CERTIFICATION TEST REPORT

Report no.:
300-ELAB-2604-EPA

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Requested by:	Company:	Rais AS
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	Postcode/town:	DK-9900 Frederikshavn
	Country:	Denmark
	Email:	info@rais.dk
	Web:	www.rais.dk

Product: Wood burner for residential heating Type: Rais Nexo 120 G USA

Sample: Incoming at DTI, Aarhus: 29 June 2022

Test period: Dates of testing: 4-7 July 2022 (both inclusive)

Procedure Testing of solid fuel appliance in accordance with DTI method "ELAB-PP-BR-15" based on relevant selection of standards and methods:

ASTM E2515	Yes
ASTM E3053 (Cordwood)	No
ASTM E2779 (Pellets)	No
US EPA Method 28R in combination with ASTM E2780 (Cribwood)	Yes
CSA B415.1	Yes
EPA Communication on ALT-125 method for Cordwood testing	No

Result: The stove/ meets the requirements of NSPS §40 CFR Part 60.

Remarks: See paragraph 2 - Remarks.

Terms: The test was accomplished under ISO17025 accreditation and in in compliance with international requirements, and the general terms and conditions of The Danish Technological Institute. The test results apply to the tested products only. This test report may be reproduced in extract only if the laboratory has approved the extract in writing. Danish Technological Institute is Notified Body with identification number 1235 and DIN Certco test laboratory, PL 168.

Issued: Date 01.09.2022, Danish Technological Institute, Aarhus, Stoves&Boiler test lab

Signature: Jes Sig Andersen
Senior Specialist

ilac-MRA DANAK
Test reg. no. 300

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1. Introduction

1.1. General

This report concerns testing of a free-standing wood heater, type Rais Nexo 120 G USA. This report is unitary report. Rais does not distinguish between CBI and non-CBI information.

1.2. Revision history

This Initial report is issued Thursday the 01.09.2022

1.3. Scope of testing

The wood heater was tested to demonstrate compliance with the NSPS 2020 limits, using the Federally approved Cribwood test to US EPA Method 28R modifying certain elements of ASTM E2780 Standard Test Method for Determining Particulate Matter Emission from Wood Heaters on combination with the CSA B.415 Performance testing of solid fuel burning heating appliances

1.4. Site

Testing was accomplished by Danish Technological Institute, Kongsvangsallé 29, DK-8000 Aarhus C, Denmark in accordance with DTI's accredited EPA test procedure ELAB-PP-BR-15 enclosed in annex 9.

1.5. Participants

DTI staff
Testing in the laboratory was accomplished by:

- Jes Sig Andersen, Senior Specialist
- Helena Strauss, Consultant

Client staff
The test work was witnessed by:

- Søren Andersen, Rais AS

1.6. Test specimen

Manufacturer:	Rais AS
Address:	Industrivej 20
Postcode/town:	DK-9900 Frederikshavn
Country:	Denmark
Product type:	Free-standing wood stove for residential heating
Combustion system:	Intermittently burning non-catalytic updraft combustion using natural fluedraft
Unit tested:	Rais Nexo 120 G USA

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Variants

There are in total 11 variants of the Rais NEXO family of stoves. They are all build over an identical firebox design and air system. There are two different base parts, one 278 mm high and another 488 mm high. Similarly, there are three different top boxes; 'small', 'medium' and 'high'
Further there are two glass variants, one having only a window in the loading door and another having also side windows. Please find the full model overview in annex 21

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Manufacturers description of the stove

Rais NEXO is a log wood stove is intended for room heating using for intermittent log wood combustion with regular refueling every 1-2 hours.

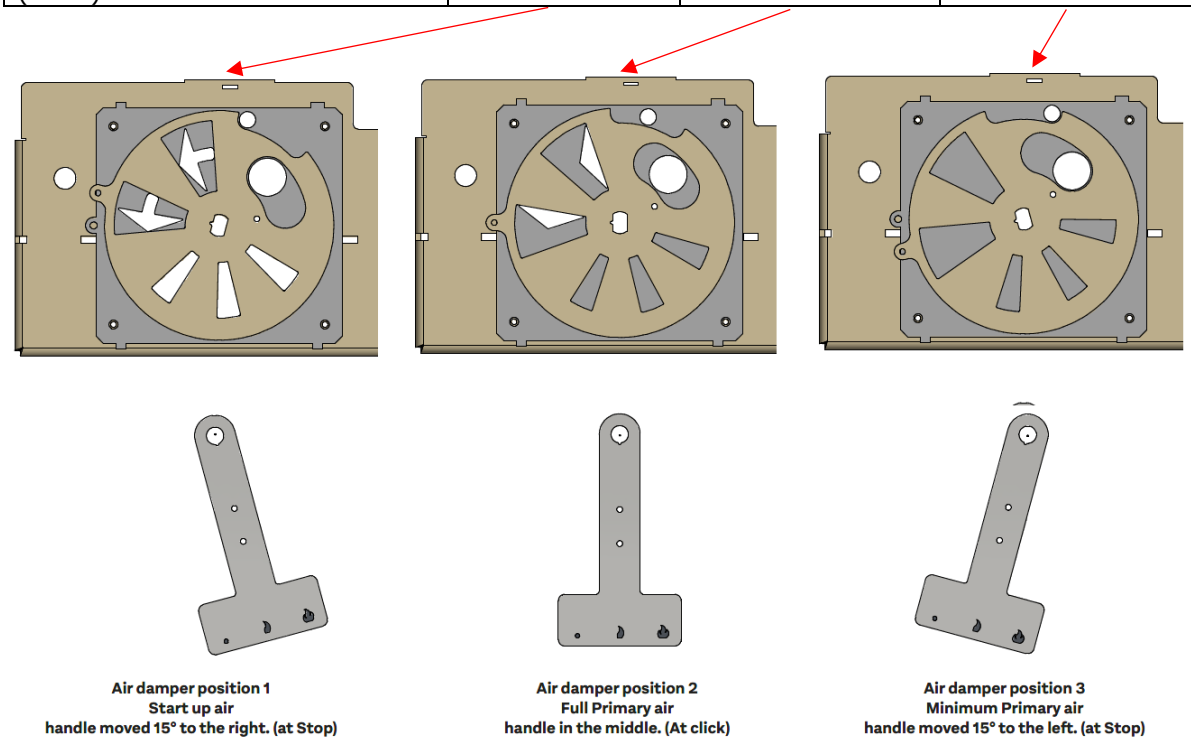
The stove is equipped with a front-loading door with handle, equipped with a glass pane. Some variants also have side windows.

Materials of Construction: The unit is constructed primarily of painted sheet steel. The firebox is lined with vermiculite firebricks and it has a cast iron shaking grate. The firebox has double baffle plates arrangement, both of vermiculite.

Flue Outlet: The 150 mm diameter flue outlet is located at the top of the appliance and is interchangeable with the cover on the back to establish a rear flue exit.

Combustion Controls: The combustion air inlet is controlled by a single handle located below the fuel loading door. Here you can open and close start-up air and control the amount of primary combustion air.

Function:	**Start-up**	**Maximum output**	**Minimum output**
Drawing reference	Pos 1	Pos 2	Pos 3
Start-up air valve (mm2)	1512	0	0
Primary variable combustion air (mm2)	950	706	0
Fixed primary combustion air (mm2)	201	201	201
Secondary combustion air (mm2)	604	604	604
Fixed pilot air (mm2)	113	113	113
Total valve cross section area (mm2)	3380	1624	918



Air damper position 1
Start up air
handle moved 15° to the right. (at Stop)

Air damper position 2
Full Primary air
handle in the middle. (At click)

Air damper position 3
Minimum Primary air
handle moved 15° to the left. (at Stop)

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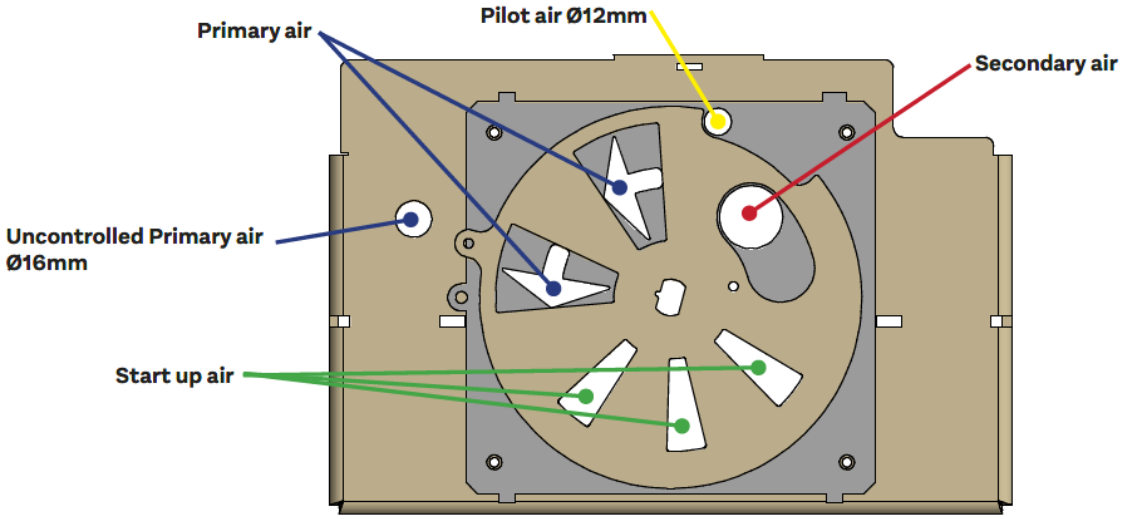
Layout of the integrated air controls disc



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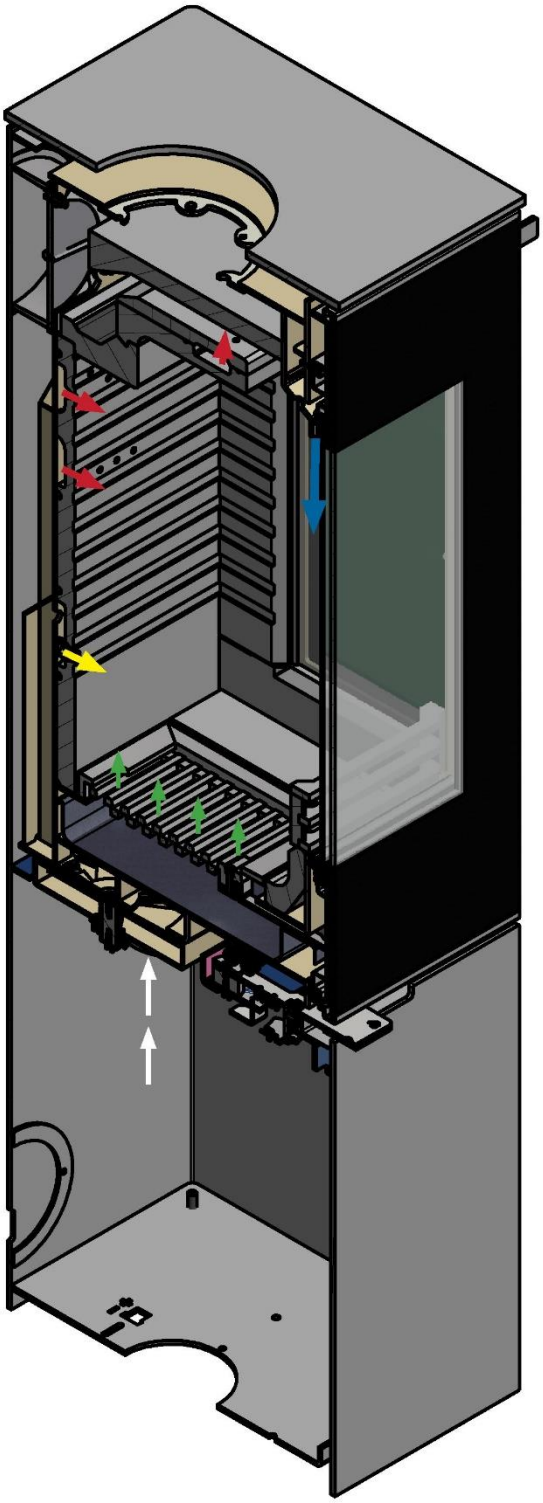
Combustion air streams

10-0000-8506USA Nexo
USA Combustion air flow

Start up air
Primary air
Secondary air
Pilart air
Combustion air inlet



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1.7. Firebox volume and test load determination

The full effective firebox volume was calculated to 0,0419 m^3 (see drawing in annex 28)
No space underneath the grate or above the flue baffle plate was taken into consideration.

Consequently, the test fuel load was calculated to a range of 4,224-5,163 kg

2. Aging prior to test

The stove had been aged for more than 52½ hours of operation prior to the certification test, taking into account 41 hours of pre-burn operation at Rais topped up by another 11½ hours of pre-burn operation at DTI. Please find documentation in annex 1 holding information on refuelling time, the platform scale mass reduction, and curves of the fluegas temperature.

3. Test results

3.1. Test schedule

The full certification test comprises four valid test runs, one from each day of the test. The stove cannot accomplish BR1 when the air controls are fully closed. Neither can it accomplish BR4 when the air controls are fully open. The weighted average PM calculation is hence based on two tests in BR2 and two tests in BR3.

Date	Test designation	Burn rate category accomplished	Remarks
04-07-2022	Low	BR2	The minimum output test with the air controls closed
05-07-2022	Intermediate low	BR2	
06-07-2022	High	BR3	The maximum output test with the air controls fully open
07-07-2022	Intermediate high	BR3	

3.2. Key overview ASTM results

	Burn rate kg dry matter/hour	1 Hour PM emission grams/hour	Overall PM emission grams/hour
#1 the 4. July	0,96	2,78	1,00
#2 the 5. July	1,04	2,02	0,70
#3 the 6. July	1,52	3,82	1,53
#4 the 7. July	1,45	3,03	1,20

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3.3. Average test results

Test #	Burn rate (kg dry/hr)	Average Emission rate (g/hr)	Energy efficiency at HHV (%)	Heat output (BTU/hr)	Emission of CO (g/min)	Weighting factor (%)
1	0,96	1,00	72,9	13.149	1,83	28,22%
2	1,04	0,70	71,9	14.037	2,17	26,95%
3	1,52	1,53	71,1	20.238	2,48	19,53%
4	1,45	1,20	72,2	19.659	2,07	25,30%
Weighted particulate emission average of 4 test runs: 1,1 grams per hour (rounded)						
Weighted average energy efficiency at HHV of 4 test runs: 72 % (rounded)						
Weighted average emission of CO of 4 test runs: 2,1 grams per minute (rounded)						
Arithmetical average emission of CO of 4 test runs: 2,1 grams per minute (rounded)						
Heat output range: 13.149 to 20.238 BTU/hr						

3.4. Summary of test #1 the 4. July 2022

Data logger file Id: 2022-07-04_07-44-13

09:23:29	Begin ignition using 1,82 kg kindling and 3 fire starter bags
10:01:40	Start of pre-test using a fuel load of 4,376 kg
10:13:18	The air controls are set in the final position for the low test (closed)
11:29:00	The door is opened, and the char remainder broken to pieces. The operation lasted 30 seconds
11:31:46	Start of the test period at platform scale 1,026 kg. The test load was 6 cribs of 287 mm length, in total 4,515 kg inc nails (wood alone 4,493 kg) The air controls were set in position 'Start-up'
11:32:16	End of loading time after 30 seconds, the door was closed
11:35:06	The start-up device was closed, and the air controls reset to 100% open combustion air
11:35:36	The air controls are gradually adjusted down towards closed position
11:36:16	The air controls are now in the final position for the low test – closed
12:31:46	The filter holders in the split sampling train is replaced after 1 hour at dry gas meter reading 3.385,53 normal liters.
15:21:31	The test is over at platform scale reading 1,026 kg

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Please find the corresponding sequence of images in annex 2

3.5. Summary of test #2 the 5. July 2022

Data logger file Id: 2022-07-05_07-34-25

08:50:22	Begin ignition using 1,922 kg kindling and 3 fire starter bags
09:29:23	Start of pre-test using a fuel load of 4,387 kg
09:37:59	The air controls are set in the final position for the low test (closed)
10:43:23	The door is opened, and the char remainder broken to pieces. The operation lasted 25 seconds
10:54:12	Start of the test period at platform scale 1,075 kg. The test load was 6 cribs of 287 mm length, in total 4,498 kg inc nails (wood alone 4,474 kg) The air controls were set in position 'Start-up'
10:54:37	End of loading time after 25 seconds, the door was closed
10:57:47	The start-up device was closed, and the air controls reset to 100% open combustion air
10:58:12	The air controls are gradually adjusted down towards closed position
10:59:12	The air controls are now in the final position for the low test – closed
11:54:12	The filter holders in the split sampling train is replaced after 1 hour at dry gas meter reading 4.984,15 normal liters.
14:24:56	The test is over at platform scale reading 1,075 kg

Please find the corresponding sequence of images in annex 3

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3.6. Summary of test #3 the 6. July 2022

Data logger file Id: 2022-07-06_07-43-08

08:46:16	Begin ignition using 1,906 kg kindling and 3 fire starter bags
09:34:31	Start of pre-test using a fuel load of 4,625 kg
09:41:59	The air controls are set in the final position for the max output test (fully open)
10:33:31	The door is opened, and the char remainder broken to pieces. The operation lasted 25 seconds
10:43:02	Start of the test period at platform scale 0,982 kg. The test load was 6 cribs of 287 mm length, in total 4,367 kg inc nails (wood alone 4,342 kg) The air controls were set in position 'Start-up'
10:43:27	End of loading time after 25 seconds, the door was closed
10:47:02	The start-up device was closed, and the air controls reset to 100% open combustion air, the final position for the max output test
11:43:02	The filter holders in the split sampling train is replaced after 1 hour at dry gas meter reading 6.438,94 normal liters.
13:04:27	The test is over at platform scale reading 0,982 kg

Please find the corresponding sequence of images in annex 4

3.7. Summary of test #4 the 7. July 2022

Data logger file Id: 2022-07-07_07-28-34

08:46:19	Begin ignition using 1,834 kg kindling and 3 fire starter bags
09:23:45	Start of pre-test using a fuel load of 4,677 kg
09:40:50	The air controls are set in the final position for the high test (fully open)
10:35:50	The door is opened, and the char remainder broken to pieces. The operation lasted 25 seconds
10:41:16	Start of the test period at platform scale 0,931 kg. The test load was 6 cribs of 287 mm length, in total 4,436 kg inc nails (wood alone 4,408 kg) The air controls were set in position 'Start-up'
10:41:41	End of loading time after 25 seconds, the door was closed
10:46:06	The start-up device was closed, and the air controls reset to 100% open combustion air, the final position for the high test
11:41:16	The filter holders in the split sampling train is replaced after 1 hour at dry gas meter reading 7.423,5 normal liters.
13:11:48	The test is over at platform scale reading 0,931 kg

Please find the corresponding sequence of images in annex 5

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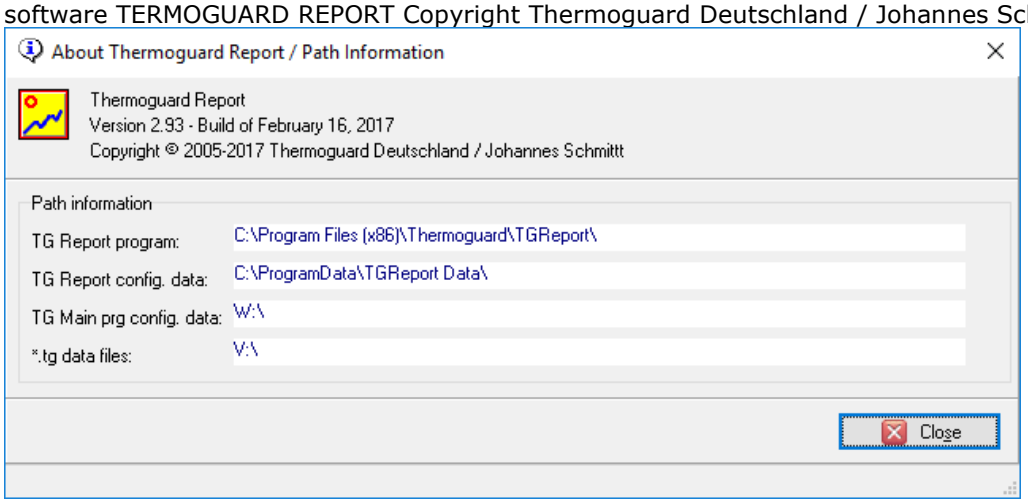
3.8. Anomalies

None

3.9. Test facility conditions

DTI is located at Kongsvangs allé 29, DK-8000 Århus Denmark, at sea level.
Latitude North: 56,1374
Longitude East: 10,1864
Altitude above sea level: 15 meters

Test facility room temperature, relative humidity and barometric pressure is monitored by the software TERMOGUARD REPORT Copyright Thermoguard Deutschland / Johannes Schmitt



Test run#	Test facility temperature (C)		Barometric pressure (mmHG)		Relative humidity (%RH)		Air velocity (m/s)	
	Before	After	Before	After	Before	After	Before	After
1	23,5	25,5	1013,7	1012,4	55,1	45,0	0,04	0,05
2	23,8	25,2	1015,2	1015,6	41,7	41,7	0,03	0,06
3	22,9	23,8	1017,2	1017,1	42,7	36,4	0,10	0,03
4	21,9	23,5	1010,4	1011,6	57,9	53,9	0,04	0,06

3.10. Test fuel properties

The test fuel used was Douglas fir cut according to the specifications of Method 28R/ASTM E2780

The specific average density of all 4 test loads was 452 kg/m^3 dry weight (threshold range 401-578 kg/m^3 dry weight)

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The fuel analysis properties are defined by the CSA B415.1, thus

Default Fuel Values	
	D. Fir
HHV (kJ/kg)	19.810
%C	48,73
%H	6,87
%O	43,9
%Ash	0,5

The test load comprises 6 cribs, each 287 mm long corresponding to 5/6 of the width of the firebox

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The pre-test fuel was of the same origin as the test fuel, 8 pieces of lumber at length 160 mm and 6 pieces at length 230 mm. The average pre-test fuel mass was 4,52 kg

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3.11. Summary of test fuel properties

Test no	#1	#2	#3	#4
Kindling mass (kg)	1,820	1,922	1,906	1,834
Pre-test fuel (kg)	4,376	4,387	4,625	4,677
Moisture on wet basis (%)	19,2	19,4	18,4	17,8
Moisture on dry basis (%)	23,7	24,0	22,6	21,6
Test lumber mass (kg)	3,272	3,228	3,119	3,195
Moisture on wet basis (%)	18,9	18,7	18,0	17,9
Moisture on dry basis (%)	23,3	23,0	21,8	21,8
Spacers mass (kg)	1,221	1,246	1,223	1,213
Moisture on wet basis (%)	16,6	18,1	16,6	16,9
Moisture on dry basis (%)	19,8	22,2	20,3	20,3
Assembled test fuel mass inc nails (kg)	4,515	4,498	4,367	4,436

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4. Test accomplishment

4.1. Remarks

The certification test was accomplished in mere accordance with the manufacturers detailed written testing instruction to the test lab. Please find the full instruction amended in annex 8

4.2. Air system and start-up operation

Rais Nexo has all air controls functions integrated in just one common lever.

When pushed fully to the left the controls are closed. When positioned in an angle 5 degrees to the right from the neutral position the combustion air supply is fully open. When positioned fully to the right, in a 15 degrees angle from the neutral position the start-up device is active. According to the instruction manual the start-up device must only be used during ignition of the fire and shortly after reloading the stove.

The start-up device was used for 4-5 minutes after reloading according to the manufacturers test instructions, until the surface of the fuel is blackened and there is a robust fire.

4.3. Sampling arrangement

The PM specimen is extracted from the Full Flow Dilution Tunnel by means of a dual probe and filter holder system as specified by ASTM E2515-11, clause 6.1.1.1. The filter holders are of type 47 mm Pall 1235. There are 3 sets of backed-up filter holders for PM sampling and one single filter holder for the room blank measurement.

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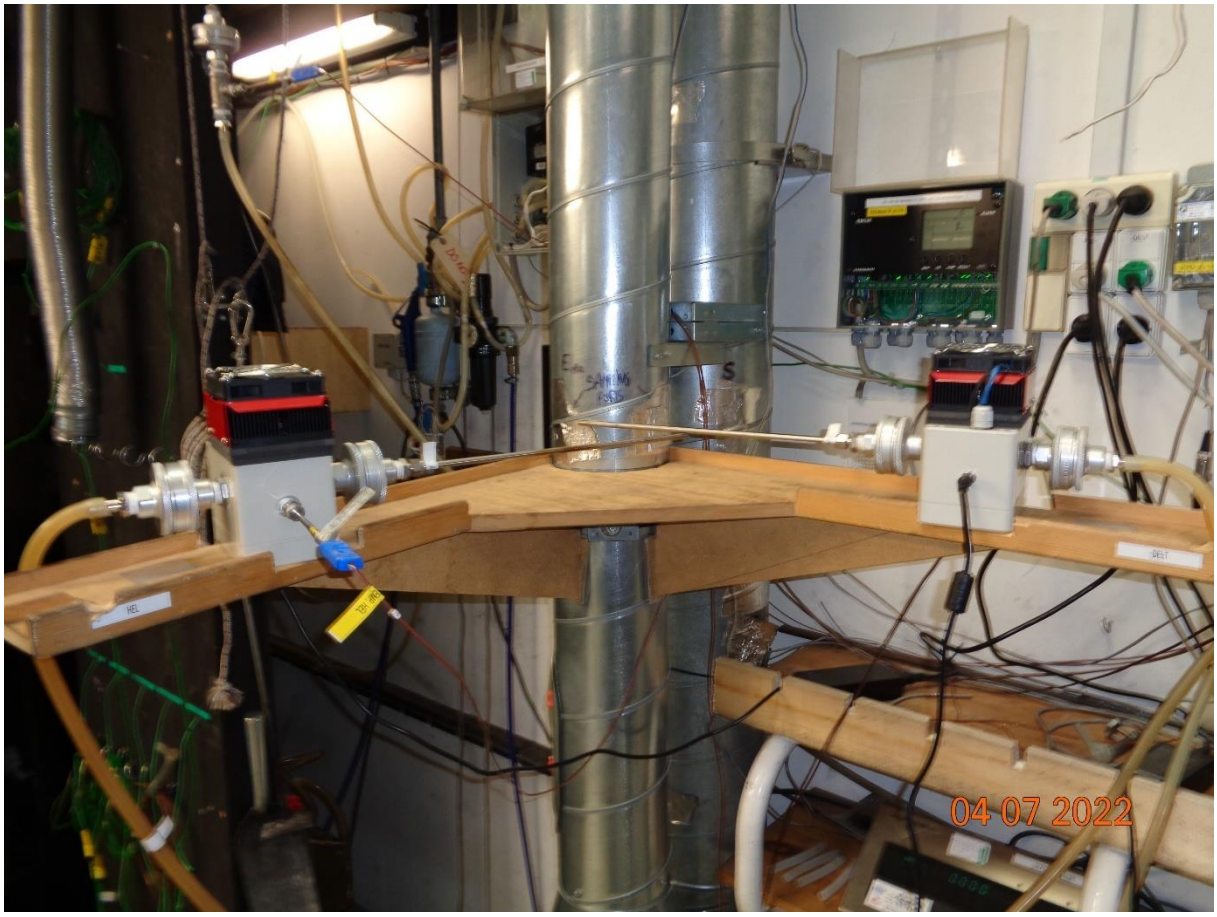

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4.4. Determination of duct pitot factor

Prior to each test, the ducts flow profile is determined by multipoint traverse operation using a pitot tube connected to a TSI micro manometer. Two times 5 points in angular directions is measured. At the same time, the ducts temperature, static pressure, and dynamic pressure is measures by the DOP logger and calculation system.

Dilution tunnel flow profile and resulting Pitot factor, #1 the 4. July

			Kanal diameter:			150	mm			
			6,70%	25%	50%	75%	93,30%	%	Average	
			12,7	37,5	75,0	112,5	137,3	mm dybde (ikke under 12,7mm)		
		1-Diam.	17,7	19,8	29,9	28,6	21,5	Pd [Pa]	6,16	m/s
		2-Diam.	18,4	26,3	29,1	23	19,1	Pd [Pa]	6,73	m/s
27,6	Pd [Pa]		23	Temp [°C]		49,9	Ps [Pa]		0,92	Fp

Dilution tunnel flow profile and resulting Pitot factor, #2 the 5. July

			Kanal diameter:			150	mm			
			6,70%	25%	50%	75%	93,30%	%	Average	
			12,7	37,5	75,0	112,5	137,3	mm dybde (ikke under 12,7mm)		
		1-Diam.	17,7	19,6	29,6	27,9	23,9	Pd [Pa]	6,27	m/s
		2-Diam.	21,4	29	29,7	23,6	19,3	Pd [Pa]	6,77	m/s
27,9	Pd [Pa]		23,5	Temp [°C]		50,2	Ps [Pa]		0,93	Fp

Dilution tunnel flow profile and resulting Pitot factor, #3 the 6. July

			Kanal diameter:			150	mm			
			6,70%	25%	50%	75%	93,30%	%	Average	
			12,7	37,5	75,0	112,5	137,3	mm dybde (ikke under 12,7mm)		
		1-Diam.	17,1	20,1	31,4	28,6	22,7	Pd [Pa]	6,30	m/s
		2-Diam.	21,6	23,1	31,9	26,3	22,1	Pd [Pa]	6,75	m/s
27,9	Pd [Pa]		22,8	Temp [°C]		50,6	Ps [Pa]		0,93	Fp

Dilution tunnel flow profile and resulting Pitot factor, #4 the 7. July

			Kanal diameter:			150	mm			
			6,70%	25%	50%	75%	93,30%	%	Average	
			12,7	37,5	75,0	112,5	137,3	mm dybde (ikke under 12,7mm)		
		1-Diam.	16,7	20,4	30,2	29,5	21,5	Pd [Pa]	6,26	m/s
		2-Diam.	21	26,3	30	24,9	20,3	Pd [Pa]	6,71	m/s
27,4	Pd [Pa]		22,5	Temp [°C]		49,3	Ps [Pa]		0,93	Fp

4.5. Sample data and precision

Test run #	Volume sampled (Nl at 0 degr C and 1013 HPa)	PM catch (mg)	Total emission (g)

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	Main train (nl)	Split train (nl)	Main train (mg)	Split train (mg)	Main train (g)	Split train (g)	Rel deviation %
1	1569,4	1573,0	4,8	4,3	4,051	3,621	5,31%
2	1449,6	1453,3	2,8	3,0	2,41	2,53	2,51%
3	969,9	974,0	4,1	4,5	3,43	3,77	4,59%
4	1038,5	1038,8	3,5	3,5	3,02	3,03	0,20%

4.6. Sample analysis

The probes and the filters and gaskets in pairs are weighed to final weight prior to and after exposure to PM material. In both instances final weight is established after a stay of minimum 24 hours in the desiccator cabinet.

Only in one instance a negative probe mass increment was recorded. That was in test #2 where the probe in the main train displayed a mass increase of -0,1 mg. The average PM catch in the main train was 2,9 mg.

In no instances the ambient room filter set displayed negative mass increase. 3 tests returned zero mg and one test returned 0,1 mg mass increase.

Please find the details of all test runs PM sample analysis in annex 11

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4.7. Fluepipe and chimney configuration

The chimney is composed by single wall uninsulated fluepipe in combination with half insulated system steel chimney compliant with ASTM E2780 clause 9.2

The single wall fluepipe extends to 2,50 m above the test rig floor. The insulated system chimney extends to 4,42 m above the test rig floor, in compliance with ASTM E2780 clause 9.2.1

Please find a schematic drawing of the chimney configuration in annex 7

The chimney was mounted on the top of the stove.

Details, test flue, extraction hood and insulated chimney part

5. Sampling methods

5.1. Particulate extraction system

The particulate matter is sampled in a Ø150 mm full flow dilution tunnel in accordance with ASTM E2515-11. There are two PM sampling trains placed angular to each other. The sampling trains consists each of a set of front and back Pall type 1235 Al 47 mm in-line Al filter holders. Filters are ADVANTEC GB-100R Ø47 mm Glass Fiber filters having 99,99% collection effectivity (%, 0,3 µm DOP) with no binder infusion. Please find the filter specification in annex 34

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The Full Flow Dilution Tunnel is built to match the design specifications of ASTM E2515, section 6.1.6. Please find a diagram of the FFDT in annex 33

Details, Ø150 mm FFDT, mixing section, elbows and adjustable extraction hood

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Details, pitot tube, temp sensor, sampling and traverse parts of the FFDT

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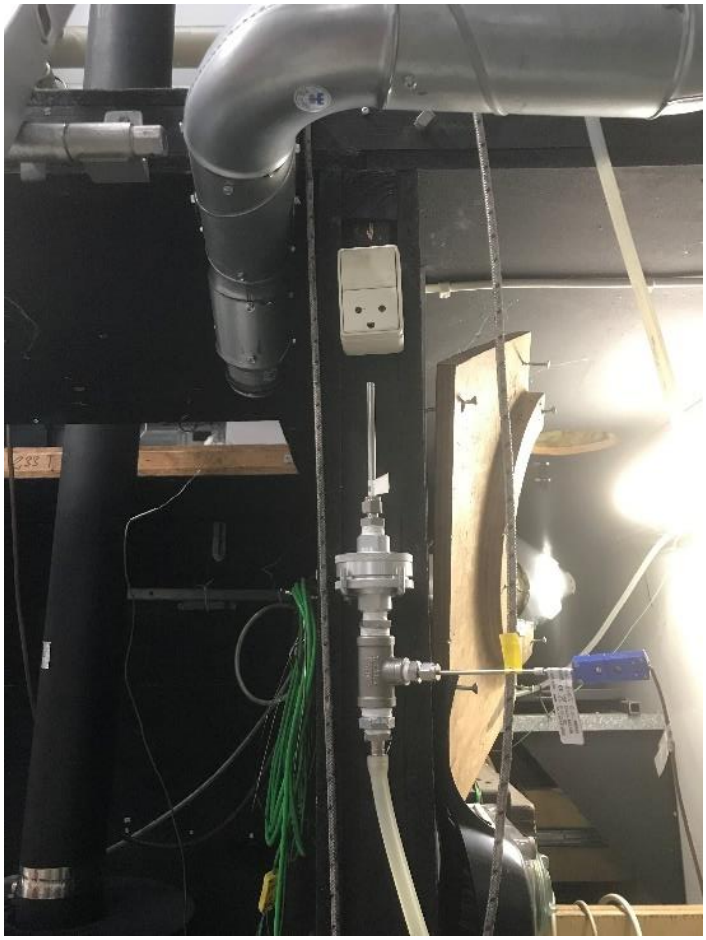
5.2. Ambient room filter blank operation

The ambient blank filter holder is placed at one end of the test trihedron rear wall, right underneath the ceiling. It is located approximately 2,5 m in a direct line from the inlet of the hood.



Placement of ambient blank filter holder

The ambient Filter Blank operation returned no negative values.

5.3. Calculation of PM emission

The calculations are enclosed in a format following the notation of equations in ASTM E2512

Please find the ASTM E2515 calculation of test #1 in annex 12; the calculations of test #2 in annex 13, the calculations of test #3 in annex 14; and the calculations test #4 in annex 15.

5.4. Calculation of energy efficiency, heat output and emission of CO

Calculation of energy efficiency, heat output and emission of CO is accomplished using the standard XLS spreadsheet adjunct to the CSA B.415-10 standard (reaffirmed in 2015) The current version is Version 2_4.

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Please find the report sheets of all 4 CSA calculations in annex 16

6. Quality assurance

6.1. Instrument calibration

DTIs instrument calibration runs in an annual cycle for most instruments, some, every two years after the successful introduction of reliable solid state electronics in lab instrumentation since decades and according to the DTIs ISO17025 accreditation of testing by DANAK. Apparatus of the volume metering system, thermocouples, barometer, and the analytical balance however twice a year according to the provisions of ASTM E2525 clause 8
There is a set of the most recent EPA instrument calibration certificates to be found in annex 10.

6.2. Logger data

Please find the sets of logger data per day, sampled every 5 seconds, and recorded every 30 seconds in annexes 17 (test #1 the 040722); 18 (test #2 the 050722); 19 (test #3 the 060722) and 20 (test #4 the 070722)

7. Documentation material

Documentation material:
- Drawings
- Part list
- Installation manual
- User's instruction
- Photos
- Labelling

Assembly drawings are held in annex 23 and parts and items drawings are held in annex 24. The Installation and operation instructions are held in annex 25 (US version) and in annex 26 (FR version). The labels are held in Annex 27.

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8. Remarks

8.1. Internal correction of dry gas meters

The Vögtlin Red-Y gasmeters have internal correction to as well temperature (here 0-degree C) and to pressure (here 1013 HPa) – the output denominated normal liters.
Consequently, in the calculations, the gasmeter temperature end pressure is entered as 0 degr C respectively 1013 HPa.

9. Discussion of test results

The rule part 40 CFR § 60.533 states in recital 5:

All documentation pertaining to a valid certification test, including the complete test report and, for all test runs: Raw data sheets, laboratory technician notes, calculations and test results. Documentation must include the items specified in the applicable test methods. Documentation must include discussion of each test run and its appropriateness and validity, and must include detailed discussion of all anomalies, whether all burn rate categories were achieved, any data not used in the calculations and, for any test runs not completed, the data collected during the test run and the reason(s) that the test run was not completed and why. The burn rate for the low burn rate category must be no greater than the rate that an operator can achieve in home use and no greater than is advertised by the manufacturer or retailer. The test report must include a summary table that clearly presents the individual and overall emission rates, efficiencies and heat outputs. Submit the test report and all associated required information, according to the procedures for electronic reporting specified in § 60.537(f).

And on a valid certification test:

Valid certification test means a test that meets the following criteria:
(1) The Administrator was notified about the test in accordance with § 60.534(g);
(2) The test was conducted by an approved test laboratory as defined in this section;
(3) The test was conducted on a wood heater similar in all material respects that would affect emissions to other wood heaters of the model line that is to be certified; and
(4) The test was conducted in accordance with the test methods and procedures specified in § 60.534.

9.1. Discussion of test #1 the 040722

The stove cannot burn below 0,80 kg/h, so instead two BR2 tests were performed, one of them #1 returning a burn rate of 0,96 kg/h (dry matter). The test was accomplished without having to regulate the secondary air supply.

The sampling trains were operated in parallel accomplishing homogenous PM catch. The relative deviation between the PM catch of the two sampling trains was 5,31% (shall be less than 7,5%) or 0,12 g/kg absolute value (shall be less than 0,5 g/kg).

The mean surface temperature was at the beginning of the test 191 degr C and at the end 160 degr C, hence a differential surface temperature from start to end at 31 degr C

The isokinetic proportional rate variation throughout the test was within 97-103% (shall be 90-110% apart from one point allowed outside of this interval)
The filter temperatures were inside of the interval 27,9-29,1 degr C (shall be within 26,7 -32,2°C or 80 – 90 °F)
The air velocities measured by the stove was 0,04 m/s from the beginning of the test and 0,05 m/s at the end of the test

#1 test was started and ended at a firebed of 1,026 kg

Hence #1 is deemed as well valid as appropriate.

9.2. Discussion of test #2 the 050722

#2 was the second BR2 test returning a burn rate of 1,04 kg/h (dry matter)

The sampling trains were operated in parallel accomplishing homogenous PM catch. The relative deviation between the PM catch of the two sampling trains was 2,51% (shall be less than 7,5%) or minus 0,03 g/kg absolute value (shall be less than 0,5 g/kg).

The mean surface temperature was at the beginning of the test 199 degr C and at the end 159 degr C, hence a differential surface temperature from start to end of 40 degr C

The isokinetic proportional rate variation throughout the test was within 98-102% (shall be 90-110% apart from one point allowed outside of this interval)
The filter temperatures were inside of the interval 27,9-29,0 degr C (shall be within 26,7 -32,2°C or 80 – 90 °F)
The air velocities measured by the stove was 0,03 m/s from the beginning of the test and 0,06 m/s at the end of the test

#2 test was started and ended at a firebed of 1,075 kg

Hence #2 is deemed as well valid as appropriate.

9.3. Discussion of test #3 the 060722

The stove cannot enter into BR4 (more than 1,90 kg/h). The highest burn rate accomplished was this #3 at 1,52 kg/h (dry matter) having the air controls fully open. Consequently, two BR3 tests were performed, #3 and #4.

The sampling trains were operated in parallel accomplishing homogenous PM catch. The relative deviation between the PM catch of the two sampling trains was 4,59% (shall be less than 7,5%) or minus 0,10 g/kg absolute value (shall be less than 0,5 g/kg).

The mean surface temperature was at the beginning of the test 228 degr C and at the end 193 degr C, hence a differential surface temperature from start to end at 35 degr C

The isokinetic proportional rate variation throughout the test was within 99-103% (shall be 90-110% apart from one point allowed outside of this interval)
The filter temperatures were inside of the interval 27,9-29,1 degr C (shall be within 26,7 -32,2°C or 80 – 90 °F)
The air velocities measured by the stove was 0,10 m/s from the beginning of the test and 0,03 m/s at the end of the test

#3 test was started and ended at a firebed of 0,982 kg

Hence #3 is deemed as well valid as appropriate.

9.4. Discussion of test #4 the 070722

#4 returned a burn rate of 1,45 kg/h (dry matter, hence clearly a BR3 test.

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The sampling trains were operated in parallel accomplishing homogenous PM catch.
The relative deviation between the PM catch of the two sampling trains was 0,20% (shall be less than 7,5%) or 0,00 g/kg absolute value (shall be less than 0,5 g/kg).

The mean surface temperature was at the beginning of the test 213 degr C and at the end 185 degr C, hence a differential surface temperature from start to end at 28 degr C

The isokinetic proportional rate variation throughout the test was within 99-102% (shall be 90-110% apart from one point allowed outside of this interval)
The filter temperatures were inside of the interval 27,9-29,1 degr C (shall be within 26,7 -32,2°C or 80 – 90 °F)
The air velocities measured by the stove was 0,04 m/s from the beginning of the test and 0,06 m/s at the end of the test

#4 test was started and ended at a firebed of 0,931 kg

Hence #4 is deemed as well valid as appropriate.

10. Test equipment

Testing was carried out at test rig C. (EPA setup)

Instrument	**Traceability**	**Instrument number Test rig C**
Scale, Mettler, 600 kg, KC 600	ELAB	270-A-1638
Thermo couples, EPA sampling train Type T	ELAB	Id No. 145092
Thermo couples, others, Type T and type K	ELAB	Id No.134396
DOP version II	-	-
Data acquisition unit, HP 34970A	DANAK 200	270-A-1630
Surface temperature, Technoterm 5500	DANAK 200	270-A-0976
Surface temperature, Dan 1200	DANAK 200	270-A-0876
Pressure gauge, Autotran 700 (flue draught)	ELAB	270-A-1632
Pressure gauge, Autotran 700 (Pd)	ELAB	Id No. 145065
Pressure gauge, Autotran 700 (Ps)	ELAB	270-A-1634
Calibrator, Jofra 650 SE	DANAK 200	270-A-0912
Scale, Mettler Toledo (15kg/1g)	ELAB	Id No. 5822
Scale, Mettler Toledo XS4002S (4,1kg/10mg)	ELAB	Id No. 135794
Scale, Mettler Toledo XS204 (220g/0,1mg)	DANAK 200	Id No. 7084
Disa Dantec flow analyser (Air velocity Laboratory)	DANAK 200	Id No. 424 (13486)
TSI Micromanometer and Pitottube (Air velocity Dillution tunnel)	DANAK 200	Id No. 4771 (270-A-2406)
Hygrometer (air humidity) Thermoguard	DANAK 200	Id No. 142357
Barometric reading (atmospheric pressure) Thermoguard / (Ahlborn)	DANAK 200	Id No. 7102
Pitot tube (air velocity in flue)	ELAB	270-A-1631-14

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Dust measuring equipment (particle measuring equipment)	-	Id No. 145093
Gas meter, Red-y (-H) (Whole charge, With outlet)	DANAK 200	Id No. 144236
Gas meter, Red-y (-D) (Divided charge with outlet)	DANAK 200	Id. No. 144239
Flow meter (-R) (Room blanc)	DANAK-200	Id No. 144257
Thermo sensor, Dilution tunnel, Pt 100	DANAK 200	270-A-1628
PST leakage meter (Brooks glass tube)	ELAB	Id no. 83013
CO/CO_2 analyser, ABB IR	ELAB	270-A-2276
Replacement CO/CO_2 analyser, ABB IR	ELAB	270-A-2276
Spangas CO/CO_2, AGA (High CO and CO_2)	Swedac	Id no. 135573
Spangas CO/CO_2, AGA (Low CO)	Swedac	Id no. 135574
Moisture meter	ELAB	Id No. 145070
Vacuum meter (-H) (Main train)	DANAK 200	Id No. 145074
Vacuum meter (-D) (Split train)	DANAK 200	Id No. 145076
Vacuum meter (-R) (Room)	DANKA 200	Id No. 145077
Pressure meter (-H) (Main train)	DANAK 200	Id No. 145078
Pressure meter (-D) (Split train)	DANAK 200	Id No. 145079
Thermometer (Fuel storage room)	ELAB	Id No. 145081

11. Annexes

Annex 1: Documentation of aging (29 pg)

Annex 2: Images from the test sequence the 4. July 2022 (5 pg)

Annex 3: Images from the test sequence the 5. July 2022 (4 pg)

Annex 4: Images from the test sequence the 6. July 2022 (3 pg)

Annex 5: Images from the test sequence the 7. July 2022 (5 pg)

Annex 6: Filter data sheet (2 pg)

Annex 7: Chimney configuration (2 pg)

Annex 8: Manufacturers test instruction to the testing laboratory (3 pg)

Annex 9: DTIs testing procedure (27 pg)

Annex 10: Set of calibration certificates (81 pg)

Annex 11: Sample analysis (5 pg)

Annex 12: Set of HF1 ASTM calculations (11 pg)

Annex 13: Set of LF1 ASTM calculations (11 pg)

Annex 14: Set of HF2 ASTM calculations (11 pg)

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Annex 15: Set of LF2 ASTM calculations (11 pg)

Annex 16: CSA reports tests #1-#4 (5 pg)

Annex 17: Set of logger data the 4. July 2022 (51 pg)

Annex 18: Set of logger data the 5. July 2022 (46 pg)

Annex 19: Set of logger data the 6. July 2022 (36 pg)

Annex 20: Set of logger data the 7. July 2022 (36 pg)

Annex 21: Models overview (2 pg)

Annex 22: Manufacturers QA Plan (8 pg)

Annex 23: Assembly drawings (24 pg)

Annex 24: Parts drawings (116 pg)

Annex 25: Manufacturer's Instructions, US version (37 pg)

Annex 26: Manufacturer's Instructions, FR version (37 pg)

Annex 27: Labels (2 pg)

Annex 28: Firebox drawing incl Volume calculation (3 pg)

Annex 29: Set of lab hand notes from the 4. July 2022 (7 pg)

Annex 30: Full Flow Dilution Tunnel Schematics (2 pg)