	135	194	143
47	1.37	61	136	75	1.0012	8.3300	11.376	853	128	140	12	141	135	194	143
48	1.37	61	136	75	1.0012	8.3301	11.446	858	128	141	12	141	135	194	143
49	1.37	61	137	75	1.0012	8.3300	11.440	861	129	141	12	141	135	194	143
50	1.33	61	137	76	1.0012	8.3301	11.052	837	129	141	12	142	136	194	144
51	1.31	61	138	76	1.0012	8.3301	10.939	835	129	142	12	142	136	195	144
52	1.31	61	138	77	1.0012	8.3300	10.934	839	130	142	12	143	136	195	144
53	1.31	61	138	77	1.0012	8.3300	10.927	841	130	142	12	143	136	195	144
54	1.31	62	139	77	1.0012	8.3300	10.930	843	130	142	12	143	137	195	144
55	1.31	62	139	77	1.0012	8.3300	10.930	846	130	143	12	143	137	195	144
56	1.31	62	139	78	1.0012	8.3299	10.929	847	130	143	12	144	137	196	144
57	1.31	62	139	78	1.0012	8.3299	10.926	849	131	142	12	144	137	196	144
58	1.30	62	138	77	1.0012	8.3299	10.848	834	131	143	13	144	138	197	144
59	1.29	62	140	78	1.0012	8.3299	10.743	841	131	144	13	144	138	197	145
60	1.29	62	140	79	1.0012	8.3299	10.737	844	131	144	13	145	138	197	145
61	1.29	62	140	79	1.0012	8.3299	10.729	846	131	144	13	145	138	198	145
62	1.29	62	141	79	1.0012	8.3299	10.728	850	132	145	13	145	138	198	145
63	1.28	62	141	79	1.0012	8.3299	10.686	849	132	145	13	145	138	198	145
64	1.28	62	141	80	1.0012	8.3299	10.688	853	132	145	13	146	139	198	145
65	1.25	62	142	80	1.0012	8.3298	10.387	829	132	145	13	146	139	199	145
66	1.24	62	142	80	1.0012	8.3298	10.345	832	133	146	13	146	139	199	145
67	1.24	62	143	81	1.0012	8.3298	10.319	834	133	146	13	146	139	199	145
68	1.24	62	143	81	1.0012	8.3297	10.304	836	133	146	13	147	140	198	145
69	1.24	62	143	81	1.0012	8.3297	10.310	838	133	146	13	147	140	198	145
70	1.24	62	143	81	1.0012	8.3297	10.293	837	133	146	13	147	140	197	145
71	1.24	62	143	81	1.0012	8.3297	10.311	839	134	147	13	147	141	197	145
72	1.24	62	143	82	1.0012	8.3296	10.298	841	134	146	12	147	140	197	144
73	1.24	62	143	81	1.0012	8.3297	10.299	833	134	146	12	147	141	197	144
74	1.24	62	143	81	1.0012	8.3297	10.306	837	134	146	12	147	141	195	145
75	1.24	62	143	81	1.0012	8.3296	10.289	836	135	147	12	147	141	195	145
76	1.24	62	143	82	1.0012	8.3296	10.289	839	135	147	12	147	141	196	145
77	1.24	62	143	82	1.0012	8.3296	10.294	839	135	147	12	147	142	197	145
78	1.24	62	144	82	1.0012	8.3297	10.291	843	135	147	12	148	142	196	145
79	1.23	62	144	83	1.0012	8.3295	10.280	848	135	148	12	148	142	196	145
80	1.24	62	145	83	1.0012	8.3296	10.298	853	136	148	12	148	143	196	145
81	1.18	62	145	83	1.0012	8.3296	9.798	816	136	148	12	148	143	196	146
82	1.16	62	145	83	1.0012	8.3296	9.671	806	136	149	12	149	143	196	146

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
83	1.19	62	145	83	1.0012	8.3295	9.920	828	137	149	12	149	143	197	146
84	1.20	62	145	83	1.0012	8.3295	9.994	831	137	149	12	149	144	196	146
85	1.20	62	145	83	1.0012	8.3295	9.986	832	137	149	12	149	144	197	146
86	1.20	62	146	84	1.0012	8.3295	9.983	839	137	149	12	150	144	196	146
87	1.17	62	146	84	1.0012	8.3294	9.772	825	138	150	12	150	144	196	146
88	1.19	62	147	85	1.0012	8.3294	9.921	842	138	150	12	151	144	196	146
89	1.20	62	147	85	1.0012	8.3294	9.983	849	138	150	12	151	145	196	146
90	1.18	62	147	85	1.0012	8.3294	9.862	840	138	150	12	151	145	197	146
91	1.18	62	147	85	1.0012	8.3293	9.793	835	138	151	12	151	145	197	147
92	1.17	62	148	86	1.0012	8.3293	9.722	833	139	151	12	151	145	197	147
93	1.14	62	148	86	1.0012	8.3293	9.504	818	139	151	12	152	145	197	147
94	1.14	62	148	86	1.0012	8.3293	9.518	821	139	151	12	152	146	197	147
95	1.14	62	149	86	1.0012	8.3292	9.524	823	139	151	12	151	146	197	145
96	1.14	62	148	86	1.0012	8.3293	9.521	821	139	151	12	152	146	197	146
97	1.14	62	149	87	1.0012	8.3293	9.518	825	139	151	12	152	146	197	146
98	1.14	62	149	87	1.0012	8.3293	9.516	827	140	152	12	152	147	197	147
99	1.14	62	149	87	1.0012	8.3293	9.536	831	140	152	12	152	146	197	147
100	1.16	62	149	87	1.0012	8.3293	9.622	838	140	151	11	152	147	196	145
101	1.16	62	149	87	1.0012	8.3292	9.681	841	140	152	12	153	147	196	147
102	1.12	62	149	87	1.0012	8.3292	9.328	813	140	152	11	152	147	197	146
103	1.16	62	149	87	1.0012	8.3292	9.658	840	140	152	12	153	147	196	147
104	1.16	62	150	87	1.0012	8.3292	9.626	841	141	153	12	153	148	196	147
105	1.16	62	150	88	1.0012	8.3291	9.654	846	141	153	12	153	148	195	147
106	1.16	62	150	88	1.0012	8.3291	9.636	846	141	153	12	154	148	195	147
107	1.16	62	150	88	1.0012	8.3292	9.627	846	141	152	11	153	148	195	145
108	1.16	62	150	87	1.0012	8.3291	9.625	842	141	153	12	154	148	195	147
109	1.16	62	150	88	1.0012	8.3290	9.629	847	142	153	12	154	149	194	147
110	1.16	62	151	88	1.0012	8.3291	9.630	849	142	153	11	153	149	195	146
111	1.16	62	150	88	1.0012	8.3291	9.624	848	142	154	11	154	149	194	147
112	1.16	62	151	88	1.0012	8.3291	9.636	853	142	153	11	152	149	195	146
113	1.13	62	150	88	1.0012	8.3291	9.445	833	143	154	11	153	150	195	147
114	1.13	62	150	88	1.0012	8.3292	9.407	829	143	154	11	154	150	194	147
115	1.13	62	151	89	1.0012	8.3291	9.417	836	143	153	10	153	150	194	146
116	1.13	62	151	88	1.0012	8.3290	9.410	830	143	154	11	154	150	194	147
117	1.13	62	151	89	1.0012	8.3291	9.404	836	143	155	11	155	150	194	148
118	1.13	62	151	89	1.0012	8.3290	9.399	837	144	155	11	155	151	194	148
119	1.13	62	152	89	1.0012	8.3290	9.427	842	144	155	11	155	151	194	148
120	1.13	62	152	90	1.0012	8.3290	9.400	842	144	155	11	155	151	194	148
121	1.13	62	152	89	1.0012	8.3290	9.396	840	144	155	11	156	151	194	148
122	1.13	62	152	90	1.0012	8.3289	9.409	846	144	155	10	154	151	195	147
123	1.13	62	152	89	1.0012	8.3289	9.409	840	144	155	11	156	152	194	148
124	1.13	62	152	90	1.0012	8.3289	9.397	845	144	156	11	156	152	194	148
125	1.13	62	153	90	1.0012	8.3289	9.401	848	145	155	10	155	152	194	148
126	1.13	63	153	90	1.0012	8.3288	9.387	848	145	156	11	156	152	195	148
127	1.13	63	153	90	1.0012	8.3288	9.372	847	145	156	11	156	152	194	148
128	1.13	63	153	90	1.0012	8.3288	9.386	849	145	156	11	157	152	194	149
129	1.13	63	153	90	1.0012	8.3288	9.376	848	145	156	11	156	152	195	148
130	1.13	63	153	90	1.0012	8.3287	9.378	849	145	156	11	156	152	196	148
131	1.13	63	153	90	1.0012	8.3287	9.373	847	145	154	8	155	153	195	147
132	1.13	63	153	90	1.0012	8.3287	9.390	845	146	156	10	157	153	194	149
133	1.12	63	153	90	1.0012	8.3286	9.367	843	146	157	11	157	153	194	149
134	1.12	63	154	91	1.0012	8.3286	9.366	851	146	156	10	156	153	195	148
135	1.13	63	153	91	1.0012	8.3286	9.372	849	146	157	11	157	153	194	149
136	1.12	63	153	91	1.0012	8.3287	9.362	848	146	157	11	157	153	195	148
137	1.12	63	154	91	1.0012	8.3286	9.358	851	146	156	10	157	153	195	148
138	1.12	63	154	91	1.0012	8.3287	9.365	851	146	157	10	157	154	194	149
139	1.12	63	153	91	1.0012	8.3287	9.369	849	146	157	10	157	154	194	150

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
140	1.12	63	154	91	1.0012	8.3287	9.360	850	147	157	11	158	154	194	149
141	1.11	63	154	92	1.0012	8.3286	9.245	846	147	157	10	157	154	194	149
142	1.11	63	154	92	1.0012	8.3286	9.220	844	147	157	10	158	154	195	149
143	1.11	62.7	154.8	92	1.0012	8.3286	9.222	849	147	157	10	158	154	195	149
144	1.11	62.8	154.8	92	1.0012	8.3286	9.212	848	147	158	10	158	154	194	150
145	1.11	62.8	155.3	92	1.0012	8.3286	9.215	852	147	158	10	158	155	195	148
146	1.10	62.8	155.1	92	1.0012	8.3285	9.192	848	147	158	10	158	155	195	150
147	1.09	62.8	155.4	93	1.0012	8.3286	9.057	839	148	158	11	159	155	194	150
148	1.09	62.8	155.8	93	1.0012	8.3286	9.055	842	148	158	10	158	155	195	149
149	1.09	62.8	155.6	93	1.0012	8.3285	9.047	839	148	158	10	159	155	195	149
150	1.09	62.9	155.8	93	1.0012	8.3285	9.050	840	148	158	10	159	155	195	150
151	1.09	62.8	155.9	93	1.0012	8.3286	9.047	842	148	159	11	159	155	194	151
152	1.09	62.9	156.0	93	1.0012	8.3285	9.046	842	148	158	10	159	155	195	149
153	1.09	62.9	155.8	93	1.0012	8.3285	9.048	840	148	156	8	158	155	194	149
154	1.09	62.9	155.2	92	1.0012	8.3285	9.046	835	148	159	10	159	155	195	151
155	1.09	62.9	155.5	93	1.0012	8.3285	9.045	837	148	157	8	158	156	195	149
156	1.08	62.9	155.1	92	1.0012	8.3285	9.036	833	149	158	9	159	156	194	150
157	1.09	62.9	155.6	93	1.0012	8.3285	9.042	838	149	157	9	158	156	194	150
158	1.09	62.9	155.6	93	1.0012	8.3285	9.038	838	149	159	10	159	156	194	150
159	1.09	62.9	155.9	93	1.0012	8.3285	9.052	842	149	158	10	159	156	194	150
160	1.09	62.9	156.1	93	1.0012	8.3285	9.041	843	149	159	10	159	156	195	151
161	1.09	62.9	156.2	93	1.0012	8.3284	9.040	843	149	159	10	159	156	195	150
162	1.09	63.0	156.1	93	1.0012	8.3284	9.042	842	149	159	10	159	157	194	151
163	1.09	63.0	155.6	93	1.0012	8.3284	9.043	838	149	159	9	159	157	194	150
164	1.09	63.0	156.2	93	1.0012	8.3284	9.052	844	150	157	7	158	157	194	151
165	1.09	63.0	155.5	93	1.0012	8.3284	9.053	838	150	158	8	159	157	194	150
166	1.09	63.0	155.4	92	1.0012	8.3284	9.045	836	150	158	9	160	157	194	150
167	1.09	63.0	155.8	93	1.0012	8.3284	9.042	839	150	158	8	158	157	195	150
168	1.09	63.0	155.8	93	1.0012	8.3284	9.045	839	150	159	9	159	157	194	150
169	1.09	63.0	156.2	93	1.0012	8.3284	9.050	843	150	159	9	159	157	196	150
170	1.09	63.0	156.0	93	1.0012	8.3284	9.048	842	150	158	8	159	158	195	150
171	1.08	63.0	156.2	93	1.0012	8.3283	9.026	841	150	159	9	160	158	194	151
172	1.07	63.0	156.3	93	1.0012	8.3284	8.871	827	150	159	9	160	158	194	151
173	1.07	63.0	156.2	93	1.0012	8.3283	8.921	831	150	160	9	160	158	194	151
174	1.09	63.0	156.7	94	1.0012	8.3283	9.067	849	150	158	8	158	158	195	150
175	1.09	63.0	156.1	93	1.0012	8.3283	9.064	843	150	159	9	159	158	194	151
176	1.09	63.1	156.3	93	1.0012	8.3283	9.069	846	151	157	7	159	158	194	151
177	1.09	63.0	155.8	93	1.0012	8.3283	9.076	842	151	160	9	160	158	194	151
178	1.09	63.0	156.4	93	1.0012	8.3283	9.060	845	151	160	9	159	158	194	151
179	1.07	63.0	156.6	94	1.0012	8.3283	8.944	836	151	159	8	159	158	194	151
180	1.09	63.1	156.1	93	1.0012	8.3283	9.039	841	151	160	9	160	158	194	151
181	1.07	63.0	156.7	94	1.0012	8.3283	8.909	834	151	160	9	161	158	194	151
182	1.08	63.0	156.4	93	1.0012	8.3284	9.013	842	151	160	9	160	158	193	152
183	1.09	62.9	156.9	94	1.0012	8.3285	9.072	853	151	160	9	160	158	194	151
184	1.09	62.9	156.8	94	1.0012	8.3285	9.066	851	151	159	8	159	158	194	151
185	1.09	62.9	156.7	94	1.0012	8.3285	9.065	850	151	159	8	160	158	193	151
186	1.09	62.9	156.1	93	1.0012	8.3285	9.067	845	151	160	9	159	158	194	151
187	1.09	62.9	156.5	94	1.0012	8.3285	9.071	849	151	159	8	159	159	195	151
188	1.09	62.9	156.1	93	1.0012	8.3285	9.068	845	151	159	8	159	159	194	151
189	1.09	62.9	156.1	93	1.0012	8.3285	9.057	844	151	160	9	161	159	194	152
190	1.09	62.9	156.7	94	1.0012	8.3285	9.062	850	151	159	8	159	159	195	151
191	1.08	62.9	156.5	94	1.0012	8.3285	8.975	840	151	159	8	159	159	195	151
	1.22	62.14	145.4	83.3	1.0012	8.3293	10.1541	160441.2	137.6	148.7	11.0	149.2	144.5	194.7	146.1

Elapsed Time	HEX Load Side								HEX Appliance Side			Partial Thermal Storage Tank		Appliance Temperature	
	Water Flow Rate, Gal / Min.	HE In, °F (T3)	HE Out, °F (T4)	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F (T11)	HE Out, °F (T10)	Delta-T	Top, °F	Bottom, °F	Out	In
Elapsed Time	Water Flow Rate, Gal / Min.	HE In, °F	HE Out, °F	Delta-T	cp_i	σ_i	Mass Flow-rate of H_2O, lb/min	Heat Output, Btu	HE In, °F	HE Out, °F	Delta-T	Top, °F	Bottom, °F		

Flow Meter Calibration Check

Manufacturer: Froling Date: 6/16/2022
Appliance: S3 Turbo 30 Run Number: 4
Project Number: 0456WB009E

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)	Accuracy, %
1.084	60.7	15.9	998.981	8.337	12.5	1.384	1.389	Preburn	100.4%
1.135	61.8	16.6	998.880	8.336	11.6	1.226	1.237	72	100.9%
1.241	63	17.2	998.765	8.335	11.2	1.083	1.086	185	100.2%

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Test Method ASTM E2515-11
Lab Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run #: 4
Date: 6/16/22

Equipment Numbers:

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	E723	122.3	121.9	0.4
C. Rear filter catch	Filter	E724	120.6	121.3	-0.7
D. Probe catch*	Probe	OES 4	114148.0	114147.7	0.3
E. Filter seals catch*	Seals	S354	4118.9	4117.5	1.4

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	E725	122.6	121.6	1.0
C. Rear filter catch	Filter	E726	121.4	121.3	0.1
D. Probe catch*	Probe	70	116833.7	116833.4	0.3
E. Filter seals catch*	Seals	S356	3374.9	3374.5	0.4

Sub-Total Total Particulate, mg: 1.8

Train 1 Aggregate Total Particulate, mg: **3.2**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	E727	123.7	121.5	2.2
B. Rear filter catch	Filter	E728	120.9	121.0	-0.1
C. Probe catch*	Probe	78	117459.5	117459.1	0.4
D. Filter seals catch*	Seals	S355	3340.7	3340.2	0.5

Total Particulate, mg: 3.0

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter	E729	121.8	121.8	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 E2780 Wood Heater Run Sheets**

Client: Froling GmbH Project Number: 0456WB009E Run Number: 4

Model: Froling S3 Turbo 30 Tracking Number: 2448 Date: 06/16/2022

Test Crew: T. Tong

OMNI Equipment ID numbers: 00637, 00209, 00283A

ASTM E2515 Lab Sheet

Assembled By:

Tony Tong

Date/Time in Dessicator:

06/16/2022, 18:30

	Weighing #1	Weighing #2	Weighing #3	Weighing #4	Weighing #5
Date/Time:	06/20/22 9:30	06/21/22 10:45	06/23/22 7:40	06/23/22 14:45	
R/H %:	18.6	16.0	8.3	7.4	
Temp:	70.8	72.1	73.9	75.9	
200 mg Audit:	200.1	200.1	200.1	200.0	
2 g Audit:	2000.3	2000.3	2000.3	2000.4	
100 g Audit	99998.0	99998.0	99998.0	99998.0	
Initials:	TT	TT	TT	TT	

Train	Element	ID #	Tare (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)	Weight (mg)
A (First Hour)	Front Filter	E723	121.9	122.3	122.3			
	Rear Filter	E724	121.3	120.6	120.6			
	Probe	OES4	114147.7	114148.0	114148.0			
	O-Ring Set	S354	4117.5	4118.9	4118.9			
A (Remainder)	Front Filter	E725	121.6	122.7	122.6			
	Rear Filter	E726	121.3	121.4	121.4			
	Probe	70	116833.4	116833.8	116833.7			
	O-Ring Set	S356	3374.5	3375.6	3375.3	3374.8	3374.9	
B	Front Filter	E727	121.5	123.7	123.7			
	Rear Filter	E728	121.0	120.8	120.9			
	Probe	78	117459.1	117459.5	117459.5			
	O-Ring Set	S355	3340.2	3341.5	3341.2	3340.6	3340.7	
BG	Filter	E729	121.8	121.9	121.8			

Technician Signature: Tony Tong Date: 06/28/2022

Tare Sheet: (check one) Probes_____ 47mm Filters✓ 100mm Filters_____ O-Ring Pair_____

Prepared By: Tony Tong Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 00283A 1 200mg

Placed in Dessicator: Date: 05/10/22 Time: 10:38 ID #	Date: 06/08/22 Time: 16:30 RH %: 16.5 T (°F): 75.7 Audit: 200.1	Date: 06/09/22 Time: 17:40 RH %: 21.6 T (°F): 71.3 Audit: TT	Date: 06/13/22 Time: 16:20 RH %: 14.3 T (°F): 71.4 Audit: 200.0	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
E701	120.9	120.9			06/13/22	0456WB009E	1
E702	121.0	121.3	121.2		06/14/22	0456WB009E	2
E703	121.0	121.1			06/13/2022	0456WB009E	1
E704	120.7	120.8			↓	↓	↓
E705	121.0	121.1					
E706	120.5	120.6					
E707	121.5	121.5					
E708	121.3	121.4					
E709	121.4	121.4			06/14/22	0456WB009E	2
E710	120.5	120.6			↓	↓	↓
E711	121.3	121.5					
E712	120.8	120.9					
E713	121.2	121.1					
E714	121.2	121.0					
E715	120.9	121.0			06/15/22	0456WB009E	3
E716	120.5	120.7			↓	↓	↓
E717	121.2	121.1					
E718	121.4	121.3					
E719	122.2	122.5	122.3				
E720	120.6	120.7					
	Initials: TT	Initials: TT	Initials: TT	Initials:			

Final Technician Signature: Tony Tong Date: 06/13/22 Evaluator signature: L.A. Moya

Tare Sheet: (check one) **Probes**____ **47mm Filters** ✓ **100mm Filters**____ **O-Ring Pair**____

Prepared By: Tony Tong Balance ID #: 0063 Thermohygrometer ID #: 0709 Audit Weight ID #/Mass: 0283 A 1200 mg

Placed in Dessicator: Date: 05/10/22 Time: 10:38 ID #	Date: 06/08/22 Time: 16:30 RH %: 16.5 T (°F): 75.7 Audit: 200.1	Date: 06/13/22 Time: 16:20 RH %: 14.3 T (°F): 71.4 Audit: 200.0	Date: 06/15/22 Time: 7:20 RH %: 18.6 T (°F): 71.7 Audit: 199.9	Date: ____ Time: ____ RH %: ____ T (°F): ____ Audit: ____	Date Used	Project Number	Run No.
E721	121.3	121.3			06/15/22	0456WB009E	3
E722	121.6	121.3	121.3				
E723	122.0	121.9			06/16/22	0456WB009E	4
E724	121.5	121.3					
E725	121.5	121.6					
E726	121.3	121.3					
E727	121.7	121.5					
E728	121.2	121.0					
E729	122.0	121.8					
E730	120.9	120.8					
E731	121.1	121.2					
E732	120.9	120.8					
E733	120.4	120.2					
E734	121.3	121.2					
E735	116.5	116.4					
E736	116.9	116.9					
E737	115.9	115.5			Not used		
E738	117.2	117.1					
E739	116.0	115.9					
E740	117.4	117.5					
	Initials: TT	Initials: TT	Initials: TT	Initials:			

Final Technician Signature: Tony Tong Date: 06/16/2022 Evaluator signature: [signature]

Tare Sheet: (check one) **Probes** ✓ **47mm Filters** ____ **100mm Filters** ____ **O-Ring Pair** ____

Prepared By: Tony Tong Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 00283A 1 1000g

Placed in Dessicator: Date: 06/08/22 Time: 15:30 ID #	Date: 06-6-22 Time: 1300 RH %: 20.0 T (°F): 71.7 Audit: 99997.9	Date: 06/13/22 Time: 7:30 RH %: 7.4 T (°F): 68.0 Audit: 99997.8	Date: 06/14/22 Time: 24.4 RH %: 71.9 T (°F): 71.6 Audit: 99998.0	Date: Time: RH %: T (°F): Audit:	Date Used	Project Number	Run No.
15	114341.0	114340.8			06/13/22	0456WB009E	1
70	116834.6	116833.5	116833.4		06/16/22	0456WB009E	4
73	117066.2	117065.6	117065.8		06/15/22	0456WB009E	3
75	117637.9	117637.7			06/13/22	0456WB009E	1
76	116961.0	116960.5	116960.7		06/15/22	0456WB009E	3
78	117459.6	117459.2	117459.1		06/16/22	0456WB009E	4
81	111861.5	111861.3			06/13/22	0456WB009E	1
3	114770.9	116011.5	116011.2		Not used		
OES3	116011.8	114770.3	114770.4		↓		
4	114856.7	114856.6			06/14/22	0456WB009E	2
OES4	114148.5	114147.7	114147.7		06/16/22	0456WB009E	4
11	114186.1	114185.9	114185.7				
13	114321.8	114321.6			06/14/22	0456WB009E	2
14	114547.6	114547.6			↓	↓	↓
17	114562.5	114562.1	114561.9		06/15/22	0456WB009E	3
30	114327.4	114327.4			Not used		
65	117079.4	117079.1	117079.4		↓		
32	114743.2	114743.2					
	Initials: TT	Initials: TT	Initials: TT	Initials:			

Final Technician Signature: Tony Tong Date: 06/14/22 Evaluator signature: John J. Morgan

Tare Sheet: (check one) **Probes**____ **47mm Filters**____ **100mm Filters**____ **O-Ring Pair** ✓

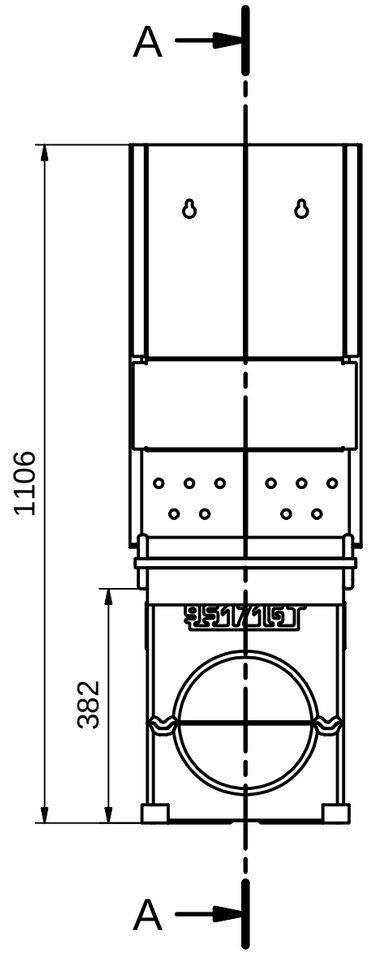
Prepared By: Tony Tang Balance ID #: 00637 Thermohygrometer ID #: 00709 Audit Weight ID #/Mass: 002834 1.5g

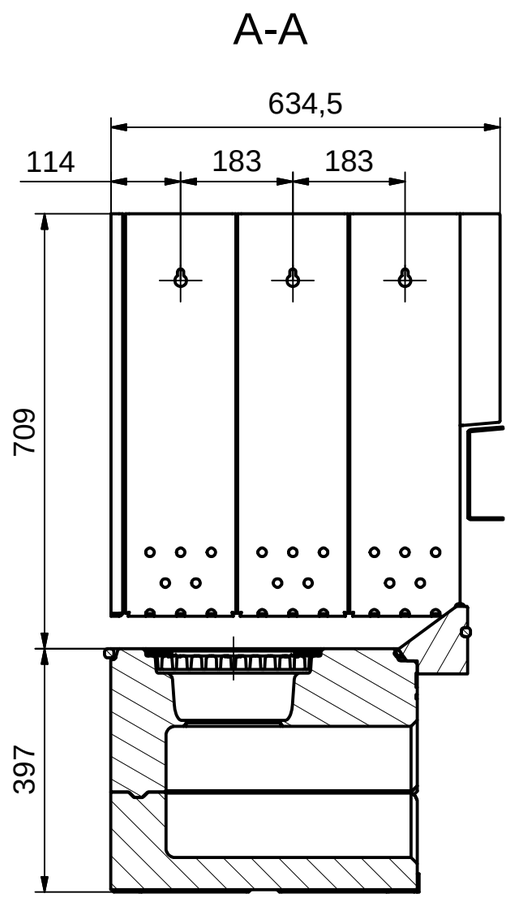
Placed in Dessicator: Date: 25/09/22 Time: 9:30	Date: 06/08/22 Time: 15:30 RH %: 18.8 T (°F): 75.3	Date: 06-10-22 Time: 1324 RH %: 20.0 T (°F): 73.0	Date: 06/13/22 Time: 7:30 RH %: 7.4 T (°F): 68.0	Date: 06/16/22 Time: 7:20 RH %: 18.6 T (°F): 71.7	Date Used	Project Number	Run No.
ID #	Audit: 5000.0	Audit: 5000.2	Audit: 4999.9	Audit: 4999.9			
S345	3325.4	3325.5 ✓			06/13/22	0456WB009E	1
S346	3277.7	3278.0	3278.0		↓	↓	↓
S347	3278.2	3278.4 ✓			↓	↓	↓
S348	3356.7	3356.9 ✓			06/14/22	0456WB009E	2
S349	4088.7	4088.9 ✓			↓	↓	↓
S350	3375.4	3375.5 ✓			↓	↓	↓
S351	3227.6	3227.8 ✓			06/15/22	0456WB009E	3
S352	3311.8	3312.0 ✓			↓	↓	↓
S353	3358.3	3358.5 ✓			↓	↓	↓
S354	4117.5	4117.5 ✓			06/16/22	0456WB009E	4
S355	3340.0	3340.2 ✓			↓	↓	↓
S356	3374.3	3374.5 ✓			↓	↓	↓
S357	4078.2	4078.4 ✓			Not used		
S358	3497.5	3498.3	3497.9	3497.7	↓		
S359					Not used		
S360					↓		
S361					↓		
S362					↓		
S363					↓		
S364					↓		
	Initials: TT	Initials: FO	Initials: TT	Initials: TT			

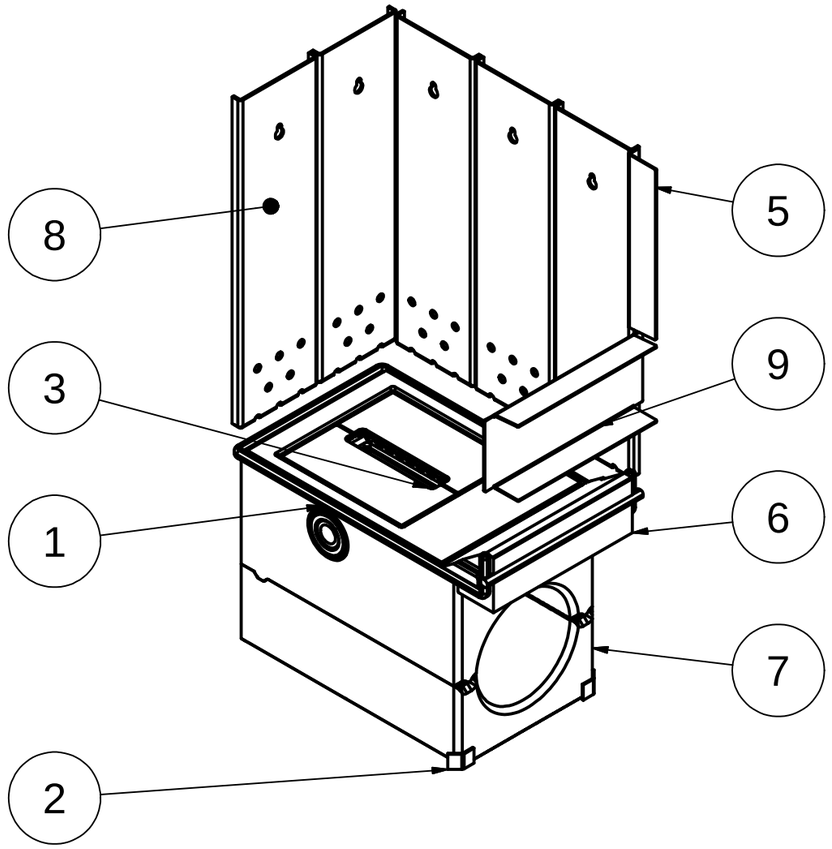
Final Technician Signature: Tony Tang Date: 06/16/2022 Evaluator signature: M. Morgan

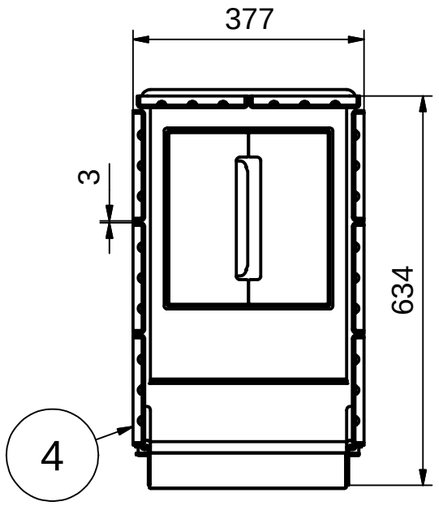
5. APPLIANCE ENGINEERING DRAWINGS

K-List Items









Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
9	1	Schutzblech	BL 3 X 251 X 364	S235JRG2	T011300
8	6	Schürze	BL 4 X 203,4 X 667,7	S235JRG2	T011299
7	1	Brennkammer			T005579
6	1	Dreieckstein			95180
5	1	Schürze vorne			95174AR
4	1	Schürze vorne			95174AL
3	2	Rost - Brennkammer	30x130x280	1.4776	42636
2	2	Winkel	Fl 30x3x50	S235JRG2	40005B
1	1	Keramik-Packung	15x15x1580	Inconel C1222	30033

STÜCKLISTE

Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 142.4 kg	Oberfläche	Artikelnummer T005230

	Datum	Name	Maßstab
Gezeichnet	18.11.2005	mawahlmu	1 : 10
Geprüft	23.05.2006	erkaltse	
Schutzvermerk ISO 16016 beachten			

FRÖLING
WÄRME AUS HOLZ
HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H.
A-4710 Grieskirchen, Industriestraße 12

Benennung
Brennkammer
FHG 20/30 und S3 18/28

Ersatz für:

Projekt
P100009

Kunde

Ers. durch:

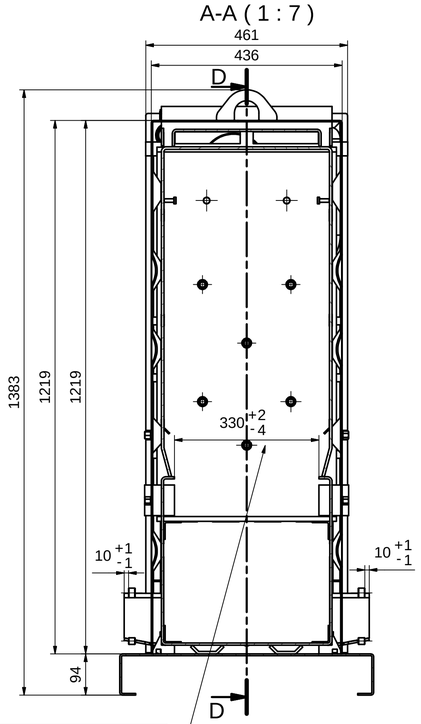
Zeichnungsnummer
Z005528-IDW

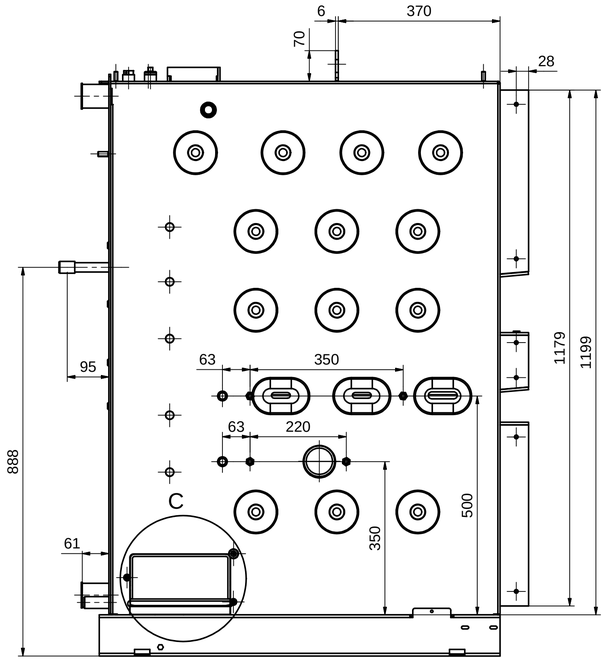
Rev.

Blatt v.
1 1

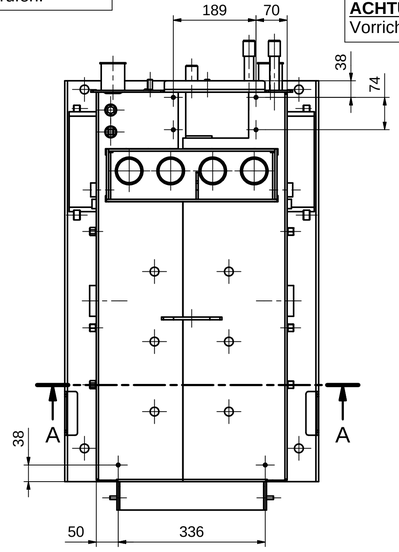
Datum	Bearbeiter	Letzte Änderung	A3

A-A (1 : 7)





ACHTUNG:
Innenmaß mit Prüflehre Z088947 prüfen!



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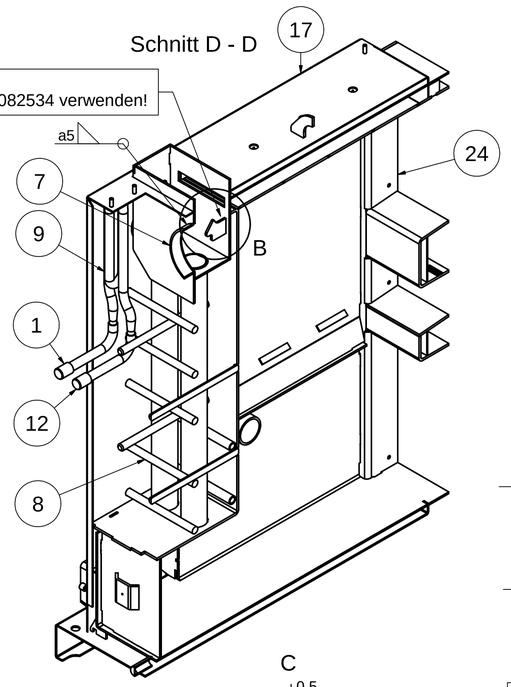
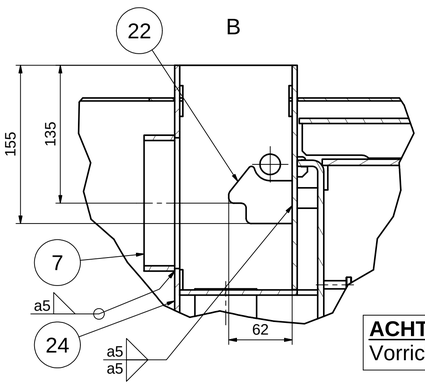
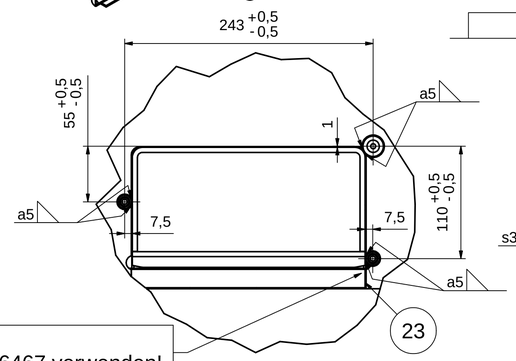
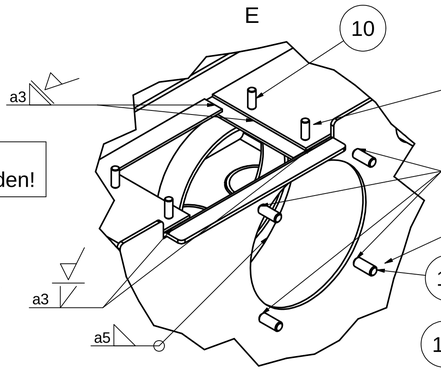


ACHTUNG:
Vorrichtung Z082534 verwenden!





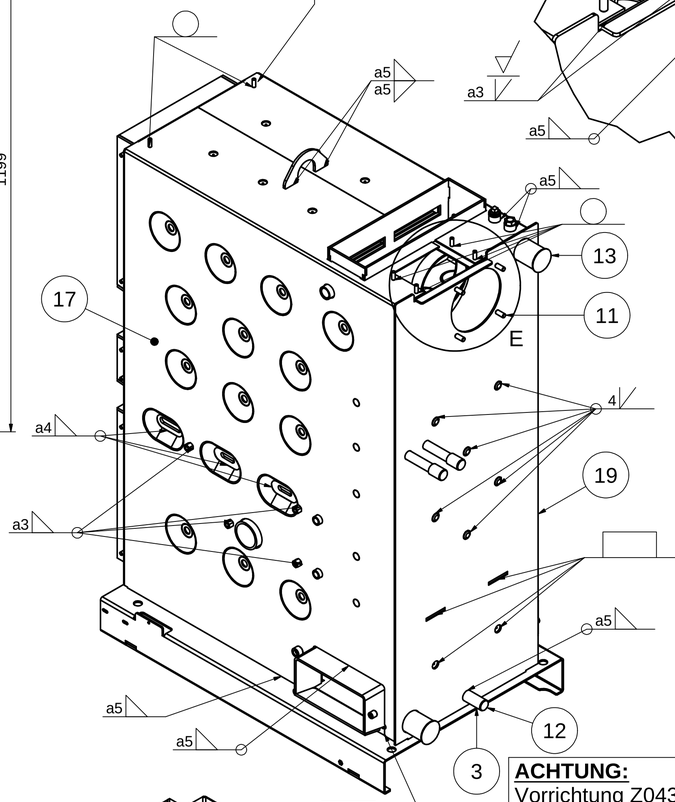
ACHTUNG:
Vorrichtung Z026467 verwenden!



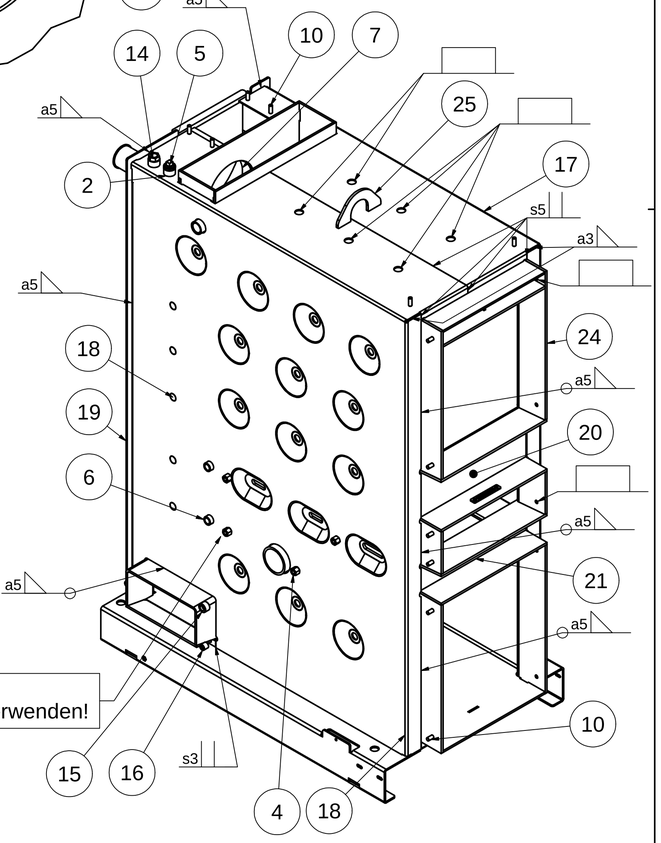
ACHTUNG:
Vorrichtung Z063795 verwenden!

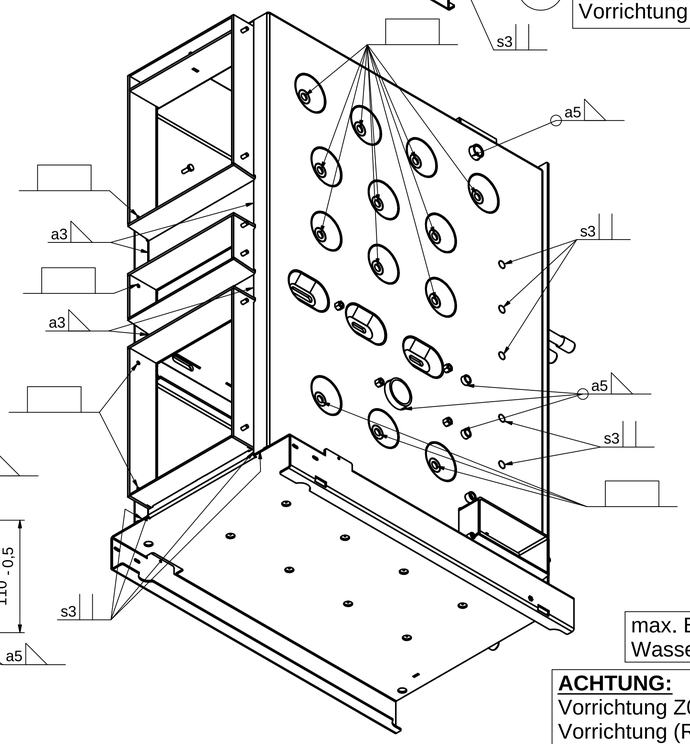
ACHTUNG:
Vorrichtung Z004689 verwenden!

ACHTUNG:
Vorrichtung Z063764 verwenden!



ACHTUNG:
Vorrichtung Z043124 verwenden!





max. Betriebsdruck: 3 bar
Wasserinhalt: 135 Liter

ACHTUNG:
Vorrichtung Z014926 verwenden!
Vorrichtung (ROBO) verwenden!
Vorrichtung Z026237 verwenden!

Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
25	1	Kranöse	BL 6 X 70 X 138	S235JRG2	T011755
24	1	Innenmantel			T005231
23	2	Blechstreifen Putztür	BL 3 X 18 X 229	S235JRG2	T005081
22	1	Nasenblech	BL 5 X 56 X 62	S235JRG2	T005060
21	1	Außenmantel vorne mitte	BL 3 X 66 X 372	S235JRG2	T005051
20	1	Außenmantel vorne oben	BL 3 X 125 X 372	S235JRG2	T005050
19	1	Rückenteil			T005016
18	1	Aussenmantel links	BL 3 X 946,9 X 1411,5	S235JRG2	T004954
17	1	Aussenmantel rechts	BL 3 X 946,9 X 1451,5	S235JRG2	T004953
16	4	Buchse	Rd ø15x15	9SMn28K	70531
15	2	Buchse	Rd ø22x15	9SMn28K	70530
14	1	Tauchhülse 1/2"	d=16x120mm	-	67034
13	2	Schutzstopfen EP340	Ø46,7-6/4"	PE	66420
12	3	Schutzstopfen EP340	Ø19,5-1/2"	PE	66415
11	4	Schweißbolzen	M10X25	Stahl	66078
10	18	Schweißbolzen	M8X22	Stahl	66075
9	1	Rippenrohrwendel		Kupfer	65202
8	5	Ankerstange	Rd ø18x436	S235JRG2	64632C
7	1	Saugrohr	Ro ø152,4x4,5x30	ST37-2	64460A
6	2	Stahlrohr geschweißt	Ro ø21,3x3,25x456	St33.2	64005A
5	1	Stopfen	1/2"-FIG.290	sw.	60001
4	8	Sechskantmutter	M10/DIN6330B	10	54285
3	1	Muffe 1/2" x 55	1/2" x 55	P235TR1	54026
2	2	Muffe 1/2" x 15	1/2" x 15	P235TR1	54009
1	2	Muffe 1/2" x 34	1/2" x 34	P235TR1	54000

STÜCKLISTE

Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 298,038 kg	Oberfläche	Artikelnummer 96100

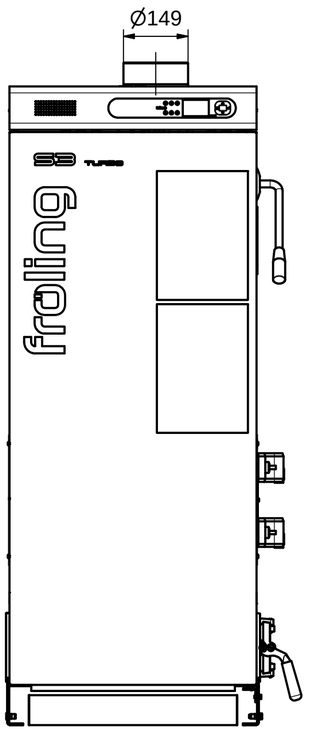
	Datum	Name	Maßstab
Gezeichnet	10.11.2005	mawahlmu	1 : 7
Geprüft	23.05.2006	erkaltse	
Schutzvermerk ISO 16016 beachten			

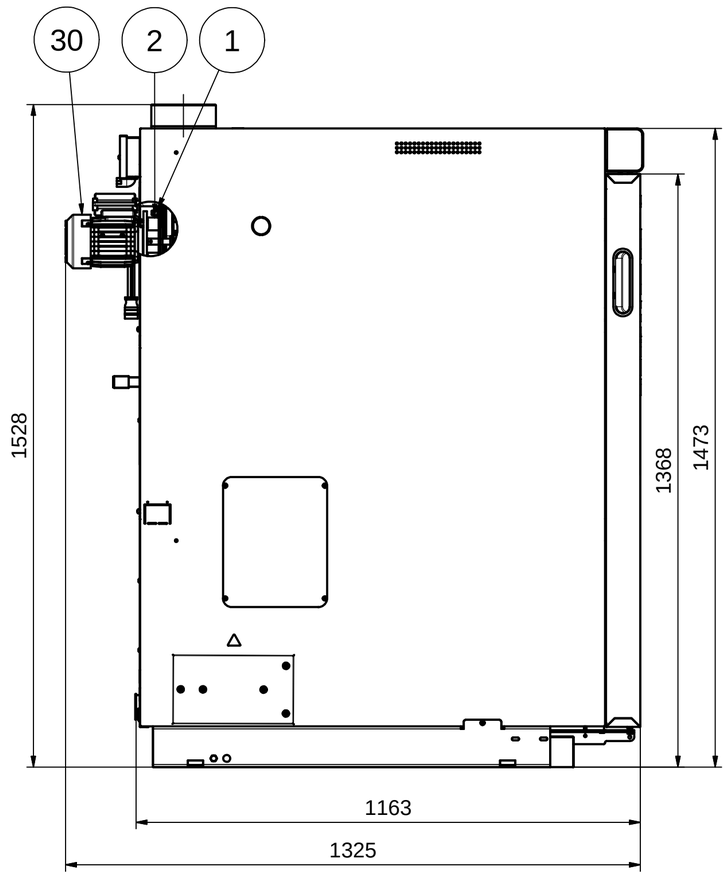
Benennung: Kesselkörper FHG 20/30, S3 18/28

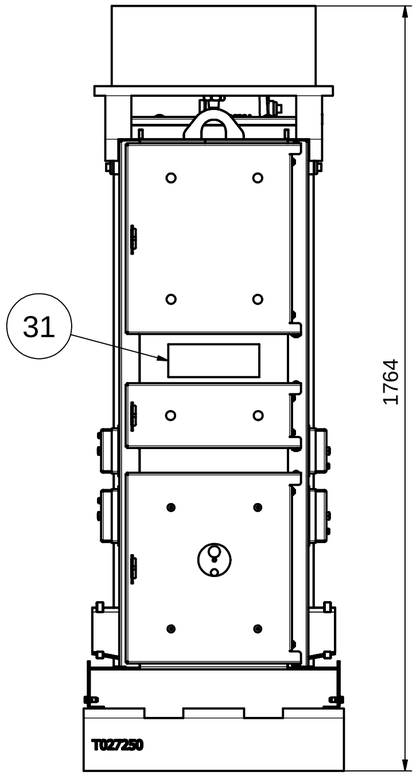
FRÖLING WÄRME AUS HOLZ
HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H.
A-4710 Grieskirchen, Industriestraße 12

Ersatz für:
Projekt: P100009
Kunde:
Ers. durch:
Zeichnungsnummer: Z005527-IDW
Rev.: F
Blatt v.: 1 1

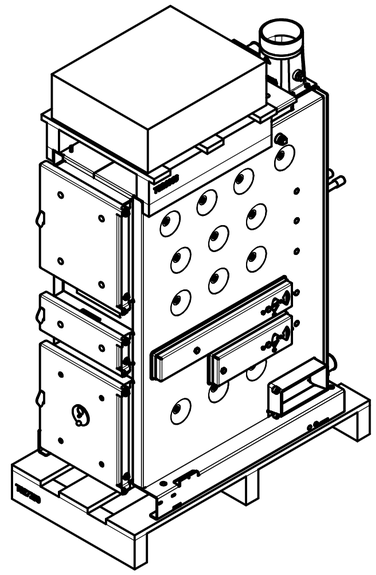
Datum	Bearbeiter	Letzte Änderung	
06.10.2016	magoetze	Stopfen Grauguss Art.60002 entfernt;	A1

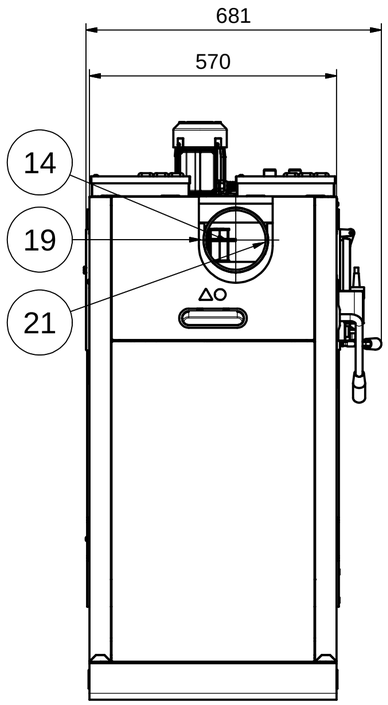


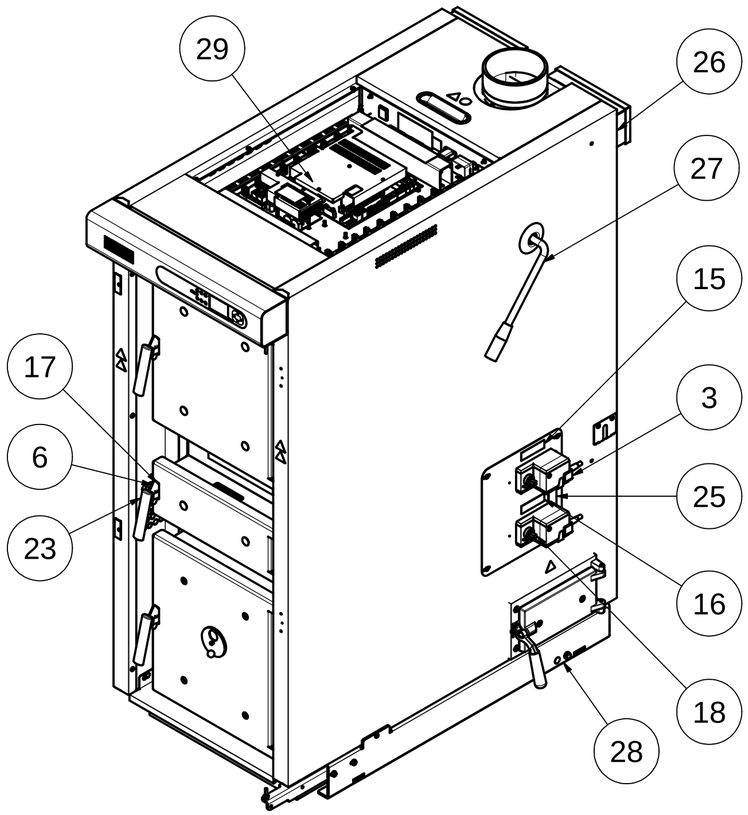


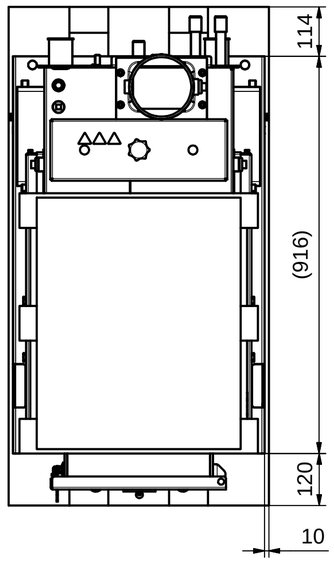


Ansicht:
Auslieferungszustand







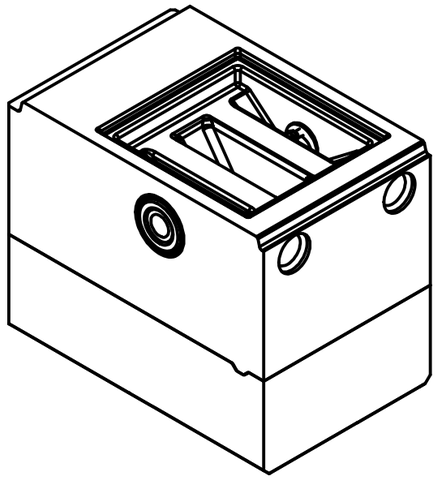


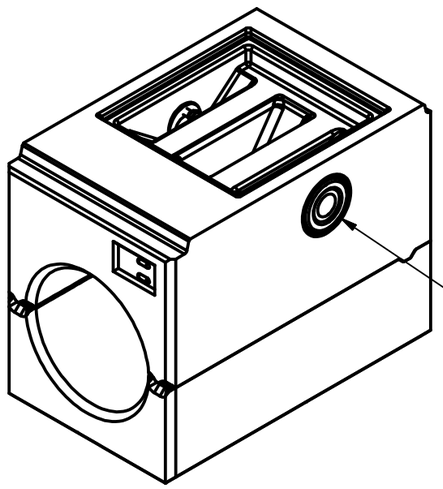
Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
31	1	Aufkleber Typenschild		-	T249419
30	1	Saugzuggebläse / UL-tauglich		-	T249404
29	1	Steuerung komplett			T249237
28	1	Kesselkörper Zusammenbau			T244482
27	1	WOS			T236664
26	1	Isolierung			T233598
25	1	Drehmomentstütze	Bl 2 x 33,3 x 185,0	verz.	T221355
24	1	Ascheschaufel			T216383
23	3	Türgriff			T206926
22	1	Schlüssel	BL 4 X 45,2 X 210,0	S235JRG2	T203889
21	1	Breitbandsonde Bosch+Verl.Kabel / US	Kabellänge 1m		T106633
20	1	Holzpalette IPPC	600X550X172	Fichtenholz	T026068
19	1	Buchse			T013287
18	2	Luftregelungsgestänge			T010597
17	3	Buchse	Rd ø10x15x20	9SMnPb28k	70532
16	1	Aufkleber Sekundärluftstellmotor	22x75	-	68122A
15	1	Aufkleber Primärluftstellmotor	22x75	-	68122
14	1	Thermoelement		-	68070B
13	3	Tauchhülse	1/2"x100	Messing	68019
12	3	Tauchfühler KVT	Kabellänge 5m	-	67486C
11	1	Anlegefühler		-	67391C
10	1	Außenfühler AF 200		-	67051
9	1	Tauchfühler KVT	Kabellänge 2m	-	67048C
8	1	Andruckfeder		-	67028
7	1	Schürgerät			66402
6	3	Sechskantschraube	M8X30/DIN933	8.8 verz.	66232
5	1	Reinigungsbürste ø54 x 1350	Ø54 X 1350	S235JRG2	65012A
4	1	Reinigungsbürste F 30x20x900	30 X 20 X 900	S235JRG2	65001
3	2	Stellmotor		-	54606A
2	4	Sechskantmutter	M10/DIN934	8 verz.	54265
1	4	Beilagscheibe	M10/DIN125A	verz.	32416

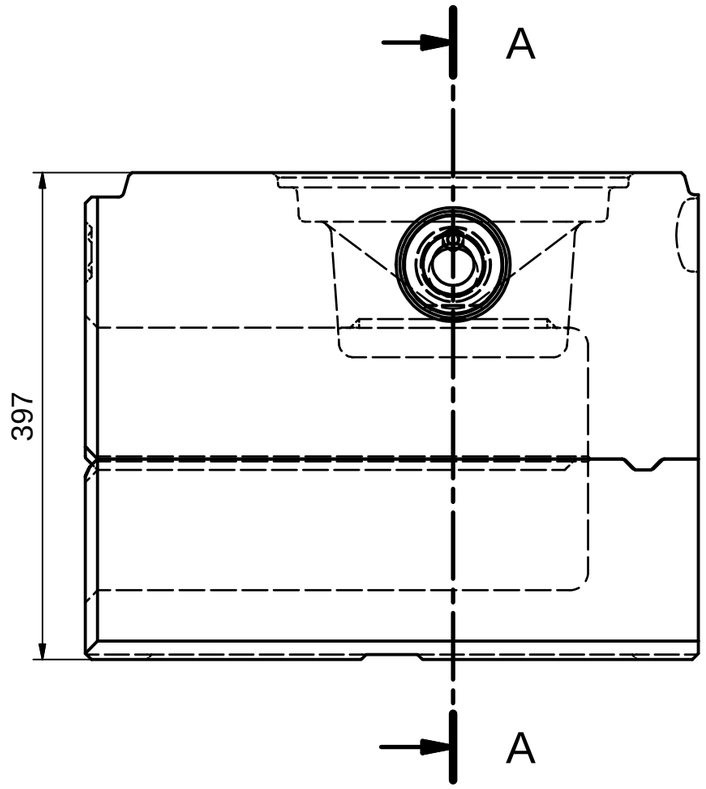
STÜCKLISTE

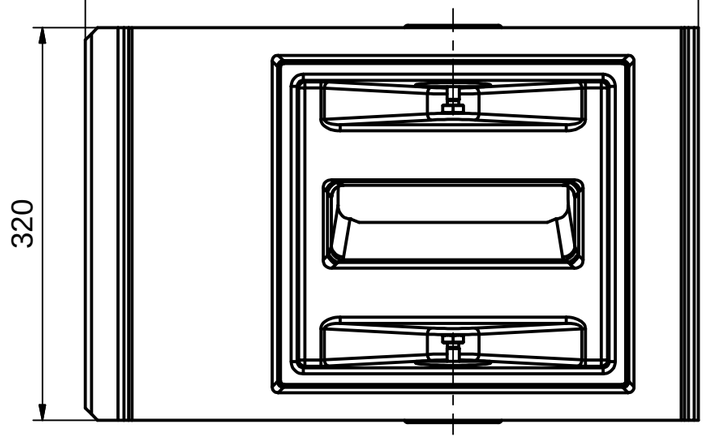
Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 689,424 kg	Oberfläche	Artikelnummer T244483	
	Datum	Name	Maßstab	Benennung
Gezeichnet	23.02.2016	malugmai	1 : 10	Zusammenbau S3 20/30 NA-EN
Geprüft	16.03.2016	sthaidin		
Schutzvermerk ISO 16016 beachten				
froling HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12	Ersatz für:	Projekt P100699	Kunde	
	Ers. durch:	Zeichnungsnummer Z088404-IDW	Rev. A	Blatt 1 v. 1

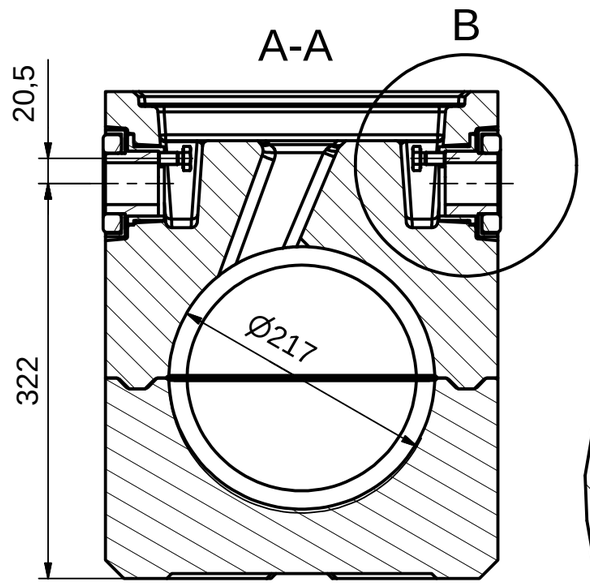
14.06.2016	sthaidin	54506 ersetzt durch 54606A; T106549 ersetzt durch T106633	
Datum	Bearbeiter	Letzte Änderung	A2

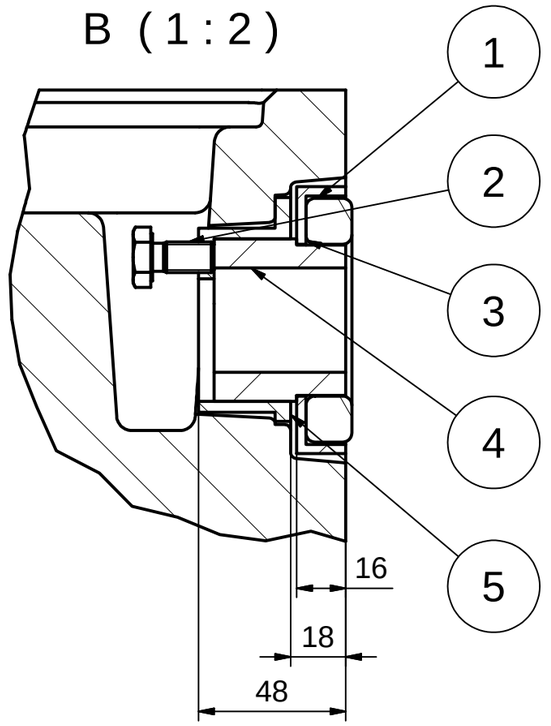












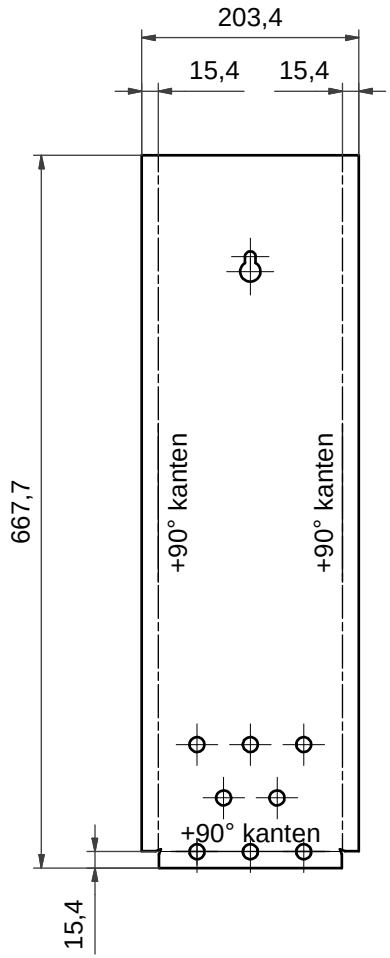
ACHTUNG:
Vorrichtung Z027395 verwenden!

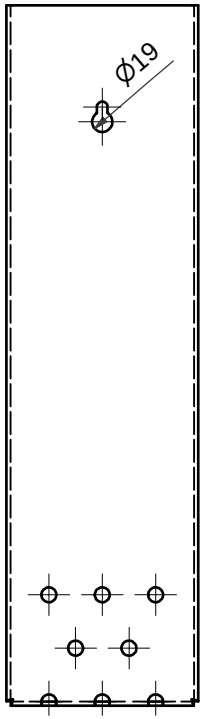
Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
6	1	Brennkammer 1460D			95171GT
5	2	Buchse	Rd ø80x30	ST52-3	70568
4	2	Buchse	Rd ø53x43	ST52-3	70567
3	2	Schnurführung	Rd ø87x16	ST52-3	70566
2	2	Sechskantschraube	M10X20/DIN933	8.8 verz.	66003
1	2	Keramik-Packung	15x15x225	Inconel C1222	30034

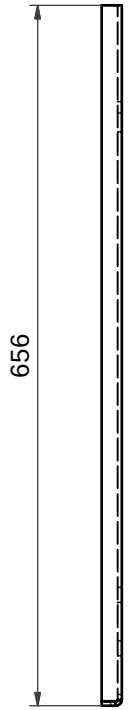
STÜCKLISTE

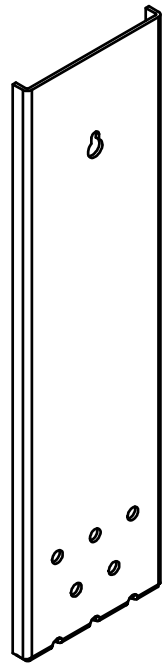
Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 93.17 kg		Oberfläche	Artikelnummer T005579
	Datum	Name	Maßstab	Benennung
Gezeichnet	10.11.2005	sthaidin	1 : 5	Brennkammer FHG 20-70, S3 18-45
Geprüft	23.05.2006	erkaltse		
Schutzvermerk ISO 16016 beachten				
FRÖLING WÄRME AUS HOLZ HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12			Ersatz für:	Projekt P200000 / Kunde
			Ers. durch:	Zeichnungsnummer Z005972-IDW / Rev. / Blatt v. 1 1
Datum	Bearbeiter	Letzte Änderung		A3

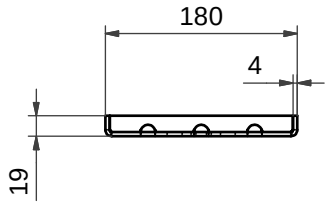
ABWICKLUNG



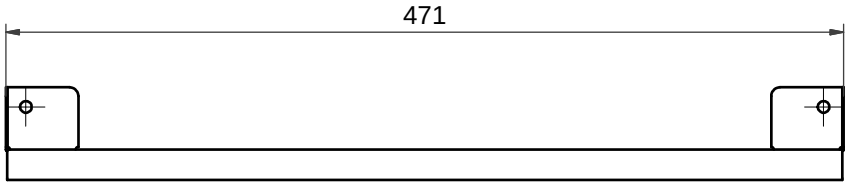


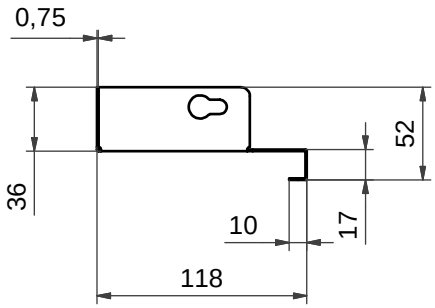




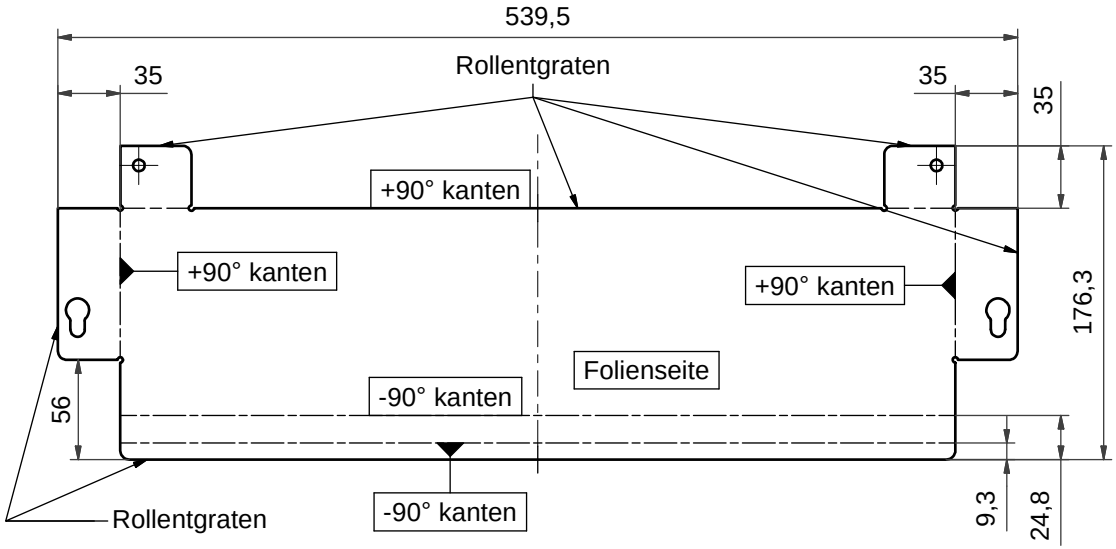


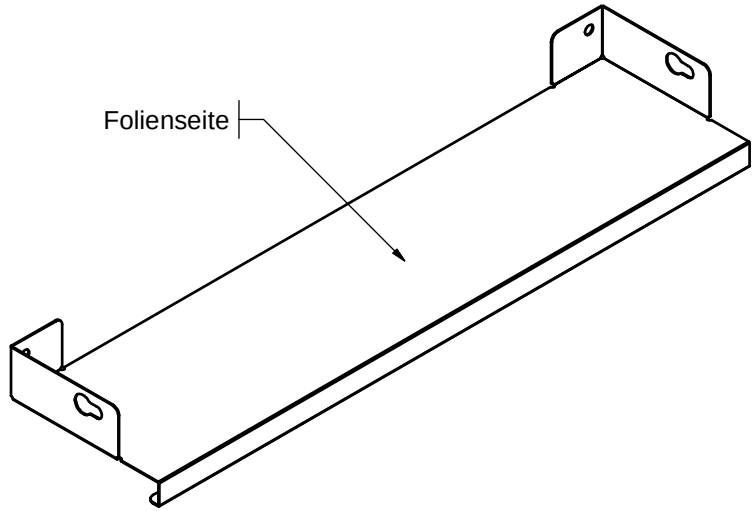
Abmessungen Bl 4x204x668				Werkstoff S235JRG2	Rohteilnorm	Rohteilnummer 32009
Toleranz EN 22768-1-m EN ISO 13920-B/F		Gewicht 4.27 kg		Oberfläche	Artikelnummer T011299	
	Datum	Name	Maßstab	Benennung Schürze Brennkammer		
Gezeichnet	18.11.2005	mawahlmu	1:5			
Geprüft	23.05.2006	erkaltse				
Schutzvermerk ISO 16016 beachten						
FRÖLING WÄRME AUS HOLZ HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12			Ersatz für:	Projekt P100009	Kunde	
			Ers. durch:	Zeichnungsnummer Z005308-IDW	Rev.	Blatt v. 1 1
Datum	Bearbeiter	Letzte Änderung				A3



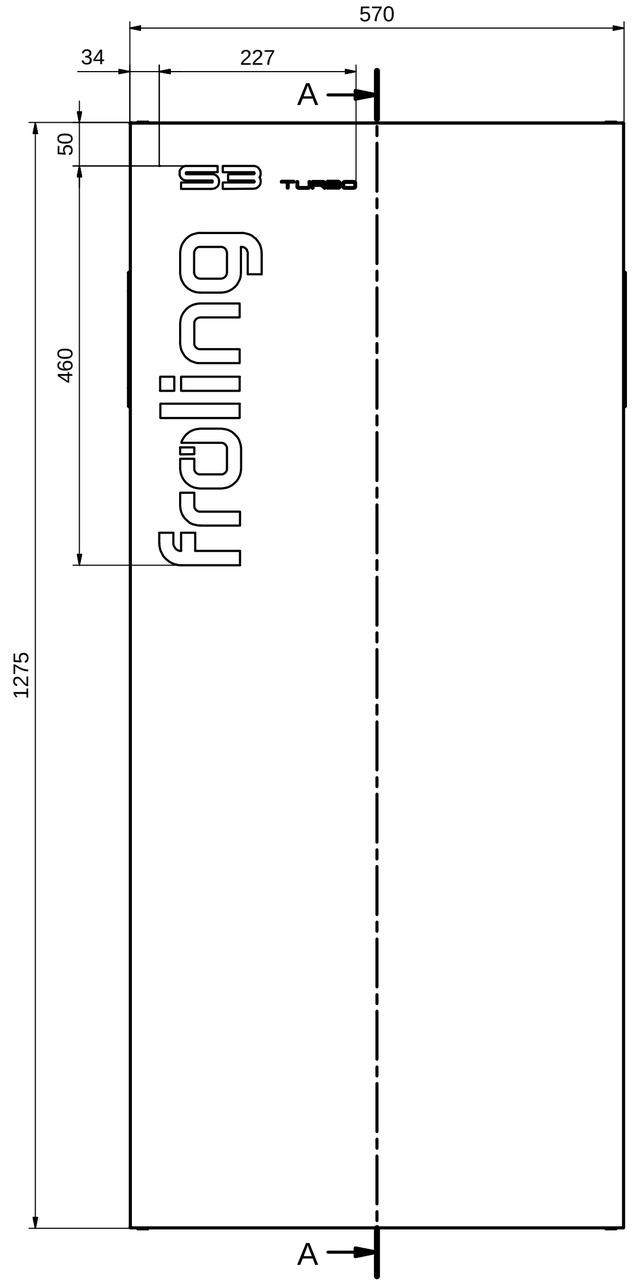


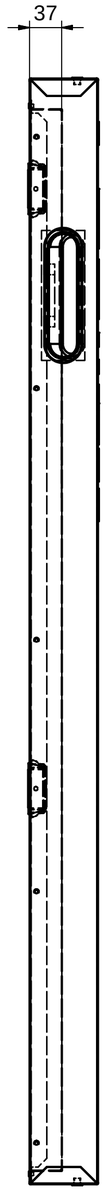
Abwicklung



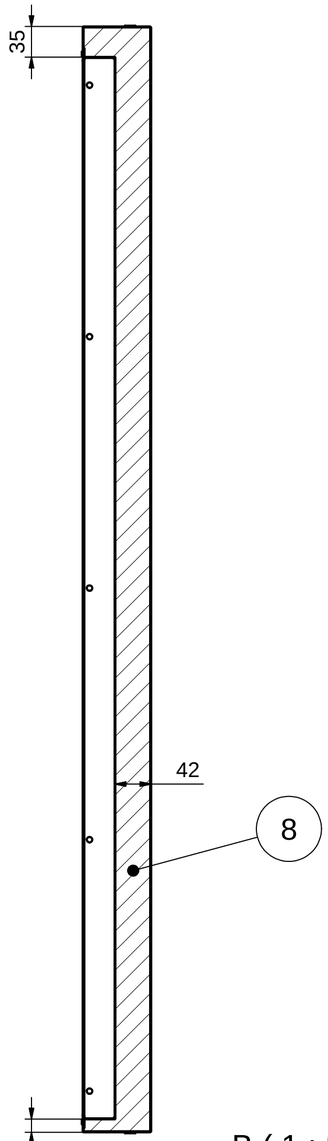


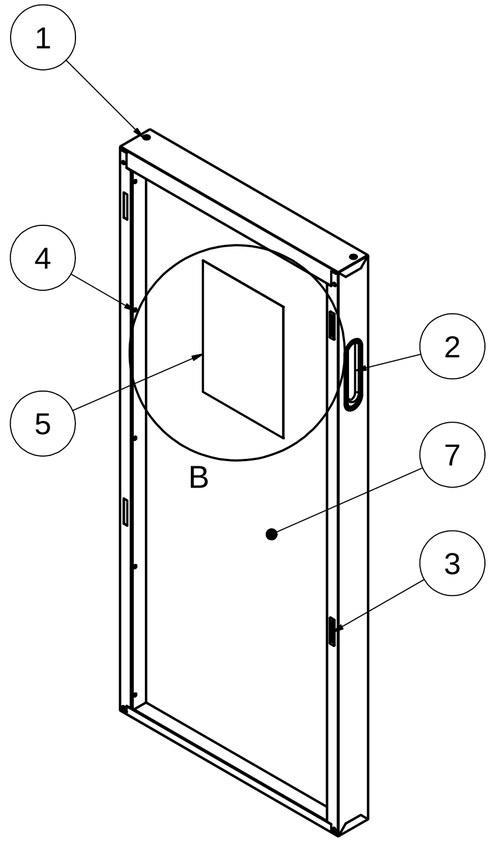
Abmessungen Bl 0,75 x 176,3 x 539,5				Werkstoff Pladurbl.RAL9005	Rohteilnorm	Rohteilnummer
Toleranz EN 22768-1-m EN ISO 13920-B/F		Gewicht 0,44 kg		Oberfläche	Artikelnummer T011306	
	Datum	Name	Maßstab	Benennung Blende Bodenisolierung FHG, S3		
Gezeichnet	24.11.2005	mawahlmu	1:3			
Geprüft	23.05.2006	erkaltse				
Schutzvermerk ISO 16016 beachten						
FRÖLING WÄRME AUS HOLZ HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12			Ersatz für:	Projekt P200000	Kunde	
			Ers. durch:	Zeichnungsnummer Z005680-IDW	Rev. A	Blatt v. 1 1
12.04.2013	mianzeng	Rollentgraten hinzugefügt				
Datum	Bearbeiter	Letzte Änderung				A3

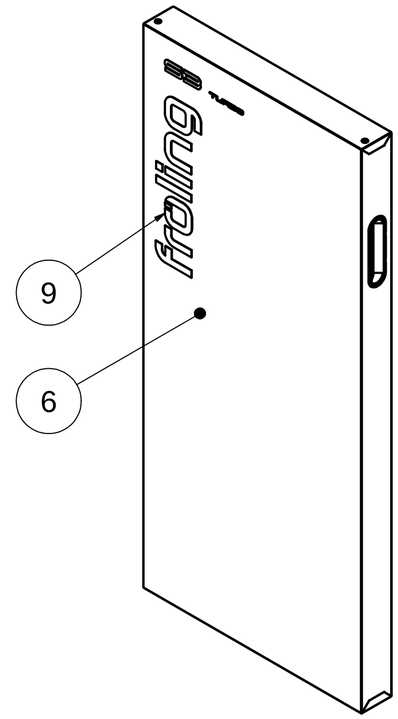


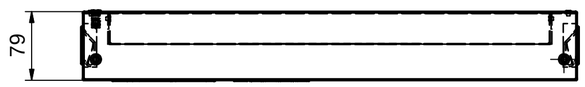


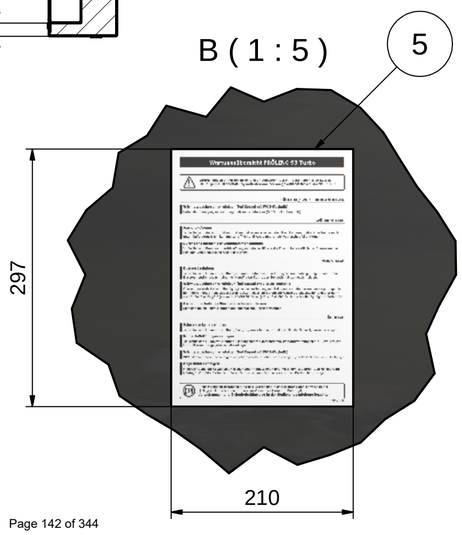
Schnitt: A-A









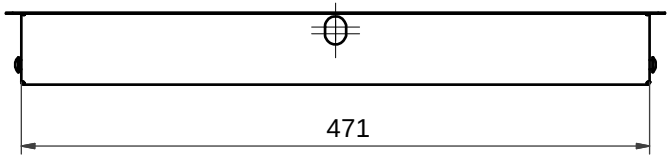


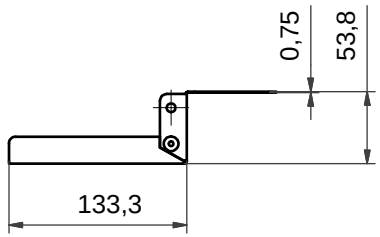
Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
9	1	Aufkleber	295x520	-	T026852
8	1	Wärmedämmfilzreste		DOMO8	T026301
7	1	Innenblende	Bl 0,75 x 577 x 1293	Pladurbl.RAL9005	T026300
6	1	Türblech	Bl 1 x 816 x 1511	ST1203	T026299
5	1	Aufkleber "Wartungsübers. S3"	297X210	-	69071
4	14	Blindniete	3,2X6/DIN7337A	Alu-schwarz	56001S
3	2	Magnetschnapper			55524
2	2	Griffmulde	17x46,3x156	ABS schwarz	43242
1	4	Glycodur Gleitlager	PBG 060808 F	-	33502

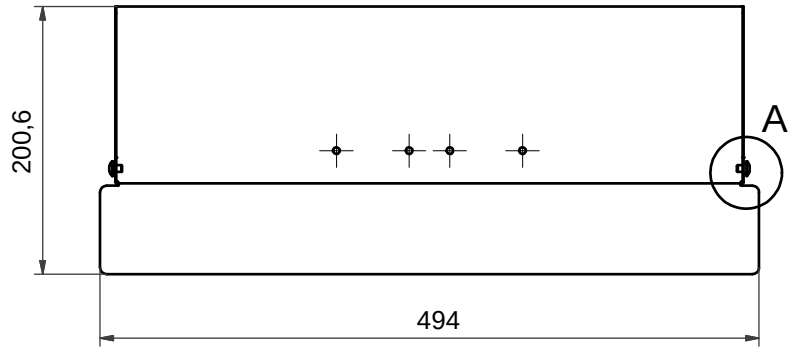
STÜCKLISTE

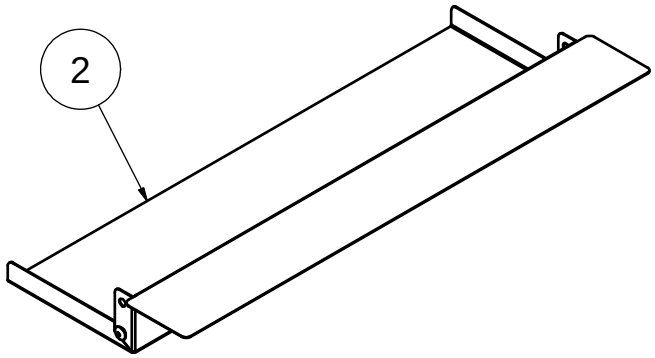
Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 14,772 kg	Oberfläche	Artikelnummer T026298	
	Datum	Name	Maßstab	Benennung
Gezeichnet	10.07.2008	gepollha	1 : 5	Isoliertür Isolierung S3 18/28
Geprüft	19.08.2008	sthaidin		
Schutzvermerk ISO 16016 beachten			Ersatz für:	Projekt P100127 / Kunde
FRÖLING WÄRME AUS HOLZ HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12			Ers. durch:	Zeichnungsnummer Z028000-IDW / Rev. B / Blatt 1 v. 1

23.09.2014	luprasch	Aufkleber "Wartungsübersicht S3" Art.69071 ergänzt	
Datum	Bearbeiter	Letzte Änderung	A2

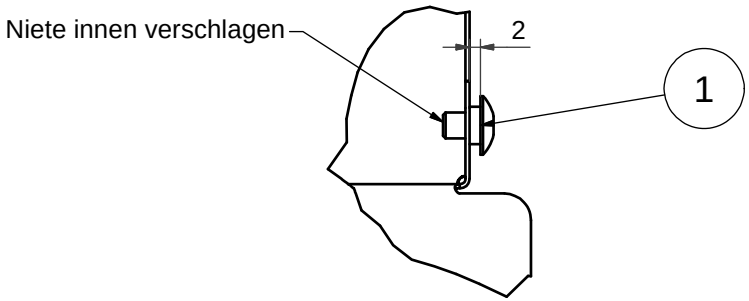








A (1 : 1)



Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
2	1	Blende oben	Bl 0,75 x 252,0 x 508,0	ST1203	T026364
1	2	Isolierniete	ø11 x 9,5	RSt36-2 gekühlt	56002

STÜCKLISTE

Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 0,75 kg	Oberfläche	Artikelnummer T026363

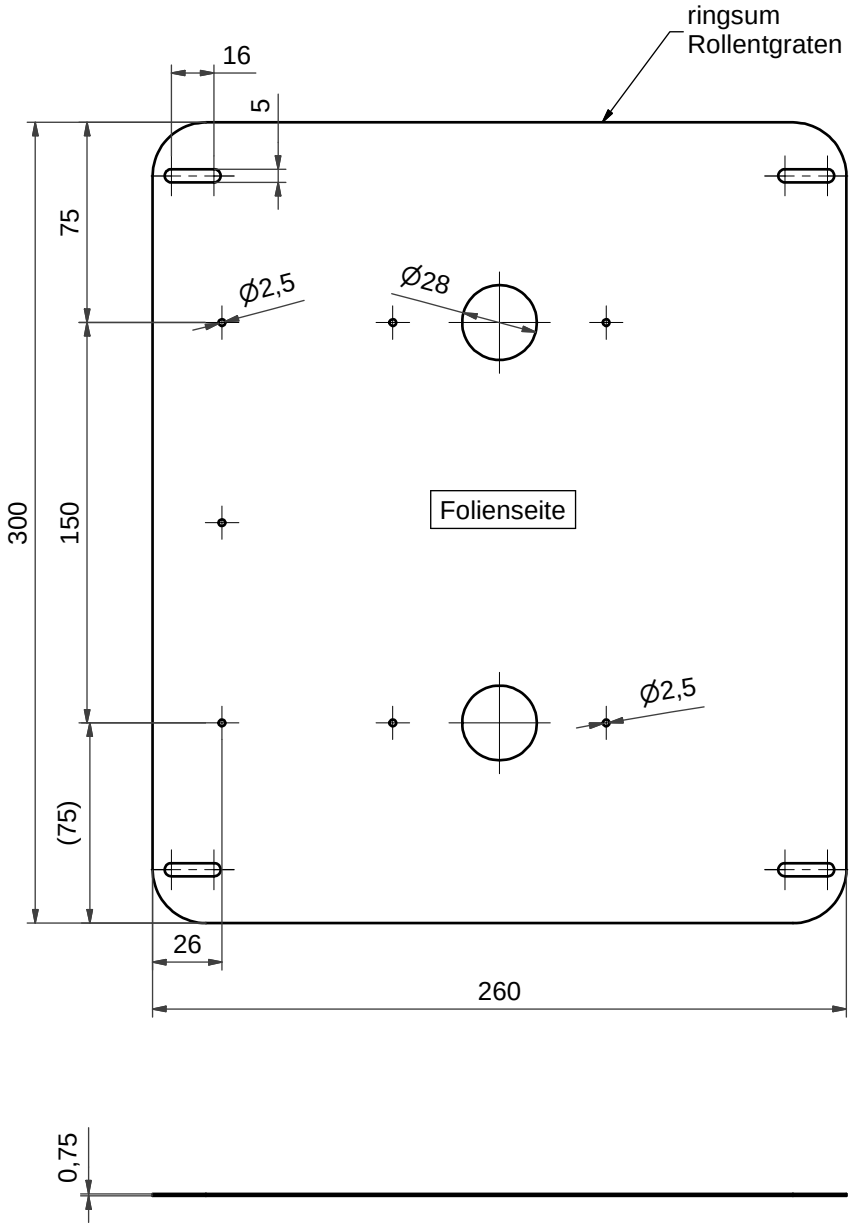
	Datum	Name	Maßstab
Gezeichnet	14.07.2008	gepollha	1:4
Geprüft	19.08.2008	sthaidin	
Schutzvermerk ISO 16016 beachten			

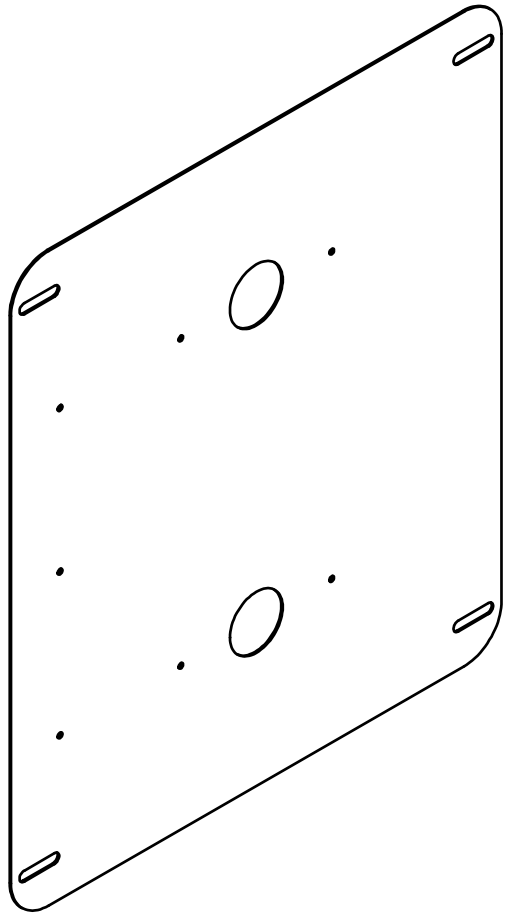
Benennung
Blende oben
Isolierung S3 18-45

fröling
HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H.
A-4710 Grieskirchen, Industriestraße 12

Ersatz für:	Projekt P200000	Kunde	
Ers. durch:	Zeichnungsnummer Z028072-IDW	Rev. A	Blatt v. 1 1

11.09.2008	mirossdo	Endschalter in eigener Baugruppe T027183	
Datum	Bearbeiter	Letzte Änderung	A3

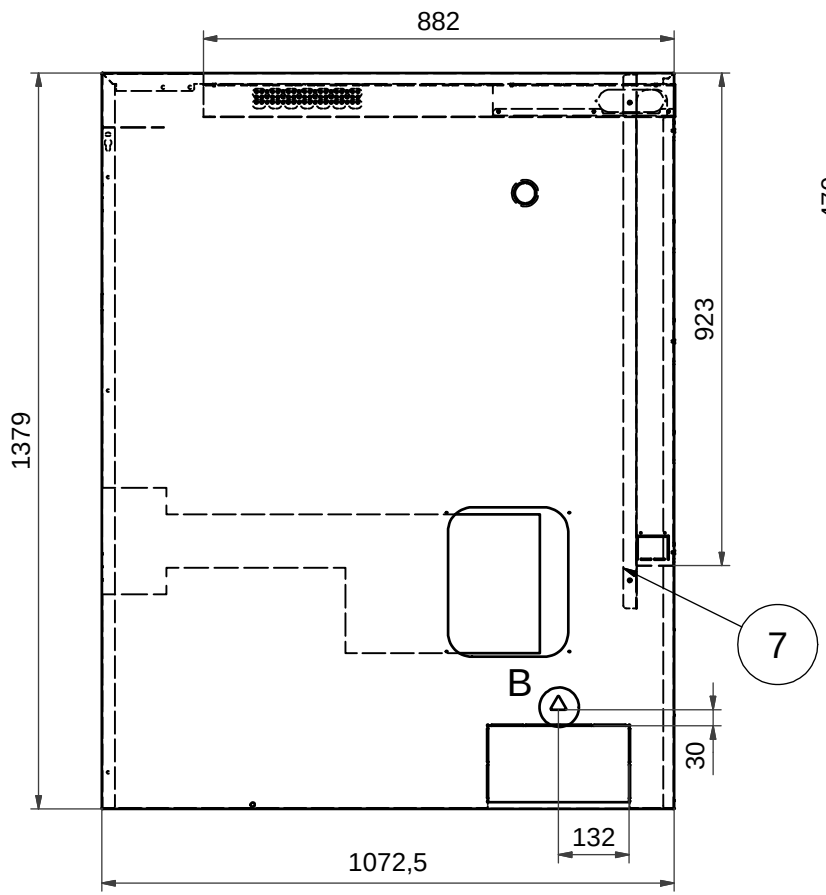


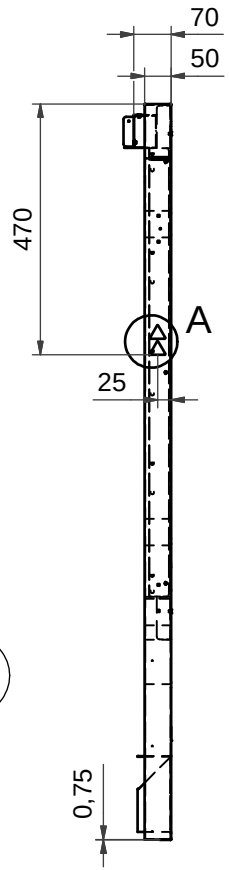


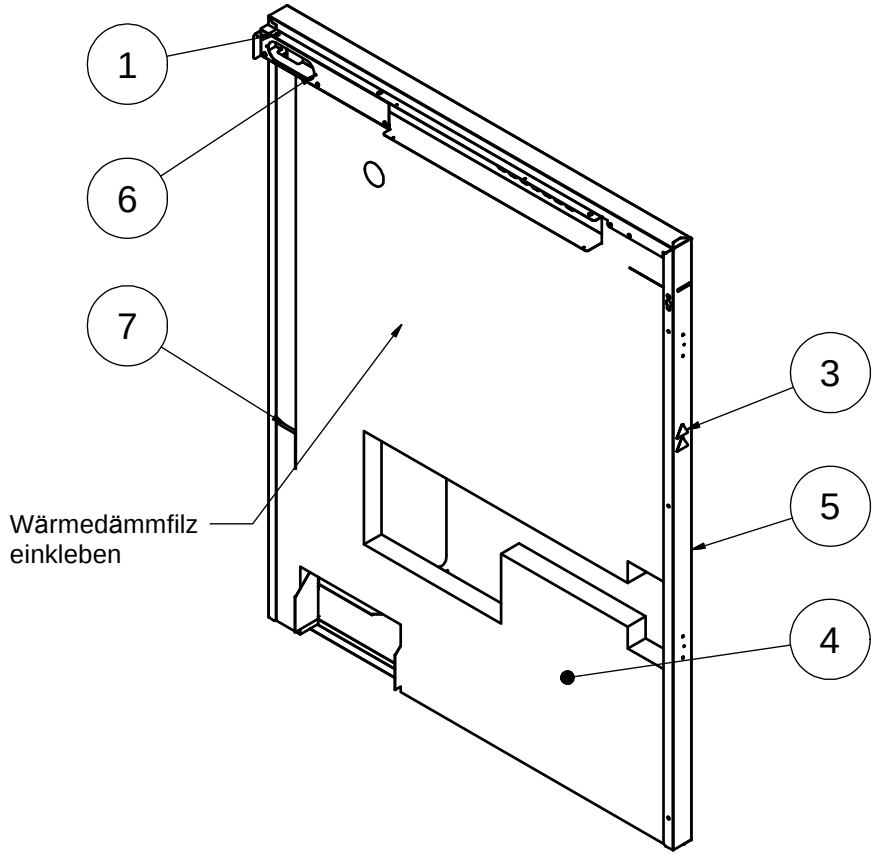
Abmessungen Bl 0,75 x 260 x 300				Werkstoff Pladurbl.RAL9006	Rohteilnorm	Rohteilnummer 31937
Toleranz EN 22768-1-m EN ISO 13920-B/F		Gewicht 0,45 kg		Oberfläche	Artikelnummer T221356	
	Datum	Name	Maßstab	Benennung Blende Isolierung S3 18-45		
Gezeichnet	10.04.2012	mianzeng	1:2			
Geprüft	23.04.2012	sthaidin				
Schutzvermerk ISO 16016 beachten						
FRÖLING WÄRME AUS HOLZ HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12			Ersatz für:	Projekt P200000	Kunde	
			Ers. durch:	Zeichnungsnummer Z056770-IDW	Rev. B	Blatt v. 1 1

12.04.2013	mianzeng	Rollentgraten hinzugefügt, Gewindeformstanzungen > ø2,5mm geändert
Datum	Bearbeiter	Letzte Änderung

A3







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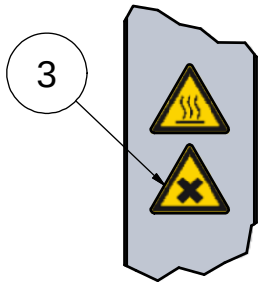

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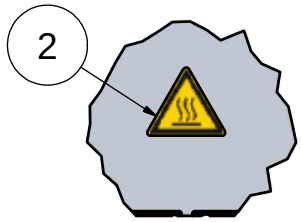
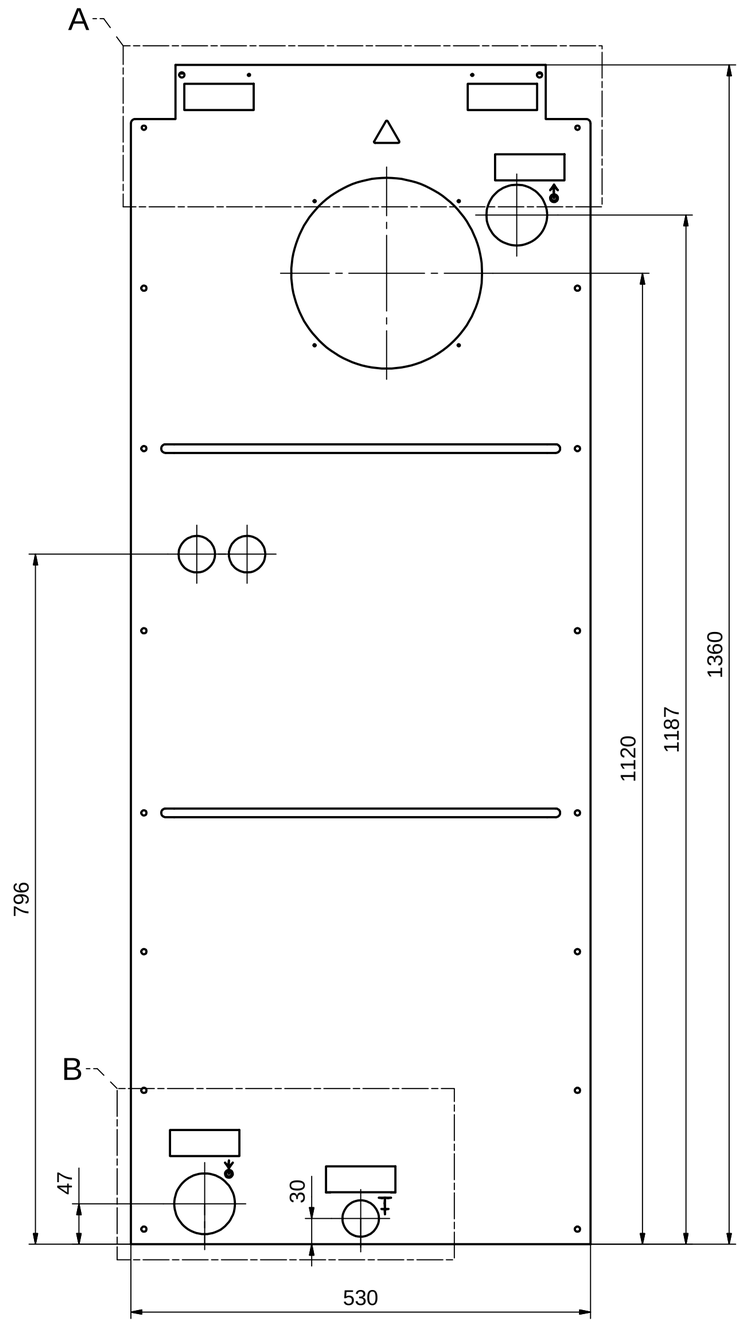


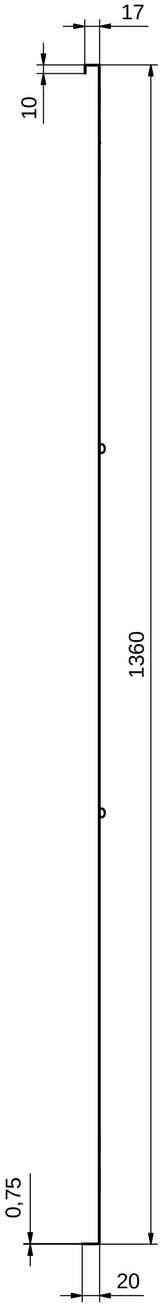
Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
7	1	Kabelkanal vertikal	Bl 0,75 x 167,5 x 1000,0	verz.	T230399
6	1	Kabelkanal horizontal rechts	Bl 0,75 x 217,0 x 900,7	verz.	T230294
5	1	Isolierseitenteil rechts	Bl 0,75 x 1210,7 x 1485,5	Pladurbl.RAL9006	T230292
4	1	Wärmedämmfilz	80 x 1070 x 1375	DOMO8	T230290
3	1	Aufkleber			T203910
2	1	Aufkleber		-	T203899
1	11	Blindniet	3,2x6	Stahl	56001

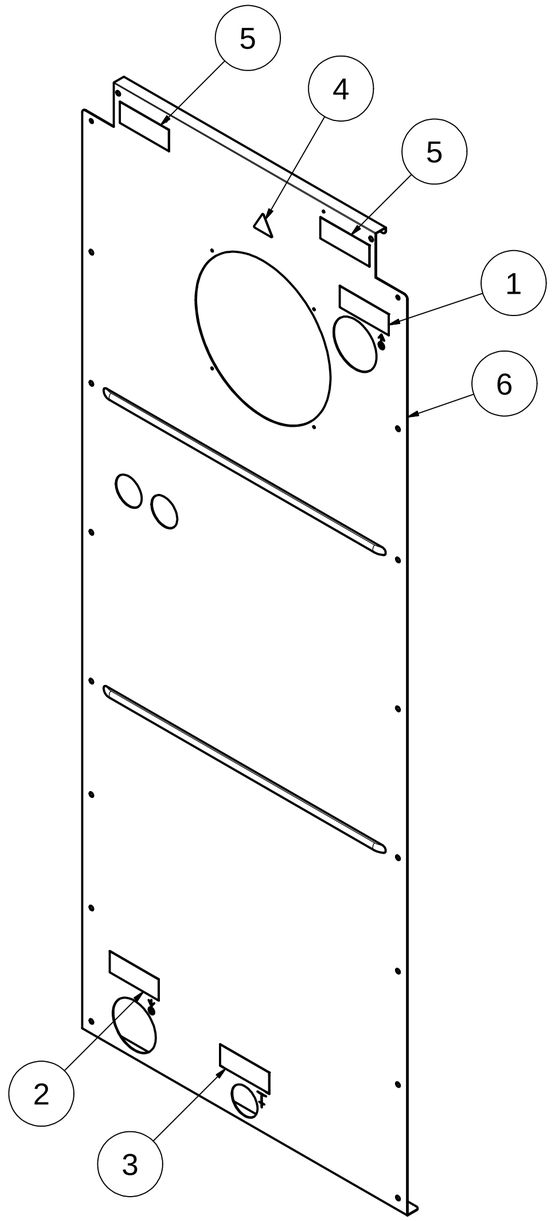
STÜCKLISTE

Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 13,42 kg	Oberfläche	Artikelnummer T230293	
	Datum	Name	Maßstab	Benennung
Gezeichnet	04.06.2013	mianzeng	1:10	Isolierseitenteil rechts Isolierung S3 18/28
Geprüft	12.06.2013	sthaidin		
Schutzvermerk ISO 16016 beachten			Ersatz für:	Projekt P100127 / Kunde
FRÖLING WÄRME AUS HOLZ HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12			Ers. durch:	Zeichnungsnummer Z064230-IDW / Rev. A / Blatt 1 v. 1

02.07.2013	mianzeng	1 Stk. Blindniete (Art. 56001) ergänzt;	
Datum	Bearbeiter	Letzte Änderung	A3







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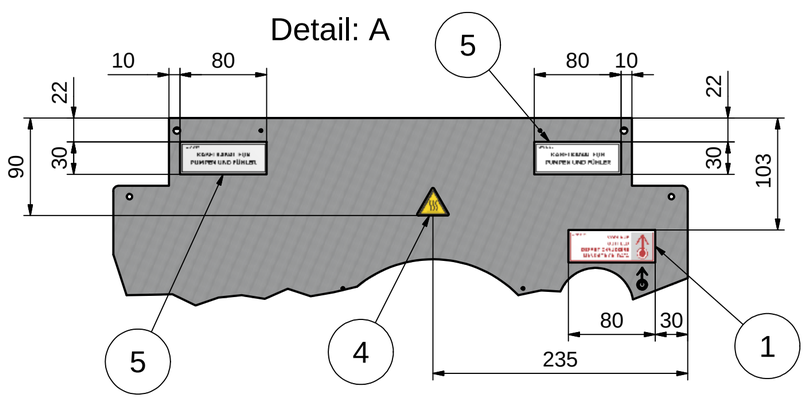

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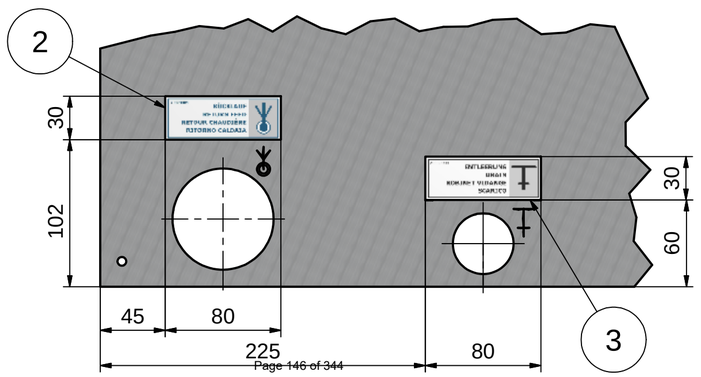

Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
6	1	Rückenteil	BL 0,75 X 530,0 X 1402,5	Pladurbl.RAL9005	T230288
5	2	Aufkleber		-	T205434
4	1	Aufkleber		-	T203899
3	1	Aufkleber Entleerung		-	60673
2	1	Aufkleber Rücklauf		-	60672
1	1	Aufkleber Vorlauf		-	60671

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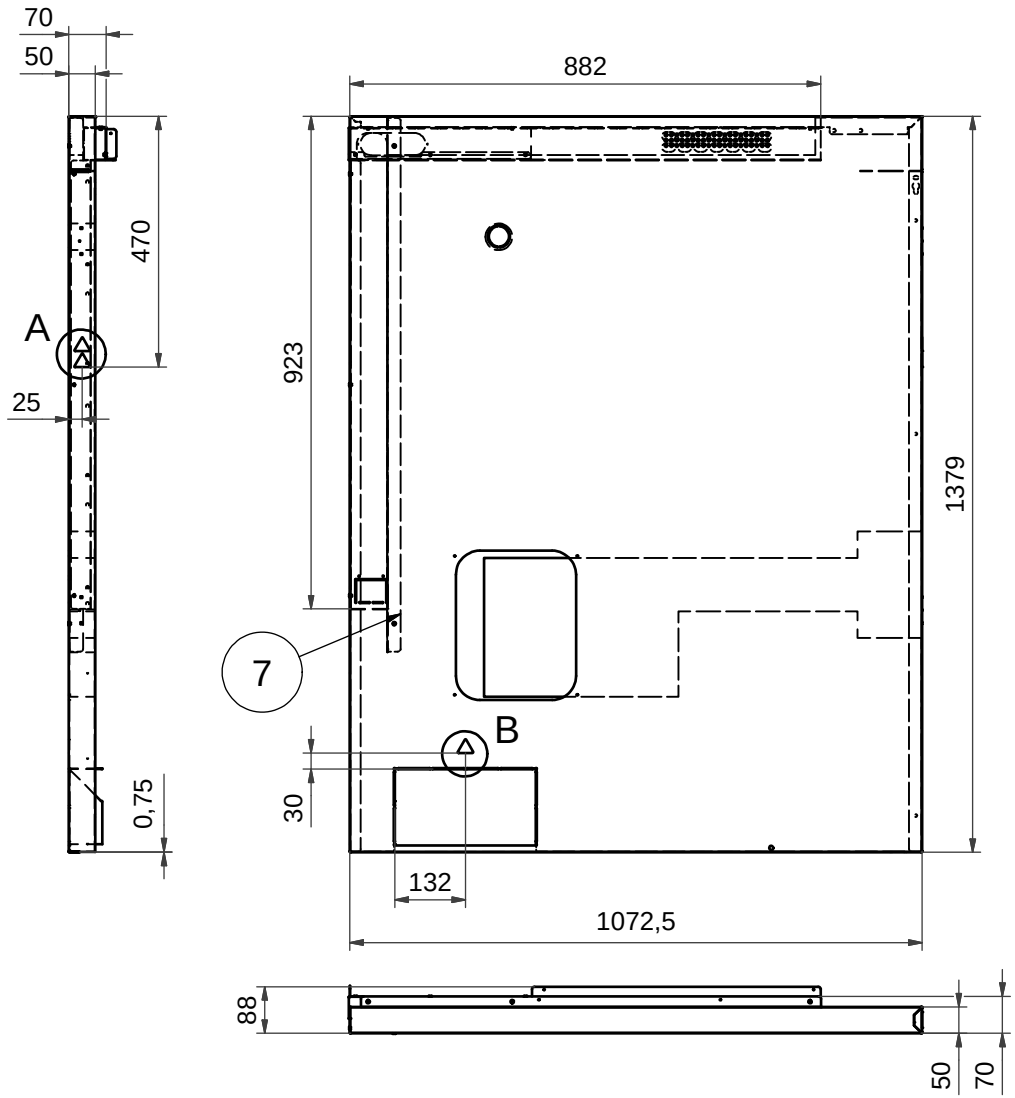
Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 4,181 kg		Oberfläche	Artikelnummer T230289
	Datum	Name	Maßstab	Benennung
Gezeichnet	05.06.2013	mianzeng	1 :5	Rückenteil Isolierung S3 18/28
Geprüft	12.06.2013	sthaidin		
Schutzvermerk ISO 16016 beachten				

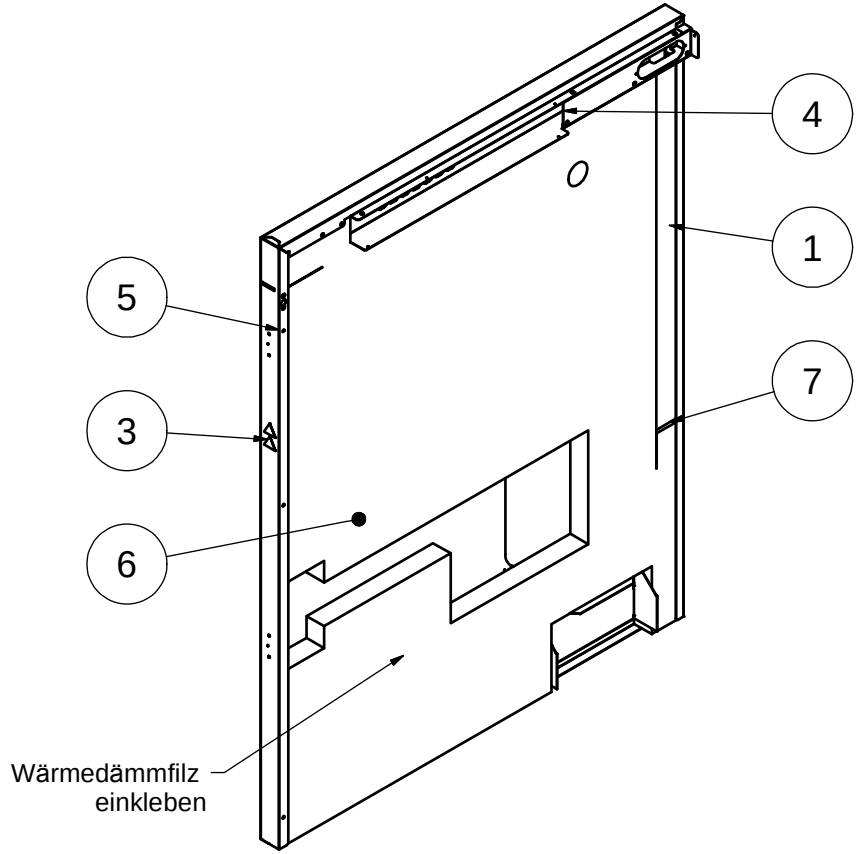
froling

HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H.
A-4710 Grieskirchen, Industriestraße 12

Ersatz für:	Projekt P100127	Kunde	
Ers. durch:	Zeichnungsnummer Z064469-IDW	Rev. A	Blatt 1 v. 1

15.03.2016	malugmai	Position Aufkleber "Vorlauf" u. "Rücklauf" geändert	
Datum	Bearbeiter	Letzte Änderung	A2

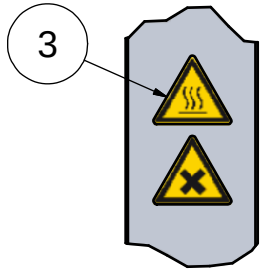




Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
7	1	Kabelkanal vertikal	Bl 0,75 x 167,5 x 1000,0	verz.	T230399
6	1	Wärmedämmfilz	80 x 1070 x 1375	DOMO8	T230290
5	1	Isolierseitenteil links	Bl 0,75 x 1210,7 x 1485,5	Pladurbl.RAL9006	T230284
4	1	Kabelkanal horizontal links	Bl 0,75 x 217 x 901	verz.	T230283
3	1	Aufkleber			T203910
2	1	Aufkleber		-	T203899
1	11	Blindniet	3,2x6	Stahl	56001

STÜCKLISTE

Detail: A



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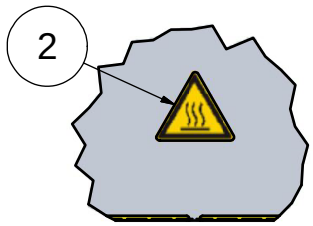


Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 13,43 kg	Oberfläche	Artikelnummer T230285

	Datum	Name	Maßstab
Gezeichnet	05.06.2013	mianzeng	1:10
Geprüft	12.06.2013	sthaidin	
Schutzvermerk ISO 16016 beachten			

Benennung: Isolierseitenteil links
Isolierung S3 18/28

FRÖLING
WÄRME AUS HOLZ
HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H.
A-4710 Grieskirchen, Industriestraße 12

Ersatz für:

Projekt: P100127

Kunde:

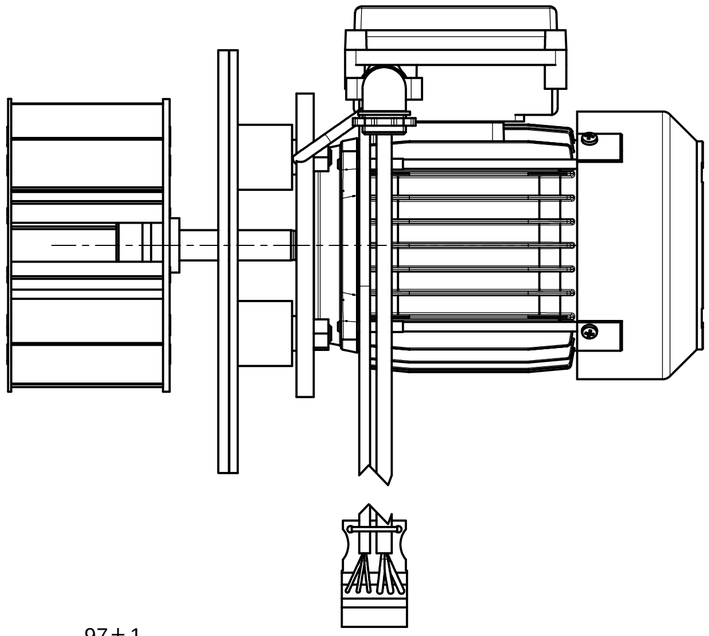
Ers. durch:

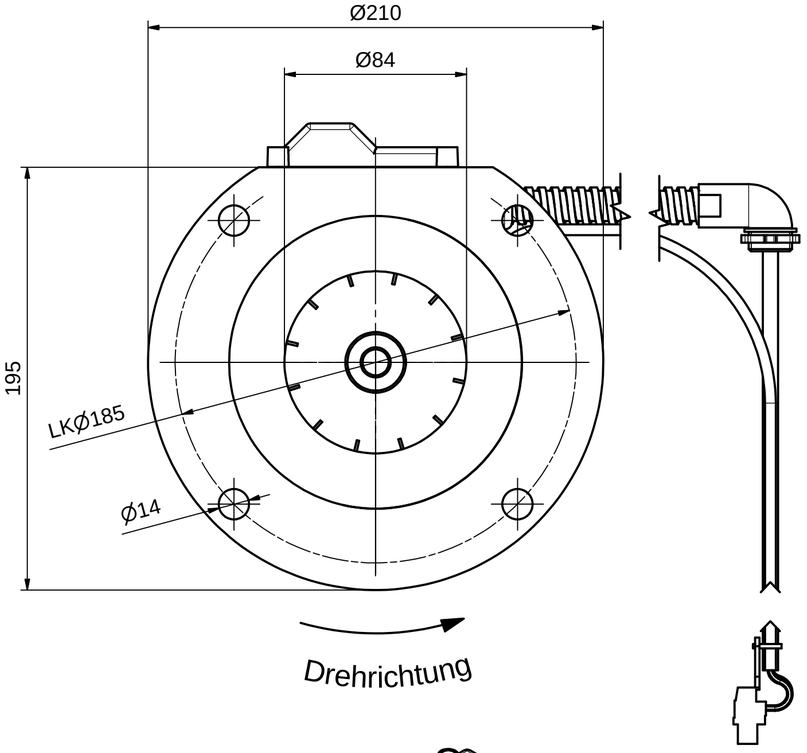
Zeichnungsnummer: Z064494-IDW

Rev.: A

Blatt v.: 1 1

Datum	Bearbeiter	Letzte Änderung	
02.07.2013	mianzeng	1 Stk. Blindniete (Art. 56001) ergänzt;	
Datum	Bearbeiter	Letzte Änderung	A3





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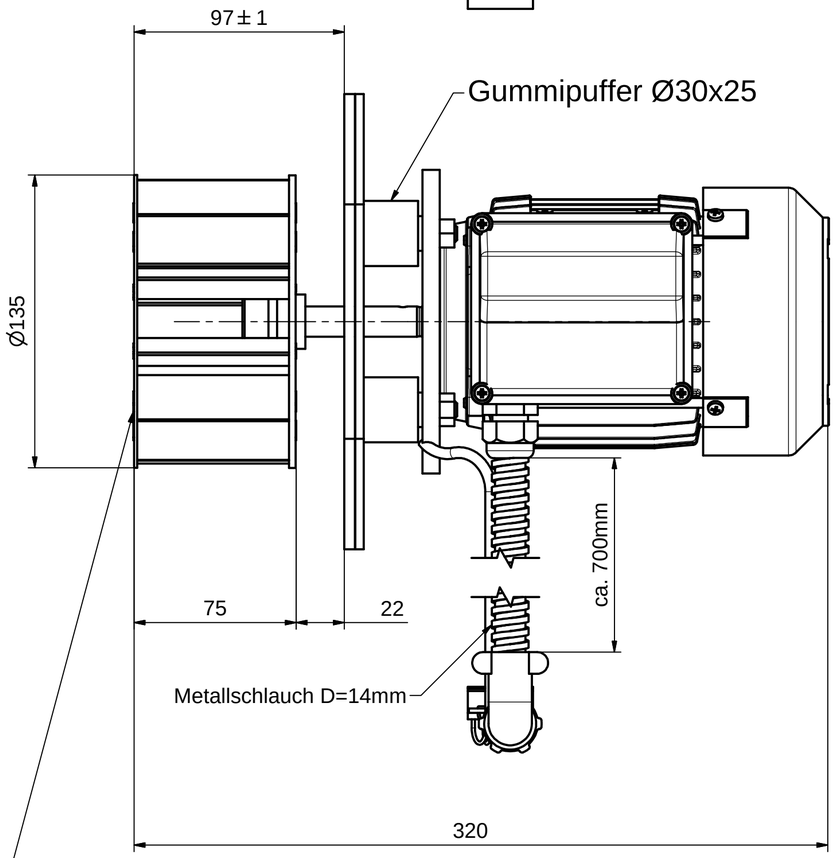

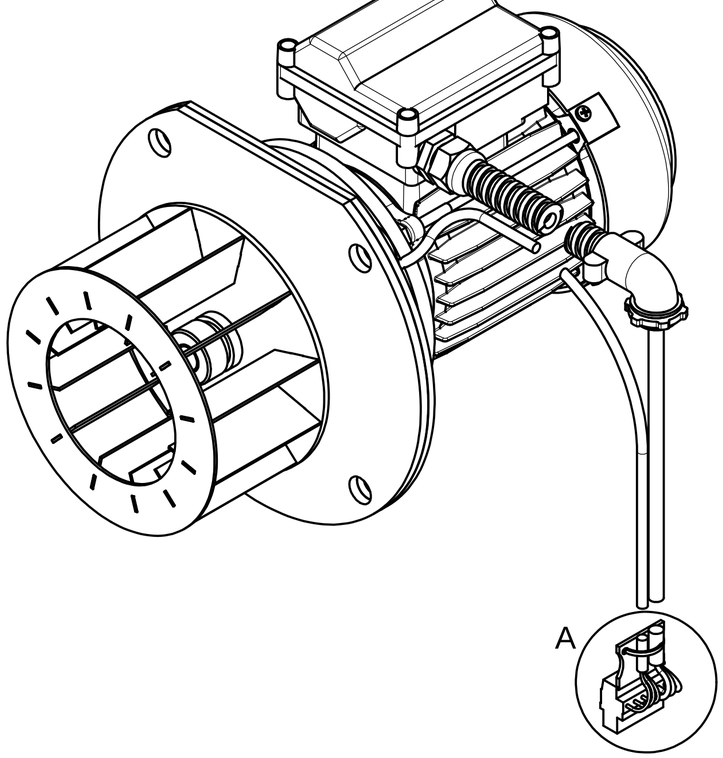

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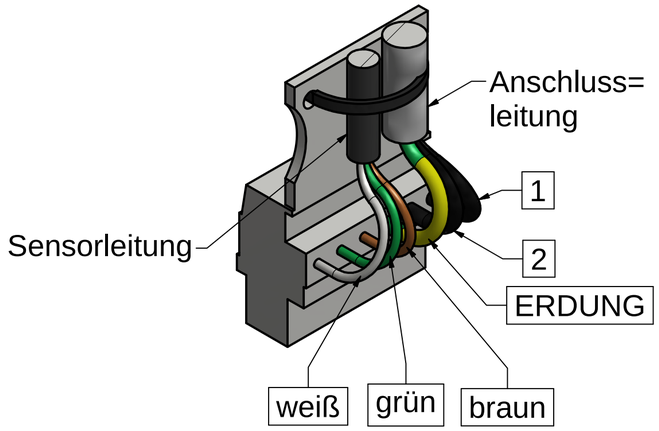

Spezifikationen:

> U_N= 220V; f_N=60Hz; n^{-1}=3360
> Thermokontakt
> UL/CSA Ausführung
> 1,9m Anschlussleitung Ölflex 191 3G1,5 AWG
mit 0,7m Metallschlauch D=14mm
sowie Schlauchverschraubung und Klemmschelle
> 1,9m Sensorleitung Unitronic LiYCY UL/CSA 3x20 / 7AWG
> Anschlussstecker 3615-01 06 K1 04

Achtung:
Schweißnaht darf max. 2mm überstehen

Toleranz EN 22768-1-m EN ISO 13920-B/F		Gewicht		Oberfläche	Artikelnummer T249404
	Datum	Name	Maßstab	Benennung	
Gezeichnet	10.03.2016	malugmai	1 : 2	Saugzuggebläse / UL-tauglich 3360U/min mit Drehzahlgeber	
Geprüft	10.03.2016	sthaidin			
Schutzvermerk ISO 16016 beachten				Ersatz für:	Projekt P200000 / Kunde
fröling HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12				Ers. durch:	Zeichnungsnummer Z088810-IDW / Rev. / Blatt 1 v. 1
Datum	Bearbeiter	Letzte Änderung			A2

Remainder of Engineering Drawings
(CBI Reports Only)

6. APPLIANCE LABELING AND OWNER'S MANUAL

S3 Turbo

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

V 134 02 22

Manufactured By: Froling GmbH, Grieskirchen, Austria
Test Standards: ANSI/UL 2523-2013, CAN/CSA B366.1-11

Test Date: July 22, 2020
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. Particulate Emissions less than 0.15 lbs/MMBtu.
U.S. ENVIRONMENTAL PROTECTION AGENCY Certified to comply with the 2020 particulate emission standards using cord wood.
Subpart QQQQ - Standards of Performance for New Residential Hydronic Heaters and Forced-Air Furnaces.

Model Modèle	Fuel Combustible	BTU/h (kW) Output Puissance Calorifique	Electrical Rating Classification Électrique	Date of Manufacture / Date de Fabrication
S3 Turbo 30	Wood	102,364 (30 kW)	230V, 60Hz, 120W	

EM
C O-TL US
OMNI-Test Laboratories, Inc.
Report # 0456WB007S, 0456WB009E

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

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

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 up to 21“ (51 cm)! Bois jusqu'à 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)

S3 Turbo

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

V 134 02 22

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Test Standards: ANSI/UL 2523-2013, CAN/CSA B366.1-11

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Serial #:

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U.S. ENVIRONMENTAL PROTECTION AGENCY Certified to comply with the 2020 particulate emission standards using cord wood.
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EM
C O-TL US
OMNI-Test Laboratories, Inc.
Report # 0456WB007S, 0456WB009E

CE
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EN 303-5

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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 up to 21“ (51 cm)! Bois jusqu'à 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

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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

OMNI-Test Laboratories, Inc.
Report # 0456WB007S, 0456WB009E

Read and follow the instructions and safety informations!
Technical changes, typographical errors and omissions reserved!
B1390422_en-us | Edition 7/15/2022

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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

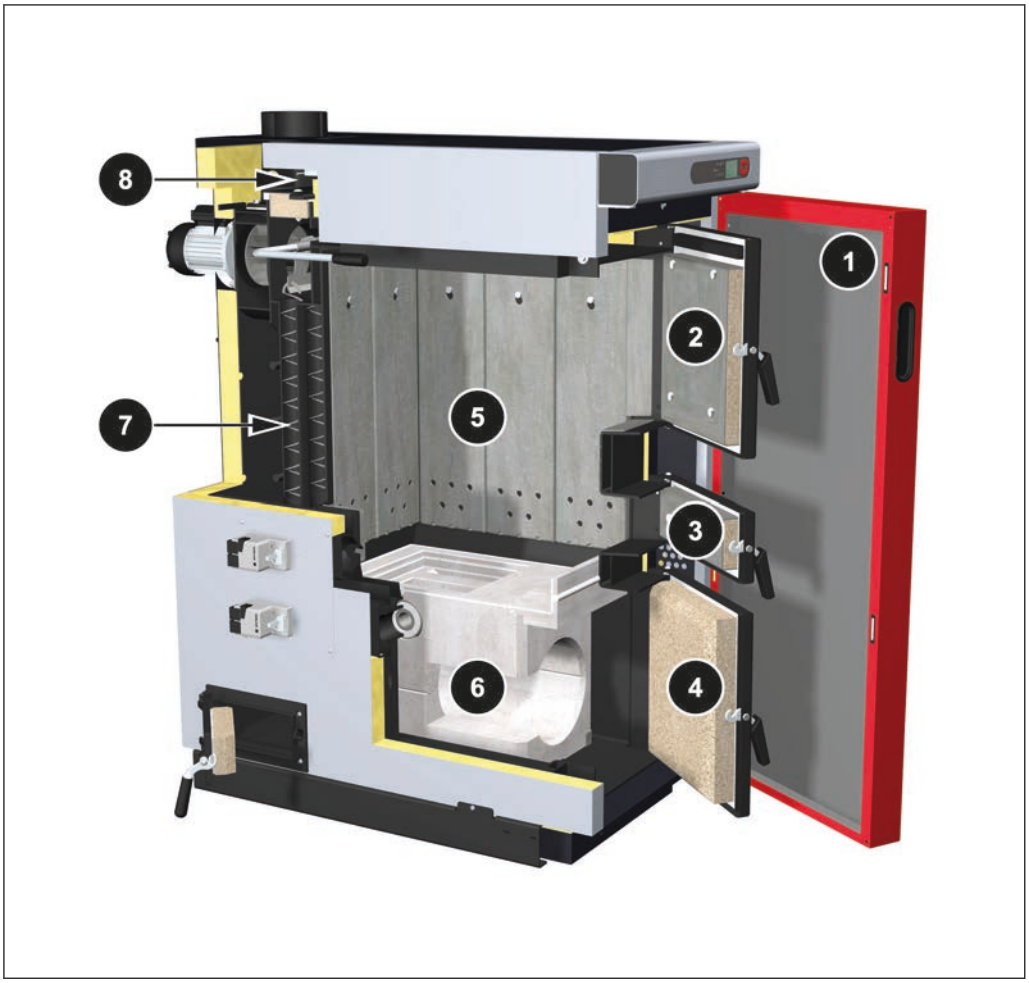
1.1 Front view

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 high operating efficiencies. If treated properly and operated according to the 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 B366.1-11 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.

The appliance is intended for use with a thermal storage reservoir:

- S3 Turbo 30: min. 400 gallons
- S3 Turbo 50: min. 600 gallons

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 2020 US Environmental Protection Agency's cord wood emissions limits for wood heaters sold after May 15, 2020.

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
⇨	Links to sections of these instructions and other relevant documents
▪	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 hydronic heating. Only use those fuels specified in the “Permitted fuels” section.

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

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

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 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 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 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.

  ↪ Misuse of the boiler can create hazardous situations.

2.3 Requirements at the place of installation

2.3.1 Approval for the heating system

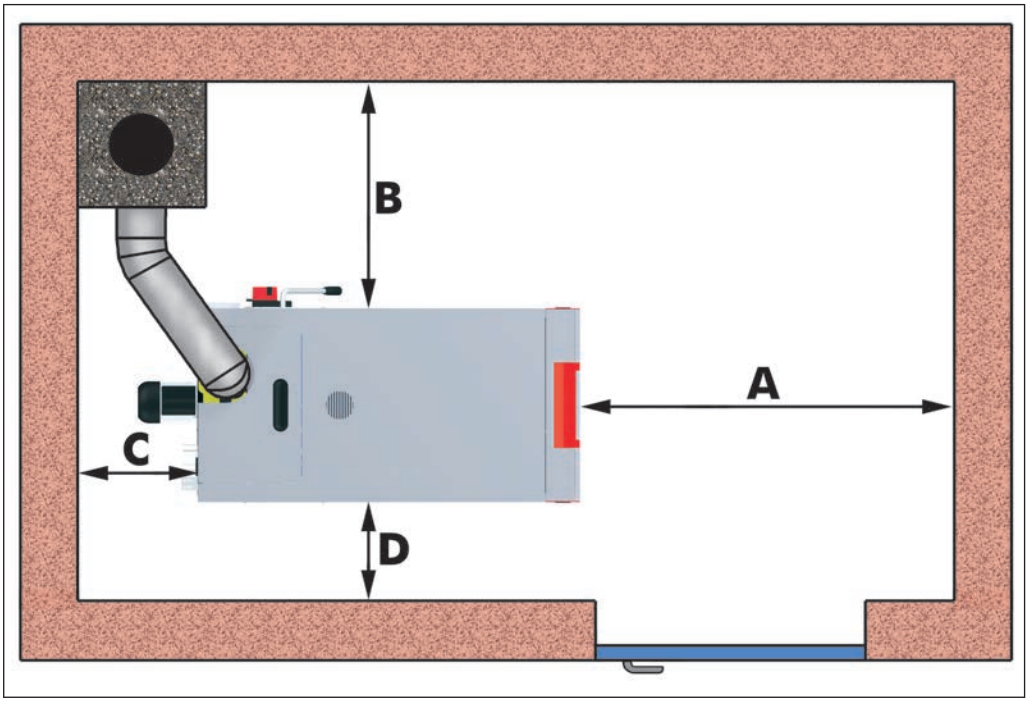
The appropriate supervisory authority (inspection agency) must always be informed when installing or modifying a heating system, and authorization must be obtained from the building authorities. Also observe ANSI/NFPA 211 and CAN/CSA B365 for the installation.

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.

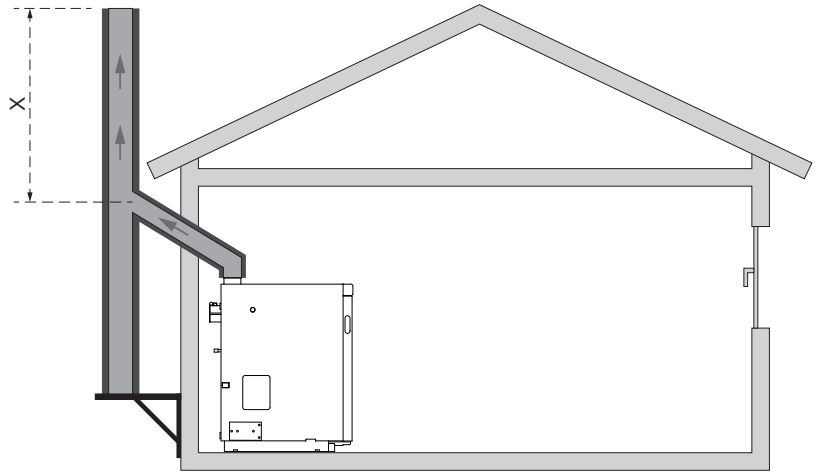
All connections must conform to NFPA 211. Consult your local chimney sweep for the installation and install the boiler in accordance with the applicable local regulations.

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.

Minimum height of the chimney

NOTICE! The chimney shall be approved by the competent authority!



Effective minimum height (X) of the chimney:

Boiler	Exhaust pipe diameter	Minimum height (X)
S3 Turbo 30	6 inches (149 mm)	17,7 feet (5,4 m)[1)]
S3 Turbo 50	6 inches (149 mm)	25,3 feet (7,7 m)[1)]

1. Requirements for chimney: double-walled stainless steel flue system, thermally insulated, external, single occupancy, sea level max. 800 m;
Requirements for connecting piece: thermally insulated, stretched length max. 1.5 m, effective height 0.5 m, max. one bend 90° and one bend 45°;

Basic data for designing the chimney connection

Description		S3 Turbo	
		30	50
Flue gas temperature at nominal load	°C	220	220
	°F	430	430
Flue gas temperature at partial load	°C	150	150
	°F	300	300
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	220 / 150 430 / 300	220 / 150 430 / 300
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

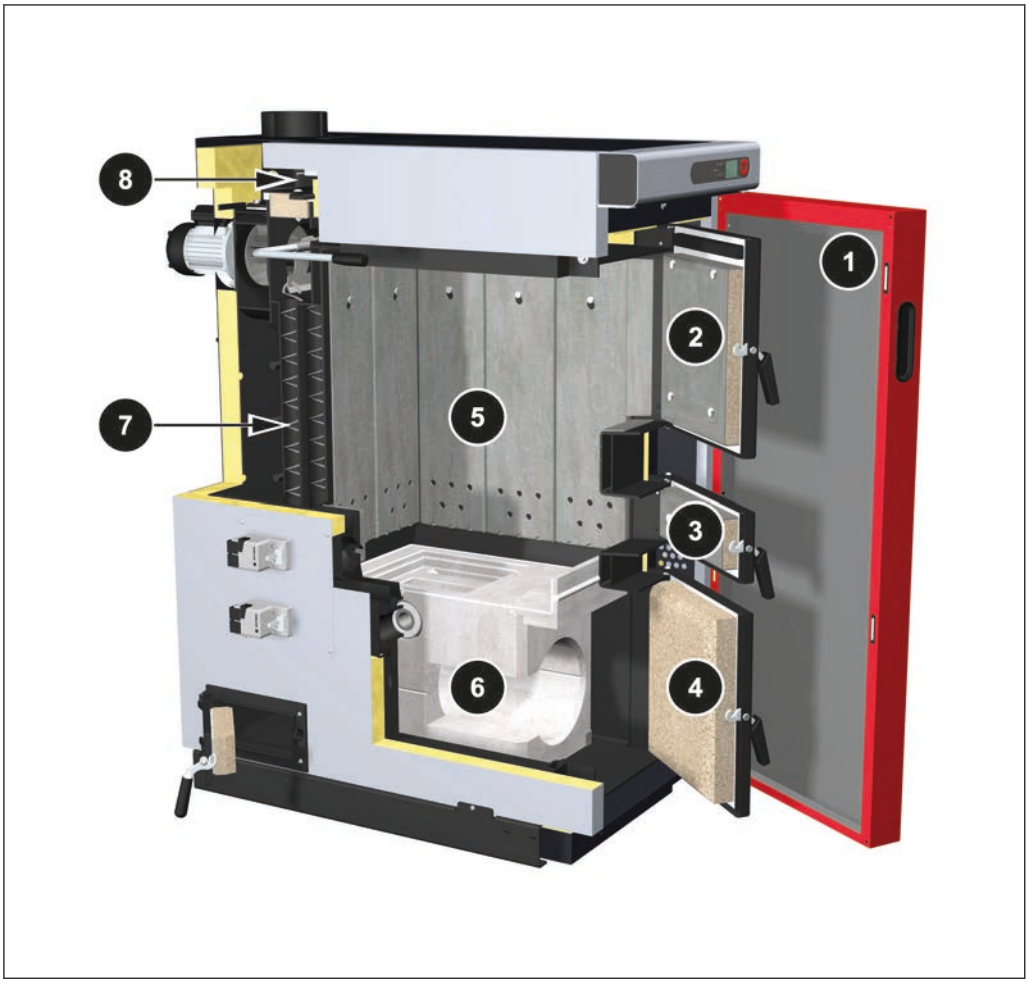
3.1 Front view

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 2020 US Environmental Protection Agency's cord wood emissions limits for wood heaters sold after May 15, 2020.

This wood pellet heater needs periodic inspection and repair for proper operation. It is against federal regulations to operate this wood pellet heater in a manner inconsistent with operating instructions in this manual. 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 16“ (41 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.

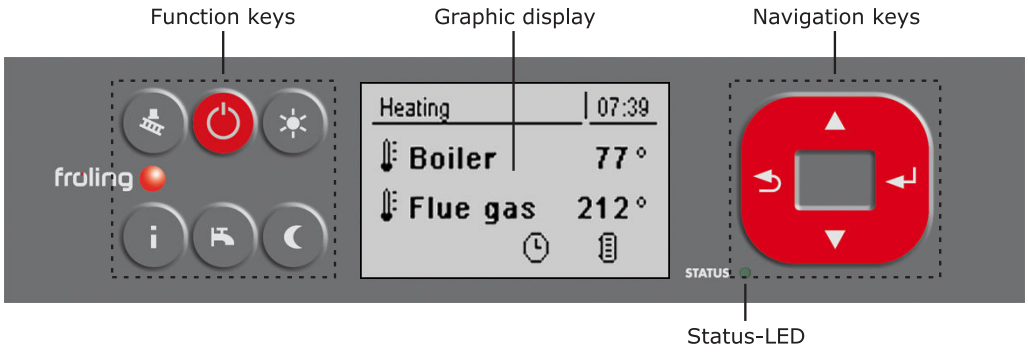
- ❒ Perform all operating steps according to the information and instructions in this manual.
- ❒ Only trained staff may carry out work to the system.
- ❒ Check the system externally for any visible damage or defects at least once a day.
- ❒ Before starting work, make sure that all covers and safety 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

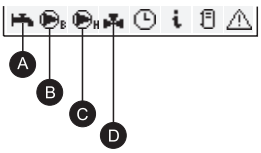
The status LED shows the operating status of the system:

- 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:



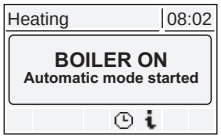
Item	Description	
A	Shows whether the storage tank (or oil boiler) is hot enough for hot water preparation.	Only for service technicians in the status menus.
B	Shown when the DHW tank or return temperature control pump is active.	
C	Shown when the heating circuit or storage tank loading pump is active.	
D	Shows the status of the heating circuit mixer.	

Function keys

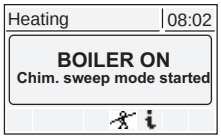
The function keys of the S-Tronic Lambda have dual assignments. Short or long pressing of the keys can access different functions (see below):

short keystroke …….. < 1 sec
long keystroke …….. > 4 sec

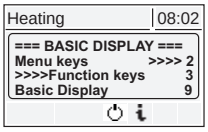
Standby key

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

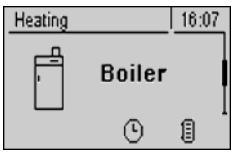
Keystroke		Function	
	short		The chimney sweep function is used for measuring boiler emissions using the chimney sweeper. For further information and the procedure for measuring emissions, see the operating instructions of the boiler and/or the “Instructions for the procedure for measuring emissions for the firewood boiler”.
	long		Function not used

Info key

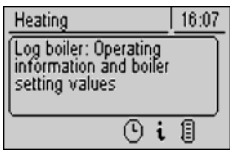
Keystroke		Function	
	Short		Shows plain text information about the menu items or fault messages.
	Long		Choose language: Deutsch, Polski, Cesky, Slovenski, Italiano, Francais, English

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:

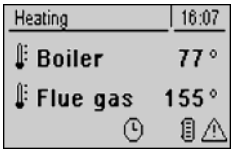


In normal operation (without pending fault messages) the info key can be pressed to display information or an explanation for every menu item or parameter.

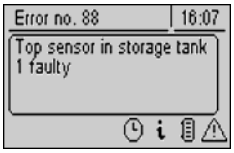


The info text is also identified by the frame and the info symbol on the status line.

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.

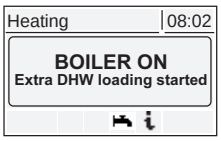
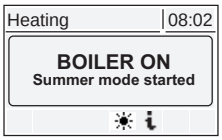


Pressing the info key calls up the information on the currently pending fault message again.

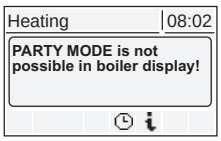
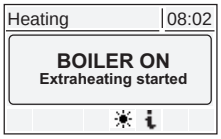
Procedure for troubleshooting:

Troubleshooting

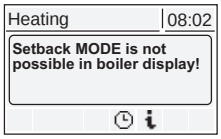
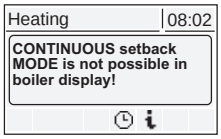
Boiler program key

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

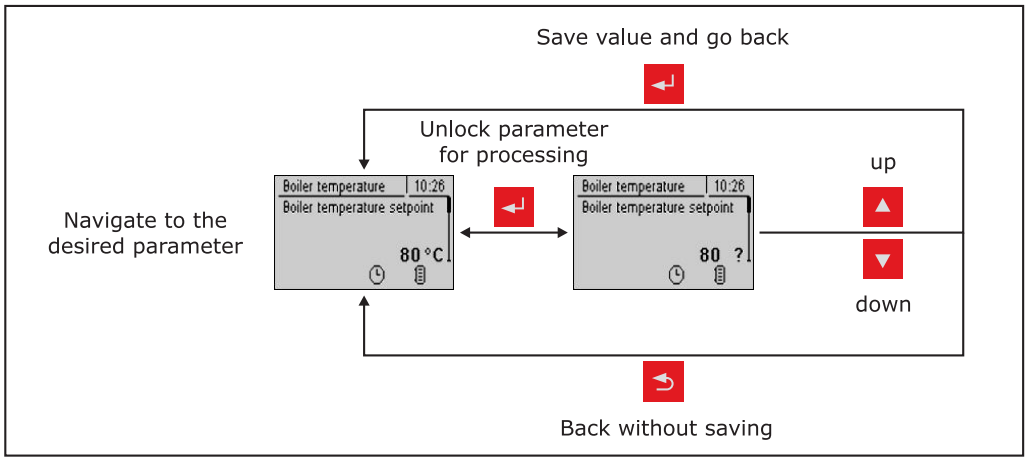
Keystroke		Function	
	short		To activate party mode on the room console. **Caution: Function only possible on the room console!** After an optional change to the room temperature setpoint, the heating circuit controller remains in heating mode until the end of the next heating period or another mode 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:

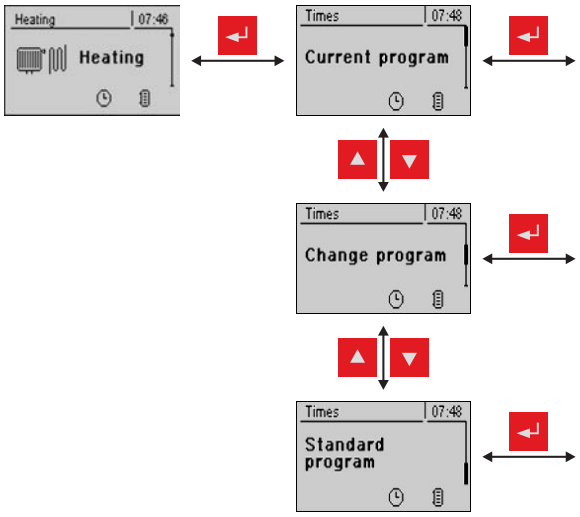


5.2.3 Setting times

The desired time window for the components can be set in the "Times" submenu in the individual menus of the heating components (heating circuits, DHW tanks ...). The structure of the time menu and the procedure for changing the times are always the same.

Example - Setting times for heating circuit 01:

In the "Heating" menu -> "Times":



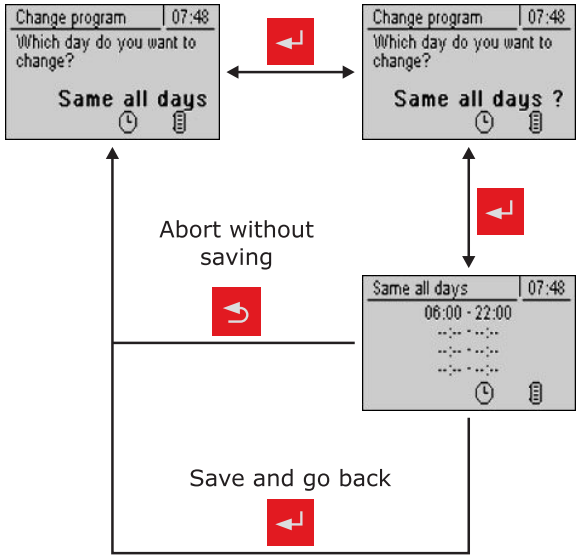
Current settings for the individual weekdays are displayed. Pressing the arrow keys changes to the next/previous weekday

See example below…

The factory set times are loaded by confirming again. (06:00 – 22:00)

Caution - the customer specific time settings are lost in the process!

… In the "Change program" menu:



After pressing the enter key you can select the day or the time period, for which the heating times are to be set:

- MO, TU, .., SU
- MO - FR
- SA - SU
- SAME ALL DAYS

After pressing the enter key again the time window for the desired day/time period is displayed.

Up to 4 different heating times can be entered sequentially here.

When the enter key is pressed, the cursor jumps to the next position, even if no time has been entered. If the cursor is in the last position, pressing the enter key saves the time window and switches to the previous menu

Deleting a time window

To delete a time window, the end time of the desired time window must be set to 24:00. If you press the up arrow key repeatedly the time disappears and is replaced by dashes. Then carry out the same process with the start time. After the enter key has been pressed repeatedly, the changes are adopted and the display returns to the previous menu.

5.3 Parameters overview

5.3.1 Heating

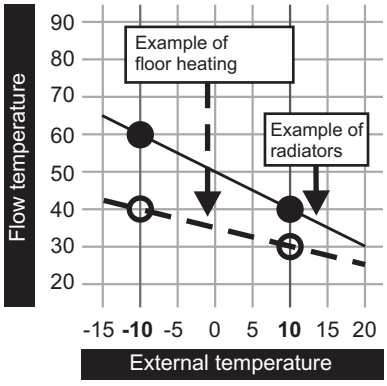
Heating - Status

Basic display → Heating → Heating circuit 1 → State

Heating circuit mode
Display and setting the heating circuit mode: ▪ **Auto:** Automatic: heating phases according to the set heating times ▪ **Extra heating:** heating circuit is activated for 6 hours. ▪ **Setback**: Setback mode; the heating phases are ignored ▪ **Continuous setback mode:** Heating circuit is reduced until activation of another mode. ▪ **Party:** party mode; the current or next setback program is ignored ▪ **OFF:** switched-off; heating circuit deactivated, only frost protection!
Actual flow temperature
Display of the current flow temperature.
Flow temperature setpoint
Display of the calculated flow temperature setpoint.
Room temperature
Prerequisite: Heating circuit used in conjunction with remote control Display of the current room temperature.
Outside air temperature
Display of the current outside air temperature.

Heating - Temperatures

Basic display ➡ Heating ➡ Heating circuit 1 ➡ Temperatures

Desired room temperature during heating mode
Prerequisite: Heating circuit used in conjunction with remote control Room temperature which is regulated during the set heating times
Desired room temperature during setback mode
Prerequisite: Heating circuit used in conjunction with remote control Room temperature which is regulated outside of the set heating times
Flow temperature SP at outside air temperature of +10°C
First setting point for definition of heating curve
Flow temperature SP at outside air temperature of -10°C
Second setting point for definition of heating curve 
Reduction of flow temperature in setback mode
The flow temperature is reduced by this value during setback mode.
External temperature, at which heating circuit pump switches off in heating mode
If the outside air temperature exceeds this value during heating, the heating circuit pumps and mixing valve are deactivated.
External temperature, at which heating circuit pump switches off in setback mode
If the outside air temperature falls below this value in setback mode, the heating circuit pumps and mixing valve are activated.
Frost protection temperature
If the room temperature or the flow temperature is lower than the set value, the heating circuit pump will be switched on and the heating circuit mixer keeps to the maximum heating circuit flow temperature that is set.
From which temperature at storage tank top should the overheating protection be activated
If the temperature at top storage tank exceeds the set value, the heating circuit is activated regardless of mode (boiler, remote control) and set heating times. The flow temperature is controlled to the value set in the parameter “Flow temperature SP at outside air temperature of -10°C”. The function will remain active until the value falls below 2°C. **Recommendation:** The overheating protection should be assigned to a high temperature heating circuit (e.g. radiators).

Heating - Times

Basic display ➡ Heating ➡ Heating circuit 1 ➡ Times

⇨ See "Setting times" [page 49]

5.3.2 Water

Water - Status

Basic display ➡ Water ➡ State

DHW tank top temperature
Current temperature of the DHW tank. The DHW tank is heated when the time window for the DHW tank loading is reached and the current temperature of the DHW tank has fallen below the value using the parameter "`Reload if DHW tank temperature is below`". A loading of the DHW tank takes place when either the time window has elapsed or the temperature value which is set under "`Set DHW temperature`" is reached.
DHW tank bottom temperature
Prerequisite: Solar panel system is regulated by Froling! Current temperature in the area of the reference sensor of the solar panel system.
DHW tank pump control
Specifies the speed of the DHW tank pump as a percentage of maximum speed.

Water - Temperatures

Basic display ➡ Water ➡ Temperatures

Set DHW temperature
When this DHW temperature is reached, DHW tank loading is stopped.
Reload if DHW tank temperature is below
If the DHW tank temperature falls below the value set here, the time window is active and the loading source (boiler or buffer tank) indicates the set loading increase, and the DHW tank loading is started.

Water - Times

Basic display ➡ Water ➡ Times

⇨ See "Setting times" [page 49]

5.3.3 Solar

Solar - Status

Basic display ➡ Solar ➡ State

Collector temperature
Display of the current temperature at the solar collector.
Top storage tank solar sensor
Display of the current temperature at the solar reference sensor in the top part of the buffer tank.
Solar temperature buffer tank bottom
Display of the current temperature at the solar reference sensor in the lower part of the buffer tank.
Actual power from solar heat meter [kW]
Display of the current output which is generated by the solar collector. The calculation of the output is only performed either when a per litre output of the collector pump has been set or an external volume pulse transmitter is used. In order to perform the calculation more precisely, the use of a collector return sensor is recommended.
Flow through [l/h]
Prerequisite: External volume pulse transmitter installed Display of the water quantity currently being pumped through the solar collector.
Todays yield [kWh]
Display of the heat quantity that has been supplied by the solar panel system today.
Daily yield 1 day ago [kWh]
Daily yield 2 days ago [kWh]
Daily yield 3 days ago [kWh]
Daily yield 4 days ago [kWh]

Daily yield 5 days ago [kWh]
Daily yield 6 days ago [kWh]
Total yield [kWh]
Display of the heat quantity which has been supplied by the solar panel system since activation of the heat meter.
DHW tank bottom temperature
Current temperature in the area of the reference sensor of the solar panel system.
Heat exchanger sec. return temperature (line to buffer tank)
Prerequisite: Hydraulic system 12 or 13 Current temperature at heat exchanger flow on the secondary side.
Collector pump runtime
Display of the total runtime of the collector pump.
Collector pump control
Display of the current speed of the collector pump as a percentage of maximum speed.
Pump between heat exchanger and buffer tank
Prerequisite: Hydraulic system 12 or 13 Display of the current speed of the pump between heat exchanger and buffer tank.
Pump between heat exchanger and DHW tank
Prerequisite: Hydraulic system 12 Display of the current speed of the pump between heat exchanger and DHW tank.
Diverter valve for top/bottom coils
Prerequisite: Hydraulic system 12 or 13 Current control of the isolating valve on the solar side. ▪ **0%** … bottom buffer tank ▪ **100%** … top buffer tank
Outfeed: 80°C / RL: 50°C **P: 0.0 kW / DFL: 0** **Today: 0 kWh** **Total: 0 kWh**
▪ **OUTFEED**: Current collector flow temperature ▪ **Return**:Current collector return feed temperature ▪ **P**:Current output which is generated by the solar collector ▪ **DFL**:Current flow rate of solar collector ▪ **Today:** Heat quantity that has been produced by the solar panel system today ▪ **Total:** Heat quantity that has been produced since activation of the solar panel system

Solar - Temperatures

Basic display ➡ Solar ➡ Temperatures

Boiler target temperature during solar charging
Up to this temperature the DHW tank is heated by the solar system. If the solar panel system is equipped with an isolating valve for switching between DHW tank and buffer solar coil, then this parameter is responsible for switching between both of these solar coils.
Temp differential to start collector pump
The collector pump activates when the collector temperature exceeds the reference temperature in the DHW tank or buffer tank by this value.
Temp difference to stop collector pump
The collector pump switches off when the difference between the collector temperature and reference temperature in the DHW tank or buffer tank is lower than this value.
Maximum buffer tank bottom temperature during solar charging
Prerequisite: Hydraulic system 12 or 13 If the sensor for the solar reference temperature in the buffer tank exceeds the specified value, the collector pump is switched off.
Collector/pump protection from a collector temp.
If the measured value of the solar collector sensor exceeds the set value, then the solar collector must cool down by 20°C within 15 minutes, otherwise the solar collector pump stops in order to protect the pump.

Solar - Heat meter

Basic display ➡ Solar ➡ Solar heat meter

Outfeed: 80°C / RL: 50°C **P: 0.0 kW / DFL: 0** **Today: 0 kWh** **Total: 0 kWh**
▪ **OUTFEED**: Current collector flow temperature ▪ **Return**:Current collector return feed temperature ▪ **P**:Current output which is generated by the solar collector ▪ **DFL**:Current flow rate of solar collector ▪ **Today:** Heat quantity that has been produced by the solar panel system today ▪ **Total:** Heat quantity that has been produced since activation of the solar panel system
Collector temperature
Display of the current temperature at the solar collector.

Actual power from solar heat meter [kW]
Display of the current output which is generated by the solar collector. The calculation of the output is only performed either when a per litre output of the collector pump has been set or an external volume pulse transmitter is used. In order to perform the calculation more precisely, the use of a collector return sensor is recommended.
Flow through [l/h]
Prerequisite: External volume pulse transmitter installed Display of the water quantity currently being pumped through the solar collector.
Todays yield [kWh]
Display of the heat quantity that has been supplied by the solar panel system today.
Daily yield 1 day ago [kWh]
Daily yield 2 days ago [kWh]
Daily yield 3 days ago [kWh]
Daily yield 4 days ago [kWh]
Daily yield 5 days ago [kWh]
Daily yield 6 days ago [kWh]
Total yield [kWh]
Display of the heat quantity which has been supplied by the solar panel system since activation of the heat meter.

5.3.4 Buffer tank

Buffer tank - Status

Basic display ➡ Buffer tank ➡ Buffer tank 01 ➡ State

Buffer tank top temperature
Display of the current temperature in the top part of the buffer tank.
Buffer tank temperature, sensor 2
Prerequisite: Master boiler in the cascade or hydraulic system 4 or fuel amount calculation Display of the current temperature in the top part of the buffer tank.
Buffer tank temperature, sensor 3
Prerequisite: Master boiler in the cascade or hydraulic system 4 or fuel amount calculation Display of the current temperature in the lower part of the buffer tank.
Buffer tank middle temperature
Prerequisite: Middle buffer tank temperature sensor installed Display of the current temperature in the mid area of the buffer tank.
Buffer tank bottom temperature
Display of the current temperature in the lower part of the buffer tank.
Buffer tank pump control
Display of the current speed of the buffer loading pump.
Buffer tank charge
Prerequisite: Master boiler in the cascade or hydraulic system 4 or fuel amount calculation Display of the current buffer tank charge.

Buffer tank - Temperatures

Basic display ➡ Buffer tank ➡ Buffer tank 01 ➡ Temperatures

Heating circuit release from following buffer tank temperature
Temperature value which must be reached to release the heating circuit pumps in the top part of the buffer tank. **NOTICE! This parameter applies for all available heating circuits!**

5.3.5 Boiler

Boiler - Status

Basic display → Boiler → State

Boiler temperature
Display of the current boiler temperature.
Flue gas temperature
Display of the current flue gas temperature.
ID fan control
Display of the current ID fan control.
Primary air
Display of the current value of the primary air flap according to controller.
Residual oxygen content
Display of the current residual oxygen content.
Return sensor
Prerequisite: Return temperature control with mixing valve or bypass pump Display of the current temperature at the boiler return.

Boiler - Temperatures

Basic display → Boiler → Temperatures

Boiler temperature setpoint
The boiler temperature is regulated to this temperature. Setting range 70 – 90°C

Boiler - General settings

Basic display ➡ Boiler ➡ General settings

Fuel selection
▪ **Dry firewood:** If firewood is to be burnt with a water content (w) of less than 15%, then this setting must be selected. A prompt message then appears to confirm whether the specified values for the chosen fuel selection should be adopted. ▪ **Wet firewood:** If firewood is to be burnt with a water content (w) of more than 15%, then this setting must be selected. A prompt message then appears to confirm whether the specified values for the chosen fuel selection should be adopted.
Modem installed
▪ **NO:** The boiler does not have a modem for data transfer installed. ▪ **YES:** The boiler has a modem for data transfer installed.
Display temperature in Fahrenheit
▪ **NO:** Displayed temperature values and settings are shown in °C. ▪ **YES:** Displayed temperature values and settings are shown in °F.
Always log data in °C
▪ **YES:** In conjunction with a data logger, all temperature values are saved in °C. ▪ **NO:** In conjunction with a data logger, all temperature values are saved in °F.
Source for ext. power demand (0 - off, 1 - 0-10V, 2 - Modbus)
Invert ext. power demand via analogue input
Input external power demand
Current external power demand

5.3.6 Boiler 2

Boiler 2 - Status

Basic display ➡ Boiler 2 ➡ State

Temperature of secondary boiler
Display of the current boiler temperature of the secondary boiler.
Burner relay status
Shows the current status of the burner relay: ▪ **0:** Secondary boiler not active ▪ **1:** Secondary boiler active
Secondary boiler pump
Prerequisite: “Isolating valve installed” parameter set to “NO” Display of the current pump control for the secondary boiler.
Secondary boiler switching valve
Prerequisite: “Isolating valve installed” parameter set to “YES” Display of the current isolating valve control of the secondary boiler.
Manual start of secondary boiler (only when ID fan is switched off)
▪ **OFF:** Secondary boiler is controlled according to the program that is set ▪ **ON:** Secondary boiler is activated immediately **NOTICE! Burner blockage noted.**

Boiler 2 - Temperatures

Basic display ➡ Boiler 2 ➡ Temperatures

Secondary boiler start delay
If there is a requirement from the heating circuit or DHW tank and the buffer tank or boiler has insufficient temperature, the secondary boiler starts after the specified delay time set here.
Secondary boiler minimum runtime
If the secondary boiler is started, it will run for at least the length of time set here.
Temperature difference between secondary boiler and buffer tank
Temperature difference between secondary boiler and upper temperature in layered tank to activate the loading pump of the secondary boiler.

5.3.7 Difference regulator

Difference regulator - Status

Basic display → Diff. control → State

Heat source sensor
Display of the current heat source temperature of the differential controller (e.g. tiled stove with water pocket, …)
Heat sink sensor
Display of the current temperature of the heat sink for the differential controller (e.g. layered tank, …)
Pump speed
Specifies the current speed of the differential controller pump.

Difference regulator - Times

Basic display → Diff. control → Times

Diff. control start time
If after reaching the specified time, the criteria for starting the differential controller is permitted, then the pumps of the differential controller starts
Diff. control stop time
Also when the criteria for starting the differential controller is fulfilled, the differential controller is only active until the specified time.

5.3.8 Circulation pump

Circulation pump - Status

Basic display → Circ. pump → State

Return temperature in secondary circulation line
Display of the current temperature at the return feed sensor of the circulation line. **NOTICE! If the parameter “Return sensor present” is set to “NO”, 0°C is permanently displayed.**
Flow switch on the domestic hot water line
▪ **0:** Flow switch detects no flow rate. ▪ **1:** Flow switch detects flow rate.
Speed of the circulation pump
Specifies the current speed of the circulation pump.

Circulation pump - Temperatures

Basic display → Circ. pump → Temperatures

Switch off the pump at what return temperature in the circulation line
If the set temperature at the return circulation line is reached, the circulation pump will be deactivated. **NOTICE! Parameter only relevant when using a return feed sensor in the circulation line!**

Circulation pump - Times

Basic display → Circ. pump → Times

⇨ See "Setting times" [page 49]

5.3.9 System

System - Current values

Basic display ➡ System ➡ Current values

Display of the current value for the relevant parameter. The parameters displayed depend on the boiler configuration!

Current status runtime
:
Software version
:

System - Error

Error - Error display

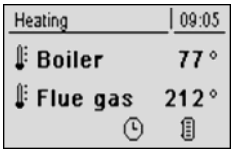
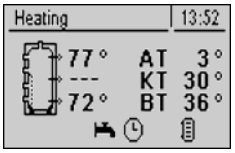
Basic display ➡ System ➡ Error ➡ Error display

Display of the current fault messages. In addition, you can also invoke time information here, such as when the fault occurred, when the fault was acknowledged and when the fault was cleared.

System - Basic display parameters

Basic display ➡ System ➡ Basic display parameters

You can individually adjust how the two items are shown in the basic display, and for each item you can choose from several parameters: e.g. boiler, flue gas, external, room, DHW tank, buffer tank top, buffer tank bottom, buffer tank graph, etc.

Position 1	Boiler	Selected
Position 2	Flue gas	Selected
		

If the “buffer tank graph” is selected, the temperatures of the top, middle (if available) and bottom buffer tank will be displayed next to the graph. In addition, further, fixed predefined values will be displayed:

OT ... Outside temperature
BT ... Boiler temperature
RT ... Room temperature (on room console BT is replaced by RT)
DT ... DHW tank temperature (if available)

System - Boiler mode

Basic display → System → Boiler mode

Boiler mode
▪ **Automatic mode:** When “Automatic” is selected, the heating circuit as well as the domestic hot water tank are supplied with heat from the buffer tank according to the selected heating times. ▪ **Domestic hot water:** In “Domestic hot water” mode, the domestic hot water tank is supplied with heat from the buffer tank within the selected domestic hot water loading times. Heating circuits are not supplied with heat. Frost protection active.

System - Language

Basic display ➡ System ➡ Language

Language - Sprache - Langue - Lingua - Jezik
▪ Deutsch, English, Francais, Italiano, Slovenski, Cesky, Polski, Svenska, Espanol, Magyar, Suomi, Dansk, Nederlands, Русский, Serbian

System - Current Date

Basic display ➡ System ➡ Current Date

Current Date
Display and setting of current date.

System - Current Time

Basic display ➡ System ➡ Current Time

Current Time
Display and setting the current time.

System - Current User Level

Basic display ➡ System ➡ Current user level

Child lock (Code “0”)
At “Child lock” level, only the “Status” menu appears. It is not possible to change parameters at this level.
Customer (Code “1”)
Standard user level for normal operation of the display. All customer-specific parameters are displayed and can be changed.
Installer / Service
Releases parameters to adjust the controller to the system components (if configured).

5.4 Before heating up the boiler

5.4.1 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!

5.4.2 Reloading intervals

Reloading intervals should be determined exclusively according to the thermal storage for efficient and environmentally-friendly heating.

5.4.3 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 69])

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

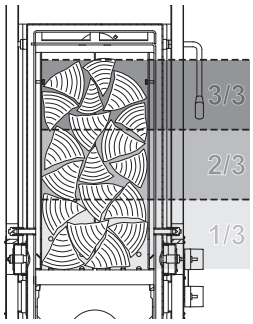
5.4.4 Fuel table

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)

5.4.5 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)

5.4.6 Reloading intervals when operating without thermal storage or if the thermal storage is too small

NOTICE

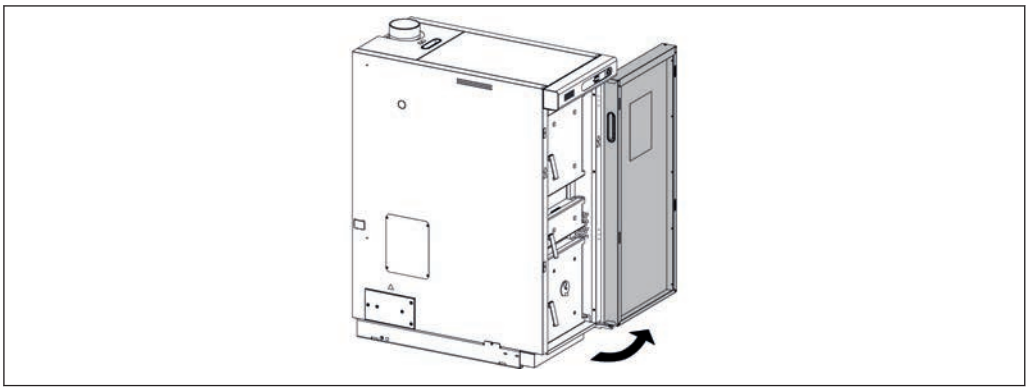
Performance-related loading:

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.

5.5 Heating up the boiler

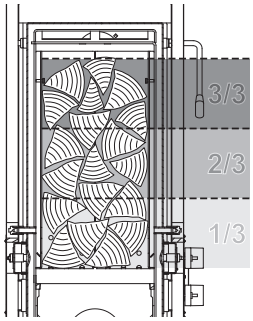


❒ Open the insulated door.

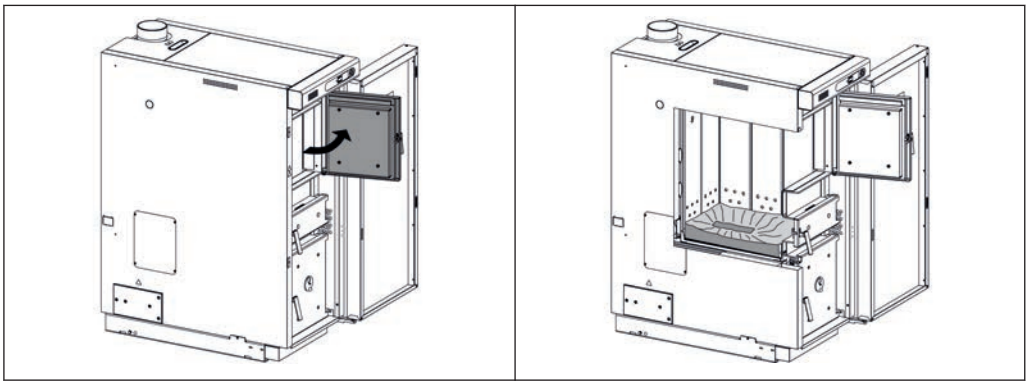
↪ The induced draft fan starts running and the boiler display alternately shows the boiler's current values and the required fuel quantity to load the thermal storage.

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.

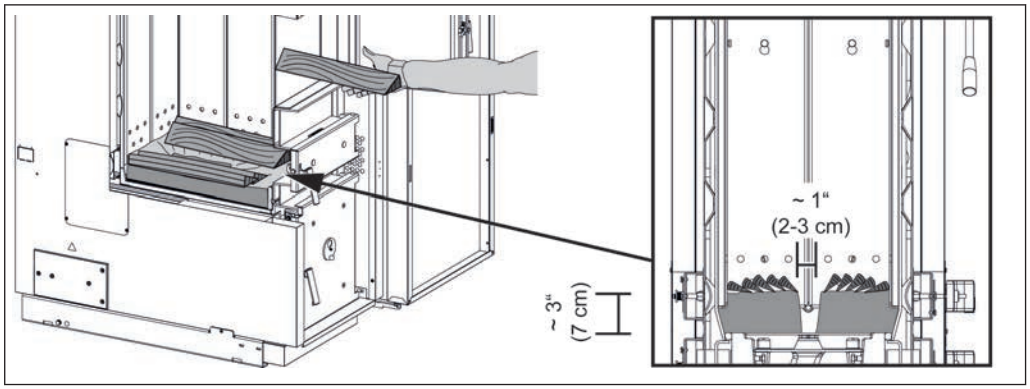


Fill level		Weight at fill level	
		S3 Turbo 30	S3 Turbo 50
3/3	Soft wood	approx. 53 lbs (24 kg)	approx. 86 lbs (39 kg)
	Hardwood	approx. 88 lbs (40 kg)	approx. 143 lbs (65 kg)
2/3	Soft wood	approx. 35 lbs (16 kg)	approx. 57 lbs (26 kg)
	Hardwood	approx. 60 lbs (27 kg)	approx. 95 lbs (43 kg)
1/3	Soft 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

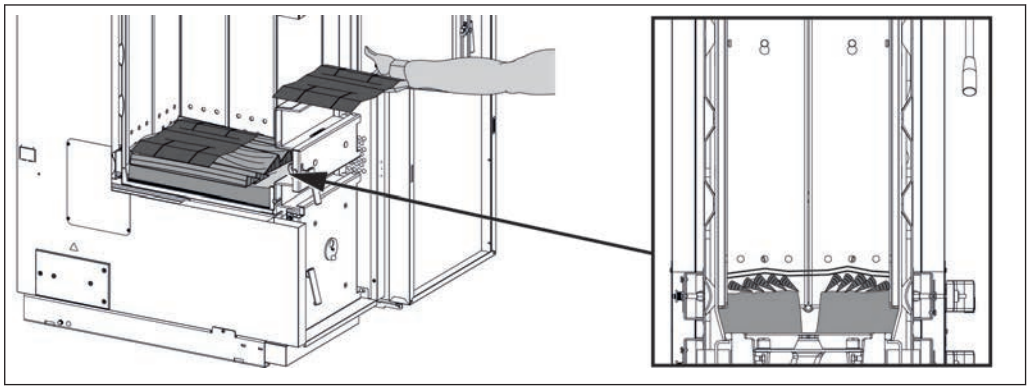
↪ Ash should remain in the boiler up to the height between the lowest and middle rows of holes, about 3" (7 cm) of the aprons. It is recommended that you do not remove the ash in the combustion chamber during each heating-up process, but rather only when the middle row of holes is no longer visible, until the remaining amount is about 3" (7 cm). This protects the combustion chamber and accelerates the heating-up process.



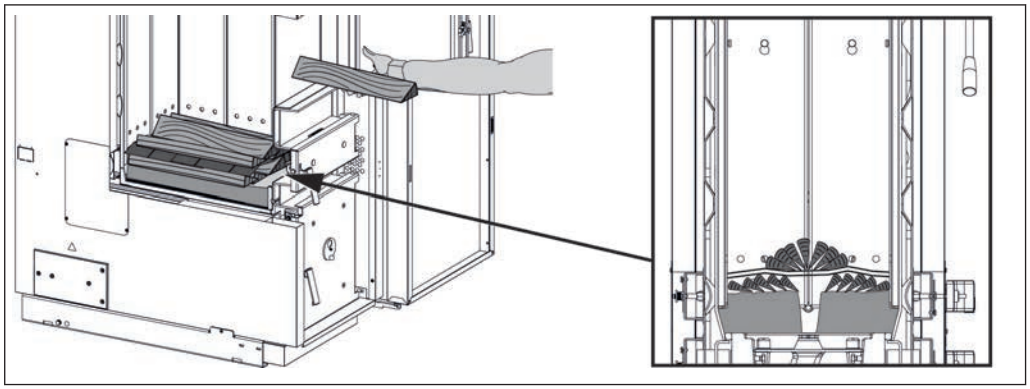
❒ Insert one layer of small-sized firewood.

➥ Approximately ten pieces of kindling with a cross-section of approximately 1“ (2-3 cm) and a length of approximately 18“ (46 cm)

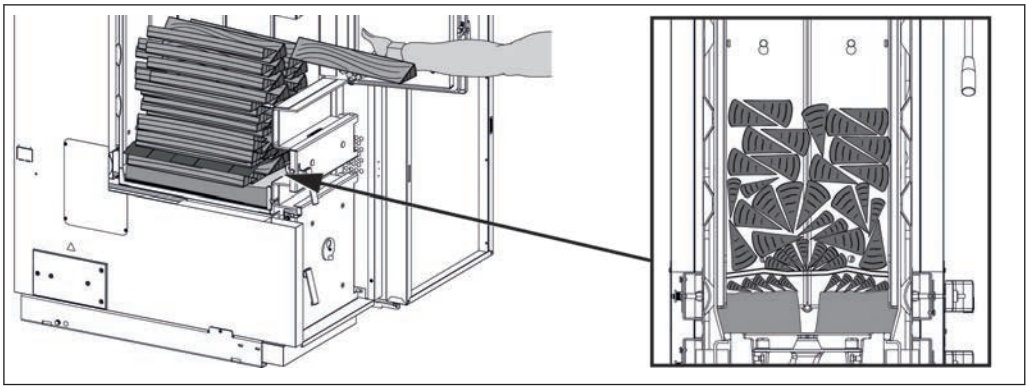
➥ Do not cover the flame slot entirely (approx. 1”, 2-3cm).



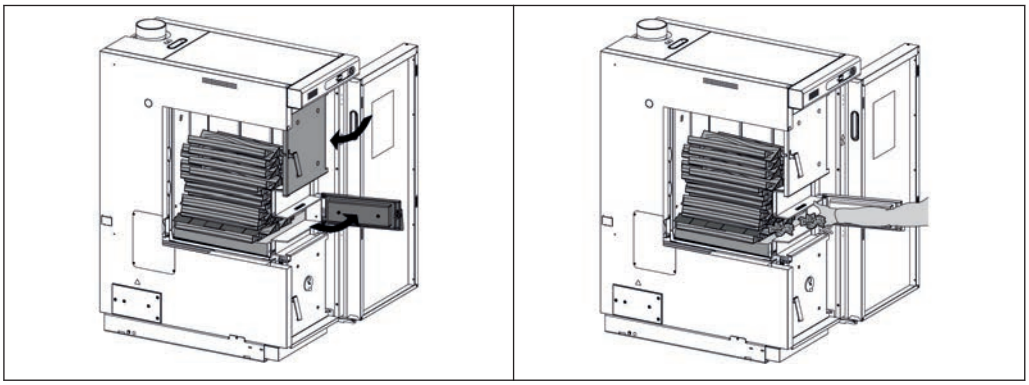
❒ After the first layer of wood, lay cardboard across the whole area.



❒ 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.

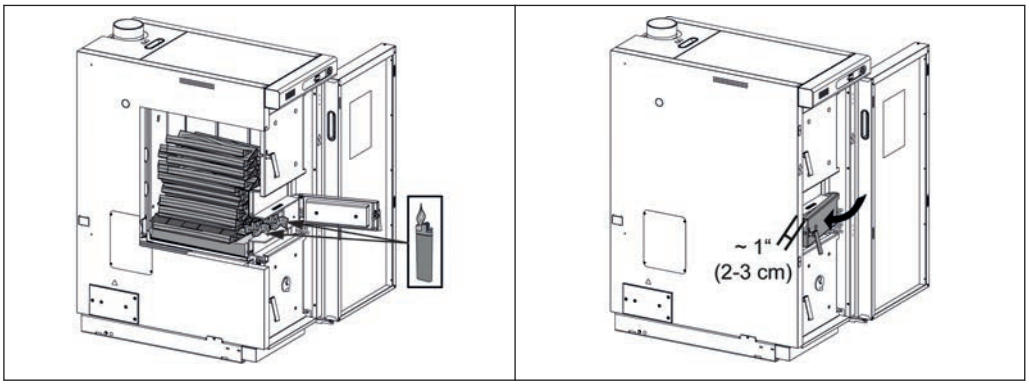


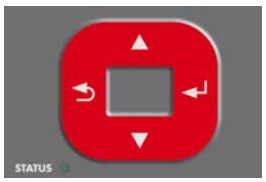
❒ Once the kindling and start-up fuel is in place, add the amount of firewood required to recharge your thermal storage.



❒ 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.

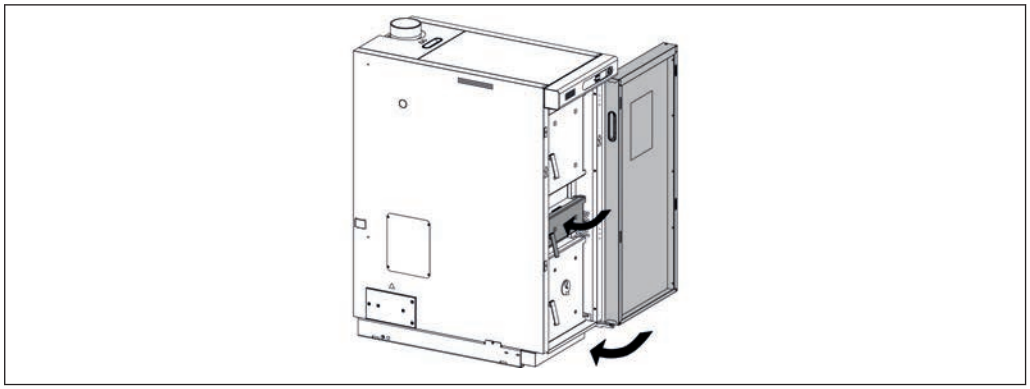
❒ Ignite paper with a lighter at several positions.

❒ 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!

5.6 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

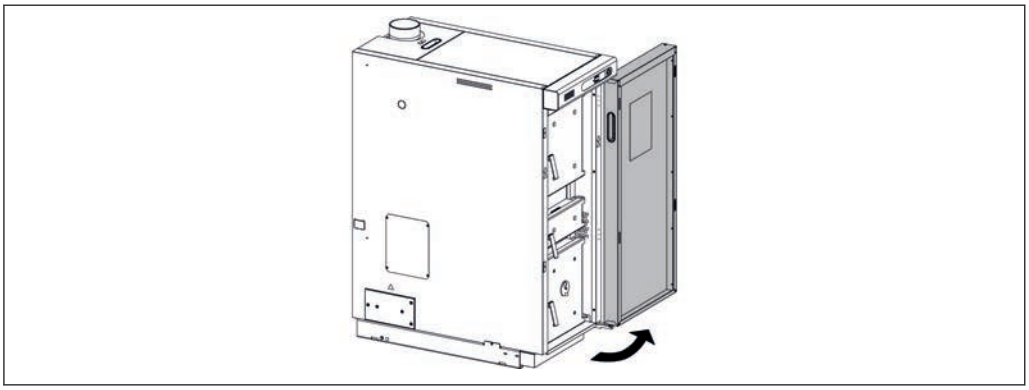
⚠ WARNING

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

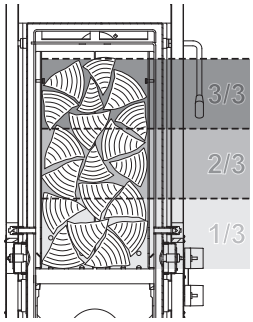
↪ The induced draft fan starts running and the boiler display now alternately shows the boiler's current values and the required fuel quantity to load the thermal storage.

↪ 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.

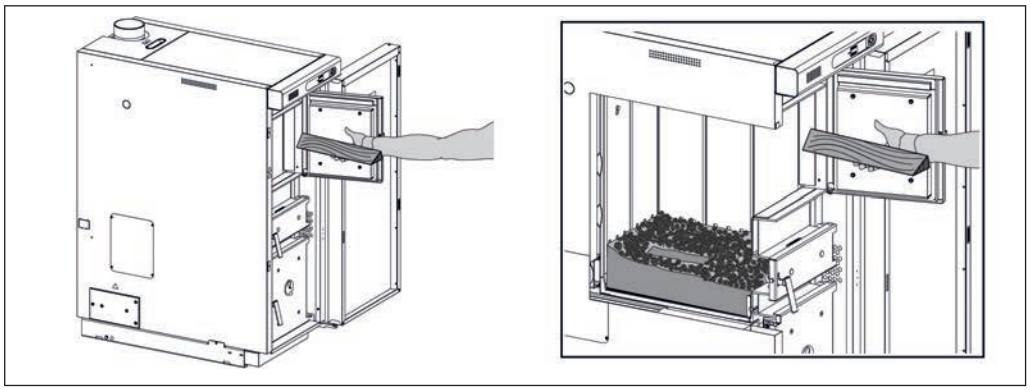
Fill level		Weight at fill level	
		S3 Turbo 30	S3 Turbo 50
3/3	Soft wood	approx. 53 lbs (24 kg)	approx. 86 lbs (39 kg)
	Hardwood	approx. 88 lbs (40 kg)	approx. 143 lbs (65 kg)
2/3	Soft wood	approx. 35 lbs (16 kg)	approx. 57 lbs (26 kg)
	Hardwood	approx. 60 lbs (27 kg)	approx. 95 lbs (43 kg)
1/3	Soft 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.

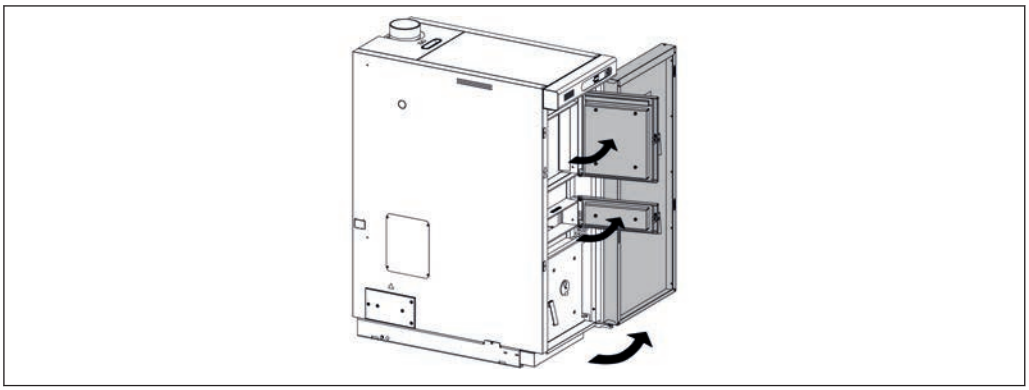
❒ The optimal time for adding fuel is when the basic firebed is achieved.

➥ A firebed is “basic” when it reaches the top row of holes in the cladding.

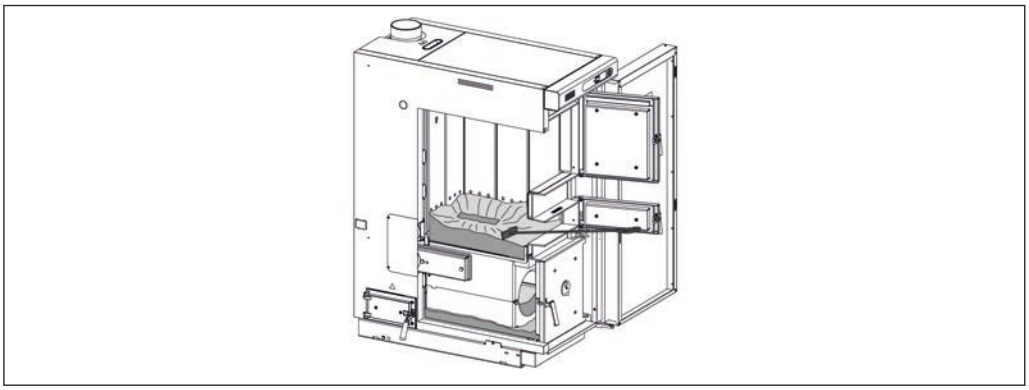


❒ Open the fuel loading door, add the prepared fuel quantity, then close the fuel loading door and insulated door again.

5.7 Remove ash

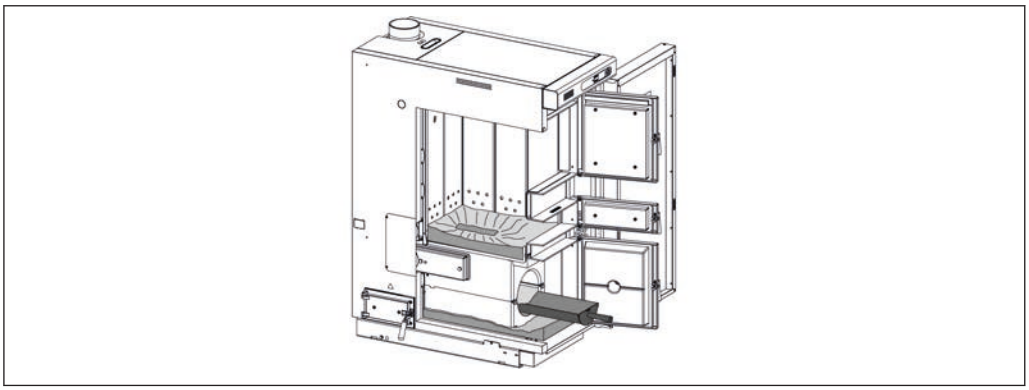


❒ Open the insulated door, pre-heating chamber door and the fuel loading chamber door



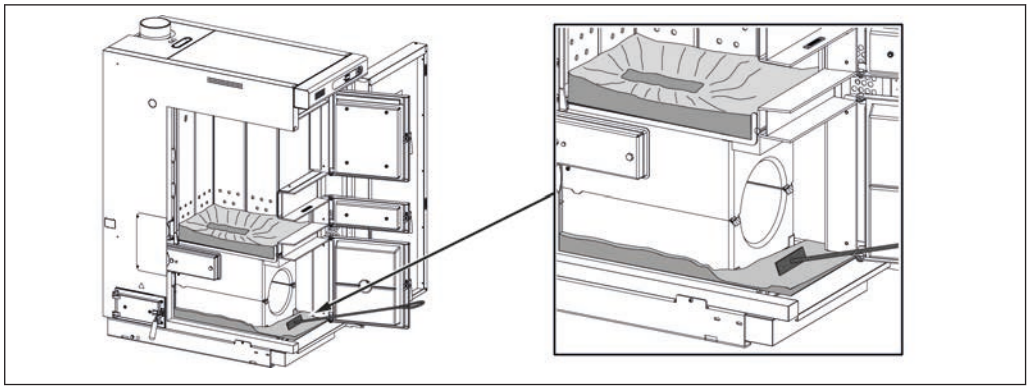
❒ Scrape the ash from the fuel loading chamber into the combustion chamber using the furnace tool.

➥ 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.

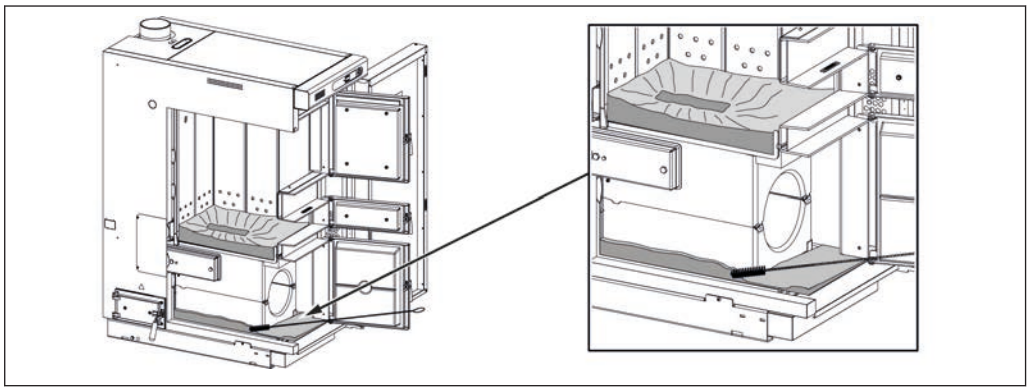


❒ Open the combustion chamber door and remove ash with a round ash shovel

➥ 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:

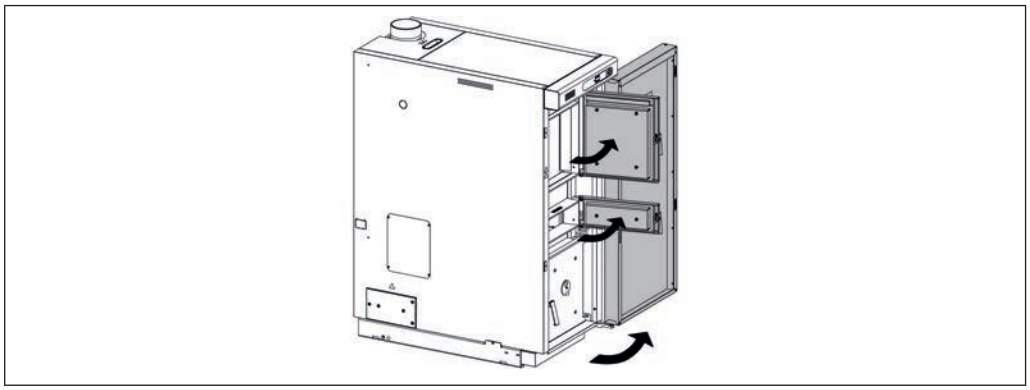
❒ Ask an expert to inspect the expansion tank.

Checking the safety valve

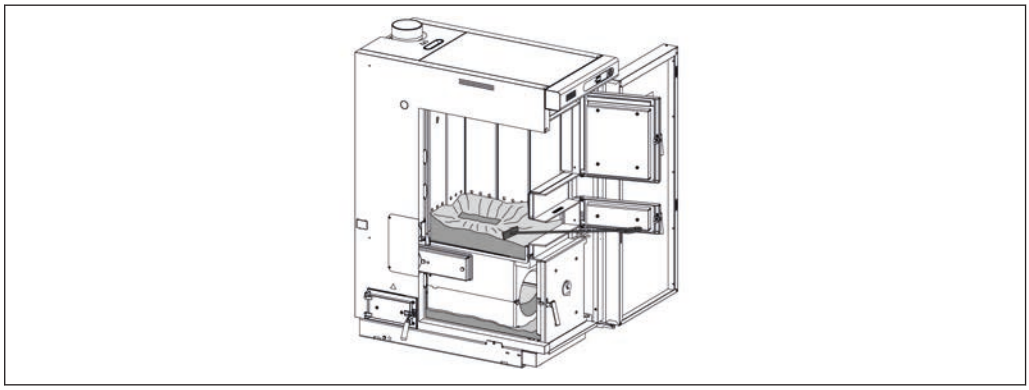
❒ Check the seal of the safety valve regularly and ensure that the valve is not dirty.

NOTICE! Inspection work must be carried out in accordance with the manufacturer's instructions.

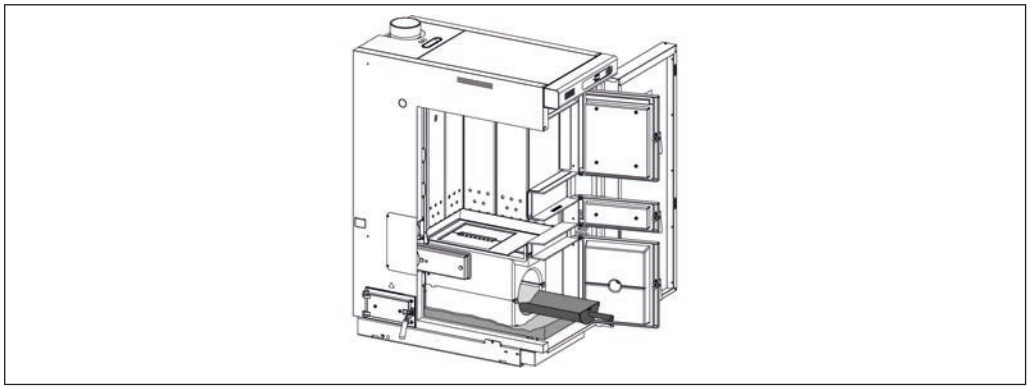
6.4.2 Remove ash



❒ Open the insulated door, pre-heating chamber door and the fuel loading chamber door

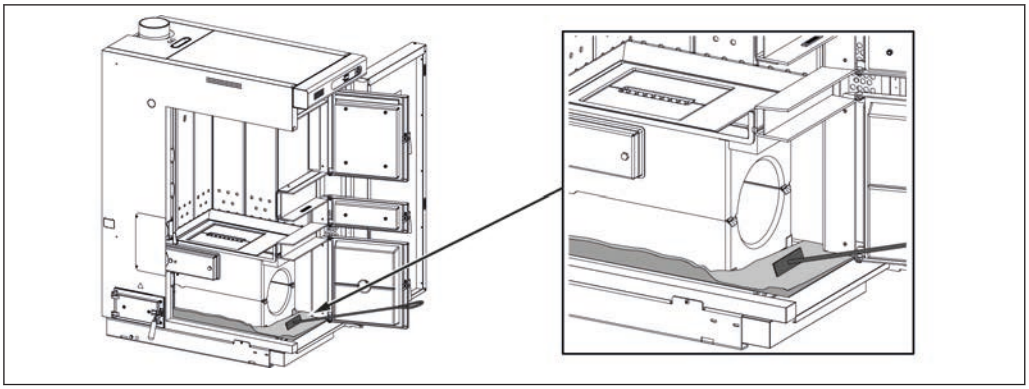


❒ Scrape the ash from the fuel loading chamber into the combustion chamber using the furnace tool.

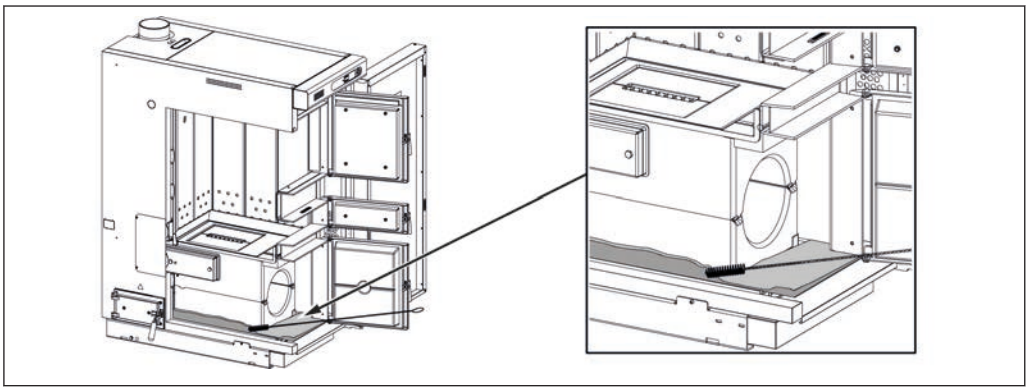


❒ Open the combustion chamber door and remove ash with a round ash shovel

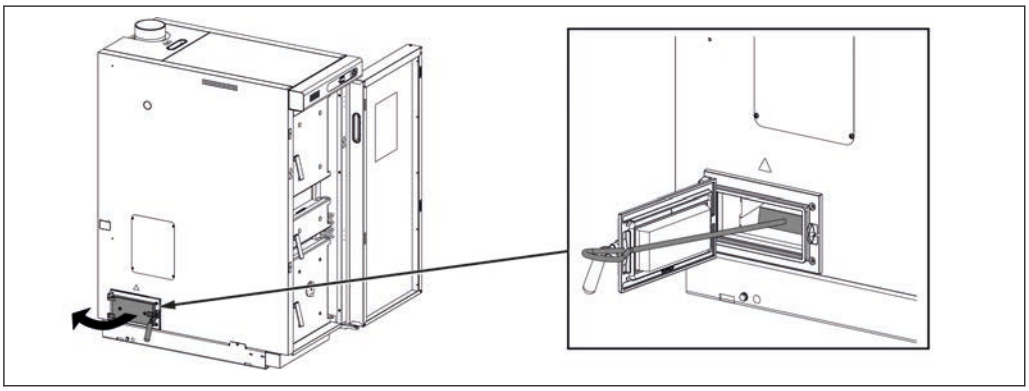
➥ Fire-proof container with cover.



❒ Remove ash in the area in front of the combustion chamber with the furnace tool.
➥ Fire-proof container with cover.



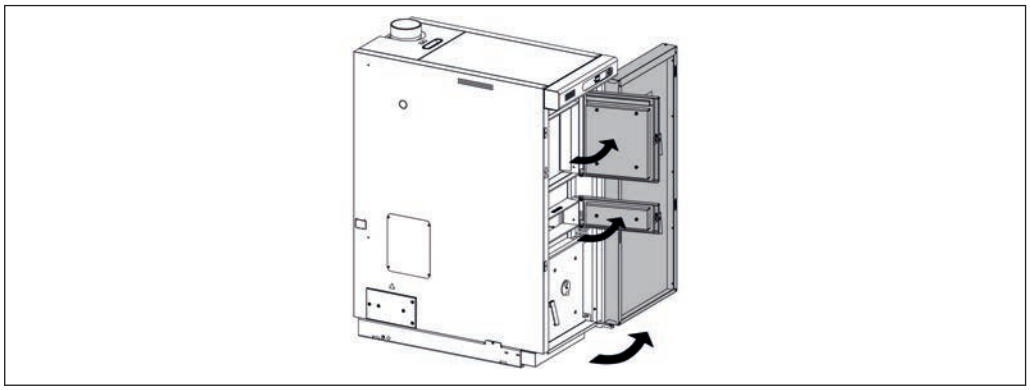
❒ Clean the passage to the left and right of the combustion chamber with small brush and remove ash
❒ Shovel the ash into a container
➥ Fire-proof container with cover



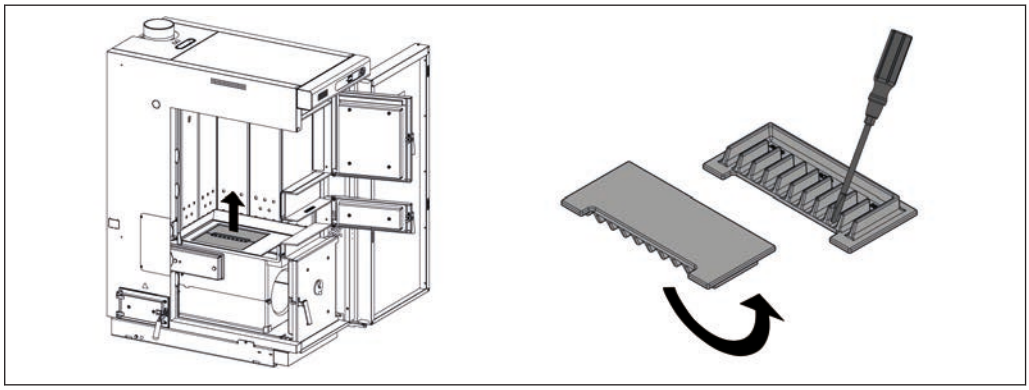
❒ Open the heat exchanger cleaning door and remove the ash with the furnance tool
➥ Fire-proof container with cover

❒ Close all boiler doors again after removing the ash.

6.4.3 Cleaning the grate



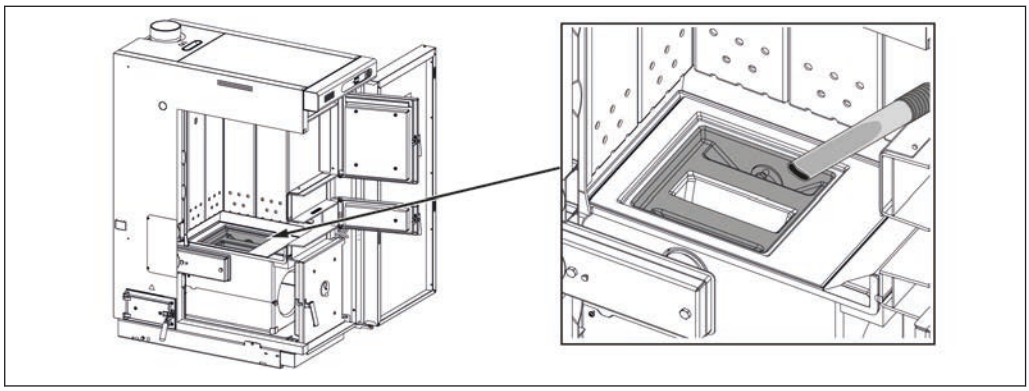
❒ Open the insulated door, pre-heating chamber door and the fuel loading chamber door.



❒ Remove both halves of the grating from the fuel-loading chamber.

❒ Turn them over and scrape the ribs with a screwdriver.

➥ Replace halves of the grating in the event of severe distortion or material thickness of less than 3 mm



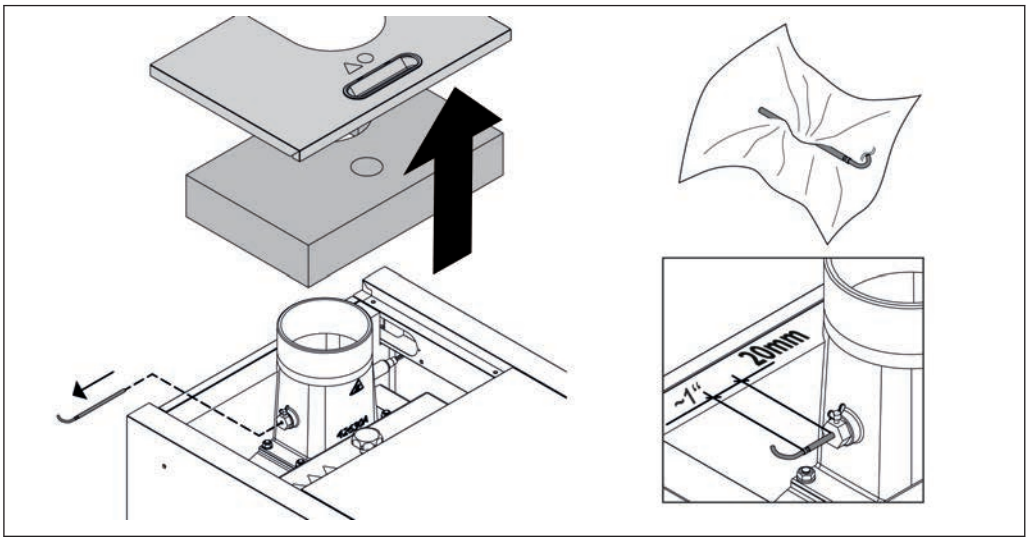
❒ Check the secondary air inlets and clean with an ash vacuum if necessary.

❒ Place the two halves of the grating back on the combustion chamber.

➥ Ensure that they are positioned correctly.

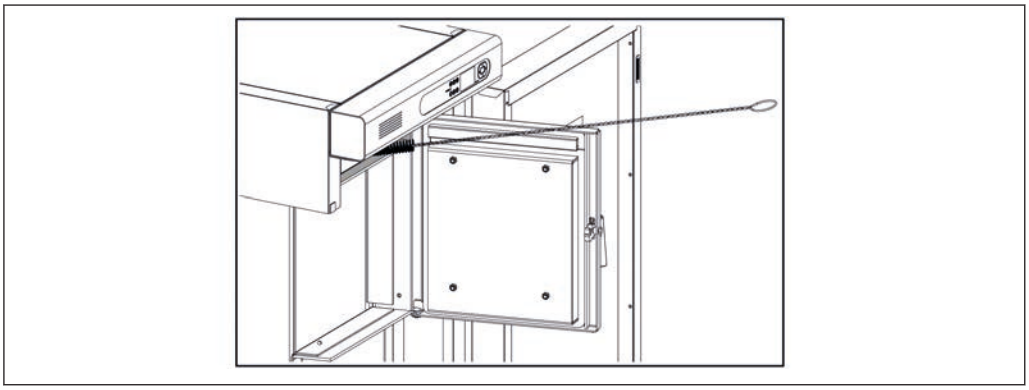
❒ Close all boiler doors after positioning the grating halves.

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.

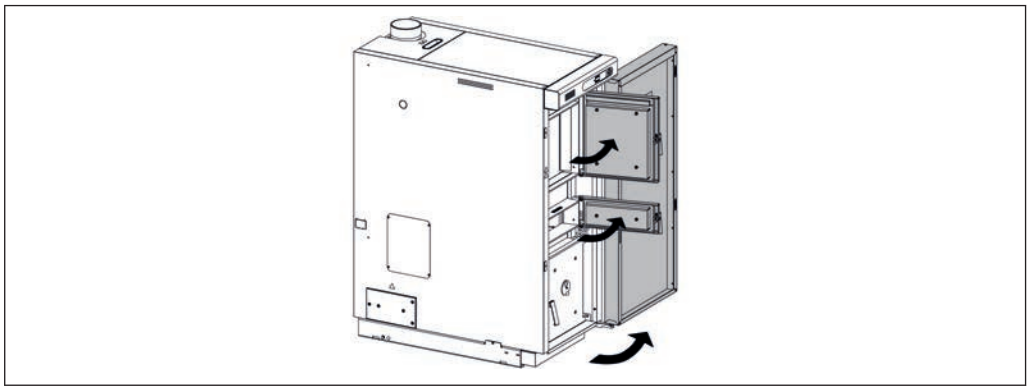
6.4.5 Cleaning the low-temperature carbonization gas duct



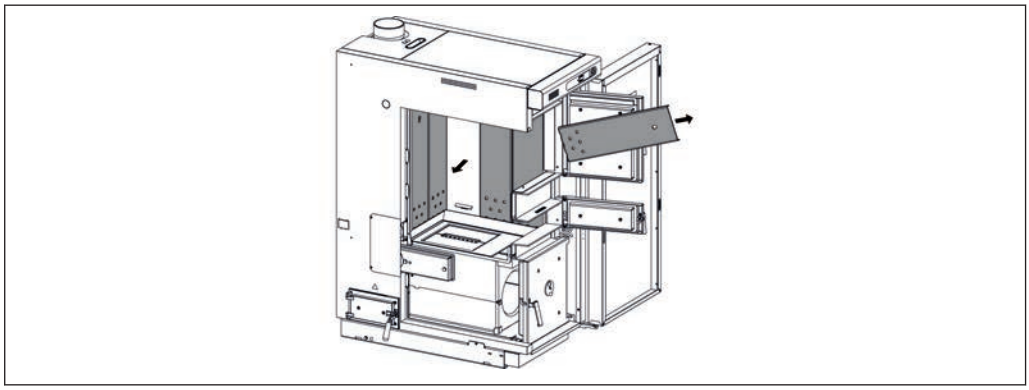
- ❒ Open the insulated door and the fuel loading chamber door
- ❒ Clean the low-temperature carbonization gas duct with a small brush

- ❒ Close all boiler doors after cleaning the low-temperature carbonization gas duct!

6.4.6 Cleaning the primary air openings



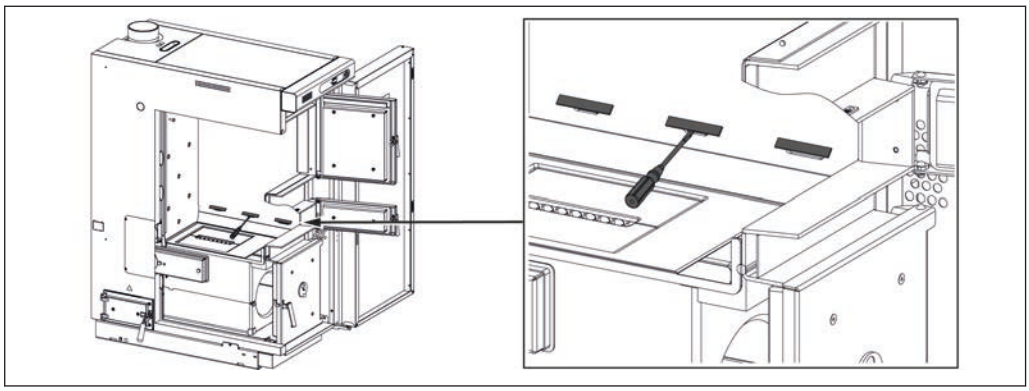
❒ Open the insulated door, pre-heating chamber door and the fuel loading chamber door.



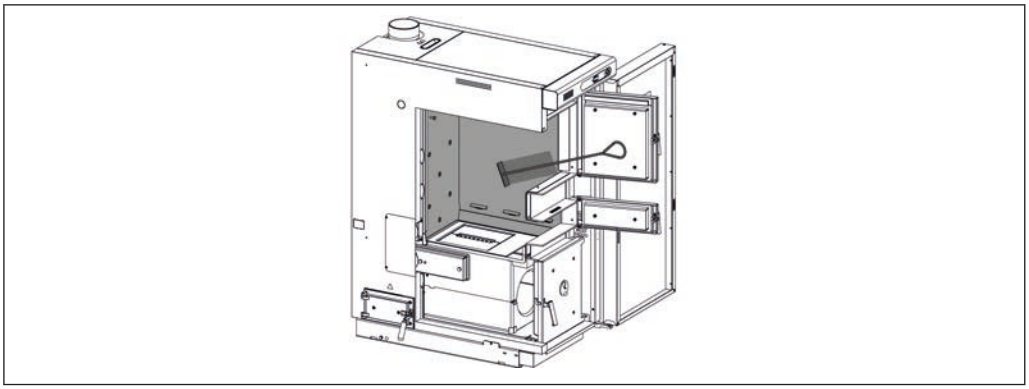
❒ Unhinge all aprons and remove from the fuel-loading chamber.

❒ Clean and check the air openings of the aprons

➥ If the air openings are greatly enlarged due to thermal effects, replace affected aprons



❒ 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.

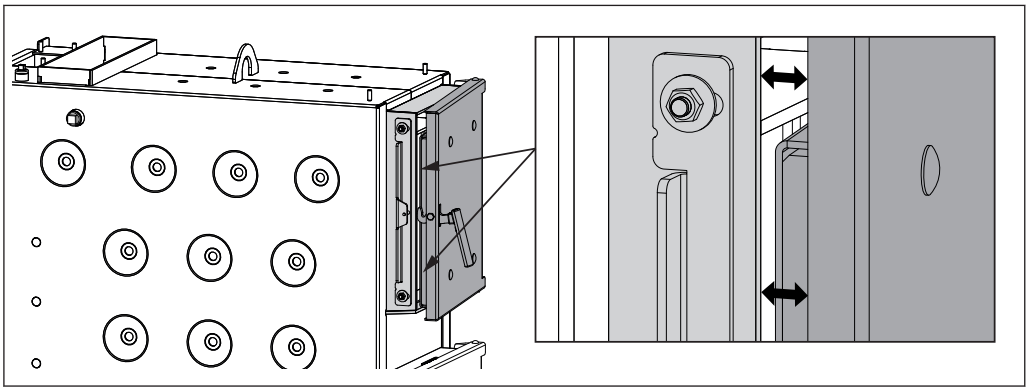
❒ After the primary air openings have been cleaned and the boiler walls scraped off, mount all aprons back in their previous position and close all the boiler doors.

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:



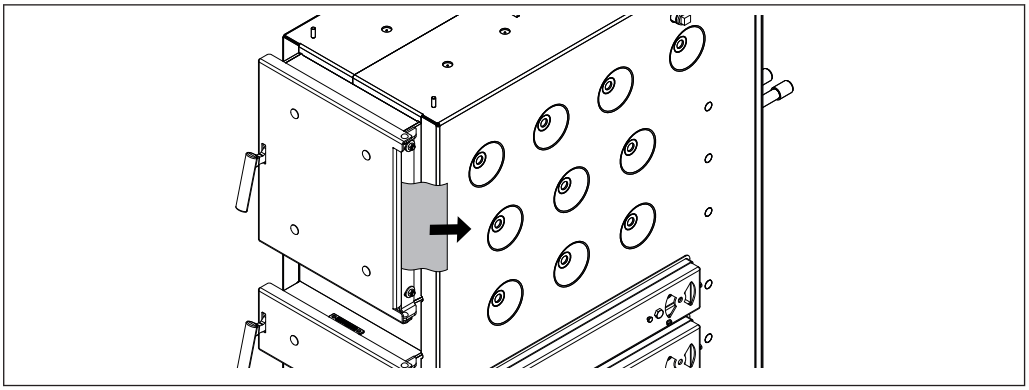
❒ Close the door

↬ 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 88]

↬ Resistance noticeable at a gap of >1” (> 3 cm):
Setting must be corrected - push the hinge toward the front
⇨ See "Adjusting the doors" [page 88]

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 88]

On the side with the door handle

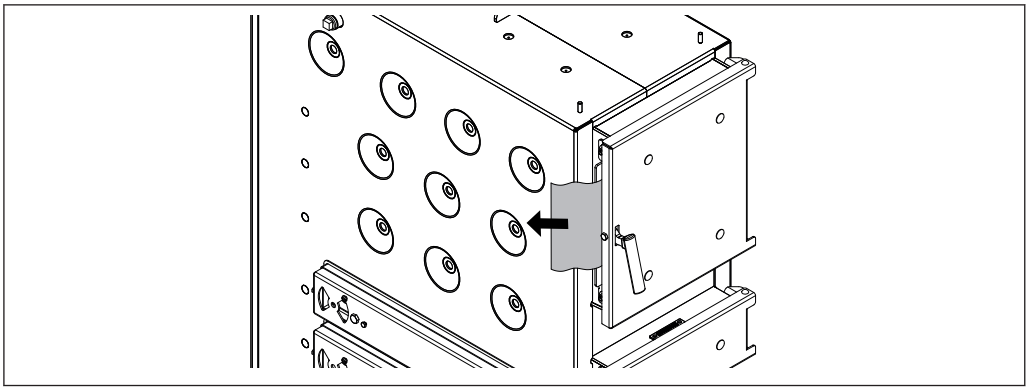
Checking the setting:

❒ 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 88]

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

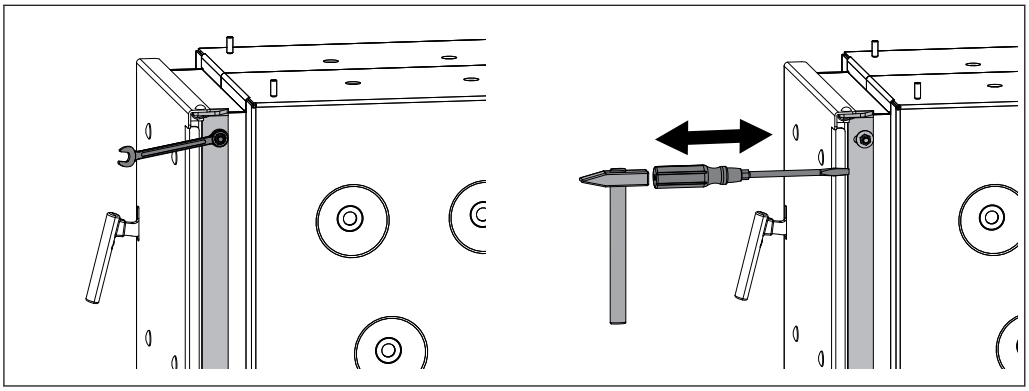
❒ Close the door

❒ 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 88]

Adjusting the doors



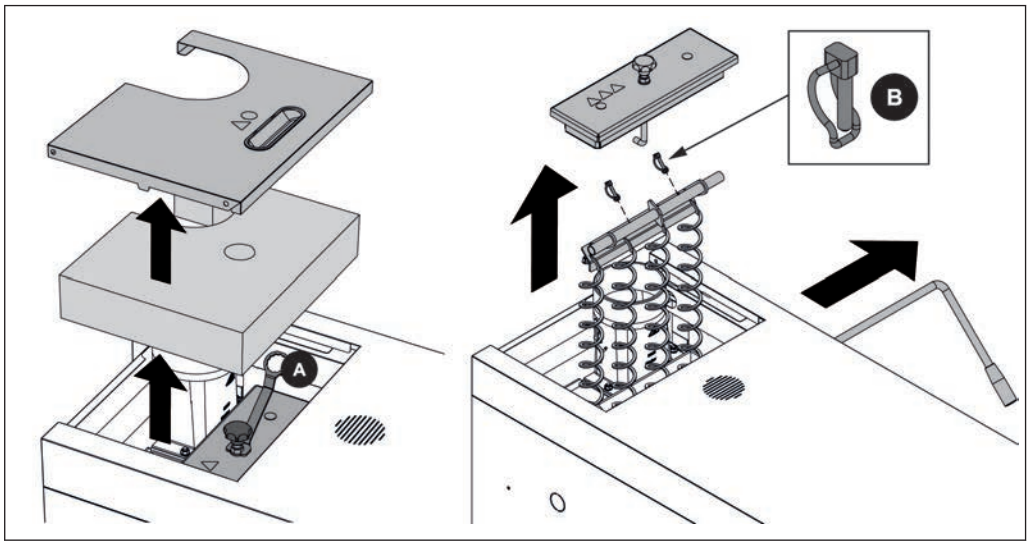
❒ Using an Allen key (AF 13), loosen the nuts on the locking plate and/or hinge at the top and bottom

❒ Use suitable tools (e.g. screwdriver and hammer) to move the locking plate and/or hinge to the rear or the front as needed

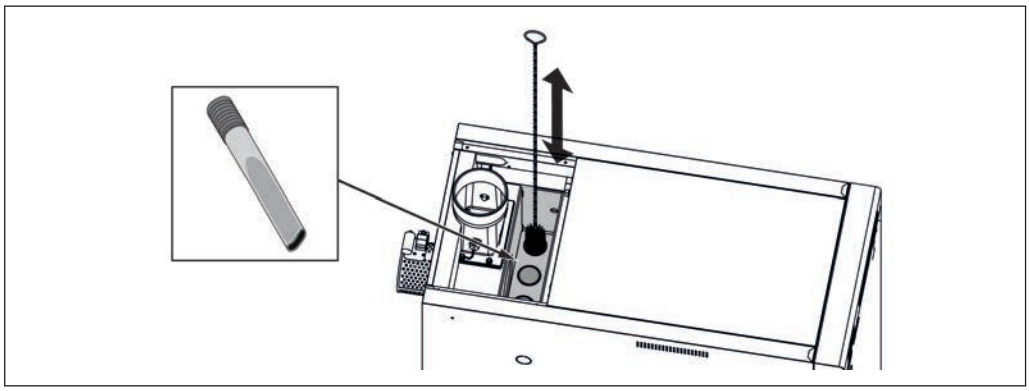
↪ Caution: the locking plate and/or hinge must be aligned in the same way at the top and bottom!

❒ Tighten the nuts at the top and bottom

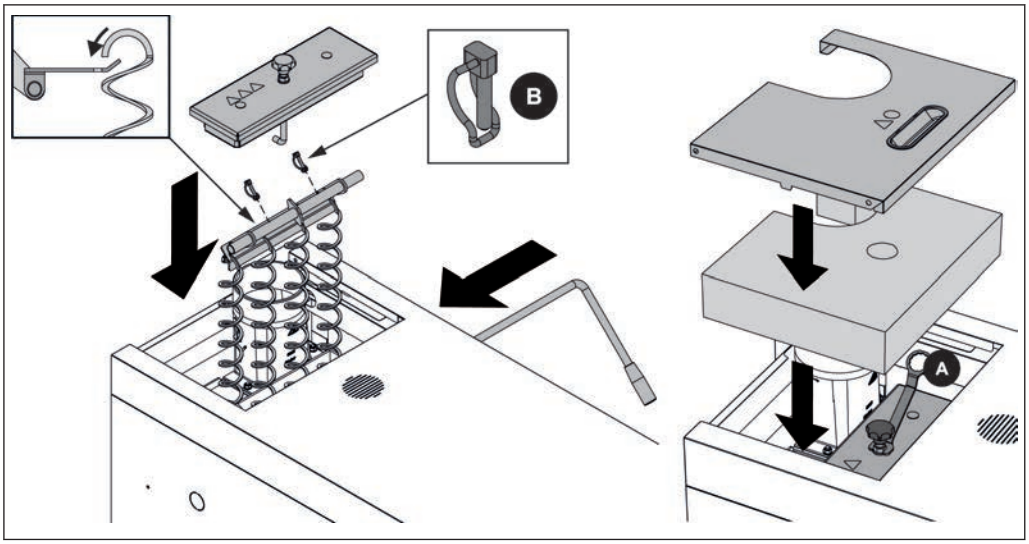
6.4.8 Cleaning the heat exchanger pipes



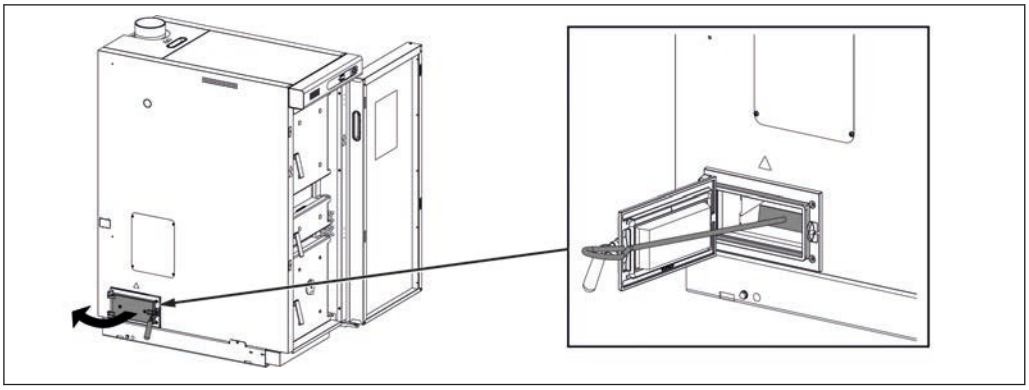
❒ Lift off the back insulating cover and remove the heat exchanger cover
  ➥ Use spanner (A) provided
❒ Remove both piping lock pins (B) and take out the WOS lever
❒ Lift out the turbolators together with the mounting bracket



❒ 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

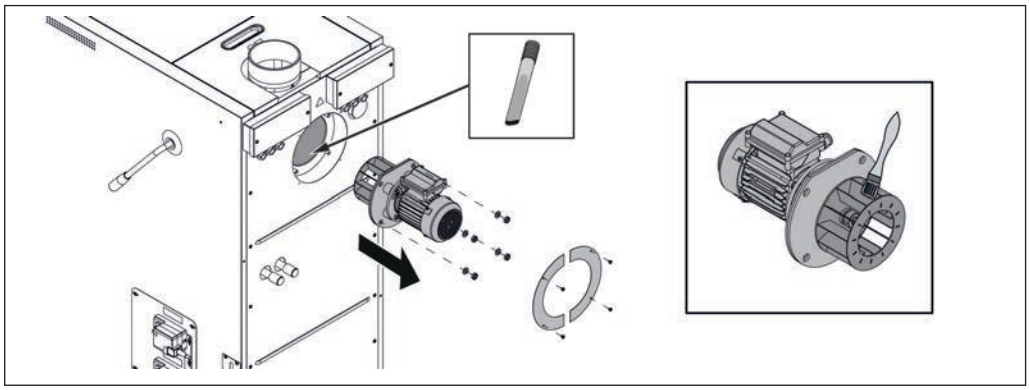


❒ Hang the WOS turbolators on the linking plate of the stay tube
  ➥ Make sure that you fit the turbolators in the right position:
  ➥ Hold the linking plate with the edge toward the top
  ➥ Hang the WOS turbolators over the edge
❒ Thread the turbolators into the heat exchanger pipes
❒ Insert the WOS 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

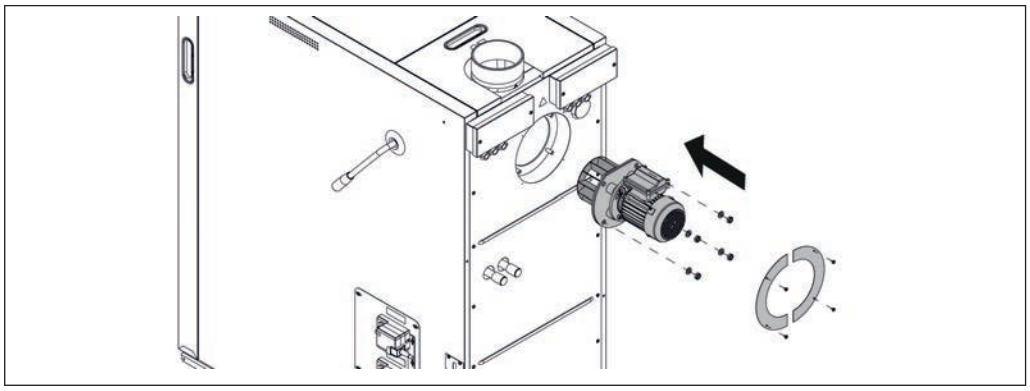
6.4.9 Cleaning the induced draft fan



❒ 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.

6.5 Parts and accessories

For parts and accessories please contact the Fröling distributor in your area:

USA	Canada
Tarm Biomass 19 Archertown Road PO Box 322 Orford, NH 03777 www.woodboilers.com	**Biothermic** **Western Canada and Northern Ontario** 349 Mooney Ave, Thunder Bay, ON (807) 355-5519 Vince@biothermic.ca **Central Ontario, Quebec and the Maritimes** 483 Mountain St., Haliburton, ON (705) 455-2314 Mike@biothermic.ca www.biothermic.ca

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

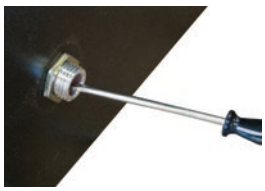
Fault description	Cause	Remedy	Staff
Display is blank	General power failure	Check the power supply	Operator
No power to the controller	Main switch is turned off	Turn on the main switch	Operator
	Residual-current circuit breaker, circuit-breaker or boiler controller circuit-breaker tripped	Switch the 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.

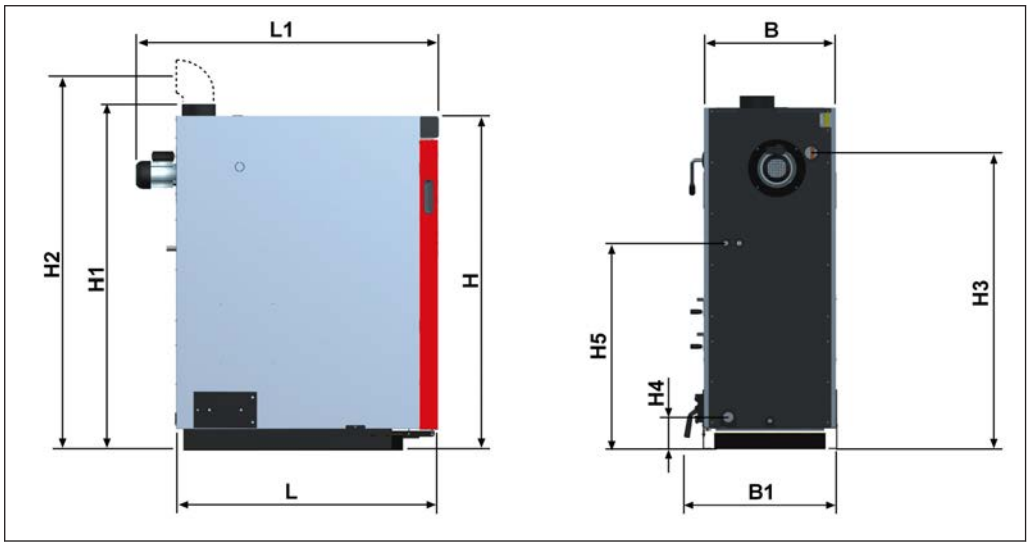
⚠ WARNING

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.

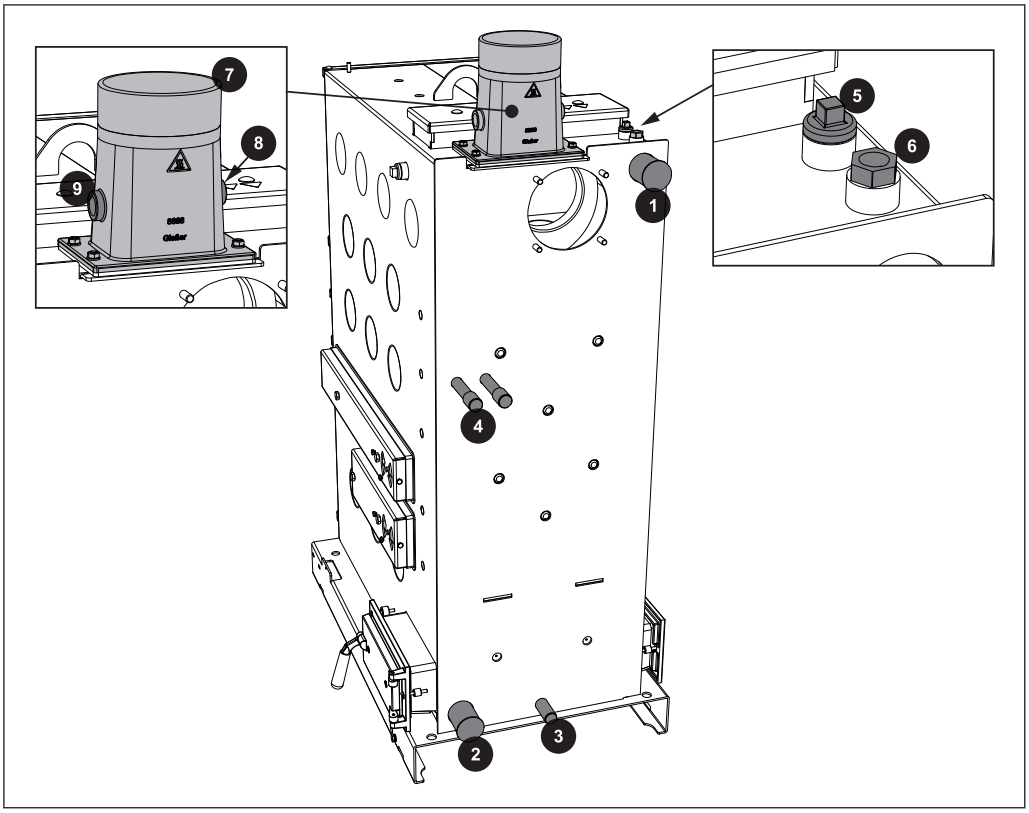
9 Technology

9.1 Dimensions



Dim.	Description	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



Item	Description	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	inches	6
8	Flue gas temperature sensor connection	inches	1/2
9	Broadband probe connection	inches	3/4

9.3 Technical data

Description		S3 Turbo 30	S3 Turbo 50
Nominal heat output	kW Btu/h	30 102,500	50 170,000
Electrical connection	230V / 60Hz / 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%)

Fröling S3 Turbo Wood Boiler Warranty

LIMITED WARRANTY - FOR USE ONLY IN UNITED STATES

Tarm Biomass warrants the steel boiler identified below and its steel doors, firebox cladding, turbulators, high temperature insulation boards, and ceramic refractory against defects in material and workmanship under normal use and service ***TO THE ORIGINAL PURCHASER AT THE ORIGINAL INSTALLATION SITE*** in the United States under the following terms.

WARRANTY IS VOID if the boiler is installed without adequate thermal storage.

BOILER BODY -- LIMITED 20 YEAR WARRANTY: Subject to the below limitations, Tarm Biomass warrants the steel boiler body (not including cast iron doors, coil, or other components) against defects in materials or workmanship causing breaks or leaks that significantly impair the boiler's performance. During the first five years of the warranty period Tarm Biomass will pay for all required labor at the usual and customary rate paid by Tarm Biomass for similar labor performed in Orford, NH, and provide or pay the cost of all materials for the repair of the warranted unit. In years six through twenty Tarm Biomass will pay the below stated percentage multiplied by the retail price of the warranted unit on the date of purchase to the original purchaser toward the cost of repair of the warranted item or, if Tarm Biomass and the original purchaser agree, use the resultant sum as a partial allowance toward Tarm Biomass' replacement of the warranted item. The original purchaser shall be responsible for all shipping and installation charges in connection with any replacement or repair.

A year for the puposes of this warranty is defined as either 365 calender days or 3000 service hours, whichever is less.

Warranty Year (beginning from date of purchase)	Percentage Tarm Biomass will pay
1-5	100%
6	60%
7	50%
8	40%
9	30%
10-20	20%

Example 1: Repair costing $250.00 in year 7, Tarm Biomass will pay $125.00 (50% of this repair).

Example 2: Boiler (original retail $4,000.00) needs major repair in year 9. Tarm Biomass will pay $1,200 (30% of $4,000) toward replacement with similar warranted unit or up to 30% of the repair cost ($1,200 maximum).

OTHER COMPONENTS -- LIMITED THREE YEAR WARRANTY

Subject to the application of the following percentages to parts and/or labor, Tarm Biomass provides the following limited warranty of each of its boiler's cast iron doors, hot water coil, refractory and combustion chambers against defects in materials or workmanship causing breaks or leaks that significantly impair the boiler's performance.

Warranty Year (beginning from date of purchase)	Percentage Tarm Biomass will pay
1	100% of parts and labor
2	100% of parts ONLY
3	50% of parts ONLY

OTHER COMPONENTS -- ONE YEAR WARRANTY

Motors, electronic controls and other electrical components have a one year warranty.

TARM BIOMASS' LIMITED EXPRESS WARRANTY IS ONLY EXTENDED TO AND COVERS THE TARM USA PRODUCT'S END USER WHO OWNS THE BUILDING IN WHICH THE TARM USA PRODUCT IS INSTALLED, AND COVERS ONLY REPAIRS OR REPLACEMENTS RESULTING FROM DEFECTS IN MATERIALS AND WORKMANSHIP.THERE ARE NO WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION IN THIS LIMITED WARRANTY, AND TLIMITED WARRANTY IS IN LIEU OF AND TO THE EXCEPTION OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, WARRANTIES OF MERCHANTABILITY OR WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE. EXCEPT AS OTHERWISE PROVIDED BY THIS LIMITED WARRANTY, TARM BIOMASS TAKES NO RESPONSIBILITY FOR THE QUALITY OF TARM BIOMASS PRODUCTS OR THAT THE GOODS WILL BE FIT FOR ANY PARTICULAR PURPOSE FOR WHICH YOU MAY BE BUYING THESE GOODS. UNDER NO CIRCUMSTANCES SHALL TARM USA BE SUBJECT TO INCIDENTAL, CONSEQUENTIAL, INDIRECT, SPECIAL, PUNITIVE, ENHANCED COMPENSATORY, OR CONTINGENT DAMAGES, WHETHER A CLAIM IS BASED ON CONTRACT, TORT, STRICT LIABILITY, OR ANY OTHER THEORY OF LAW, ALL SUCH DAMAGES AND CLAIMS BEING SPECIFICALLY DISCLAIMED.

Tarm Biomass' limited warranty is void if a Tarm Biomass product is installed by someone other than a qualified contractor whose principal occupation is the sale or installation of plumbing and heating equipment, or if the original purchaser fails to have the boiler serviced or inspected at least once every two years by an experienced and qualified service person. Repairs or replacements under this limited warranty must be performed by your dealer or someone authorized by him. You may be required to present this limited warranty to the dealer before any work is performed. You must pay for any work performed that is not covered by this limited warranty or that is not authorized by the dealer. Tarm Biomass' limited warranty shall be construed under the laws of New Hampshire. Any dispute arising out of this warranty shall be tried only in a court in the State of New Hampshire, including the United States District Court for the State of New Hampshire. If any legal action is brought in connection with this limited warranty, the prevailing party shall be entitled to recover all reasonable expenses it incurs in the action, including its reasonable attorneys' fees, from the nonprevailing party.

TARM USA'S LIMITED WARRANTY EXPRESSLY EXCLUDES COVERAGE FOR THE FOLLOWING:

1. Ordinary wear and tear and repairs or replacements necessitated by normal use.
2. Repairs or replacements arising from corrosion including, but not limited to, the effects of a corrosive water supply or corrosive by-products of combustion formed when a boiler is run during warm weather temperatures or under other conditions that do not permit the boiler to reach necessary operating temperatures on a frequent basis as described in the Owner's Manual provided by Tarm Biomass.
3. Repairs or replacements of fittings, motors, fuel units, oil and gas burners, any and all controls, relief or regulating valves, transformers, and accessories.
4. Repairs or replacements to repair damage caused by (i) operation with inadequate draft, (ii) having installed a boiler model that is incorrectly sized for the application (too few or too many BTU's under normal operating conditions) or that is otherwise inappropriate for the application, (iii) excessive boiler internal temperature, (iv) burning other than pure wood, or (v) any similar use that violates or is not recommended in the Owner's Manual provided by Tarm Biomass.
5. The repair or replacement of any component furnished by any other manufacturer or damage caused by the functioning or malfunctioning of any such component.

This warranty gives you specific legal rights. You may also have other rights that vary from state to state. This warranty shall not be construed as inconsistent with any federal, state, or municipal law, regulation, or code that was applicable to the original installation site on the date the Tarm Biomass product was installed.

Questions regarding this warranty may be referred to:

Tarm Biomass, 19 Archertown Rd, P.O. Box 322, Orford, NH 03777 U.S.A. (603) 795-9100

KEEP THIS INFORMATION FOR YOUR RECORDS:

Model: _____ Place of Purchase:

_____

Serial No.: _____ Installation Date:

_____

Installer_____

7. Quality Assurance / Quality Control

Archived Test Specimen

The tested unit was sealed by OMNI-Test Laboratories after the completion of certification testing. This unit will be stored at the manufacturer's premises in the sealed state until 5 years after the certification test at the following address:

Fröling Heizkessel- und Behälterbau GmbH;
Gewerbepark Stritzing
Dr. Ernst Hutterer Straße 1
4710 St. Georgen bei Grieskirchen, Austria

Figure 22 – Archived Unit, Right 3/4

Figure 23 – Archived Unit, Left 3/4

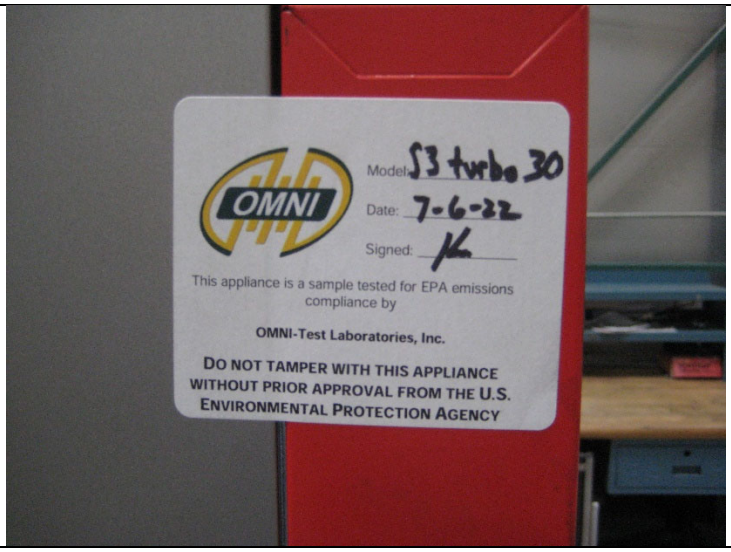


Figure 24 - Example seal place on archived unit

Manufacturer's Quality Assurance Plan

The following quality assurance plan has been developed to ensure all that all units within the model line are similar in all material respects that would affect emissions to the sample tested under this report, in accordance with § 60.533 (m) / § 60.5475 (m).

Introduction QA plan Fröling S3 log boiler

The consistent quality of the Froling S3 log boilers is mainly assured by the process of ***pressure test / final inspection***. We have provided the corresponding checking sheet in a separate document. The pressure test is conducted with every single boiler, the final inspection is done with every 75th boiler (first unit of a production lot)

This document here should in addition explain the very modern manufacturing process within Froling.

Scope of this document

This document is valid for the following types of boilers

Type of boiler	Internal manufacturing code
S3 30 kW	96100
S3 50 kW	96102

Description of metal processing

All metal parts are designed by our CAD engineers and cut by a CAM state-of-the-art laser cutting plant of the make TRUMPF.

The machines are serviced once a year by the manufacturers according to their own checklist. Any deviations are corrected and the machine is calibrated new.

TRUMPF Trumatic L 3050

Technical Data

Manufacturer:	TRUMPF
Type:	Trumatic L 3050
Year of Manufacturing:	2003
Working Area:	3000 x 1500 x 115 mm
Laser Power:	5000 Watt
Control:	Siemens Sinumerik 840 D
Working Hours:	68.219h/33.543h
Max. Sheet Thickness:	25 mm
Max. Speed:	200 / 300 m/min
Accuracy:	0,1 mm
Length:	11100 mm
Height:	2400 mm
Width:	4600 mm
Weight:	12000 kg

The laser cutting machine has an accuracy of +/- 0,1mm as per technical data sheet. This guarantees that all metal parts look exactly the same and as specified in the electronic CAD drawing.

Inspection of dimensions and k-list elements

The dimensional check and the inspection of features is carried out with every first boiler of a production lot as per QS inspection instructions for the ***inspection of k-list elements*** (see separate check list). This means every 75th boiler is undergoing this procedure.

Straightness, evenness and parallelism limits for door frames as per Froling Norm- : FN-006
Unevenness is to be rectified before the pressure test. No burrs or points of impact are to be made.
Check evenness with ruler.

Figure 1

Figure 2

Figure 3

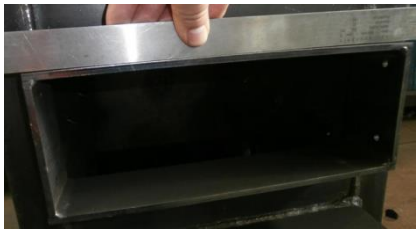
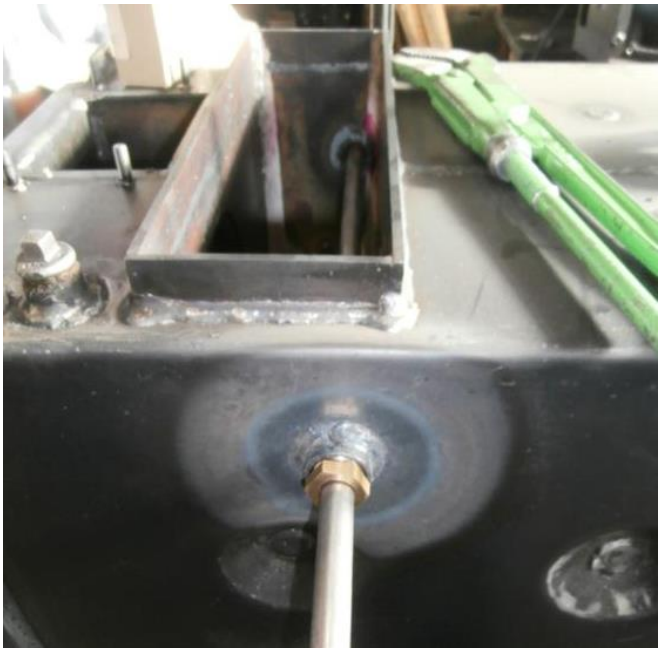


Figure 4

Figure 5

Figure 6

WOS nozzles have to be in line;
Check with shaft and brass bearing



Attention:
Welding and grinding residues have to be removed completely.
Residues such as welding sprays, oils and other substances which have a negative impact on the following paint work are to be removed totally.

Figure 7

Door diagonals

The difference at the diagonals of a door shall not be more than +/- 1,5mm.

The face of the door opening has to be even (max 2mm tolerance).

Be aware that there is the danger of injury especially on the sharp edges of the doors.

Edges and corners have to be bevelled slightly.
(Grind off sharp edges. max 0,5 mm x 45°)

Figure 8

Figure 9

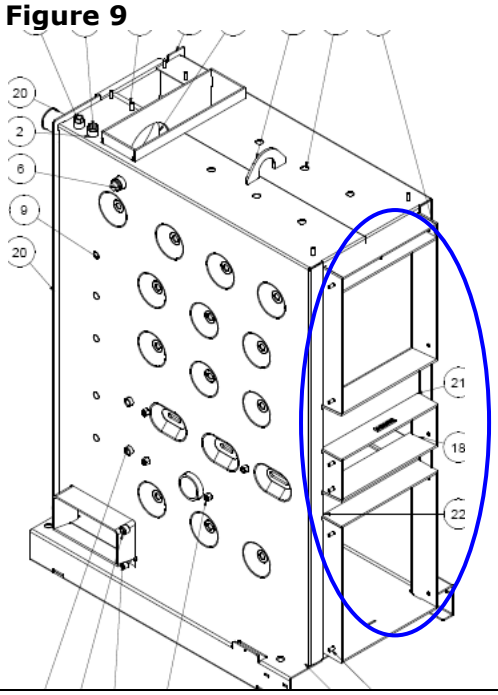


Figure 10

Grind lateral corner of door frame

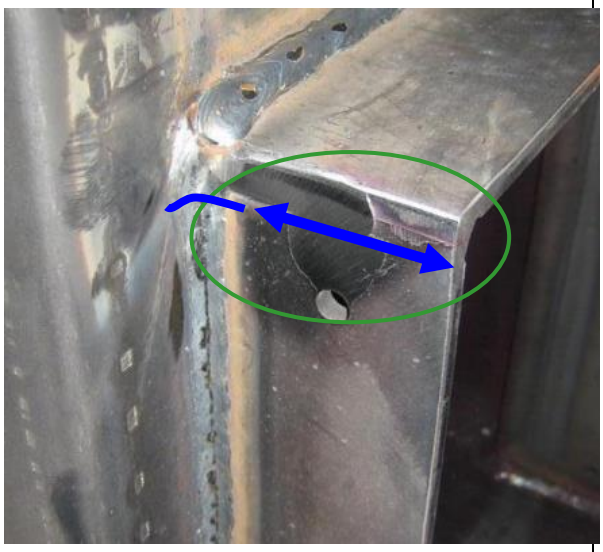


Figure 11

Check correct position of immersion sleeve

Check correct position of plug.

ATTENTION: Do not completely screw in brass immersion sleeve against stop during tightening.

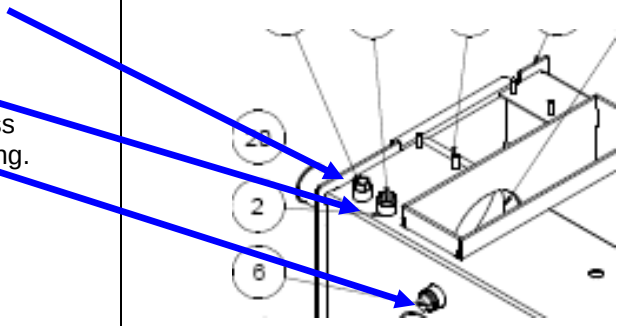


Figure 12

Metal strip inside jacket max. with a3 weld seam, otherwise too much welding distortion

Figure 13

Check distance of safety battery.

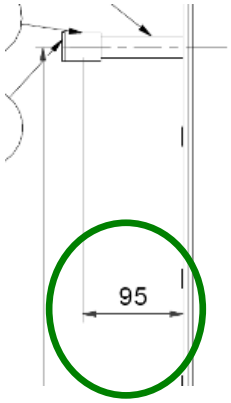


Figure 14

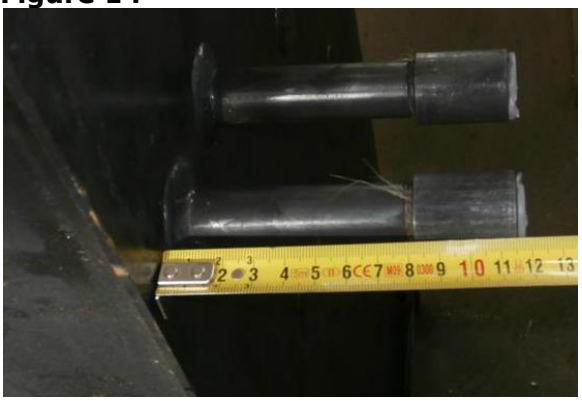


Figure 15

Check distance of bolts

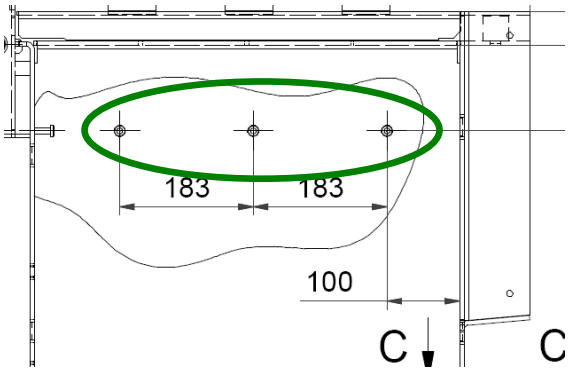


Figure 16

Check combustion chamber

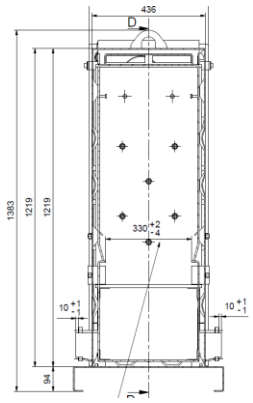


Figure 17

Figure 18

Check lower tolerance limit UTG 326,0 mm.

Inspection gauge has to fit in over whole inspection area.

Figure 19

Check higer tolerance limit OTG 332,0 mm.

Inspection gauge must not fit in over whole inspection area.

Figure 17

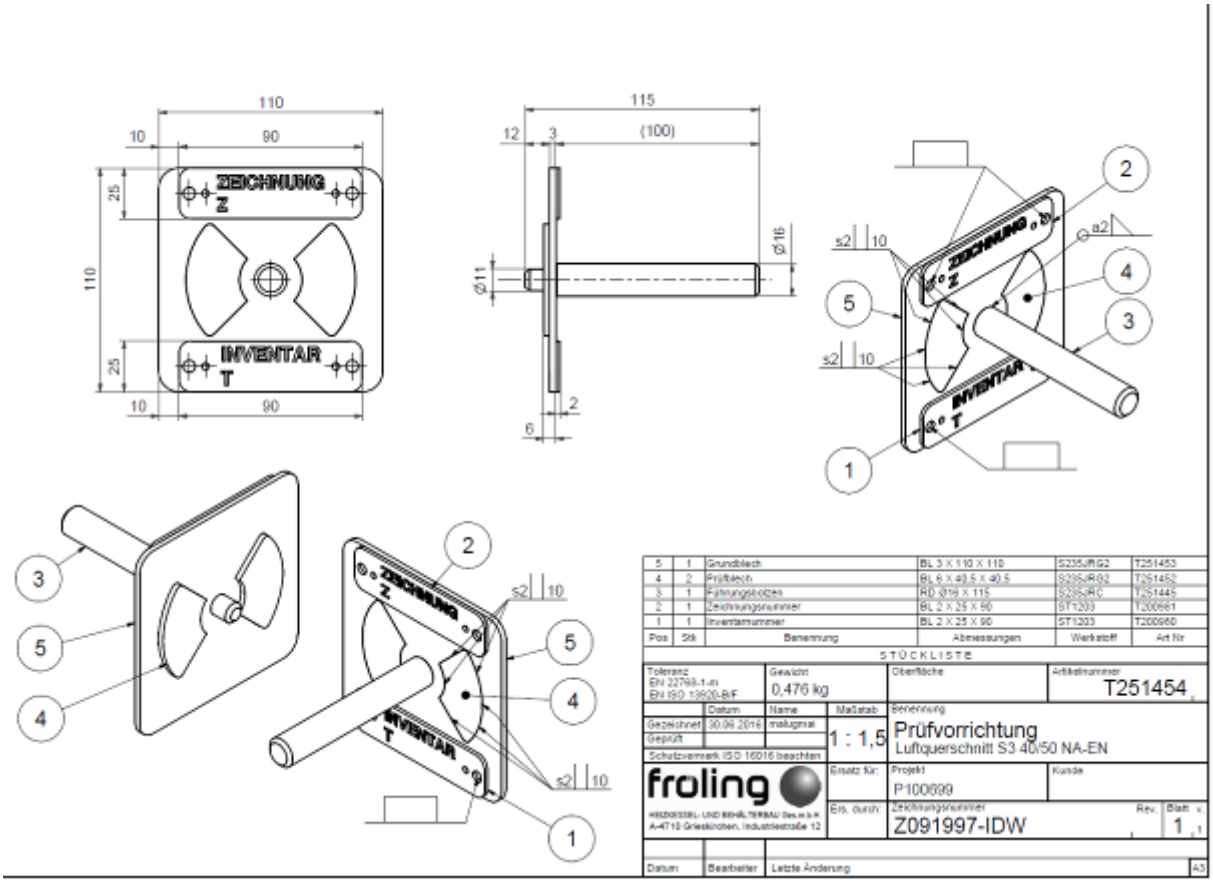


Figure 21

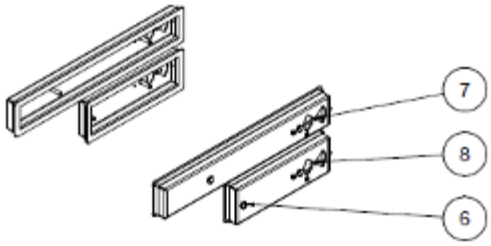


Figure 22

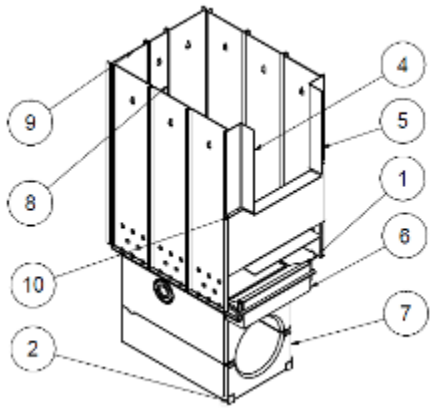


Figure 23

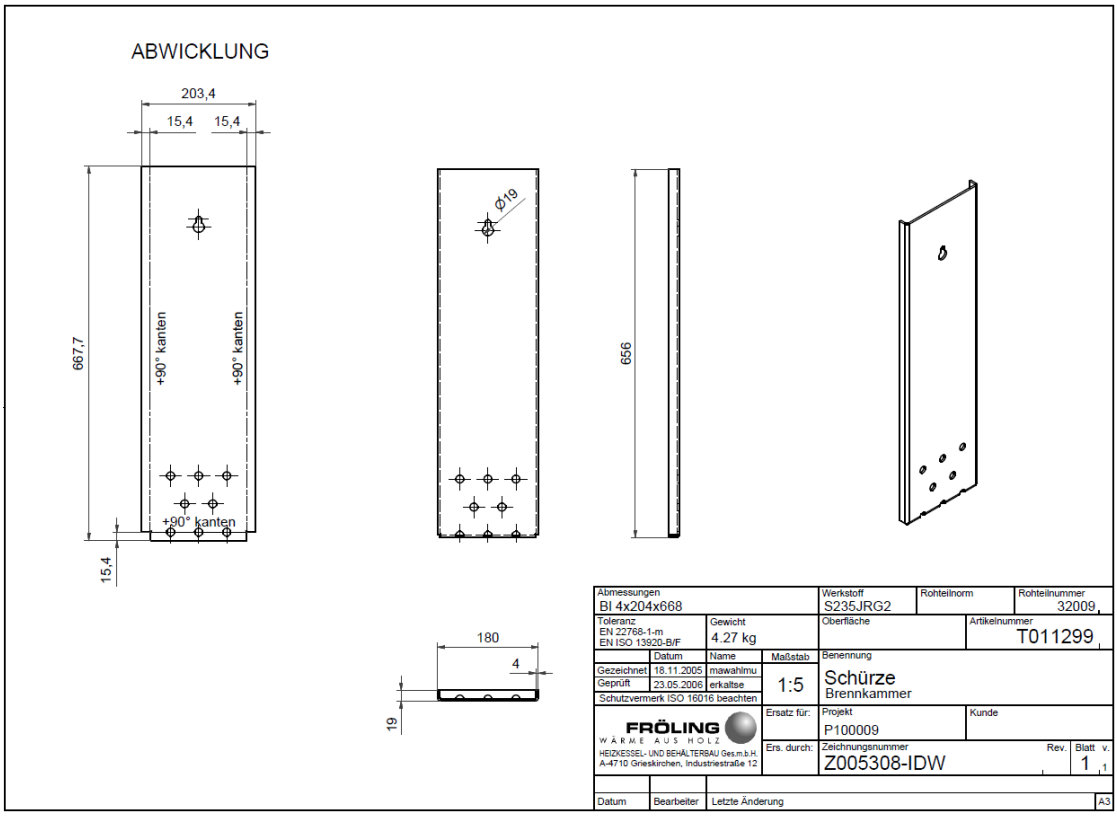


Figure 25

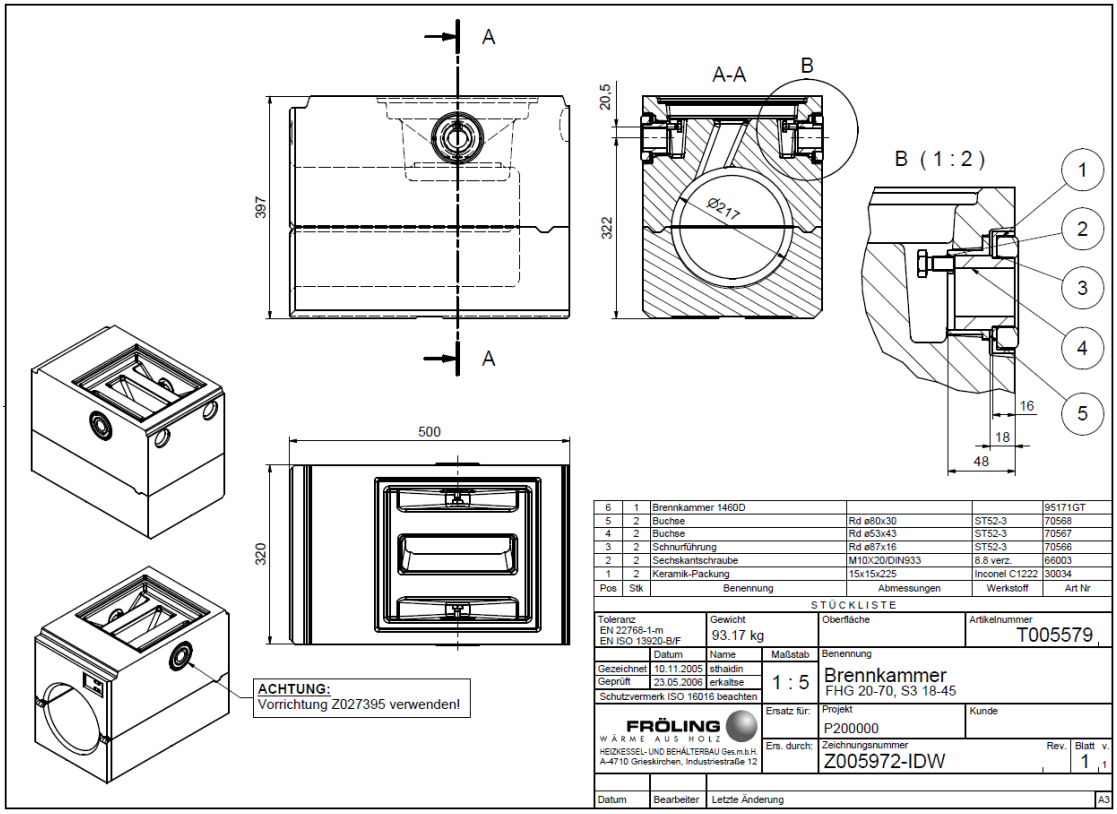


Figure 26

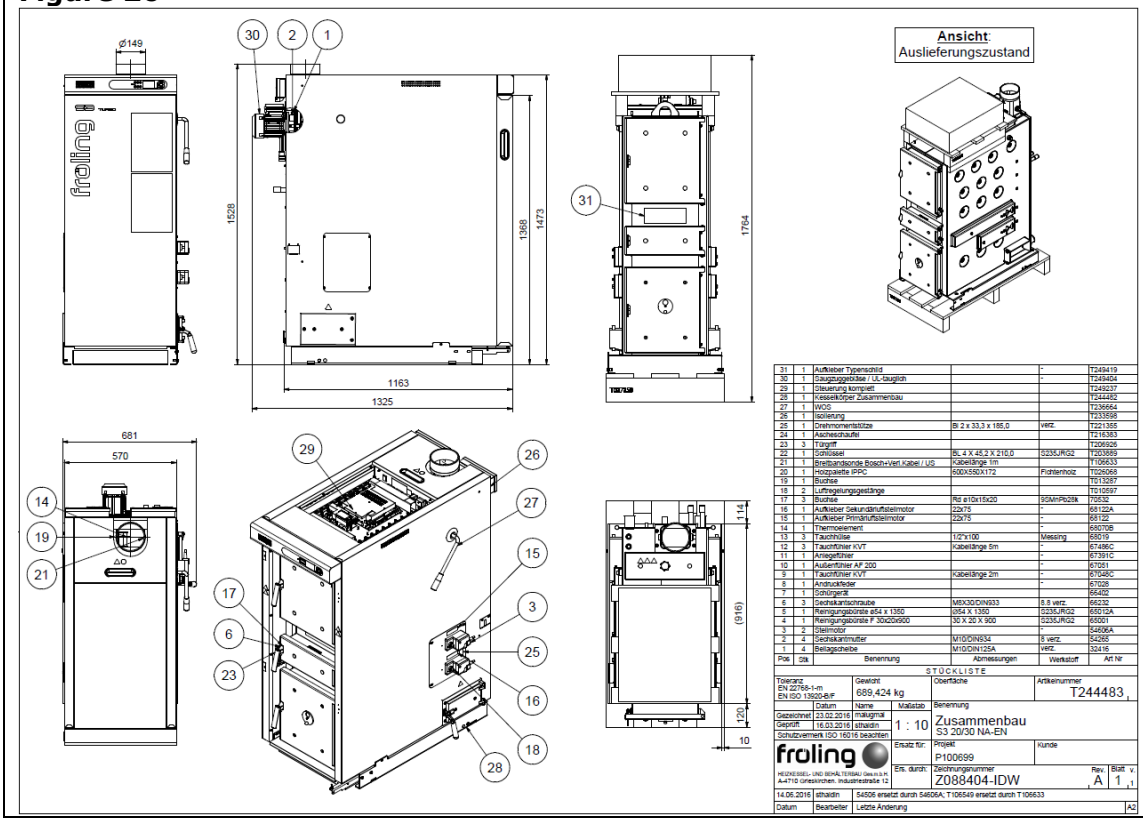


Figure 27

Figure 28

Figure 29

Figure 30

Figure 31

Figure 32

Check tightness of door

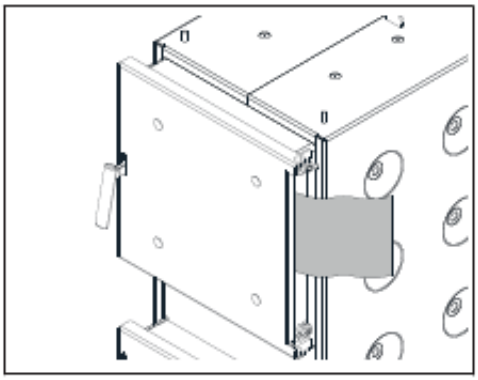


Figure 33

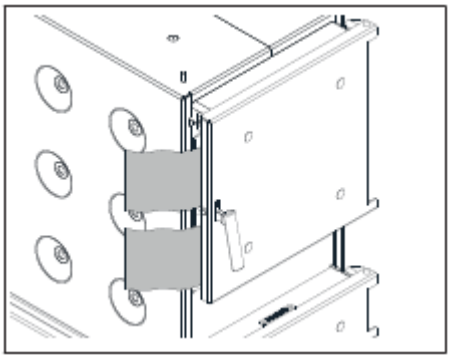
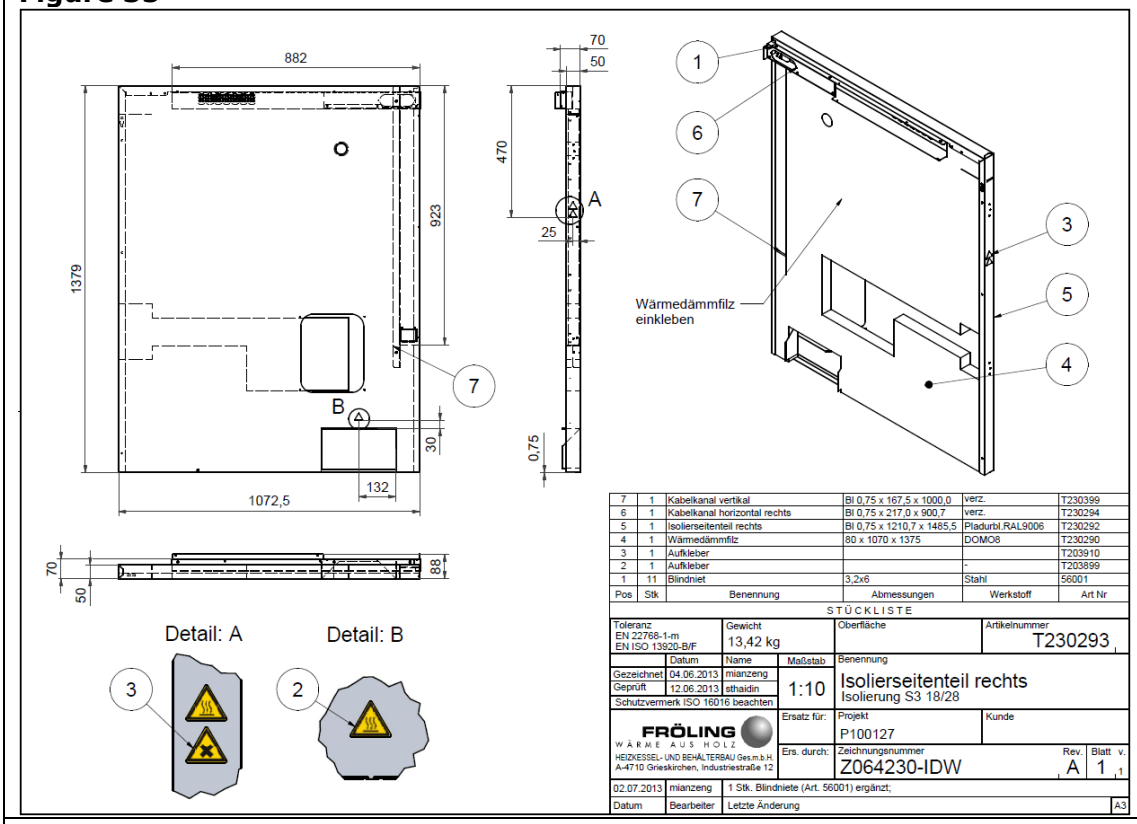


Figure 34

Open door
Place a sheet of paper at upper and lower section of door handle between door and boiler.
Close door.
Sheet cannot be pulled out – door is tight.

Figure 35

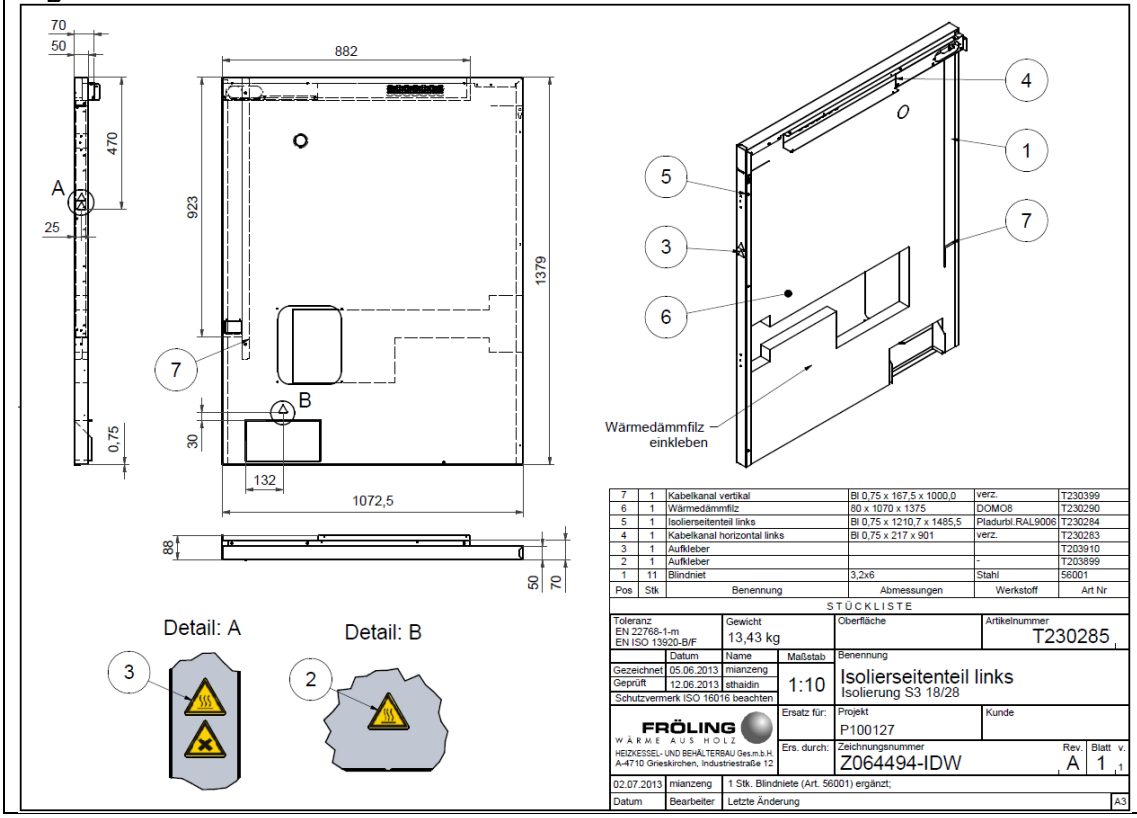


Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
7	1	Kabelkanal vertikal	Bl 0,75 x 167,5 x 1000,0	verz.	T230399
6	1	Kabelkanal horizontal rechts	Bl 0,75 x 217,0 x 900,7	verz.	T230294
5	1	Isolierseitenteil rechts	Bl 0,75 x 1210,7 x 1485,5	Pladurbl.RAL9006	T230292
4	1	Wärmedämmfilz	80 x 1070 x 1375	DOMO8	T230290
3	1	Aufkleber			T203910
2	1	Aufkleber		-	T203899
1	11	Blindniet	3,2x6	Stahl	56001

STÜCKLISTE

Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 13,42 kg	Oberfläche	Artikelnummer T230293	
	Datum	Name	Maßstab	Benennung
Gezeichnet	04.06.2013	mianzeng	1:10	Isolierseitenteil rechts Isolierung S3 18/28
Geprüft	12.06.2013	sthaidin		
Schutzvermerk ISO 16016 beachten				
FRÖLING WÄRME AUS HOLZ HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12		Ersatz für:	Projekt P100127	Kunde
		Ers. durch:	Zeichnungsnummer Z064230-IDW	Rev. A / Blatt 1 v. 1
02.07.2013	mianzeng	1 Stk. Blindniete (Art. 56001) ergänzt;		
Datum	Bearbeiter	Letzte Änderung		A3

Figure 36



Pos	Stk	Benennung	Abmessungen	Werkstoff	Art Nr
7	1	Kabelkanal vertikal	Bl 0,75 x 167,5 x 1000,0	verz.	T230399
6	1	Wärmedämmfilz	80 x 1070 x 1375	DOMO8	T230290
5	1	Isolierseitenteil links	Bl 0,75 x 1210,7 x 1485,5	Pladurbl.RAL9006	T230284
4	1	Kabelkanal horizontal links	Bl 0,75 x 217 x 901	verz.	T230283
3	1	Aufkleber			T203910
2	1	Aufkleber		-	T203899
1	11	Blindniet	3,2x6	Stahl	56001

STÜCKLISTE

Toleranz EN 22768-1-m EN ISO 13920-B/F	Gewicht 13,43 kg	Oberfläche	Artikelnummer T230285	
	Datum	Name	Maßstab	Benennung
Gezeichnet	05.06.2013	mianzeng	1:10	Isolierseitenteil links Isolierung S3 18/28
Geprüft	12.06.2013	sthaidin		
Schutzvermerk ISO 16016 beachten				
FRÖLING WÄRME AUS HOLZ HEIZKESSEL- UND BEHÄLTERBAU Ges.m.b.H. A-4710 Grieskirchen, Industriestraße 12		Ersatz für:	Projekt P100127	Kunde
		Ers. durch:	Zeichnungsnummer Z064494-IDW	Rev. A / Blatt 1 v. 1
02.07.2013	mianzeng	1 Stk. Blindniete (Art. 56001) ergänzt;		
Datum	Bearbeiter	Letzte Änderung		A3

Figure 37

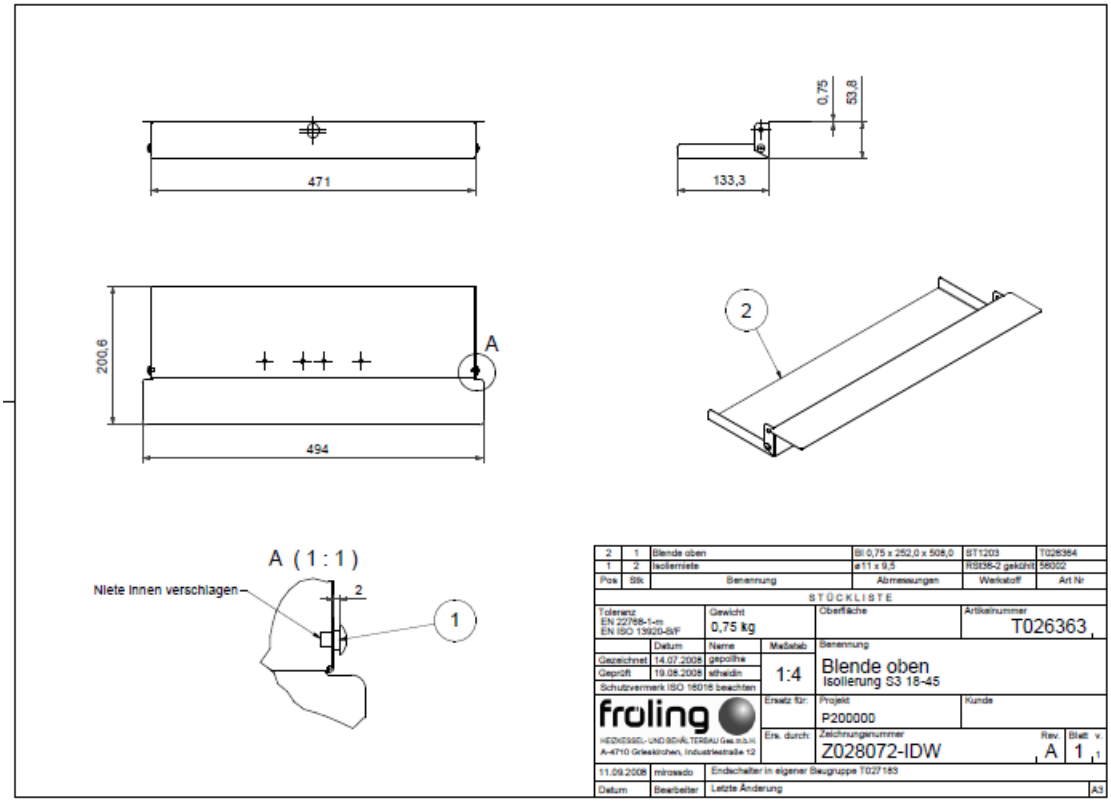


Figure 38

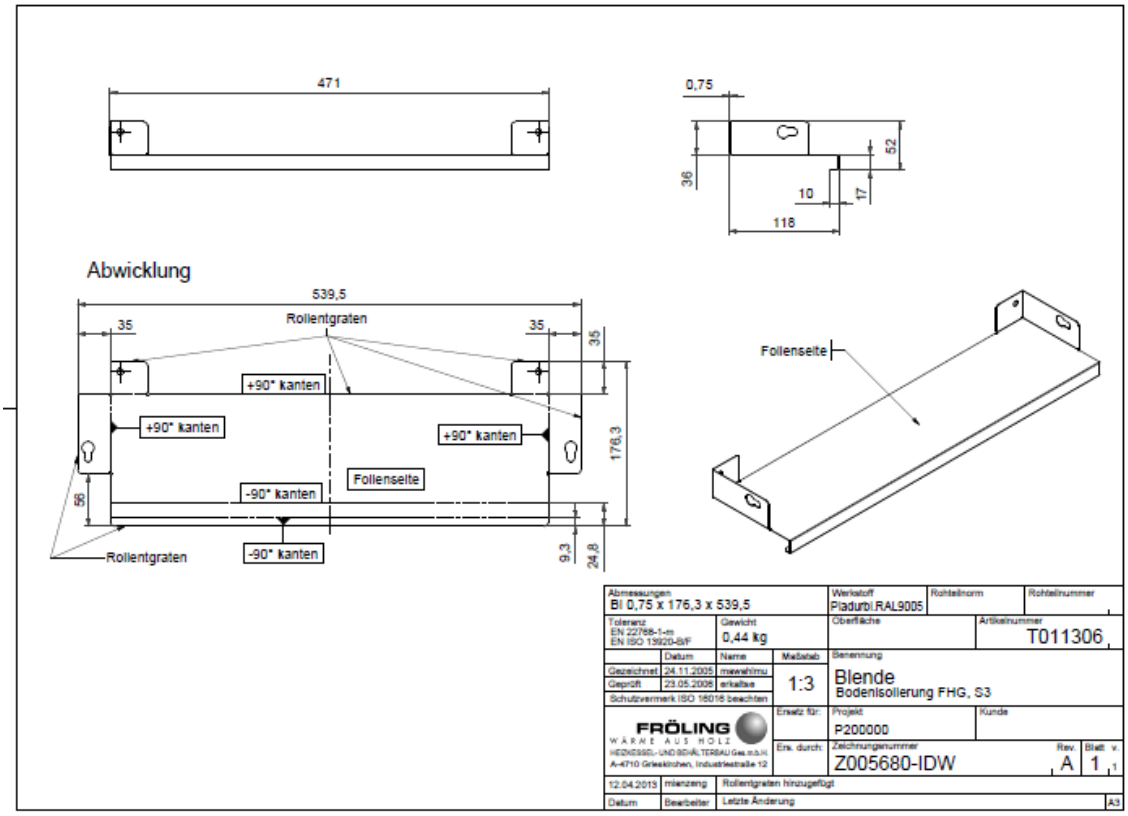


Figure 39

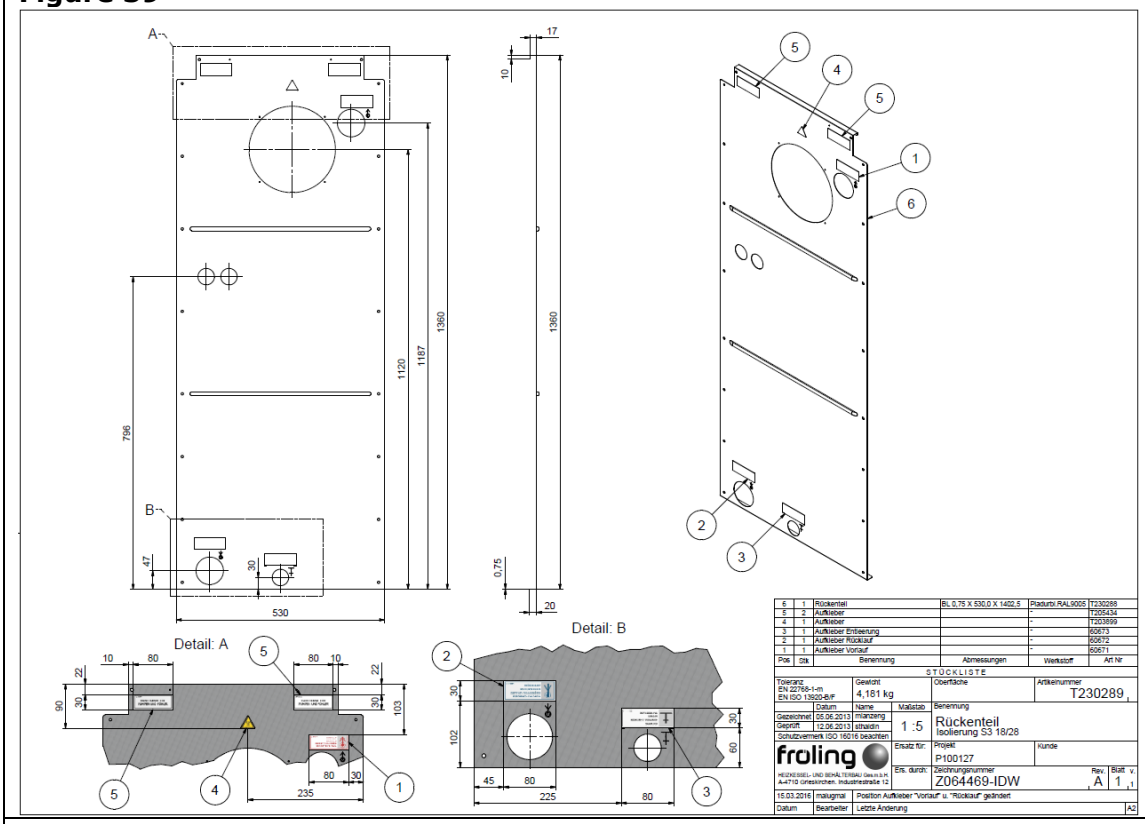


Figure 40

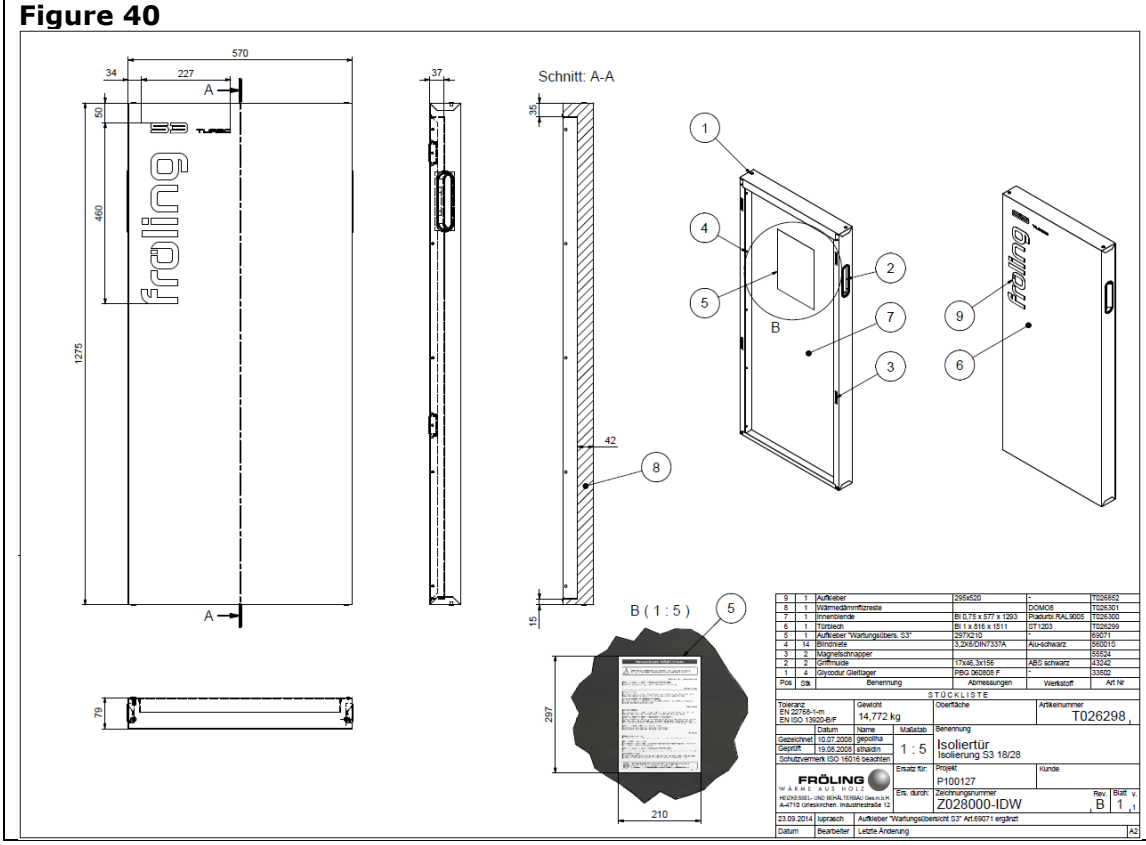


Figure 41

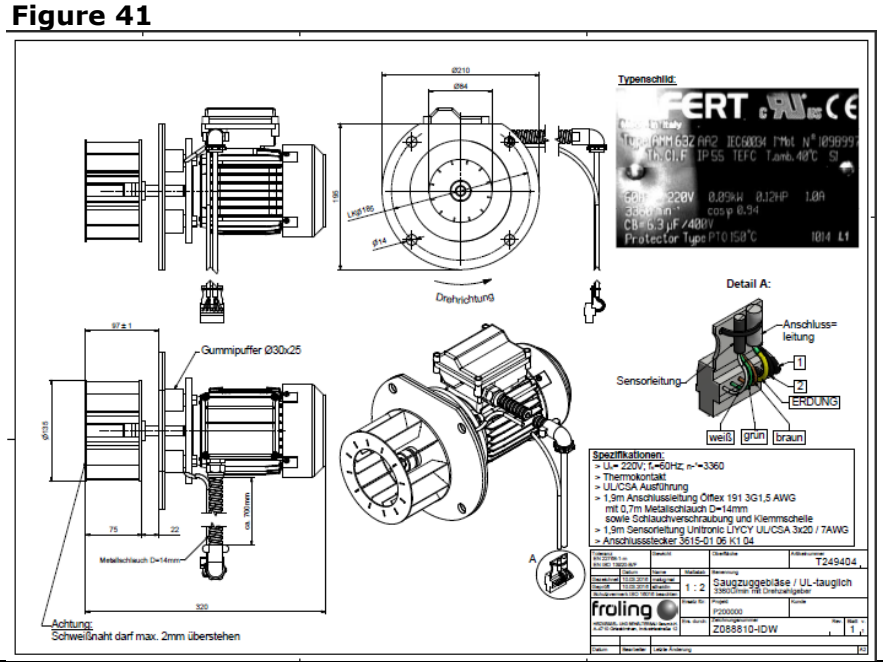
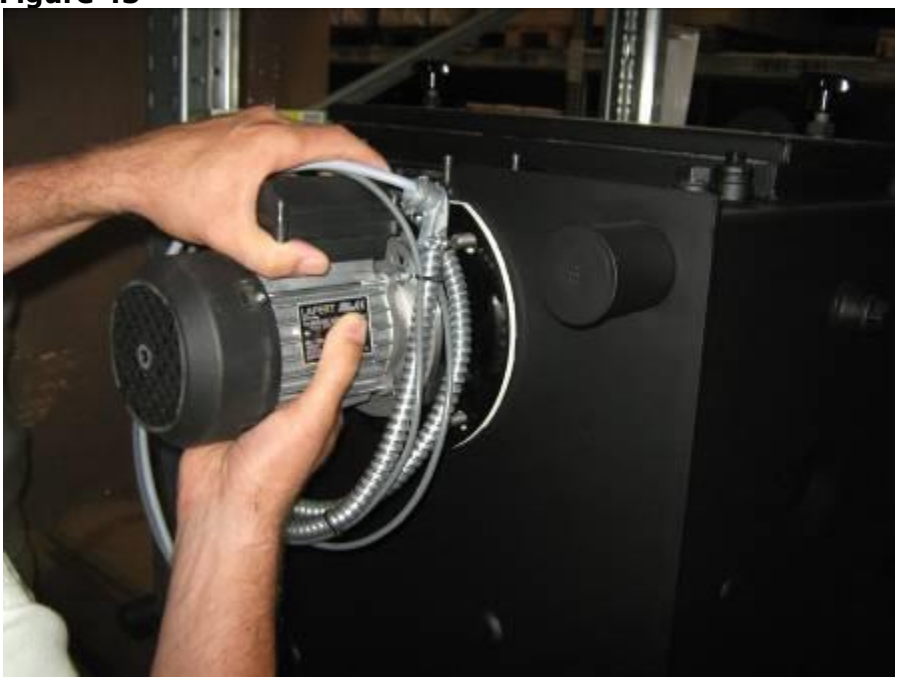


Figure 42

Compare type plate with specification on drawing.

Figure 43



Take ID fan out of package and hold it onto the mounting position.
With this the position of the bolts and the correct fitting is checked.

Pressure test

The pressure test is done with every single boiler as per QS instructions **pressure test / final inspection.** Pressure is 4,5 bar at 90 min holding time.

FRÖLING - QS - inspection instructions						Supplier	LAFAT		S	Inspection
pressure test / final inspection						Type:	S3 - 96100		boiler body	
test pressure:	4,5	bar.		test medium:		Order Nr.:	1007546		Stk.:	75
holding time:	90	min.		water		Equipmentnumber from to:				
1.) visual check of welds and general appearence						200 256 629	-	200 256 703		
Turn to foreman in case of uncertainly							AM+IM	AM	IM	Serie
2.) repair untightness and enter in ispection table					Serie	Nr. of boilers				0
						Nr. of errors	0	0	0	0
3.) check first unit of produktion batchfor measurements as per list attached						% error				#DIV/0!
					Kessel	avg errors	#DIV/0!	#DIV/0!	#DIV/0!	
errorlimit:	AM 6	IM 2	AM+IM 8			errors - MAX	0	0	0	
						errors - MIN	0	0	0	

	Nr. of error before positive check				
lfd.Nr.	outer	inner	Sum	Tester	Date
256 629					
256 630					
256 631					
256 632					

	Nr. of error before positive check				
lfd. Nr.	outer	inner	Sum	Tester	Date
256 660					
256 661					
256 662					
256 663					

Instructions:
Remove swarf, welding spatter, welding residues and any oily residues!
Especially oily residues can mean higher cleaning effort before painting. In addition to that, untightness is more difficult to detect.

Clean boilers before starting the pressure test.

Empty and drain boilers completely after pressure test.

FRÖLING - QAP - inspection instructions				Supplier	**Fröling - CJDO**		
Inspection of k-list elements				Type:	**S3 - 96100**	Boiler body	
				Order Nr	1007546	lot size	**75**
Check first unit of production lot for measurements as per list below.				EquipmentNr	**200.256.629**		
figure	**Inspection item**	**equipment**	**nominal size**	**actual size**	**Ref k-list drawing**	**Date**	**Inspector**
1	evenness outer jacket left vertical	feeler gauge / ruler	max 4,5mm		**Z005527**		
2	evenness outer jacket left horizontal	feeler gauge / ruler	max. 3mm		**Z005527**		
1	evenness outer jacket right vertical	feeler gauge / ruler	max 4,5mm		**Z005527**		
2	evenness outer jacket right horizontal	feeler gauge / ruler	max. 3mm		**Z005527**		
3	evenness door frame ignition door	feeler gauge / ruler	max. 2mm		**Z005527**		
4	evenness flue gas box	feeler gauge / ruler	max. 1mm		**Z005527**		
5	evenness door frame fire box	feeler gauge / ruler	max. 2mm		**Z005527**		
6	WOS nozzels in line	shaft and brass bearing	shaft has to turn		**Z005527**		
x	boiler free of weld spatter	visual	OK		**Z005527**		
x	boiler free of swarf	visual	OK		**Z005527**		
x	boiler free of welding spray / oil	visual	OK		**Z005527**		
7	dimensional check of door diagonal fire box	tape measure	max. 1,5mm		**Z005527**		
7	dimensional check of door diagonal ignition door	tape measure	max. 1,5mm		**Z005527**		
7	dimensional check of door diagonal cumbustion chamber	tape measure	max. 1,5mm		**Z005527**		
7	dimensional check face ignition area	tape measure	max. 2mm		**Z005527**		
7	dimensional check face fire box	tape measure	max. 2mm		**Z005527**		
7	dimensional check face combustion chamber	tape measure	max. 2mm		**Z005527**		
8,9	all edges of door frames are bevelled	visual	max 0,5x45°		**Z005527**		
10	dimensional check evenness hinge plate	tape measure	mind. 40mm		**Z005527**		
11	immersion sleeve in right position	visual	as per drawing		**Z005527**		
11	plug in right position	visual	as per drawing		**Z005527**		
11	brass pocket is not screwed in fully against stop	visual	as per drawing		**Z005527**		

12	metal strip inside welded with max. A3 welding seam	visual / welding seam gauge	as per drawing		**Z005527**		
13,14	distance of nozzle safety battery	tape measure	95mm		**Z005527**		
15	distance of bolt for hot apron left front	tape measure	100mm		**Z005527**		
15	distance of bolt for hot apron left center	tape measure	183mm		**Z005527**		
15	distance of bolt for hot apron left rear	tape measure	183mm		**Z005527**		
15	distance of bolt for hot apron right front	tape measure	100mm		**Z005527**		
15	distance of bolt for hot apron right center	tape measure	183mm		**Z005527**		
15	distance of bolt for hot apron right rear	tape measure	183mm		**Z005527**		
16, 17, 18, 19	inspection combustion chamber	testing gauge	330 (+2/-4)		**Z005527**		
20	Inspect cross section of air intake with gauge	testing gauge	O.K				
21	Check position of 4 air channels as per drawing Z005528	visual	O,K		**Z005528**		
22	Check position of lining aprons Z005528	visual	O,K		**Z005528**		
23	Check dimensions of lining apron Z005308	caliper	203,4 +/- 0,5		**Z005308**		
23	Check dimensions of lining apron Z005308	caliper	762,7 +/-0,8		**Z005308**		
25	Check dimension of combustion chamber Z005972	caliper	217 +/-0,5		**T005972**		
25	Check dimension of combustion chamber Z005972	caliper	397 +/-0,5		**T005972**		
25	Check dimension of combustion chamber Z005972	caliper	500 +/-0,8		**T005972**		
25	Check dimension of combustion chamber Z005972	caliper	320 +/-0,5		**T005972**		
22	Check positioning of combustion chamber Z005528	visual	O,K		**Z005528**		
26	Check dimensions of flue gas spigot	caliper	149 +0,5/-1,0				
27	Check position of flue gas spigot as per picture	visual	O.K.				
28,29, 30,31, 32	Check clearance of rope gaskets (circumferential from beginning to end)	visual	0mm				
33,34	Tightness test with paper combustion chamber door	strip muss fest	O.K.				

33,34	Tightness test with paper filling door	strip muss fest	O.K.				
33,34	Tightness test with paper ignition door	strip muss fest	O.K.				
33,34	Tightness test with paper upper cover	strip muss fest	O.K.				
35	Dimensional check insulation panel right as per Z064230	tape measure	1479 +/-1,2		**Z064230**		
35	Dimensional check insulation panel right as per Z064230	caliper	100 +/-0,3		**Z064230**		
35	Dimensional check insulation panel right as per Z064230	tape measure	1162,5 +/-1,2		**Z064230**		
36	Dimensional check insulation panel left as per Z064494	tape measure	1479 +/-1,2		**Z064494**		
36	Dimensional check insulation panel left as per Z064494	caliper	100 +/-0,3		**Z064494**		
36	Dimensional check insulation panel left as per Z064494	tape measure	1162,5 +/-1,2		**Z064494**		
37	Dimensional check top cover lid as per Z028072	caliper	471 +/-0,8		**Z028072**		
38	Dimensional check cover lid as per Z005680	caliper	471 +/-0,8		**Z005680**		
39	Dimensional check rear panel as per Z064469	tape measure	1460 +/-1,2		**Z064469**		
39	Dimensional check rear panel as per Z064469	caliper	630 +/-0,8		**Z064469**		
40	Dimensional check insulation door as per Z028000	caliper	570 +/-0,8		**Z028000**		
40	Dimensional check insulation door as per Z028000	tape measure	1375 +/-1,2		**Z028000**		
40	Dimensional check insulation door as per Z028000	caliper	79 +/-0,3		**Z028000**		
41,42	Compare type plate with specification on drawing Z088810	visual	O.K		**Z088810**		
43	Check position of ID fan as per. Picture	visual	O.K.				
41	Dimensional check ID fan as per Z088810	caliper	84 +/-0,3		**Z088810**		
41	Dimensional check ID fan as per Z088810	caliper	LK185		**Z088810**		
41	Dimensional check ID fan as per Z088810	caliper	14 +/-0,2		**Z088810**		
41	Dimensional check ID fan as per Z088810	caliper	97 +/-1		**Z088810**		
41	Dimensional check ID fan as per Z088810	caliper	135 +/-0,5		**Z088810**		

CERTIFICATE

ZERTIFIKAT | CERTIFICATE | CERTIFICAT | CERTIFICADO | СЕРТИФИКАТ | شهادة | 证书 | 인증서

TÜV AUSTRIA

Management system as per EN ISO 9001:2015

In accordance with TÜV AUSTRIA CERT procedures, it is hereby certified that

fröling

FRÖLING Heizkessel- und Behälterbau Ges.m.b.H.
Industriestraße 12
A-4710 Grieskirchen

applies a management system in line with the above standard for the following scope

development, production, sale and service of biomass boilers (log wood, wood chip and pellet boilers, wood gas CHP, control systems, feed systems, tanks and heat exchangers)

Certificate Registration No. 201006394

Valid until 2024-09-11
Initial certification: 1997-01-14

Certification Body
at TÜV AUSTRIA CERT GMBH

Vienna, 2021-10-05

This certification was conducted in accordance with TÜV AUSTRIA CERT auditing and certification procedures and is subject to regular surveillance audits.
TÜV AUSTRIA CERT GMBH Deutschstraße 10 A-1230 Wien www.tuv.at

Akkreditierung Austria 0943 ISO/IEC 17021-1

Online Verification
www.tuv.at/certcheck

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Equipment Calibrations

Equipment Used

Manufacturer: Froling
Model: S3 Turbo 30
Tracking No.: 2448
Project No.: 0456009E
Test Dates: June 13 - June 16, 2022

Lab ID #	Description	Cal Date	Cal Due	Attachment Type
00296-T55	Tape Measure	6/30/2021	6/30/2022	Cal Record
00340	Wood Moisture Meter	VBU[1]		
00431	Wood Moisture Meter Calibrator	11/6/2021	11/6/2022	Cal Certificate
00211	Datalogger	5/12/2022	5/12/2023	Cal Record
00335	Dry Gas Meter	5/10/2022	11/10/2022	Cal Record
00335A	Thermometer	5/10/2022	11/10/2022	Cal Record
00335B	Manometer	5/10/2022	11/10/2022	Cal Record
00336	Dry Gas Meter	5/10/2022	11/10/2022	Cal Record
00336A	Thermometer	5/10/2022	11/10/2022	Cal Record
00336B	Manometer	5/10/2022	11/10/2022	Cal Record
00410	Manometer	3/1/2022	3/1/2023	Cal Certificate
00594	CO/CO2 Analyzer	VBU[2]		
00356	Platform Scale	9/21/2021	9/21/2022	Cal Certificate
00322	Dry Gas Meter	2/10/2022	8/10/2022	Cal Record
00717	OMEGA Fluid Flow Sensor	VBU[3]		
00353	Scale	12/3/2021	12/3/2023	Cal Certificate
00637	Analytical Scale	1/11/2022	7/8/2022	Cal Certificate
00283A	F-Class Audit Weight Set	10/26/2018	10/1/2023	Cal Certificate
00709	Thermometer/Hygrometer	1/27/2021	1/27/2022	Cal Record
00255	10 lb. F-Class Audit Weight	7/6/2021	7/6/2026	Cal Certificate
00716	Barometer	4/19/2022	4/19/2024	Cal Certificate
00648	Stopwatch	10/4/2021	10/4/2022	Cal Record
00677	Anemometer	1/6/2022	1/6/2023	Cal Certificate
114003	Nitrogen (Zero Gas)			
DT0034101	Span Gas, CO/CO2	2/7/2020	2/7/2028	Cal Certificate

[1]Verified Before Use with equipment #00431

[2]Verified Before Use with gas bottles (114003 and DT0034101)

[3]Verified Before, During and After each test. See individual Test Runs.

RECORD OF CALIBRATION

Calibration Record No. 00221-220512

Equipment Description:	Keithley Data Logger	Calibration Date:	5/12/2022
OMNI Equipment no.:	OMNI - 00211	Previous Calibration Date:	N/A
Manufacturer:	Keithley	Next Calibration Due Date:	5/12/2023
Model:	2700	Review Date:	5/12/2023
Serial Number:	780669	Returned to Service Date:	5/12/2023

Annual	
OMNI - 00211	
Keithley Data Logger	
Calibration Date:	5/12/22
Due Date of Cal:	5/12/23
Type K tc :	MU = +/- 0.383 °F (k=2)
Type T tc :	MU = +/- 0.383 °F (k=2)

OMNI-Test Laboratories has been audited and found to be in compliance with ISO/IEC 17025. This accreditation allows OMNI to perform equipment calibrations as a test laboratory on equipment used in testing practices in its laboratory. Any measurement on an accredited calibration not covered by OMNI's scope of accrediadtion are noted within this document.

OMNI-Test Laboratories maintains documentation related to traceability of all its standards to the SI via National Institute of Standards (NIST), National Research Council (NRC) of Canada, or other recognized national or international standard bodies, or to measurable conditions created in our laboratory , or accepted fundamental and/or natural physical constraints, ratio type of calibration or by comparison to consensus standards.

Complete records of work performed are maintained by OMNI-Test Laboratories and are available for inspection. Laboratory assets used in performance of this calibration are listed below.

The results in this Calibration Record relate only to the item being calibrated.

Uncertainties have been estimated at a 95 percent confidence level (*k=2*). Limitations on the use of this instrument are detailed in the manufacturer's instruction manual.

NOTES / REMARKS:

Equipment Used to Perform Calibration

OMNI ID No.	Manufacturer / Model No.	Description	Cal Date	Cal Due
OMNI - 00373	Omega Engineering / CL24	Thermocoupler Calibrator/Thermometer	10/20/21	10/20/22

Calibrated By: K. Morgan Reviewed By / Date: K. Morgan / 5/12/22

Page 1 of 1

Certificate of Calibration

Certificate Number: 749605

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

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

ACCREDITED
0723.01
Calibration

PO: 210356
Order Date: 05/28/2021
Authorized By: N/A

Property #: OMNI-00255
User: N/A
Department: N/A
Make: Rice Lake
Model: 10 Lbs. (Class F)
Serial #: OMNI-00255
Description: Mass
Procedure: DCN 500901
Accuracy: Class F (±450mg)

Calibrated on: 07/06/2021
*Recommended Due: 07/06/2026
Environment: 20 °C 52 % RH
* As Received: Within Tolerance
* As Returned: Within Tolerance
Action Taken: Calibrated
Technician: 126

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

This mass meets class F specifications.
Received/returned without accessories.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
256A	Rice Lake	W0133K	Mass Set,	09/18/2022	741788
484A	Rice Lake	1kg-10kg (Class ASTM 1)	Mass Set,	07/02/2023	748551
550A	And (A&D) Co.	HP-30K	Balance 30 Kg	12/31/2021	739307

Measurement Data

Parameter / Measurement Description	Range	Unit	Reference	Min	Max	*Error	UUT	Uncertainty
Before/After								Accredited = ü
Mass								
10 Lbs.		g	4535.92400000	4535.47400004	4536.3740000	0.2288327	4536.1528327 g	3.5E-01 ü

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

Reviewer

3 Issued 07/08/2021 Rev # 15

Inspector

Certificate of Calibration

Certificate Number: **685888**

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: **180188**
Order Date: 10/09/2018
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, 21pc
Procedure: DCN 500901
Accuracy: Class F

Calibrated on: 10/26/2018
*Recommended Due: 10/26/2023
Environment: 20 °C 57 % RH
* As Received: Within Tolerance
* As Returned: Within Tolerance
Action Taken: Calibrated
Technician: **139**

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.

This set meets Class F specifications.
Received and returned eight (8) masses in a black case secured by a rubber band.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
723A	Rice Lake	1mg-200g (Class 0)	Mass Set,	03/23/2019	668240
800A	Sartorius	MSA225W100DI	Analytical Balance	12/11/2018	663857

Measurement Data

Parameter / Measurement Description	Range Unit	Reference	Min	Max	[k]Error	UUT	Uncertainty Accredited = ✓
Before/After							
Mass							
Dot	200 mg	200.00030	199.4603	200.5403	0.0500	200.0503 mg	6.2E-01 ✓
	1 g	1.00000880	0.9991088	1.0009088	0.0000000	1.0000088 g	1E-03 ✓
	2 g	2.00001470	1.9989147	2.0011147	0.0003250	2.0003397 g	1.3E-03 ✓
	5 g	5.00000840	4.9985084	5.0015084	0.0000400	4.9999684 g	1.7E-03 ✓
	10 g	10.0000100	9.998010	10.002010	0.000245	9.999765 g	2.3E-03 ✓
Dot	20 g	20.0000140	19.996014	20.004014	0.000990	20.001004 g	4.6E-03 ✓
	50 g	49.9999660	49.989966	50.009966	0.000595	49.999371 g	1.1E-02 ✓
	100 g	100.000000	99.98000	100.02000	0.00194	99.99806 g	2.3E-02 ✓

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 10/29/2018 Rev # 15

Inspector

CALIBRATION DATA SHEET

TAPE MEASURE CALIBRATION

Date	6/30/2021
Technician	Tony Tong

Tape Measure Title	16' Tape Measure
Tape Measure Track #	OMNI-00296-T55
Standard Reference Used	OMNI-00281

SIDE A - OUTER MEASUREMENT												
Increment	0"-1"	1"-2"	2"-3"	3"-4"	4"-5"	5"-6"	6"-7"	7"-8"	8"-9"	9"-10"	10"-11"	11"-12"
Random Value Selected	**[3/16"]**	**1 5/16 "**	**2 2/16 "**	**3 1/16 "**	**4 7/16 "**	**5 2/16 "**	**6 8/16 "**	**7 11/16 "**	**8 4/16 "**	**9 15/16 "**	**10 12/16 "**	**11 10/16"**
Trial 1	6/32 "	1 10/32 "	2 4/32 "	3 2/32 "	4 14/32 "	5 4/32 "	6 16/32 "	7 22/32 "	8 8/32 "	9 31/32 "	10 24/32 "	11 20/32 "
Trial 2	6/32 "	1 10/32 "	2 4/32 "	3 2/32"	4 14/32 "	5 4/32 "	6 16/32 "	7 22/32 "	8 8/32 "	9 31/32 "	10 24/32 "	11 20/32 "
Trial 3	6/32 "	1 10/32 "	2 4/32 "	3 2/32 "	4 14/32 "	5 4/32 "	6 16/32 "	7 22/32 "	8 8/32 "	9 30/32 "	10 25/32 "	11 20/32 "

SIDE A - INNER MEASUREMENT												
Increment	0"-1"	1"-2"	2"-3"	3"-4"	4"-5"	5"-6"	6"-7"	7"-8"	8"-9"	9"-10"	10"-11"	11"-12"
Random Value Selected	**[3/16"]**	**1 5/16 "**	**2 2/16 "**	**3 1/16 "**	**4 7/16 "**	**5 2/16 "**	**6 8/16 "**	**7 11/16 "**	**8 4/16 "**	**9 15/16 "**	**10 12/16 "**	**11 10/16 "**
Trial 1	4/32 "	1 8/32 "	2 3/32 "	3 1/32 "	4 13/32 "	5 3/32 "	6 15/32 "	7 21/32 "	8 7/32 "	9 29/32 "	10 23/32 "	11 18/32 "
Trial 2	4/32 "	1 8/32 "	2 3/32 "	3 1/32 "	4 13/32 "	5 3/32 "	6 15/32 "	7 21/32 "	8 7/32 "	9 29/32 "	10 23/32 "	11 18/32 "
Trial 3	4/32 "	1 9/32 "	2 3/32 "	3 1/32 "	4 13/32 "	5 3/32 "	6 15/32 "	7 21/32 "	8 7/32 "	9 29/32 "	10 23/32 "	11 18/32 "

SIDE B - OUTER MEASUREMENT												
Increment	0"-1"	1"-2"	2"-3"	3"-4"	4"-5"	5"-6"	6"-7"	7"-8"	8"-9"	9"-10"	10"-11"	11"-12"
Random Value Selected	**[3/16"]**	**1 5/16 "**	**2 2/16 "**	**3 1/16 "**	**4 7/16 "**	**5 2/16 "**	**6 8/16 "**	**7 11/16 "**	**8 4/16 "**	**9 15/16 "**	**10 12/16 "**	**11 10/16 "**

Trial 1	7/32 "	1 11/32 "	2 4/32 "	3 2/32 "	4 14/32 "	5 5/32 "	6 16/32 "	7 22/32 "	8 8/32 "	9 30/32 "	10 24/32 "	11 20/32 "
Trial 2	7/32 "	1 11/32 "	2 4/32 "	3 2/32 "	4 15/32 "	5 5/32 "	6 16/32 "	7 23/32 "	8 8/32 "	9 30/32 "	10 24/32 "	11 20/32 "
Trial 3	7/32 "	1 11/32 "	2 4/32 "	3 3/32 "	4 15/32 "	5 5/32 "	6 16/32 "	7 22/32 "	8 8/32 "	9 30/32 "	10 24/32 "	11 20/32 "

SIDE B - INNER MEASUREMENT												
Increment	0"-1"	1"-2"	2"-3"	3"-4"	4"-5"	5"-6"	6"-7"	7"-8"	8"-9"	9"-10"	10"-11"	11"-12"
Random Value Selected	**[3/16"]**	**1 5/16 "**	**2 2/16 "**	**3 1/16 "**	**4 7/16 "**	**5 2/16 "**	**6 8/16 "**	**7 11/16 "**	**8 4/16 "**	**9 15/16 "**	**10 12/16 "**	**11 10/16 "**
Trial 1	5/32 "	1 9/32 "	2 3/32 "	3 1/32 "	4 13/32 "	5 3/32 "	6 15/32 "	7 20/32 "	8 7/32 "	9 28/32 "	10 22/32 "	11 19/32 "
Trial 2	5/32 "	1 9/32 "	2 3/32 "	3 1/32 "	4 13/32 "	5 3/32 "	6 15/32 "	7 20/32 "	8 7/32 "	9 28/32 "	10 22/32 "	11 19/32 "
Trial 3	5/32 "	1 9/32 "	2 3/32 "	3 1/32 "	4 13/32 "	5 3/32 "	6 15/32 "	7 20/32 "	8 7/32 "	9 28/32 "	10 22/32 "	11 19/32 "

Thermal Metering System Calibration
Y Factor

Manufacturer:	Apex Instsruments
Model:	MC563 Source Sampler
Serial Number:	601001
OMNI Tracking No.:	OMNI-00322
Calibrated Orifice:	☐ Yes

Previous Calibration Comparision

Date	8/24/2021	Acceptable Deviation (5%)	Deviation
y Factor	1.017	0.05085	0.006
Acceptance	Acceptable		

Current Calibration

Acceptable y Deviation	0.020
Maximum y Deviation	0.007
Acceptable dH@ Deviation	N/A
Maximum dH@ Deviation	N/A
Acceptance	Acceptable

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

Calibration Date:	02/10/22	
Calibrated by:	Tony Tong	
Calibration Frequency:	Six Month	
Next Calibration Due:	8/10/2022	
Instrument Range:	1.000	cfm
Standard Temp.:	68	oF
Standard Press.:	29.92	"Hg
Barometric Press., Pb:	30.47	"Hg
Signature/Date:	Tony Tong	02/10/2022
		2/23/22

Reference Standard *			
Standard Calibrator	Model	Standard Test Meter	
	S/N	OMNI-00001	
	Calib. Date	10-Dec-21	
	Calib. Value	0.9980	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	2.00	1.00	0.25
Initial Reference Meter	783.263	771.035	764.558
Final Reference Meter	789.352	781.146	770.376
Initial DGM	0	0	0
Final DGM	5.958	9.98	5.77
Temp. Ref. Meter (°F), Tr	59.7	59.7	60.1
Temperature DGM (°F), Td	61.0	61.0	59.0
Time (min)	8.0	19.2	34.5
Net Volume Ref. Meter, Vr	6.089	10.111	5.818
Net Volume DGM, Vd	5.958	9.98	5.77
Gas Meter y Factor =	**1.018**	**1.011**	**1.004**
Gas Meter y Factor Deviation (from avg.)	0.007	0.000	0.007
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 x (y factor (ref)) x (Pb + (Pr/ 13.6)) x (Td + 460)]/ [Vd x (Pb + (Pd / 13.6)) x (Tr + 460)]
** 3. dH@ = 0.0317 x Pd / (Pb (Td + 460)) x [(Tr + 460) x 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-EP
Serial Number:	606001
OMNI Tracking No.:	OMNI-00335
Calibrated Orifice:	☐ Yes

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

Calibration Date:	05/10/22	
Calibrated by:	Tony Tong	
Calibration Frequency:	Six Month	
Next Calibration Due:	11/10/2022	
Instrument Range:	1.000	cfm
Standard Temp.:	68	oF
Standard Press.:	29.92	"Hg
Barometric Press., Pb:	30.23	"Hg
Signature/Date:	Tony Tong	/05/11/2022

Previous Calibration Comparision

Date	11/11/2021	Acceptable Deviation (5%)	Deviation
y Factor	1.007	0.05035	0.004
Acceptance	Acceptable		

Current Calibration

Acceptable y Deviation	0.020
Maximum y Deviation	0.003
Acceptable dH@ Deviation	N/A
Maximum dH@ Deviation	N/A
Acceptance	Acceptable

Reference Standard *			
Standard Calibrator	Model	Standard Test Meter	
	S/N	OMNI-00001	
	Calib. Date	10-Dec-21	
	Calib. Value	0.9980	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	2.00	1.28	1.00
Initial Reference Meter	956.762	962.557	967.885
Final Reference Meter	962.448	967.828	973.271
Initial DGM	0	0	0
Final DGM	5.688	5.336	5.461
Temp. Ref. Meter (°F), Tr	61.0	61.7	62.2
Temperature DGM (°F), Td	68.0	71.0	73.0
Time (min)	29.0	33.5	38.5
Net Volume Ref. Meter, Vr	5.686	5.271	5.386
Net Volume DGM, Vd	5.688	5.336	5.461
Gas Meter y Factor =	**1.006**	**1.000**	**1.002**
Gas Meter y Factor Deviation (from avg.)	0.003	0.003	0.001
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 x (y factor (ref)) x (Pb + (Pr/ 13.6)) x (Td + 460)]/ [Vd x (Pb + (Pd / 13.6)) x (Tr + 460)]

** 3. dH@ = 0.0317 x Pd / (Pb (Td + 460)) x [(Tr + 460) x 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.

Temperature Calibration EPA Method 28 R, ASTM 2515							
Booth:	Temperature Monitor Type:					Equipment Number:	
E 3	National Instruments Logger					00335, 00336	
Reference Meter Number: 00373				Calibration Due Date: 10/20/2022			
Calibration Performed By:			Date:	Ambient Temperature(°F):		Barometric Pressure(inHg):	
Tony Tong			05/10/2022	67.9		30.23	
Input Temp (°F)	**Ambient**	**Meter A**	**Meter B**	**Filter A**	**Filter B**	**Tunnel**	**FB Interior**
0	1	0	1	0	0	0	0
100	101	100	100	100	100	100	100
300	301	300	300	300	300	300	300
500	501	500	500	500	500	500	500
700	701	700	700	700	700	700	700
1000	1001	1001	1001	1000	1001	1000	1000
1500	1501	1501	1501	1501	1501	1500	1500
2000	2001	2001	2001	2001	2001	2000	2000

Input (°F)	**FB Top**	**FB Bottom**	**FB Back**	**FB Left**	**FB Right**	**Imp A**	**Imp B**	**Cat**	**Stack**
0	0	0	0	0	0	0	0	0	0
100	100	100	100	100	100	100	100	100	100
300	300	300	300	300	300	300	300	300	300
500	500	500	500	500	500	500	500	500	500
700	700	700	700	700	700	700	700	700	700
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1500	1500	1500	1500	1500	1500	1501	1501	1501	1500
2000	2000	2000	2000	2000	2000	2001	2001	2001	2001

Technician Signature: Tony Tong Date: 05/11/2022

Reviewed By: Date: 5/11/22

DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA SHEET

Instrument to be calibrated: Pressure Transducer (Flue Draft)

Maximum Range: 0 – 1" H_2O ID Number: OMNI- 00335

Calibration Instrument: Digital Manometer ID Number: OMNI- 00633

Date: 05/10/2022 By: Tony Tong

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 0.0 – 0.2	0.114	0.124	0.010	1.0
20-40% Max. Range 0.2 – 0.4	0.226	0.234	0.008	0.8
40-60% Max. Range 0.4 – 0.6	0.463	0.470	0.007	0.7
60-80% Max. Range 0.6 – 0.8	0.666	0.671	0.005	0.5
80-100% Max. Range 0.8 – 1.0	0.873	0.876	0.003	0.3

*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: Tony Tong Date: 05/11/2022

Reviewed by: [signature] Date: 5/11/22

Thermal Metering System Calibration
Y Factor

Manufacturer:	Apex
Model:	XC-60-EP
Serial Number:	606002
OMNI Tracking No.:	OMNI-00336
Calibrated Orifice:	☐ Yes

Previous Calibration Comparision

Date	11/15/2021	Acceptable Deviation (5%)	Deviation
y Factor	1.001	0.05005	0.002
Acceptance	Acceptable		

Current Calibration

Acceptable y Deviation	0.020
Maximum y Deviation	0.001
Acceptable dH@ Deviation	N/A
Maximum dH@ Deviation	N/A
Acceptance	Acceptable

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

Calibration Date:	05/10/22	
Calibrated by:	Tony Tong	
Calibration Frequency:	Six Month	
Next Calibration Due:	11/10/2022	
Instrument Range:	1.000	cfm
Standard Temp.:	68	oF
Standard Press.:	29.92	"Hg
Barometric Press., Pb:	30.23	"Hg
Signature/Date:	Tony Tong	/ 05/11/2022

Reference Standard *			
Standard Calibrator	Model	Standard Test Meter	
	S/N	OMNI-00001	
	Calib. Date	10-Dec-21	
	Calib. Value	0.9980	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	1.90	1.12	0.80
Initial Reference Meter	973.445	980.191	987.955
Final Reference Meter	979.939	987.673	993.567
Initial DGM	0	0	0
Final DGM	6.573	7.579	5.699
Temp. Ref. Meter (°F), Tr	62.8	64.3	64.5
Temperature DGM (°F), Td	74.0	75.0	77.0
Time (min)	31.5	47.0	42.0
Net Volume Ref. Meter, Vr	6.494	7.482	5.612
Net Volume DGM, Vd	6.573	7.579	5.699
Gas Meter y Factor =	**1.002**	**1.003**	**1.004**
Gas Meter y Factor Deviation (from avg.)	0.001	0.001	0.001
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 x (y factor (ref)) x (Pb + (Pr/ 13.6)) x (Td + 460)]/ [Vd x (Pb + (Pd / 13.6)) x (Tr + 460)]

** 3. dH@ = 0.0317 x Pd / (Pb (Td + 460)) x [(Tr + 460) x 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.

Temperature Calibration EPA Method 28 R, ASTM 2515							
Booth:	Temperature Monitor Type:					Equipment Number:	
E 3	National Instruments Logger					00335, 00336	
Reference Meter Number: 00373				Calibration Due Date: 10/20/2022			
Calibration Performed By:			Date:	Ambient Temperature(°F):		Barometric Pressure(inHg):	
Tony Tong			05/10/2022	67.9		30.23	
Input Temp (°F)	**Ambient**	**Meter A**	**Meter B**	**Filter A**	**Filter B**	**Tunnel**	**FB Interior**
0	1	0	1	0	0	0	0
100	101	100	100	100	100	100	100
300	301	300	300	300	300	300	300
500	501	500	500	500	500	500	500
700	701	700	700	700	700	700	700
1000	1001	1001	1001	1000	1001	1000	1000
1500	1501	1501	1501	1501	1501	1500	1500
2000	2001	2001	2001	2001	2001	2000	2000

Input (°F)	**FB Top**	**FB Bottom**	**FB Back**	**FB Left**	**FB Right**	**Imp A**	**Imp B**	**Cat**	**Stack**
0	0	0	0	0	0	0	0	0	0
100	100	100	100	100	100	100	100	100	100
300	300	300	300	300	300	300	300	300	300
500	500	500	500	500	500	500	500	500	500
700	700	700	700	700	700	700	700	700	700
1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
1500	1500	1500	1500	1500	1500	1501	1501	1501	1500
2000	2000	2000	2000	2000	2000	2001	2001	2001	2001

Technician Signature: Tony Tong Date: 05/11/2022

Reviewed By: Date: 5/11/22

DIFFERENTIAL PRESSURE GAUGE CALIBRATION DATA SHEET

Instrument to be calibrated: Pressure Transducer (Pitot ΔP)

Maximum Range: 0 – 1" H_2O ID Number: OMNI- 00336

Calibration Instrument: Digital Manometer ID Number: OMNI- 00633

Date: 05/10/2022 By: Tony Tong

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 0.0 – 0.2	0.102	0.105	0.003	0.3
20-40% Max. Range 0.2 – 0.4	0.281	0.285	0.004	0.4
40-60% Max. Range 0.4 – 0.6	0.491	0.496	0.005	0.5
60-80% Max. Range 0.6 – 0.8	0.717	0.720	0.003	0.3
80-100% Max. Range 0.8 – 1.0	0.914	0.918	0.004	0.4

*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: Tony Tong Date: 05/11/2022

Reviewed by: [signature] Date: 5/11/22

Certificate of Calibration

Certificate Number: 759535

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

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

PO: 210376
Order Date: 11/04/2021
Authorized By: N/A

ACCREDITED CERT # 0723.01

Property #: OMNI-00353
User: N/A
Department: N/A
Make: Unknown
Model: MTW-150K
Serial #: MKW04072
Description: Scale, 330lb
Procedure: DCN 500887
Accuracy: +/-0.4 LB.

Calibrated on: 12/03/2021
*Recommended Due: 12/03/2022
Environment: 18 °C 47 % RH
* As Received: Within Tolerance
* As Returned: Within Tolerance
Action Taken: Calibrated
Technician: 135

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 and returned with power cord.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
88A	Rice Lake	25 Lbs and 50 Lbs (Class	Mass Set, 25 pc Custom	05/17/2022	759451
838A	Rice Lake	61lb (1lb-20lb)	Mass Set, Custom, 8 pc,	01/20/2022	750551

Measurement Data

Parameter / Measurement Description	Range	Unit	Reference	Min	Max	*Error	UUT	Uncertainty	Accredited = ü
Before/After									
Force									
		lbs	66.00	65.6	66.4	0.1	66.1 lbs	6.7E-02	ü
		lbs	132.00	131.6	132.4	0.1	132.1 lbs	7.3E-02	ü
		lbs	198.00	197.6	198.4	0.2	198.2 lbs	8E-02	ü
		lbs	264.00	263.6	264.4	0.3	264.3 lbs	8.6E-02	ü
		lbs	330.00	329.6	330.4	0.3	330.3 lbs	9.3E-02	ü

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

Reviewer

3 Issued 12/07/2021 Rev # 15

Inspector

Established 1974

QUALITY CONTROL SERVICES

LABORATORY EQUIPMENT • SALES • SERVICE • CALIBRATION • REPAIRS
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(503) 236-2712 • FAX (503) 235-2535 • www.qc-services.com

A2LA ACCREDITED
CERTIFICATE #1550.01

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

Report Number: OMNE03069076210921

A2LA ACCREDITED
CERTIFICATE OF CALIBRATION WITH DATA

INSTRUMENT INFORMATION

Item	Make	Model	Serial Number	Customer ID	Location
Scale	Weigh-Tronix	WI-125x5000x0.5lt	069076	356	Lab
Units	**Readability**	**SOP**	**Cal Date**	**Last Cal Date**	**Cal Due Date**
lbs	0.5	QC033	9/21/21	10/1/20	9/2022

FUNCTIONAL CHECKS

SHIFT TEST	LINEARITY	REPEATABILITY	ENVIRONMENTAL CONDITIONS
Test Wt: 1000 Tol: 2.5	Test Wt: HB44 Tol: HB44	Test Wt: 1000 Tol: 2.5	☐ Good ☑ Fair ☐ Poor
As-Found: Pass:☑ Fail:☐	As-Found: Pass:☑ Fail:☐	As-Found: Pass:☑ Fail:☐	Temperature: 21.5°C
As-Left: Pass:☑ Fail:☐	As-Left: Pass:☑ Fail:☐	As-Left: Pass:☑ Fail:☐	

CALIBRATION DATA

Standard	As-Found	As-Left	Expanded Uncertainty
1000	999.0	1000.5	0.31
700	699.5	700.0	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	12/14/19	12/2021	20172265

Permanent Information Concerning this Equipment:

Old s/n 53719

Comments/Information Concerning this Calibration

9/21 RH= 53%. Used 3660.0 lbs of dead load to be able to walk scale up close to capacity. Accurate to 4660.0 lbs.

Report prepared/reviewed by: JC **Date:** 9/22/21 **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.

Certificate of Calibration

Certificate Number: 765754

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

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

PO: 220392
Order Date: 02/24/2022
Authorized By: N/A

Property #: OMNI-00410
User: N/A
Department: N/A
Make: Dwyer
Model: 1430
Serial #: OMNI-00410
Description: Microtector
Procedure: 500908
Accuracy: ±0.00025" WC

Calibrated on: 03/01/2022
*Recommended Due: 03/01/2023
Environment: 19 °C 34 % RH
* As Received: Limited
* As Returned: Limited
Action Taken: Calibrated
Technician: 53

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.

Previous limitation for calibration of micrometer head only continued.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
541A	Select	E8FED2	Gage Block Set, 8pc	12/16/2022	761560

Measurement Data

Parameter / Measurement Description	Range	Unit	Reference	Min	Max	*Error	UUT	Uncertainty	
Before/After								Accredited =	ü
Length									
		Inch	0.1300	0.129	0.131	0.000	0.130 Inch	2.5E-05	ü
		Inch	0.3850	0.384	0.386	0.000	0.385 Inch	2.5E-05	ü
		Inch	0.6150	0.614	0.616	0.000	0.615 Inch	2.5E-05	ü
		Inch	0.8700	0.869	0.871	0.000	0.870 Inch	2.5E-05	ü
		Inch	1.0000	0.999	1.001	0.000	1.000 Inch	2.5E-05	ü

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

Reviewer

3 Issued 03/02/2022 Rev # 15

Inspector

Certificate of Calibration

Certificate Number: 759534

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

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

PO: 210376
Order Date: 11/04/2021
Authorized By: N/A

Property #: OMNI 00431
User: N/A
Department: N/A
Make: Delmhorst
Model: MCS-1
Serial #: OMNI 00431
Description: Moisture Calibrator
Procedure: Raw Data
Accuracy: Raw Data

Calibrated on: 11/06/2021
*Recommended Due: 11/06/2022
Environment: 22 °C 39 % RH
* As Received: Other - See Remarks
* As Returned: Other - See Remarks
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.

Data is provided for your determination of acceptability and reported measure value only.

Standards Used

Std ID	Manufacturer	Model	Nomenclature	Due Date	Trace ID
281A	Hewlett-Packard	3458A	Digital Bench Multimeter, 8.5 D	07/13/2022	747943

Measurement Data

Parameter / Measurement Description	Range	Unit	Reference	Min	Max	*Error	UUT	Uncertainty	Accredited = ü
Before/After									
Resistance									
12 %		MOhm	120.00000	0.0000	0.0000	1.4204	121.4204 MOhm	5.8E-02	ü
22 %		MOhm	1.100000	0.00000	0.00000	0.00013	1.10013 MOhm	5.7E-02	ü

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

Reviewer

3 Issued 11/08/2021 Rev # 15

Inspector

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

A2LA ACCREDITED
CERTIFICATE #1550.01

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

Report Number: OMNE03B729400181220111

A2LA ACCREDITED
CERTIFICATE OF CALIBRATION WITH DATA

INSTRUMENT INFORMATION

Item	Make	Model	Serial Number	Customer ID	Location
Balance	Mettler	MS104TS	B729400181	N/A	Lab
Units	**Readability**	**SOP**	**Cal Date**	**Last Cal Date**	**Cal Due Date**
g	0.0001	qcs012	1/11/22	7/14/21	7/2022

FUNCTIONAL CHECKS

ECCENTRICITY
Test Wt: 50 Tol: 0.0001
As-Found: Pass: ☑ Fail: ☐
As-Left: Pass: ☑ Fail: ☐

LINEARITY
Test Wt: 20x4 Tol: 0.0001
As-Found: Pass: ☑ Fail: ☐
As-Left: Pass: ☑ Fail: ☐

STANDARD DEVIATION
Test Wt: 100 Tol: 0.0001

1. 99.9999	5. 99.9999	9. 100.0001
2. 99.9999	6. 100.0000	10. 100.0000
3. 99.9999	7. 100.0000	Result
4. 100.0001	8. 100.0001	0.00008

ENVIRONMENTAL CONDITIONS
☐ Good ☑ Fair ☐ Poor
Temperature: 18.4°C

A2LA ACCREDITED SECTION OF REPORT

Standard	As-Found	As-Left	Expanded Uncertainty
100	99.9995	99.9999	0.00022
80	79.9994	79.9999	0.00022
50	49.9999	50.0003	0.00021
20	19.9999	20.0002	0.00021
1	1.0000	1.0000	0.00021
0.1	0.1005	0.1001	0.00021

CALIBRATION STANDARDS

Item	Make	Model	Serial Number	Cal Date	Cal Due Date	NIST ID
Weight Set	Rice Lake	20kg to 1mg	7133	4/23/21	4/2022	20210704

Permanent Information Concerning this Equipment:

Comments/Info Concerning this Calibration:
01/22 Adjusted span.

Report prepared/reviewed by: R. B. **Date:** 1-11-22 **Technician:** R. Butcher
Signature: R. Butcher

THIS CERTIFICATE SHALL NOT BE REPRODUCED 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 and readability of the unit under test. The uncertainty is expanded with a k factor of 2 for an approximate 95% level of confidence. Instruments listed above were calibrated using standards traceable to the National Institute of Standards and Technology (NIST). Calibration data reflect results at the time and location of calibration. Calibration data should be reviewed to insure that the instrument is performing to its required accuracy. Calibrations comply with ISO/IEC 17025 and ANSI/Z540-1-1994 quality standards.

NIST Stopwatch Calibration, Time Proficiency Testing Procedure and Data Sheet

Date: 10 / 04 / 21 User/Technician: Tony Tong ☐ Pass ☐ Fail

NIST traceable stopwatch *OMNI* tracking number: 00649 Last Cal: 09/28/21

Stopwatch to be tested for time proficiency *OMNI* tracking number: 00648

1. Start the NIST traceable stopwatch: at a predetermined time (i.e. 1.00 minutes), the technician shall start the watch being tested. When 15.00 seconds have passed (i.e. the NIST traceable stopwatch reads 1 minute, 15 seconds), the technician shall stop the watch being tested. Record the target time interval (i.e. 15.00 seconds). Repeat this step twice and record the data.

2. Repeat step #1 for each of the following target time intervals: 30.00 seconds, 10.00 minutes, and 30 minutes.

3. If the delta between the target time and measured time is less than 5% of the target time interval or 2.00 seconds (whichever is less), then the technician has demonstrated proficiency with the specific instrument utilized in the proficiency test. The proficiency is valid for a period of 12 months.

4. Archive the proficiency test data and information, including the effective date and expiration date of the proficiency, in the equipment record for the instrument involved.

Target time: 15.00 seconds	#1 Measured time: 14”99	#2 Measured time: 14”93	#3 Measured time: 14”89
Target time: 30.00 seconds	#1 Measured time: 30”02	#2 Measured time: 29”91	#3 Measured time: 30”06
Target time: 45.00 seconds	#1 Measured time: 44”90	#2 Measured time: 45”04	#3 Measured time: 45”06
Target time: 60.00 seconds	#1 Measured time: 59”93	#2 Measured time: 1’00”05	#3 Measured time: 1’00”07
Target time: 10.00 minutes	#1 Measured time: 10’00”05	#2 Measured time: 10’00”06	#3 Measured time: 9’59”97
Target time: 30.00 minutes	#1 Measured time: 29’59”88	#2 Measured time: 30’00”11	#3 Measured time: 29’59”90

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

This calibration procedure is confirmed by the manufacturer as a proper method for evaluating the accuracy of timers.

Technician Signature: Tony Tong Date: 10/05/2021

Reviewed by: [signature] Date: 10/05/21

Tektronix®

ACCREDITED

CALIBRATION CERT #2357.22

Certificate of Calibration

16992685

Instrument Identification

Company ID: 74857
OMNI-TEST
MICHAEL CASTILLO
13327 NE ARIPORT WAY
PORTLAND, OR 97230

PO Number: 210388

Instrument ID: **OMNI-00677**
Manufacturer: DWYER INSTRUMENTS
Description: ANEMOMETER VANE

Model Number: VT-200
Serial Number: 18200149
SW/FW Version: INDETERMINATE

Certificate Information

Reason For Service: CALIBRATION
Type of Cal: ACCREDITED 17025 WITH UNCERTAINTIES
As Found Condition: IN TOLERANCE
As Left Condition: IN TOLERANCE
Procedure: 33K6-4-1769-1 VELOCITY, TEMP, AND FLOW REV: 9/30/15
Remarks: *SW/FW version is unobtainable due to age or design of instrument.*

Technician: HAROLD DICKS
Cal Date 06Jan2022
Cal Due Date: 06Jan2023
Interval: 12 MONTHS
Temperature: 22.8 C
Humidity: 39.3 %

Tektronix certifies the performance of the above instrument has been verified using test equipment of known accuracy, traceable to the International System of Units (SI) through a National Metrology Institute such as NIST, NPL or PTB. The methods and procedures used comply with ISO/IEC 17025. The reported expanded measurement uncertainty is stated as the standard measurement uncertainty multiplied by the coverage factor k=2 such that the coverage probability corresponds to approximately 95%.
Dimensional testing length measurements are performed in accordance with A2LA R205 – Specific Requirements: Calibration Laboratory Accreditation Program and are deemed equivalent to that of a calibration.

This certificate and associated attachments relate only to the items calibrated. No representation is made about the long-term stability of this unit. Any number of factors can influence the calibration that may cause the unit to drift out of specification before the calibration interval has expired. Calibration due dates appearing on the certificate or label are determined by the customer for administrative purposes and do not imply continued conformance to specifications.

This certificate shall not be reproduced, except in full, without the written approval of the issuing calibration laboratory.

Data Report Attached.

Approved By: HAROLD DICKS
Service Representative

Issue Date: 1/6/2022

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Manufacturer	Model	Cal Date	Date Due
16752746	17021560	TEMP/HUM RECORDER	OMEGA	iTHX-SD	14Sep2021	14Sep2022
14942663REV1	38-1005980	PITOT TUBE AIRFLOW SYSTEM	SYPRIS	AF12319/PX653	16Aug2019	16Aug2024
16339637	38-1007264	PLATINUM RESISTANCE THERMOMETER	HART SCIENTIFIC	1502A/5612	19Mar2021	19Mar2022

Tektronix®

ACCREDITED

CALIBRATION CERT #2357.22

Certificate of Calibration

16992685

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Manufacturer	Model	Cal Date	Date Due
16861091	38-1018828	TEMP/HUMIDITY PROBE	VAISALA	HMP45A	28Oct2021	28May2023
16868882	B0023974	DATA ACQUISITION/SWITCH UNIT	AGILENT	34970A	02Nov2021	02Jun2023
16579756REV1	C100008	HIGH ACCURACY PRESSURE TRANSDUCER	MKS INSTRUMENTS	120AD-00001RCU	24Jun2021	24Apr2022
16865796	C100831	PRESSURE TRANSDUCER	OMEGA	PX409-16B5V	31Oct2021	31May2023
16930414	H058567	DIGITAL PRESSURE GAGE	MENSOR	2101	24Nov2021	24Jun2023

Tektronix®

Certificate Number: 16992685

Manufacturer: DWYER INSTRUMENTS
ID / Asset Number: OMNI-00677

Model Number: VT-200
Calibration Date: 06-Jan-2022

Function / Range	Nominal Value	As Found	Result	As Left	Result	Min	Max	Units	Uncertainty
Velocity									
Velocity	313	336	Pass	Same	Pass	284	342	FPM	4.8 FPM
	781	813	Pass	Same	Pass	738	824	FPM	21 FPM
	2999	3018	Pass	Same	Pass	2889	3109	FPM	62 FPM
	5985	6083	Pass	Same	Pass	5785	6185	FPM	140 FPM
	7581	7770	Pass	Same	Pass	7334	7828	FPM	180 FPM
Temperature									
Temperature	51.15	50.75	Pass	Same	Pass	49.35	52.95	F	0.12 F
	77.01	77.52	Pass	Same	Pass	75.21	78.81	F	0.12 F
	111.09	111.21	Pass	Same	Pass	109.29	112.89	F	0.13 F

Decision Rule 1 - Accredited Calibration Datasheets may contain measurements that are not covered by the Scope of Accreditation. These measurements are indicated by a pound sign(#). Measurement Uncertainty IS NOT taken into account for determining PASS or FAIL.

********END OF MEASUREMENT REPORT********

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-709 , 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: 01/27/2021 Technician: Tony Tong

Time in desiccate: 12:00 Recording time: 17:00

NIST Standard Temperature: 66.8 °F NIST Standard Humidity: 14.0

Test Unit Temperature Reading: 66.5 °F Test Unit Humidity Reading: 12.3

Test unit OMNI- 00709 is X or was not _____ within acceptable limits.

Technician Signature: Tony Tong

Comments: Humidity difference between NIST standard and test meter is 1.7%. With a full scale of 95% of the meter, it has a 1.79% error of full span.

ilac-MRA A2LA ACCREDITED A2LA Certificate No. 1750.01 Calibration

Calibration complies with ISO/IEC 17025, ANSI/NCSL Z540-1, and 9001

Cert. No.: 6530-13314053

Traceable® Certificate of Calibration for Digital Barometer

Manufactured for and distributed by : Traceable® Products 12554 Galveston Rd B230, Webster, TX 77598

Instrument Identification:

Model: 6530,68000-49 S/N: 221461635 Manufacturer: Control Company

Standards/Equipment:

Description	Serial Number	Due Date	NIST Traceable Reference
Digital Barometer	D4540001	29 Nov 2022	1000474068
Chilled Mirror Hygrometer	44654/2H3737	13 Dec 2023	19994
Climate Chamber	W619.0019		
Digital Thermometer	210888692	18 Oct 2022	12739668

Certificate Information:

Technician: 57 Procedure: CAL-31 Cal Date: 19 Apr 2022 Cal Due Date: 19 Apr 2024

Test Conditions: 48.96%RH 24.99°C 1020mBar

Calibration Data: (New Instrument)

Unit(s)	Nominal	As Found	In Tol	Nominal	As Left	In Tol	Min	Max	±U	TUR
%RH	N.A.	N.A.		50.02	51	Y	47	53	0.74	>4:1
°C	N.A.	N.A.		25.24	25.2	Y	24.84	25.64	0.05	>4:1
mb/hPa	N.A.	N.A.		805.26	806	Y	801	809	0.62	>4:1
mb/hPa	N.A.	N.A.		910.02	911	Y	906	914	0.62	>4:1
mb/hPa	N.A.	N.A.		1014.65	1015	Y	1011	1019	0.62	>4:1

This certificate indicates Traceability to standards provided by (NIST) National Institute of Standards and Technology and/or a National Standards Laboratory.

A Test Uncertainty Ratio of at least 4:1 is maintained unless otherwise stated and is calculated using the expanded measurement uncertainty. Uncertainty evaluation includes the instrument under test and is calculated in accordance with the ISO "Guide to the Expression of Uncertainty in Measurement : (GUM). The uncertainty represents an expanded uncertainty using a coverage factor k=2 to approximate a 95% confidence level. In tolerance conditions are based on test results falling within specified limits with no reduction by the uncertainty of the measurement. The results contained herein relate only to the item calibrated. This certificate shall not be reproduced except in full, without written approval of Control Company.

Nominal=Standard's Reading; As Left=Instrument's Reading; In Tol=In Tolerance; Min/Max=Acceptance Range; ± U=Expanded Measurement Uncertainty; TUR=Test Uncertainty Ratio; Accuracy=±(Max-Min)/2; Min=As Left Nominal(Rounded) – Tolerance; Max= As Left Nominal(Rounded) + Tolerance;

Nicol Rodriguez, Quality Manager

Marisa Elms, Technical Manager

Note :

Maintaining Accuracy:

In our opinion once calibrated your Digital Barometer should maintain its accuracy. There is no exact way to determine how long calibration will be maintained. Digital Barometer change little, if any at all, but can be affected by aging, temperature, shock, and contamination.

Recalibration:

For factory calibration and re-certification traceable to National Institute of Standards and Technology contact Control Company.

Issue Date : 19 Apr 2022

CONTROL COMPANY 12554 Galveston RD Suite B230 Webster TX USA 77598
Phone 281 482-1714 Fax 281 482-9448 sales@control3.com www.traceable.com

Control Company is an ISO/IEC 17025:2017 Calibration Laboratory Accredited by (A2LA) American Association for Laboratory Accreditation, Certificate No. 1750.01.
Control Company is ISO 9001:2015 Quality Certified by DNV GL, Certificate No. CERT-01805-2006-AQ-HOU-ANAB.
International Laboratory Accreditation Cooperation - Multilateral Recognition Arrangement (ILAC-MRA).

Traceable® is a registered trademark of Control Company

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PRAXAIR
Making our planet more productive

FEB 24 2020

DocNumber: 299345

Praxair Distribution, Inc.
5700 S. Alameda Street
Los Angeles CA 90058
Tel: 323-585-2154
Fax: 714-542-6689
PGVP ID: F22020

CERTIFICATE OF ANALYSIS / EPA PROTOCOL GAS

Customer & Order Information

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

Certificate Issuance Date: 02/07/2020
Praxair Order Number: 71237269
Part Number: NI CD17CO8E-AS
Customer PO Number: 79225905

Fill Date: 02/03/2020
Lot Number: 70086003404
Cylinder Style & Outlet: AS CGA 590
Cylinder Pressure and Volume: 1300 psig 99 ft3

Certified Concentration

ProSpec EZ Cert

Expiration Date: 02/07/2028		NIST Traceable
Cylinder Number: DT0034101		Expanded Uncertainty
16.94 %	**Carbon dioxide**	**± 0.5 %**
4.32 %	**Carbon monoxide**	**± 0.6 %**
16.97 %	**Oxygen**	**± 0.2 %**
Balance	**Nitrogen**	

Certification Information:

Certification Date: 02/07/2020 *Term:* 96 Months *Expiration Date:* 02/07/2028

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

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

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

Analytical Data:

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

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

Requested Concentration: 17 %
Certified Concentration: 16.94 %
Instrument Used: Horiba VIA-510 S/N 20C194WK
Analytical Method: NDIR
Last Multipoint Calibration: 01/24/2020

First Analysis Data:						Date	02/07/2020
Z:	0	R:	19.98	C:	16.94	Conc:	16.94
R:	19.98	Z:	0	C:	16.95	Conc:	16.95
Z:	0	C:	16.95	R:	19.99	Conc:	16.95
UOM:	%				Mean Test Assay:		16.94 %

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

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

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

Requested Concentration: 4.25 %
Certified Concentration: 4.32 %
Instrument Used: Horiba VIA-510 S/N UB9UCSYX
Analytical Method: NDIR
Last Multipoint Calibration: 01/31/2020

First Analysis Data:						Date	02/07/2020
Z:	0	R:	5	C:	4.32	Conc:	4.32
R:	5	Z:	0	C:	4.32	Conc:	4.32
Z:	0	C:	4.32	R:	5.01	Conc:	4.32
UOM:	%				Mean Test Assay:		4.32 %

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

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

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

Requested Concentration: 17 %
Certified Concentration: 16.97 %
Instrument Used: OXYMAT 5E
Analytical Method: Paramagnetic
Last Multipoint Calibration: 01/24/2020

First Analysis Data:						Date	02/07/2020
Z:	0	R:	20.88	C:	16.98	Conc:	16.97
R:	20.88	Z:	0	C:	16.98	Conc:	16.97
Z:	0	C:	17	R:	20.9	Conc:	16.99
UOM:	%				Mean Test Assay:		16.97 %

Reference Standard: Type / Cylinder #: GMIS / CC707388
Concentration / Uncertainty: 20.87 % ±0.108%
Expiration Date: 12/14/2026
Traceable to: SRM # / Sample # / Cylinder #: SRM 2659a / 71-E-19 / FF22331
SRM Concentration / Uncertainty: 20.863% / ±0.021%
SRM Expiration Date: 08/23/2021

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

Analyzed By: Jose Vasquez

Certified By: Jenna Lockhart

Information contained herein has been prepared at your request by qualified experts within Praxair Distribution, Inc. While we believe that the information is accurate within the limits of the analytical methods employed and is complete to the extent of the specific analyses performed, we make no warranty or representation as to the suitability of the use of the information for any purpose. The information is offered with the understanding that any use of the information is at the sole discretion and risk of the user. In no event shall the liability of Praxair Distribution, Inc., arising out of the use of the information contained herein exceed the fee established for providing such information.

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.

E_T	Total particulate emissions, grams
$E_{g/MJ}$	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
E_{avg}	Weighted Average Emissions, pounds per million Btu of heat output
HHV	Higher heating value of fuel = 8600 Btu/lb
LHV	Lower heating value of fuel = 7988 Btu/lb.
ΔT	Temperature difference between water entering and exiting heat exchanger
Q_{out}	Total heat output, Btu
Q_{in}	Total heat input availible in in test fuel charge, Btu
M	Mass flow rate of water, lb/min
v_i	Volume of water indicated by flow meter at the i^{th} reading, gallons
v_f	Volumetric flow-rate of water in heat exchange system, gallons per minute
t_i	Data sampling interval, min
Θ	Total length of test run, hours
η_{del}	Delivered heating efficiency, %
η_{SLM}	Over-all efficiency determined using CSA B415.1-10
η_{avg}	Weighted average delivered efficiency, %
F_i	Weighting factor for heat category i
T1	Temperature of water at the inleton the supply side of the heat exchanger, °F
T2	Temperature of the water at the outlet on the supply side of the heat exchanger, °F
T3	Temperature of the water at the inlet on the load side of the heat exchanger, °F
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	Fuel moisture content, % dry basis
MC_i	Average moisture content of individual fuel pieces, % dry basis
σ	Density of water, lb. per gallon
Cp	Specific heat of water, Btu per pound °F
Csteel	Specific heat of steel, (0.1 Btu/lb•°F
$Q_{in\ gross}$	Gross heat input from all fuel sources, Btu
$Q_{in\ net}$	Net heat input, Btu
W_{fuel}	Fuel charge weight, pounds

Continuation of symbols used in calculations:

W_i	Weight of individual fuel pieces, pounds
W_{app}	Weight of empty appliance, pounds
W_{water}	Weight of water in supply side of system
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
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
PR	Proportional rate variation, %

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)

$$TI_{avg} = \frac{193 + 138}{2}$$

TI_{avg} = **165.4353 °F**

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

ASTM E2618 Equation (2):

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

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=155)

$$TF_{avg} = \frac{193 + 138}{2}$$

TF_{avg} = **165.695412 °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:

$$MC_{avg} = \frac{[(\ 8.6\ *\ 22.9\ )\ +\ (\ 6.6\ *\ 20.8\ )\ \ldots +\ (\ 7.2\ *\ 23.0\ )]}{8.6\ +\ 6.6\ \ldots\ +\ 7.2}$$

MC_{avg} = **21.53 % dry basis**

= **17.72 % 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:

$$Q_{in\ gross} = \frac{45.6}{1 + (\quad 21.53 \quad /100)} * 8600$$

$Q_{in\ gross}$ = **322674** **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:

$Q_{in\ net}$ = 322674 - (0 · 12000)

$Q_{in\ net}$ = **322674** **Btu**

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

ASTM E2618 Equation (A2.4):

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

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:

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

C_{pa} = 1.0014 + (-0.000003485 · (165.4 + 165.7)/2)

C_{pa} = **1.000823005** **Btu/lb·°F**

Q_{unit} = (1471.6 · 0.1 + 1.0008230047169 · 274.5)·(165.7 - 165.4)

Q_{unit} = **110** **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 · 59) + (-0.00006225 · 59^2)) x 0.1337

σ = **8.333** **lb/gal**

M_i = 4.26 x 8.33

M_i = **35.46** **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 46.02 x 35.46 x 1

$Q_{load\ @\ t=1}$ = **1634** **Btu**

Sum for Run 1:

Q_{load} = **257,284** **Btu**

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

ASTM E2618 Equation (A2.6):

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

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:

$Q_{storage}$ = (736 x 0.1 + 1.001 x 3145) · (118.1 - 121)

$Q_{storage}$ = **-8746** **Btu**

Q_{out_total} – Total heat output, Btu

ASTM E2618 Equation (A2.7):

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

Sample Calculation:

$Q_{Out-Total}$ = 257,284 + 110 + -8746

$Q_{Out-Total}$ = **248,649 Btu**

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

ASTM E2618 Equation (15):

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

Where,

θ = Total length of test run in hours

Sample Calculation:

θ = 155 /60

θ = 2.58 hrs

Heat Output Rate = 248,649 / 2.583333

Heat Output Rate = **96251** **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 = 257,284 / 2.583

Load Heat Output Rate = **99594** **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 = 0.2 + 0.3 + 0.7

m_n = 1.2 mg

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

m_n = 0.0 + 0.5 + 0.8

m_n = 1.3 mg

Train 1 Aggregate:

m_n = 1.2 + 1.3

m_n = 2.5 mg

Using equation for Train 2:

m_n = 0.0 + 0.7 + 1.7

m_n = 2.4 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:

$$V_{m(std)} = \frac{24.866 \times 1.003 \times 17.64 \times \frac{(30.18 + \frac{1.29}{13.6})}{(76.36 + 460)}}{}$$

$V_{m(std)}$ = 24.83 ft3

Using equation for Train 2:

$$V_{m(std)} = \frac{24.742 \times 1.003 \times 17.64 \times \frac{(30.18 + \frac{1.13}{13.6})}{(76.07 + 460)}}{}$$

$V_{m(std)}$ = 24.71 ft3

Using equation for ambient train:

$$V_{m(std)} = \frac{33.08 \times 1.011 \times 17.64 \times \frac{(30.18 + \frac{0.34}{13.6})}{(70 + 460)}}{}$$

$V_{m(std)}$ = 33.62 ft3

Using equation for First Hour Train:

$$V_{m(std)} = \frac{9.594 \times 1.003 \times 17.64 \times \frac{(30.16 + \frac{1.30}{13.6})}{(73 + 460)}}{}$$

$V_{m(std)}$ = 9.632 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:

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

$$V_s = \frac{0.835}{} \text{ x } 85.49 \text{ x } \frac{0.99}{} \text{ x } \frac{0.178}{} \text{ x } \left(\frac{92.372 + 460}{\left(\frac{30.175}{} + \frac{-0.25}{13.6} \right) \text{x } 28.78} \right)^{1/2}$$

V_s = 10.04 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:

$$C_s = 0.001 \times \frac{2.5}{24.83}$$

C_s = 0.000101 g/dscf

For Train 2

$$C_s = 0.001 \times \frac{2.4}{24.71}$$

C_s = 0.000097 g/dscf

For Ambient Train

$$C_s = 0.001 \times \frac{0.0}{33.62}$$

C_s = 0.000000 g/dscf

For First Hour Train:

$$C_s = 0.001 \times \frac{1.2}{9.63}$$

C_s = 0.000125 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:

$$Q_{sd} = 3600 \times (1 - 0.02) \times \underline{10.04} \times \underline{0.785} \times \frac{528}{\underline{92.37} + 460} \times \frac{\underline{30.175} + \frac{\underline{-0.246}}{13.6}}{29.92}$$

Q_{sd} = <u>26814.23</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 = (0.000101 - 0.000000) x 26814.23 x 155 /60

E_T = 6.97 g

For Train 2

E_T = (0.000097 - 0.000000) x 26814.2 x 155 /60

E_T = 6.73 g

Average

E = 6.85 g

For First Hour Train

E_T = (0.000125 - 0.000000) x 26814.23 x 60 /60

E_T = 3.34 g

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

7.5% of the average =	0.51
Train 1 difference =	0.12
Train 2 difference =	0.12

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):

$$PR = \left(\frac{155 \times 0.146 \times 10.04 \times (76.36 + 460) \times (126.0 + 460)}{1 \times 24.87 \times 10.71 \times (70.00 + 460) \times (92.4 + 460)} \right) \times 100$$

PR = 91.66 %

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:

$E_{g/MJ}$ = 6.85 / (248,649 x 0.001055)
$E_{g/MJ}$ = **0.0261** **g/MJ**

$E_{lb/MMBtu\ output}$ = (6.85 / 453.59)/(248649 x 10^{-6})
$E_{lb/MMBtu\ output}$ = **0.061** **lb/MMBtu output**

$E_{g/kg}$ = 6.85 /((45.6 x 0.4536) / (1 + 21.53 /100))
$E_{g/kg}$ = **0.403** **g/kg**

$E_{g/hr}$ = 6.85 / (155 / 60)
$E_{g/hr}$ = **2.65** **g/hr**

$$E_{g/hr\ 10{,}000\ Btu} = \frac{6.85}{((155 / 60) \times (248649 / 10{,}000))}$$

First hour emissions:

$E_{g/kg}$ = 3.34 /((19.4312 x 0.4536) / (1 + 21.534386 /100))
$E_{g/kg}$ = **0.461** **g/kg**

$E_{g/hr}$ = 3.34 / (60 / 60)
$E_{g/hr}$ = **3.34** **g/hr**

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

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

Sample calculation:

η_{del} = (248649 / 322674) x 100

η_{del} = **77.06** %

EPA 30-day Notice

United States
Environmental Protection
Agency

OMB Control No. 2060-0161
Approval expires 03/31/2019

OMB Control No. 2060-0693
Approval expires 03/31/2019

EPA Form 6400-05

RESIDENTIAL WOOD HEATER 30-DAY NOTIFICATION

INSTRUCTIONS

The manufacturer of an affected wood/pellet heater/central heater model line must notify the U.S. Environmental Protection Agency (EPA) of the date that certification testing is scheduled to begin. The EPA at least 30 days before the start of testing.

This notification must be signed by a responsible representative of the manufacturer or an authorized representative. Once completed, this notification must be submitted to WoodHeaterReports@epa.gov.

Affected residential wood-burning room heaters currently include, but are not limited to, adjustable burn rate stoves, catalytic adjustable burn rate stoves; hybrid adjustable burn rate stoves; single burn rate stoves; and pellet stoves. (40 CFR Part 60, Subpart AAA)

Affected residential wood-burning central heaters currently include, but are not limited to, indoor hydronic heaters ("wood boilers"); outdoor hydronic heaters ("outdoor wood boilers"); and forced-air furnaces ("warm air furnaces"). (40 CFR Part 60, Subpart QQQQ)

The public reporting and recordkeeping burden for this collection of information is estimated to average 8 hours per response. Send comments on the Agency's need for this information, the accuracy of the provided burden estimates, and any suggested methods for minimizing respondent burden, including through the use of automated collection techniques to the Director, Regulatory Support Division, U.S. Environmental Protection Agency (EPA) (2822T), 1200 Pennsylvania Ave., NW, Washington, D.C. 20460. Include the OMB control number in any correspondence. Do not send the completed application to this address.

Disclaimer: The statutory provisions and the EPA regulations described in this document contain legally binding requirements. This document is not a substitute for those provisions or regulations, nor is it a regulation itself. In the event of a discrepancy, please refer to Part 60 Subparts AAA AND QQQQ, Sections 60.537 and 60.5479. If you have additional questions, please contact Rafael Sanchez at 202-564-7028, Residential Wood Heater Compliance Program Lead, or via email at sanchez.rafael@epa.gov.

MANUFACTURER INFORMATION

Manufacturer's Name:
Fröling Heizkessel und Behälterbau Ges.m.b.H.

Manufacturer's Physical Address:
Industriestrasse 12
4710 Grieskirchen
Austria

Manufacturer's Mailing Address (if different from physical address):

Name and Title of Manufacturer's Responsible/Authorized Representative Submitting this Application:
Mr. Werner Emhofer, Export Sales Manager

Manufacturer's Contact E-mail:
w.emhofer@froeling.com

Manufacturer's Phone Number:
+43 7248 606 0

Manufacturer's Website Address:
www.froeling.com

Manufacturer's Website Address where the test report and owner's manual will be posted, if known:

AFFECTED WOOD HEATER MODEL INFORMATION

Model Name(s) (as appearing on the certification test report). Please note: the model name and design number must clearly distinguish one model from another. The name and design number cannot include the EPA symbol or logo or name or derivatives such as "EPA":
Froling S3 Turbo 30

Model Number(s) (as appearing on the certification test report, if applicable):
Froling S3 Turbo 30

Heater Type Check one):	☐Adjustable Burn Rate Wood Heater	☐Pellet Stove	☐Single Burn Rate Heater	☒Hydronic Heater	☐Forced Air Furnace
Hydronic Heater Type (Check one):	☐Full Storage	☒Partial Storage	☐No External Storage	☒Indoor	☐Outdoor
Forced-Air Furnace Type (Check one):	☐Small (less than 65,000 BTU/hr heat output)		☐Large (greater than 65,000 BTU/hr heat output)		
Fuel Tested (Check one):	☐Crib	☐Pellet	☒Cordwood	☐Wood Chips	☐Other:
Certification Step:	☐2015	☐2016 (FAFs only)	☐2017 (FAFs only)	☒2020 (ALL HEATERS)	

Equipped with a catalytic combustor? ☐Yes ☒No

EPA-APPROVED TEST LABORATORY

Name of EPA-Approved Test Laboratory: OMNI-Test Laboratories, Inc.

Name(s) of Person(s) Authorized and/or Responsible for Conducting Certification Test: Bruce Davis

Phone: (503) 643-3788	**E-mail: bdavis@omni-test.com**	**Fax:**
City: Portland	**State: Oregon**	**ZIP Code: 97230**

EPA-APPROVED THIRD-PARTY CERTIFIER

Name of EPA-Approved Third-Party Certifier: OMNI-Test Laboratories, Inc.		
Name(s) of Person(s) Authorized and/or Responsible for Reviewing Test Report and/or Issuing Certification of Conformity: Alex Tiegs		
Phone: (503) 643-3788	**E-mail: atiegs@omni-test.com**	**Fax:**
City: Portland	**State: Oregon**	**ZIP Code: 97230**

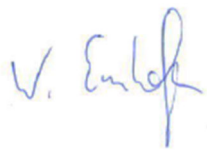
COMPLIANCE TEST INFORMATION

Test Method(s): ASTM E-2618; ASTM E2515	
Date(s) of Proposed Test: June 13th, 2022	
Testing Location (Name and Address): OMNI-Test Laboratories / 13327 NE Airport Way / Portland, OR 97230	
Technician's Contact Name: Bruce Davis	**Title: Testing Manager**
Phone Number: (503) 643 - 3788	**Email Address: bdavis@omni-test.com**

Werner EMHOFER, Export Sales Manager

_____

Print Name and Title of Authorized Official



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Signature

May 27th , 2022

_____

Date

Telephone Number: +43 7248 606 0

Email Address: w.emhofer@froeling.com

Remarks:

This is an amendment to the notice sent on April 02nd 2022 for test commencing May 02nd 2022. Due to delays associated with hydraulic components the testing has been delayed and the delayed re-commencement date will be June 13th 2022.

v1

OMNI-Test Laboratories Quality Assurance / Quality Control Statement

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 30 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.

8. Appendix A

Uncorrected Filter Data and Calculations

UNCORRECTED
(Negative Filter Weights Taken A Zero)

Test Method ASTM E2515-11
Lab Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run #: 1
Date: 6/13/22

Equipment Numbers:

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	E701'	121.3	120.9	0.4
C. Rear filter catch	Filter	E703'	121.0	121.1	0.0
D. Probe catch*	Probe	15	114341.0	114340.8	0.2
E. Filter seals catch*	Seals	S345	3326.2	3325.5	0.7

Sub-Total | Total Particulate, mg: | 1.3

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	E704'	121.7	120.8	0.9
C. Rear filter catch	Filter	E705'	120.7	121.1	0.0
D. Probe catch*	Probe	81	111861.3	111861.3	0.0
E. Filter seals catch*	Seals	S346	3278.8	3278.0	0.8

Sub-Total | Total Particulate, mg: | 1.7

Train 1 Aggregate | Total Particulate, mg: | **3.0**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	E706'	121.0	120.6	0.4
B. Rear filter catch	Filter	E707'	121.8	121.5	0.3
C. Probe catch*	Probe	75	117637.7	117637.7	0.0
D. Filter seals catch*	Seals	S347	3280.1	3278.4	1.7

Total Particulate, mg: 2.4

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter	E708'	121.4	121.4	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

Method ASTM E2618 with PTS Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Comments:	

Parameters:

Run Number:	1
Test Date:	6/13/22
Total Fuel Weight (lb):	45.6
Average Moisture of Fuel (% dry):	21.53
Average Moisture of Fuel (% wet):	17.72
Average Temperature of Appliance Water at Start of Test (°F):	165.4
Average Temperature of Appliance Water at End of Test (°F):	165.7
Average Thermopile Reading (°F):	46.6
Average Load Side Liquid Flow Rate (gal/min):	4.3
Time Interval (min):	155
Burn Rate (kg/hr):	6.59
Emissions (g):	7.55
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

Calculations:

HHV Heat Input (Btu):	322674
Net HHV Heat Input (Btu):	322674
Net HHV Heat Input Rate (Btu/hr):	124906
LHV Heat Input (Btu):	299712
Net LHV Heat Input (Btu):	299712
Net LHV Heat Input Rate (Btu/hr):	116017
Appliance Water Specific Heat (Btu/lb°F):	1.001
Tank Water Specific Heat (Btu/lb°F):	1.001
Q_{unit} (Btu):	110
Q_{Load} (Btu):	257284
$Q_{Storage}$ (Btu):	-8746
Total Heat Output (Btu):	248649
Total Heat Output Rate (Btu/hr):	96251
Total Particulate Emissions (g):	7.55
Time Interval (hr):	2.6
Load Output Rate (Btu/hr):	99594
Emissions Factor(g/kg):	0.444
Total Particulate Emissions Rate (g/MJ):	0.029
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.067**
Total Particulate Emissions (g/hr):	2.92
Delivered Efficiency, HHV (%):	**77.1**
First Hour Emissions Factor (g/kg):	0.50
First Hour Emissions Rate (g/hr):	3.62

Hydronic Heating Appliances - Test Method ASTM E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run: 1
Test Date: June 13, 2022

Burn Rate	**6.59 kg/hr dry**
Average Tunnel Temperature	92 degrees F
Average Gas Velocity in Dilution Tunnel - vs	10.04 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	26814 dscf/hour
Average Delta p	0.032 inches H20
Average Delta H	1.29 inches H20
Total Time of Test	155 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**3.62** g/hr
	0.50 g/kg
Complete Run:	**2.92** g/hr
	0.44 g/kg
	0.07 lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	24.87 cubic feet	24.74 cubic feet	33.08 cubic feet
Average Gas Meter Temperature	76 degrees F	76 degrees F	70 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	24.8 dscf	24.7 dscf	33.6 dscf
Total Particulates - mn	3 mg	2.4 mg	0 mg
Particulate Concentration (dry-standard)	0.000121 grams/dscf	0.000097 grams/dscf	0.000000 grams/dscf
Particulate Emissions	8.37 grams	6.73 grams	
Particulate Emission Rate	3.24 grams/hour	2.60 grams/hour	
Difference from Average	0.82 grams	0.82 grams	
Emissisons Factor	0.49 g/kg	0.40 g/kg	

Results Are Not Acceptable

AVERAGE

Total Sample Volume - Vm	24.80 cubic feet
Average Gas Meter Temperature	76 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	24.8 dscf
Train Precesion 7.5%	**10.87 grams**
Train Precision 0.5g/kg	0.10 grams/kg
Particulate Concentration (dry-standard)	0.00011 grams/dscf
Particulate Emissions	7.55 grams
7.5% of the average particulate emissions	0.57 grams

ADDITIONAL ACCEPTANCE CRITERIA

PTS Water Temperature at test start >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	9.59 cubic feet
Average Gas Meter Temperature	73 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	9.63 dscf
Total Particulates - mn	1.3 mg
Particulate Concentration (dry-standard)	0.00013 grams/dscf
Particulate Emissions	3.62 grams
Burn Rate	7.25 (dry kg/hr)

OMNI-Test Laboratories, Inc.

Test Method ASTM E2515-11
Lab Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run #: 2
Date: 6/14/22

Equipment Numbers:

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	E702'	122.8	121.2	1.6
C. Rear filter catch	Filter	E709'	120.4	121.4	0.0
D. Probe catch*	Probe	4	114856.7	114856.6	0.1
E. Filter seals catch*	Seals	S348	3358.5	3356.9	1.6

Sub-Total Total Particulate, mg: 3.3

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	E710'	121.4	120.6	0.8
C. Rear filter catch	Filter	E711'	119.6	121.5	0.0
D. Probe catch*	Probe	13	114321.6	114321.6	0.0
E. Filter seals catch*	Seals	S349	4092.2	4088.9	3.3

Sub-Total Total Particulate, mg: 4.1

Train 1 Aggregate Total Particulate, mg: **7.4**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	E712'	124.3	120.9	3.4
B. Rear filter catch	Filter	E713'	121.8	121.1	0.7
C. Probe catch*	Probe	14	114547.8	114547.6	0.2
D. Filter seals catch*	Seals	S350	3375.6	3375.5	0.1

Total Particulate, mg: 4.4

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter	E714'	121.0	121.0	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

Method ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Comments:	

Parameters:

Run Number:	2
Test Date:	6/14/22
Total Fuel Weight (lb):	45.6
Average Moisture of Fuel (% dry):	20.97
Average Moisture of Fuel (% wet):	17.33
Average Temperature of Appliance Water at Start of Test (°F):	119.4
Average Temperature of Appliance Water at End of Test (°F):	177.9
Average Thermopile Reading (°F):	84.8
Average Load Side Liquid Flow Rate (gal/min):	0.314
Time Interval (min):	178
Burn Rate (kg/hr):	5.76
Emissions (g):	12.23
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

Calculations:

$Q_{in\ gross}$ (HHV, Btu):	314348
$Q_{in\ net}$ (HHV, Btu):	293948
Net HHV Heat Input Rate (Btu/hr):	99084
$Q_{in\ gross}$ (LHV, Btu):	291978
$Q_{in\ net}$ (LHV, Btu):	271578
Net LHV Heat Input Rate (Btu/hr):	91543
Appliance Water Specific Heat (Btu/lb°F):	1.001
Tank Water Specific Heat (Btu/lb°F):	1.001
Q_{unit} (Btu):	24666
Q_{Load} (Btu):	38559
$Q_{Storage}$ (Btu):	135785
Total Heat Output (Btu):	199010
Total Heat Output Rate (Btu/hr):	67082
Total Particulate Emissions (g):	12.23
Time Interval (hr):	3.0
Load Output Rate (Btu/hr):	12997
Emissions Factor(g/kg):	0.72
Total Particulate Emissions Rate (g/MJ):	0.058
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.136**
Total Particulate Emissions (g/hr):	4.12
Delivered Efficiency, HHV (%):	67.7
First Hour Emissions Factor (g/kg):	0.78
First Hour Emissions Rate (g/hr):	6.83

OMNI-Test Laboratories, Inc.

Hydronic Heating Appliances - Test Method ASTM E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run: 2
Test Date: June 14, 2022

Burn Rate	**5.76 kg/hr dry**
Average Tunnel Temperature	91 degrees F
Average Gas Velocity in Dilution Tunnel - vs	7.4 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	19908 dscf/hour
Average Delta p	0.030 inches H20
Average Delta H	1.28 inches H20
Total Time of Test	178 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**6.83** g/hr
	0.78 g/kg
Complete Run:	**4.12** g/hr
	0.72 g/kg
	0.14 lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	28.50 cubic feet	28.52 cubic feet	45.12 cubic feet
Average Gas Meter Temperature	77 degrees F	77 degrees F	70 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	28.5 dscf	28.5 dscf	46.0 dscf
Total Particulates - mn	7.4 mg	4.4 mg	0 mg
Particulate Concentration (dry-standard)	0.000260 grams/dscf	0.000154 grams/dscf	0.000000 grams/dscf
Particulate Emissions	15.35 grams	9.12 grams	
Particulate Emission Rate	5.17 grams/hour	3.07 grams/hour	
Difference from Average	3.12 grams	3.12 grams	
Emissisons Factor	0.90 g/kg	0.53 g/kg	

Results Are Not Acceptable

AVERAGE

Total Sample Volume - Vm	28.51 cubic feet
Average Gas Meter Temperature	77 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	28.5 dscf
Train Precesion 7.5%	**25.47 grams**
Train Precision 0.5g/kg	0.36 grams/kg
Particulate Concentration (dry-standard)	0.00021 grams/dscf
Particulate Emissions	12.23 grams
7.5% of the average particulate emissions	0.92 grams

ADDITIONAL ACCEPTANCE CRITERIA

PTS Water Temperature >120 °F at Start of Test	**Acceptable**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	9.57 cubic feet
Average Gas Meter Temperature	74 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	9.62 dscf
Total Particulates - mn	3.3 mg
Particulate Concentration (dry-standard)	0.00034 grams/dscf
Particulate Emissions	6.83 grams
Burn Rate	8.76 (dry kg/hr)

OMNI-Test Laboratories, Inc.

Test Method ASTM E2515-11
Lab Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run #: 3
Date: 6/15/22

Equipment Numbers:

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	E715'	122.7	121.0	1.7
C. Rear filter catch	Filter	E716'	119.9	120.7	0.0
D. Probe catch*	Probe	17	114562.3	114561.9	0.4
E. Filter seals catch*	Seals	S351	3229.1	3227.8	1.3

Sub-Total | Total Particulate, mg: | 3.4

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	E717'	123.1	121.1	2.0
C. Rear filter catch	Filter	E718'	120.6	121.3	0.0
D. Probe catch*	Probe	73	117065.8	117065.8	0.0
E. Filter seals catch*	Seals	S352	3312.7	3312.0	0.7

Sub-Total | Total Particulate, mg: | 2.7

Train 1 Aggregate | Total Particulate, mg: | **6.1**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	E719'	126.1	122.3	3.8
B. Rear filter catch	Filter	E720'	119.4	120.7	0.0
C. Probe catch*	Probe	76	116961.1	116960.7	0.4
D. Filter seals catch*	Seals	S353	3360.9	3358.5	2.4

Total Particulate, mg: 6.6

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter	E721	121.3	121.3	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

Method ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Comments:	

Parameters:

Run Number:	3
Test Date:	6/15/22
Total Fuel Weight (lb):	46.6
Average Moisture of Fuel (% dry):	20.39
Average Moisture of Fuel (% wet):	16.94
Average Temperature of Appliance Water at Start of Test (°F):	108.9
Average Temperature of Appliance Water at End of Test (°F):	178.4
Average Thermopile Reading (°F):	108.9
Average Load Side Liquid Flow Rate (gal/min):	0.4
Time Interval (min):	194
Burn Rate (kg/hr):	5.43
Emissions (g):	15.59
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

Calculations:

HHV Heat Input (Btu):	332886
Net HHV Heat Input (Btu):	310086
Net HHV Heat Input Rate (Btu/hr):	95903
LHV Heat Input (Btu):	309197
Net LHV Heat Input (Btu):	286397
Net LHV Heat Input Rate (Btu/hr):	88576
Appliance Water Specific Heat (Btu/lb°F):	1.001
Tank Water Specific Heat (Btu/lb°F):	1.001
Q_{unit} (Btu):	29359
Q_{Load} (Btu):	62565
$Q_{Storage}$ (Btu):	120479
Total Heat Output (Btu):	212403
Total Heat Output Rate (Btu/hr):	65692
Total Particulate Emissions (g):	15.59
Time Interval (hr):	3.2
Load Output Rate (Btu/hr):	19350
Emissions Factor(g/kg):	0.89
Total Particulate Emissions Rate (g/MJ):	0.070
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.162**
Total Particulate Emissions (g/hr):	4.82
Delivered Efficiency, HHV (%):	**68.5**
First Hour Emissions Factor (g/kg):	0.87
First Hour Emissions Rate (g/hr):	8.28

OMNI-Test Laboratories, Inc.

Hydronic Heating Appliances - Test Methods ASTM E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run: 3
Test Date: June 15, 2022

Burn Rate	**5.43 kg/hr dry**
Average Tunnel Temperature	91 degrees F
Average Gas Velocity in Dilution Tunnel - vs	8.7 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	23233 dscf/hour
Average Delta p	0.029 inches H20
Average Delta H	1.26 inches H20
Total Time of Test	194 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**8.28** g/hr **0.87** g/kg
Complete Run:	**4.82** g/hr **0.89** g/kg **0.16** lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	31.11 cubic feet	31.08 cubic feet	48.61 cubic feet
Average Gas Meter Temperature	80 degrees F	80 degrees F	71 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	30.6 dscf	30.6 dscf	48.9 dscf
Total Particulates - mn	6.1 mg	6.6 mg	0 mg
Particulate Concentration (dry-standard)	0.000199 grams/dscf	0.000216 grams/dscf	0.000000 grams/dscf
Particulate Emissions	14.97 grams	16.21 grams	
Particulate Emission Rate	4.63 grams/hour	5.01 grams/hour	
Difference from Average	0.62 grams	0.62 grams	
Emissisons Factor	0.85 g/kg	0.92 g/kg	
	Results Are Acceptable		

AVERAGE

Total Sample Volume - Vm	31.10 cubic feet
Average Gas Meter Temperature	80 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	30.6 dscf
Train Precesion 7.5%	**3.97 grams**
Train Precision 0.5g/kg	0.07 grams/kg
Particulate Concentration (dry-standard)	0.00021 grams/dscf
Particulate Emissions	15.59 grams
7.5% of the average particulate emissions	1.17 grams

ADDITIONAL ACCEPTANCE CRITERIA

PTS Water Temperature >120 °F at Start of Test	**Acceptable**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	9.63 cubic feet
Average Gas Meter Temperature	77 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	9.54 dscf
Total Particulates - mn	3.4 mg
Particulate Concentration (dry-standard)	0.00036 grams/dscf
Particulate Emissions	8.28 grams
Burn Rate	9.54 (dry kg/hr)

Test Method ASTM E2515-11
Lab Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run #: 4
Date: 6/16/22

Equipment Numbers:

TRAIN 1 (First Hour emissions)

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
B. Front filter catch	Filter	E723	122.3	121.9	0.4
C. Rear filter catch	Filter	E724	120.6	121.3	0.0
D. Probe catch*	Probe	OES 4	114148.0	114147.7	0.3
E. Filter seals catch*	Seals	S354	4118.9	4117.5	1.4

Sub-Total	Total Particulate, mg:	2.1

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	E725	122.6	121.6	1.0
C. Rear filter catch	Filter	E726	121.4	121.3	0.1
D. Probe catch*	Probe	70	116833.7	116833.4	0.3
E. Filter seals catch*	Seals	S356	3374.9	3374.5	0.4

Sub-Total	Total Particulate, mg:	1.8
Train 1 Aggregate	Total Particulate, mg:	**3.9**

TRAIN 2

Sample Component	Reagent	Filter, Probe or Dish #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch	Filter	E727	123.7	121.5	2.2
B. Rear filter catch	Filter	E728	120.9	121.0	0.0
C. Probe catch*	Probe	78	117459.5	117459.1	0.4
D. Filter seals catch*	Seals	S355	3340.7	3340.2	0.5

	Total Particulate, mg:	3.1

AMBIENT

Sample Component	Reagent	Filter # or Probe #	Weights		
			Final, mg	Tare, mg	Particulate, mg
A. Front filter catch*	Filter	E729	121.8	121.8	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

Method ASTM E2618-13 Heat Output Results

Manufacturer:	Froling
Model:	S3
Tracking No.:	2448
Project No.:	0456WB009E
Technician:	TT / KM
Comments:	

Parameters:

Run Number:	4
Test Date:	6/16/22
Total Fuel Weight (lb):	44.9
Average Moisture of Fuel (% dry):	21.73
Average Moisture of Fuel (% wet):	17.85
Average Temperature of Appliance Water at Start of Test (°F):	167.5
Average Temperature of Appliance Water at End of Test (°F):	172.8
Average Thermopile Reading (°F):	103.8
Average Load Side Liquid Flow Rate (gal/min):	1.2
Time Interval (min):	191
Burn Rate (kg/hr):	5.26
Emissions (g):	10.28
Fuel HHV (Btu/lb):	8600
Fuel LHV (Btu/lb):	7988

Calculations:

HHV Heat Input (Btu):	317223
Net HHV Heat Input (Btu):	317223
Net HHV Heat Input Rate (Btu/hr):	99651
LHV Heat Input (Btu):	294648
Net LHV Heat Input (Btu):	294648
Net LHV Heat Input Rate (Btu/hr):	92560
Appliance Water Specific Heat (Btu/lb°F):	1.001
Tank Water Specific Heat (Btu/lb°F):	1.001
Q_{unit} (Btu):	2213
Q_{Load} (Btu):	160441
$Q_{Storage}$ (Btu):	87502
Total Heat Output (Btu):	250156
Total Heat Output Rate (Btu/hr):	78583
Total Particulate Emissions (g):	10.28
Time Interval (hr):	3.2
Load Output Rate (Btu/hr):	50400
Emissions Factor(g/kg):	0.61
Total Particulate Emissions Rate (g/MJ):	0.039
Total Particulate Emissions Rate (lbs/mmbtu output):	**0.091**
Total Particulate Emissions (g/hr):	3.23
Delivered Efficiency, HHV (%):	**78.9**
First Hour Emissions Factor (g/kg):	0.98
First Hour Emissions Rate (g/hr):	6.11

UNCORRECTED
(Results reflect negative filter weights taken as Zero)

Hydronic Heating Appliances - Test Method ASTM E2618-13
Test Results

Manufacturer: Froling
Model: S3
Tracking No.: 2448
Project No.: 0456WB009E
Run: 4
Test Date: June 16, 2022

Burn Rate	**5.26 kg/hr dry**
Average Tunnel Temperature	95 degrees F
Average Gas Velocity in Dilution Tunnel - vs	10.4 feet/second
Average Gas Flow Rate in Dilution Tunnel - Qsd	27484 dscf/hour
Average Delta p	0.028 inches H20
Average Delta H	1.25 inches H20
Total Time of Test	191 minutes

PARTICULATE EMISSIONS RESULTS

First Hour:	**6.11** g/hr
	0.98 g/kg
Complete Run:	**3.23** g/hr
	0.61 g/kg
	0.09 lbs/mmbtu output

	SAMPLE TRAIN 1	SAMPLE TRAIN 2	AMBIENT SAMPLE TRAIN
Total Sample Volume - Vm	30.72 cubic feet	30.49 cubic feet	44.35 cubic feet
Average Gas Meter Temperature	85 degrees F	85 degrees F	72 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	29.9 dscf	29.7 dscf	44.5 dscf
Total Particulates - mn	3.9 mg	3.1 mg	0 mg
Particulate Concentration (dry-standard)	0.000130 grams/dscf	0.000105 grams/dscf	0.000000 grams/dscf
Particulate Emissions	11.42 grams	9.15 grams	
Particulate Emission Rate	3.59 grams/hour	2.87 grams/hour	
Difference from Average	1.13 grams	1.13 grams	
Emissisons Factor	0.68 g/kg	0.55 g/kg	

Results Are Not Acceptable

AVERAGE

Total Sample Volume - Vm	30.60 cubic feet
Average Gas Meter Temperature	85 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	29.8 dscf
Train Precesion 7.5%	**11.04 grams**
Train Precision 0.5g/kg	0.14 grams/kg
Particulate Concentration (dry-standard)	0.00012 grams/dscf
Particulate Emissions	10.28 grams
7.5% of the average particulate emissions	0.77 grams

ADDITIONAL ACCEPTANCE CRITERIA

PTS Water Temperature >120 °F at Start of Test	**Acceptable**
Proportional Rate Variation >80%	**Acceptable**
90% of PR Values between 90-110%	**Acceptable**

SAMPLE TRAIN 1 - FIRST HOUR

Total Sample Volume - Vm	9.62 cubic feet
Average Gas Meter Temperature	81 degrees F
Total Sample Volume (Standard Conditions) - Vmstd	9.44 dscf
Total Particulates - mn	2.1 mg
Particulate Concentration (dry-standard)	0.00022 grams/dscf
Particulate Emissions	6.11 grams
Burn Rate	6.26 (dry kg/hr)

9. Revision History

Date Issued	Project No.	Tech. & Evaluator	Report Sect.	Summary of Changes
7/19/22	0456WB009E	Tony Tong Ken Morgan	ALL	First Issue of Report
7/20/22	0456WB009E Ed. 001	Tony Tong Ken Morgan	7	Added information related to the storage location of the archived specimen.
11/01/22	0456WB009E Ed. 002	Ken Morgan	3	Updated Tables 10 and 11 on page 25 to include the Weighted Average Stack Loss Efficiencies
				Added Table 12 “Year-Round Use Weighting – Carbon Monoxide Emission Rates (page 25)
				Added Table 13 “Heating Season Weighting – Carbon Monoxide Emission Rates (page 25)
				Added “Uncorrected” Negative Filter Weight PM emissions to Table 1, page 21
			6	Appended warranty information after User Manual describing where to get replacement parts. page 251
			9	Added Appendix A – Uncorrected Filter Data and Calculations, page 331