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**Test report of the smoke emission of  
MICRO/4 KW  
of Thornhill Eco Design Ltd.**

SGS registration	
Our reference	EZKA/11/057-2
Revision	1
Date report	July 27, 2011
Author report	J. Dekker

Revision history		
Rev.	Date	Changes
0	July 27, 2011	
1		
2		
3		

At revision the prior editions of this report are to be discarded.

## Project management data

### General

Company name	Thornhill Eco Design Ltd
Address	Charing Cottage, Garlinge Green, Canterbury, Kent, CT45RS UK
Contact person	Mr G. Thornhill
Email address	www.cosi.co.uk
Reference number customer	-
Reference number SGS	EZKA/11/057-2



### Appliance

Name	Micro/4 kW
Category	Space heating appliance fired by solid fuel.
Material	Steel body, combustion chamber and baffle made of vermiculite.

### Measurement information

Test category	Determining the smoke emission.
Method	NEN EN 13240: 2001- 2004 / BS 3841-2 : 1994
Period	July 2011
Measurement technician	R. van den Berg

### Authentication

Consultant	Manager Environmental Services
 J. Dekker	 J. Boot

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## 1 Introduction

This is a test report of a freestanding appliance fired by wood in accordance with BS 3841-2:1994. Test procedures are based on the European Standard EN13240.

The aim of the tests is to verify if it is likely that the appliance meets the requirements of guideline PD 6434:1969 when installed and operated as prescribed by the manufacturer.

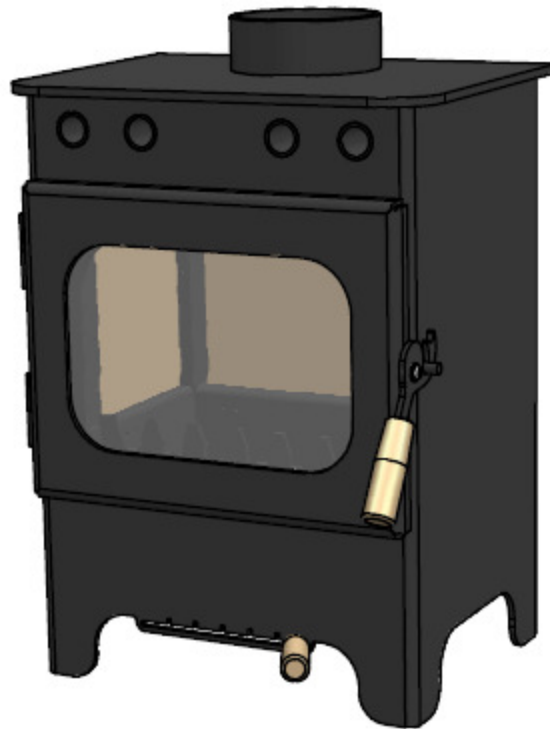
This report describes the results of the dust emission measurements at different heat outputs and control settings of the appliance Micro/4kW of Thornhill Eco Design Ltd when burning wood.

<b>Laboratory</b> Name, address	SGS Nederland BV Leemansweg 51 6827 BX Arnhem The Netherlands
<b>Notified under EC number</b>	0608
<b>Manufacturer</b> Name, address	Thornhill Eco Design Ltd Charing Cottage, Garlinge Green, Canterbury Kent CT45RS UK
<b>Appliance</b>	Micro/4kW
<b>Nominal heat output</b>	4 kW
<b>Recommended fuel</b>	Wood logs.
<b>Test category</b>	Determining the smoke emission at different burning rates and settings when burning wood.

## 2 Description of the room heater

Room heater Micro/4kW is a steel plate stove. The combustion chamber of the stove is equipped with a double glazed front window door and is insulated with vermiculite. The air supply is adjustable with one regulator at the low end of the door. The appliance is equipped with two baffle plates. The flue gas connection is located at the top of the appliance.

*Picture of the room heater*



### 3 Test procedure

#### 3.1 General

The tests are carried out according to European standard EN13240. Tests are executed at different heat outputs and control settings. For each test approximately the same weight of test fuel (beech) is used.

During each test period emitted particles are sampled by using the dilution tunnel method. The emission of dust is quantified by using the gravimetric method. The optical density of the smoke is measured by using the scattered light method.

By UK customary practice the permitted average smoke emission is related to the heat output of the appliance. Test work to EN 13240 showed that the stove, operating at an output of 4.6 kW has an efficiency of 90%. As most appliances are designed to have the best performance at nominal heat output the efficiency and thus the output, differs at lower and higher settings. Therefore the test laboratory chooses to monitor and report all parameters of EN13240 of each separate test.

#### 3.2 Dust measurement

The emission of dust was determined by using the two following methods.

##### *Gravimetric method*

The flue gas from the top of the test chimney is mixed with ambient air in a dilution tunnel. The diluted flue gas is sampled by using a sampling train in which the particulate matter is collected on a glass fibre filter. The diluted flue gas was iso-kinetic sampled. The filters are conditioned and weighed before and after the tests. The dilution rate was determined by monitoring the CO<sub>2</sub> concentration in both the test chimney and the dilution tunnel. More information about the procedure can be found in annex C. A drawing of the test rig can be found in annex D.

##### *Optical method*

The flue gas is continuously monitored by an optical device using the scattered light method. The relation between the output of this device (SI, no dimension) and the obscuration of the emitted smoke (Ringelmann) is defined by SGS and the results are placed in annex A.

#### 3.3 Settings

After positioning the appliance on the test rig, pre-tests were carried out to determine the behaviour of the appliance at different settings.

The combustion air enters the fire chamber through various holes at the sides of the appliance. The amount of combustion air can be regulated by one controller positioned at the low end of the appliance. When this slide is in its minimum position there is still air entering the combustion chamber. However during the pre tests too much smoke was observed in this position. The manufacturer decides to increase the inlet hole to 19mm. This provides the same amount of air when the controller is in position "2". This makes the setting to obtain the nominal heat output the lowest possible position.

The used settings were maintained during the whole burning period. Occasionally the amount of combustion air was increased for a short period to lid the fire after refuel. Information about the used settings is placed in the table below.

*Table 3.3: Used settings*

Setting of air slide	Burning rate		
	Nominal*	Intermediate	High
- Controller	"2"	"3.5"	"5"

\* *Nominal = Low*

## 4 Measurements

The following paragraphs contain the results of the measurements. The specification of the fuel used during the tests is followed by the results of the smoke emission tests at the different burning rates. Results of the optical measurements (graphs) are given in annex A.

### 4.1 Test fuel specification

Analytical information of the test fuel in accordance to EN13240 (as fired)

Test fuel	moisture %	ash %	Volatile matter % dry, ash free	H %	C %	S %	Hu kJ/kg	Size, length cm
Beech	13.4	1.16	84.2	4.7	43.6	0.03	16,086	20

## 4.2 Nominal heat output (1)

		Test 1	Test 2	Test 3	Mean of 3 tests
Date (dd-mm-yy)		06-07-11	06-07-11	06-07-11	
Test fuel		beech	beech	beech	
Total mass	kg	0.79	0.90	0.92	<b>0.87</b>
<u>Setting of:</u>					
- Controller		"2"	"2"	"2"	<b>"2"</b>
Mean flue draught	Pa	11.8	11.8	12.5	<b>12.0</b>
Mean flue gas temperature	K	136	124	130	<b>130</b>
Mean CO <sub>2</sub> concentration	vol%	12.06	13.16	13.32	<b>12.87</b>
Mean CO concentration at 13% O <sub>2</sub>	vol%	0.36	0.40	0.31	<b>0.36</b>
Efficiency	%	88.4	89.3	89.7	<b>89.2</b>
Mean nominal heat to space	kW	4.8	5.1	5.0	<b>4.9</b>
Stack gas volume DT	Nm <sup>3</sup> /h	188	212	202	<b>201</b>
Diameter DT	m	0.15	0.15	0.15	<b>0.15</b>
Speed DT	m/s	2.96	3.34	3.17	<b>3.16</b>
Nozzle diameter	mm	10	10	10	<b>10</b>
Surface Nozzle	m <sup>2</sup>	7.85E-05	7.85E-05	7.85E-05	<b>7.85E-05</b>
Speed nozzle	m/s	4.52	3.48	3.36	<b>3.79</b>
Iso-Kinetics	%	1.53	1.04	1.06	<b>1.21*</b>
Duration	h	0.65	0.71	0.74	<b>0.70</b>
Sampled volume	Nm <sup>3</sup>	0.915	0.765	0.767	<b>0.816</b>
Sampling flow rate	Nm <sup>3</sup> /h	1.28	0.98	0.95	<b>1.07</b>
Dust mass	mg	2.7	2.5	1.5	<b>2.2</b>
Dust concentration	mg/Nm <sup>3</sup>	3.2	3.6	2.1	<b>3.0</b>
Dilution ratio	-	24.3	28.6	27.7	<b>26.9</b>
Dust concentration	mg/Nm <sup>3</sup>	79	102	59	<b>80</b>
Dust concentration at 13% O <sub>2</sub>	mg/Nm <sup>3</sup>	49	58	34	<b>47</b>
Stack gas volume at 13% O <sub>2</sub>	Nm <sup>3</sup> /h	12.5	13.1	12.9	<b>12.8</b>
Dust emission	g/h	0.6	0.8	0.4	<b>0.6</b>
PD6434 permitted	g/h	6.6	6.7	6.7	<b>6.6</b>
% of time above Ringelmann 2	%	0	4	3	<b>-</b>

\* over iso-kinetic.



### 4.3 Nominal heat output (2)

		Test 4	Test 5	Test 6	Mean of 3 tests
Date (dd-mm-yy)		06-07-11	06-07-11	06-07-11	
Test fuel		beech	beech	beech	
Total mass	kg	0.80	0.84	0.82	<b>0.82</b>
<u>Setting of:</u>					
- Controller		"2"	"2"	"2"	<b>"2"</b>
Mean flue draught	Pa	11.3	12.4	11.9	<b>11.8</b>
Mean flue gas temperature	K	123	130	127	<b>127</b>
Mean CO <sub>2</sub> concentration	vol%	11.86	12.44	13.18	<b>12.49</b>
Mean CO concentration at 13% O <sub>2</sub>	vol%	0.42	0.22	0.32	<b>0.32</b>
Efficiency	%	88.7	89.9	89.8	<b>89.4</b>
Mean nominal heat to space	kW	4.2	4.5	4.4	<b>4.4</b>
Stack gas volume DT	Nm <sup>3</sup> /h	188	203	191	<b>194</b>
Diameter DT	m	0.15	0.15	0.15	<b>0.15</b>
Speed DT	m/s	2.95	3.19	3.01	<b>3.05</b>
Nozzle diameter	mm	10	10	10	<b>10</b>
Surface Nozzle	m <sup>2</sup>	7.85E-05	7.85E-05	7.85E-05	<b>7.85E-05</b>
Speed nozzle	m/s	5.51	3.70	5.01	<b>4.74</b>
Iso-Kinetics	%	1.87	1.16	1.67	<b>1.56*</b>
Duration	h	0.50	0.50	0.50	<b>0.50</b>
Sampled volume	Nm <sup>3</sup>	0.865	0.580	0.786	<b>0.744</b>
Sampling flow rate	Nm <sup>3</sup> /h	1.56	1.05	1.42	<b>1.34</b>
Dust mass	mg	1.9	0.5	1.9	<b>1.4</b>
Dust concentration	mg/Nm <sup>3</sup>	2.4	1.0	2.7	<b>2.0</b>
Dilution ratio	-	27.4	28.4	29.2	<b>28.4</b>
Dust concentration	mg/Nm <sup>3</sup>	67	27	79	<b>57</b>
Dust concentration at 13% O <sub>2</sub>	mg/Nm <sup>3</sup>	42	17	45	<b>35</b>
Stack gas volume at 13% O <sub>2</sub>	Nm <sup>3</sup> /h	10.9	11.6	11.4	<b>11.3</b>
Dust emission	g/h	0.5	0.2	0.5	<b>0.4</b>
PD6434 permitted	g/h	6.4	6.5	6.5	<b>6.5</b>
% of time above Ringelmann 2	%	1	3	0	<b>-</b>

\* over iso-kinetic.

#### 4.4 Intermediate heat output

		Test 1	Test 2	Test 3	Mean of 3 tests
Date (dd-mm-yy)		07-07-11	07-07-11	07-07-11	
Test fuel		beech	beech	beech	
Total mass	kg	0.75	0.75	0.8	<b>0.77</b>
<u>Setting of:</u>					
- Controller		"3.5"	"3.5"	"3.5"	<b>"3.5"</b>
Mean flue draught	Pa	11.9	12.0	11.9	<b>11.9</b>
Mean flue gas temperature	K	135	140	143	<b>140</b>
Mean CO <sub>2</sub> concentration	vol%	9.46	9.36	10.53	<b>9.81</b>
Mean CO concentration at 13% O <sub>2</sub>	vol%	0.26	0.22	0.15	<b>0.21</b>
Efficiency	%	87.1	86.9	88.2	<b>87.5</b>
Mean nominal heat to space	kW	5.5	5.2	5.2	<b>5.3</b>
Stack gas volume DT	Nm <sup>3</sup> /h	205	194	174	<b>190</b>
Diameter DT	m	0.15	0.15	0.15	<b>0.15</b>
Speed DT	m/s	3.23	3.05	2.74	<b>2.98</b>
Nozzle diameter	mm	10	10	10	<b>10</b>
Surface Nozzle	m <sup>2</sup>	7.85E-05	7.85E-05	7.85E-05	<b>7.85E-05</b>
Speed nozzle	m/s	3.17	3.33	3.49	<b>3.33</b>
Iso-Kinetics	%	0.98	1.09	1.27	<b>1.12</b>
Duration	h	0.50	0.50	0.50	<b>0.50</b>
Sampled volume	Nm <sup>3</sup>	0.498	0.523	0.550	<b>0.524</b>
Sampling flow rate	Nm <sup>3</sup> /h	0.90	0.94	0.99	<b>0.94</b>
Dust mass	mg	1.7	1.1	0.6	<b>1</b>
Dust concentration	mg/Nm <sup>3</sup>	3.8	2.3	1.2	<b>2.4</b>
Dilution ratio	-	17.4	17.2	17.4	<b>17.3</b>
Dust concentration	mg/Nm <sup>3</sup>	66	40	21	<b>41</b>
Dust concentration at 13% O <sub>2</sub>	mg/Nm <sup>3</sup>	53	33	16	<b>33</b>
Stack gas volume at 13% O <sub>2</sub>	Nm <sup>3</sup> /h	14.7	13.8	13.7	<b>14.1</b>
Dust emission	g/h	0.8	0.5	0.2	<b>0.5</b>
PD6434 permitted	g/h	6.8	6.7	6.7	<b>6.8</b>
% of time above Ringelmann 2	%	0	0	3	<b>-</b>

#### 4.5 High heat output (1)

		Test 1	Test 2	Test 3	Mean of 3 tests
Date (dd-mm-yy)		07-07-11	07-07-11	07-07-11	
Test fuel		beech	beech	beech	
Total mass	kg	0.86	0.75	0.79	<b>0.80</b>
<u>Setting of:</u>					
- Controller		"5"	"5"	"5"	<b>"5"</b>
Mean flue draught	Pa	12.3	12.2	11.9	<b>12.1</b>
Mean flue gas temperature	K	170	163	163	<b>165</b>
Mean CO <sub>2</sub> concentration	vol%	11.51	10.37	11.11	<b>10.98</b>
Mean CO concentration at 13% O <sub>2</sub>	vol%	0.30	0.30	0.24	<b>0.28</b>
Efficiency	%	86.3	85.7	86.7	<b>86.2</b>
Mean nominal heat to space	kW	5.4	4.4	4.6	<b>4.8</b>
Stack gas volume DT	Nm <sup>3</sup> /h	160	146	144	<b>150</b>
Diameter DT	m	0.15	0.15	0.15	<b>0.15</b>
Speed DT	m/s	2.52	2.29	2.26	<b>2.36</b>
Nozzle diameter	mm	10	10	10	<b>10</b>
Surface Nozzle	m <sup>2</sup>	7.85E-05	7.85E-05	7.85E-05	<b>7.85E-05</b>
Speed nozzle	m/s	4.92	4.61	4.09	<b>4.54</b>
Iso-Kinetics	%	1.95	2.02	1.81	<b>1.93*</b>
Duration	h	0.50	0.50	0.50	<b>0.50</b>
Sampled volume	Nm <sup>3</sup>	0.744	0.703	0.629	<b>0.692</b>
Sampling flow rate	Nm <sup>3</sup> /h	1.39	1.30	1.16	<b>1.28</b>
Dust mass	mg	1.4	1.7	0.7	<b>1</b>
Dust concentration	mg/Nm <sup>3</sup>	2.0	2.6	1.2	<b>1.9</b>
Dilution ratio	-	16.9	17.0	16.9	<b>16.9</b>
Dust concentration	mg/Nm <sup>3</sup>	34	44	20	<b>33</b>
Dust concentration at 13% O <sub>2</sub>	mg/Nm <sup>3</sup>	23	33	14	<b>23</b>
Stack gas volume at 13% O <sub>2</sub>	Nm <sup>3</sup> /h	14.4	11.8	12.4	<b>12.9</b>
Dust emission	g/h	0.3	0.4	0.2	<b>0.3</b>
PD6434 permitted	g/h	6.8	6.5	6.5	<b>6.6</b>
% of time above Ringelmann 2	%	0	0	0	<b>-</b>

\* over iso-kinetic.

#### 4.6 High heat output (2)

		Test 4	Test 5		Mean of 2 tests
Date (dd-mm-yy)		07-07-11	07-07-11		
Test fuel		beech	beech		
Total mass	kg	0.86	0.80		<b>0.83</b>
<u>Setting of:</u>					
- Controller		"5"	"5"		"5"
Mean flue draught	Pa	12.0	12.5		<b>12.3</b>
Mean flue gas temperature	K	160	165		<b>162</b>
Mean CO <sub>2</sub> concentration	vol%	10.75	11.08		<b>10.91</b>
Mean CO concentration at 13% O <sub>2</sub>	vol%	0.12	0.31		<b>0.21</b>
Efficiency	%	87.5	86.1		<b>86.8</b>
Mean nominal heat to space	kW	4.8	4.6		<b>4.7</b>
Stack gas volume DT	Nm <sup>3</sup> /h	153	143		<b>148</b>
Diameter DT	m	0.15	0.15		<b>0.15</b>
Speed DT	m/s	2.41	2.25		<b>2.33</b>
Nozzle diameter	mm	10	10		<b>10</b>
Surface Nozzle	m <sup>2</sup>	7.85E-05	7.85E-05		<b>7.85E-05</b>
Speed nozzle	m/s	4.57	4.28		<b>4.43</b>
Iso-Kinetics	%	1.90	1.90		<b>1.90*</b>
Duration	h	0.50	0.50		<b>0.50</b>
Sampled volume	Nm <sup>3</sup>	0.713	0.670		<b>0.692</b>
Sampling flow rate	Nm <sup>3</sup> /h	1.29	1.21		<b>1.25</b>
Dust mass	mg	1.3	2.7		<b>2.0</b>
Dust concentration	mg/Nm <sup>3</sup>	2.0	4.5		<b>3.2</b>
Dilution ratio	-	16.8	16.9		<b>16.8</b>
Dust concentration	mg/Nm <sup>3</sup>	34	75		<b>54</b>
Dust concentration at 13% O <sub>2</sub>	mg/Nm <sup>3</sup>	24	52		<b>38</b>
Stack gas volume at 13% O <sub>2</sub>	Nm <sup>3</sup> /h	12.7	12.5		<b>12.6</b>
Dust emission	g/h	0.3	0.6		<b>0.5</b>
PD6434 permitted	g/h	6.6	6.5		<b>6.6</b>
% of time above Ringelmann 2	%	0	0		<b>-</b>

\* over iso-kinetic.

## 5 Evaluation of the results

### 5.1 Conclusion

The average dust emission at different heat outputs and settings of appliance Micro/4kW of Thornhill Eco Design Ltd. was determined by using the dilution tunnel method based on British Standard BS 3841-2:1994. By comparing the test results of the gravimetric dust measurements with the maximum acceptable dust emission described in PD 6434:1969 it can be concluded that, when the appliance is operated as described by the manufacturer the maximum permitted dust emission is not exceeded. No individual gravimetric smoke measurement was greater than the permitted mean result of the tests.

During all tests the optical density of the smoke was determined by the use of an optical device. Occasionally the smoke emission reached an objectionably high level. Because of the short periods this occurred, which is less than 10% of the whole burning period, this is acceptable.

Test	Mean heat output to space	Dust emission		Optical density		Approved
		Measured	PD6434 permitted*	Time above Ringelmann 2	Permitted	
-	kW	g/h	g/h	%	%	-
Nominal 1	4.8	0.6	6.6	0	10	yes
Nominal 2	5.1	0.8	6.7	4	10	yes
Nominal 3	5.0	0.4	6.7	3	10	yes
Nominal 4	4.2	0.5	7.8	1	10	yes
Nominal 5	4.5	0.2	7.3	3	10	yes
Nominal 6	4.4	0.5	7.9	0	10	yes
Inter 1	5.5	0.8	6.8	0	10	yes
Inter 2	5.2	0.5	6.7	0	10	yes
Inter 3	5.2	0.2	6.7	3	10	yes
High 1	5.4	0.3	6.8	0	10	yes
High 2	4.4	0.4	6.5	0	10	yes
High 3	4.6	0.2	6.5	0	10	yes
High 4	4.8	0.3	6.6	0	10	yes
High 5	4.6	0.6	6.5	0	10	yes

\* Calculation of permitted smoke emission: 5.0 g/h + 0.1 g/h per 0.3 kW

### 5.2 Recommendations

As the customary practice in the UK requires that an exempted fireplace has to be constructed or adapted in such manner that it is impractical to operate it in a way whereby significant smoke will be emitted, we recommend to change the radius of the hole of the air inlet to 19 mm (instead of 17mm). This will provide sufficient combustion air when the controller is in its minimum position.

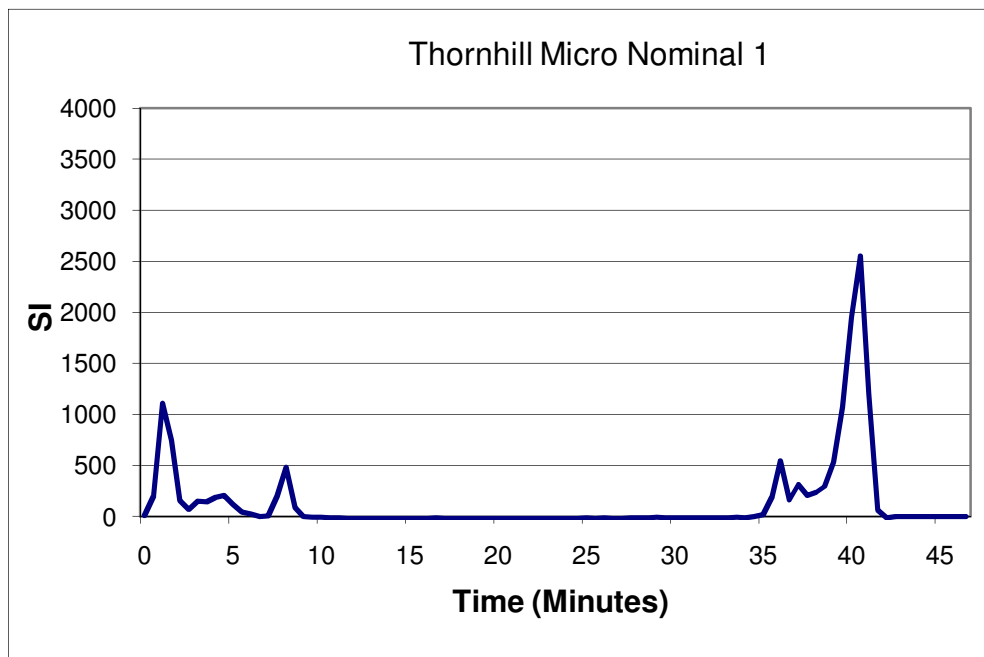


## **Annex A**

### **Graphs**

## Graph A-01

Condition	Nominal heat output
Test number	1 of 6
Setting of: - controller	"2"



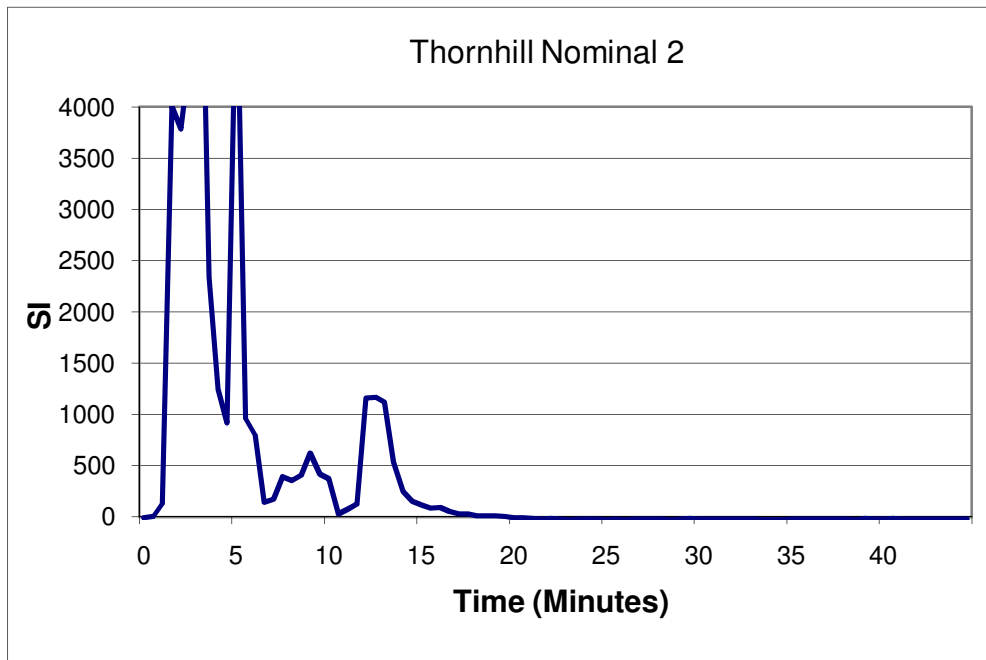
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 =0% (maximum permitted; 10%)

## Graph A-02

Condition	Nominal heat output
Test number	2 of 6
Setting of: - controller	"2"



The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

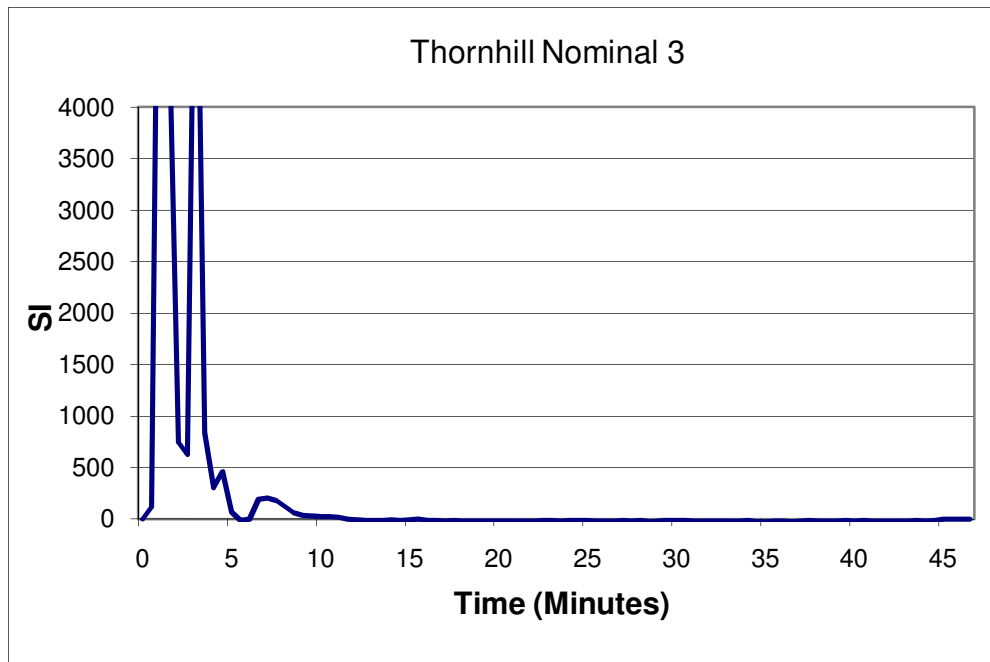
SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 4% (maximum permitted; 10%)



### Graph A-03

Condition	Nominal heat output
Test number	3 of 6
Setting of: - controller	"2"



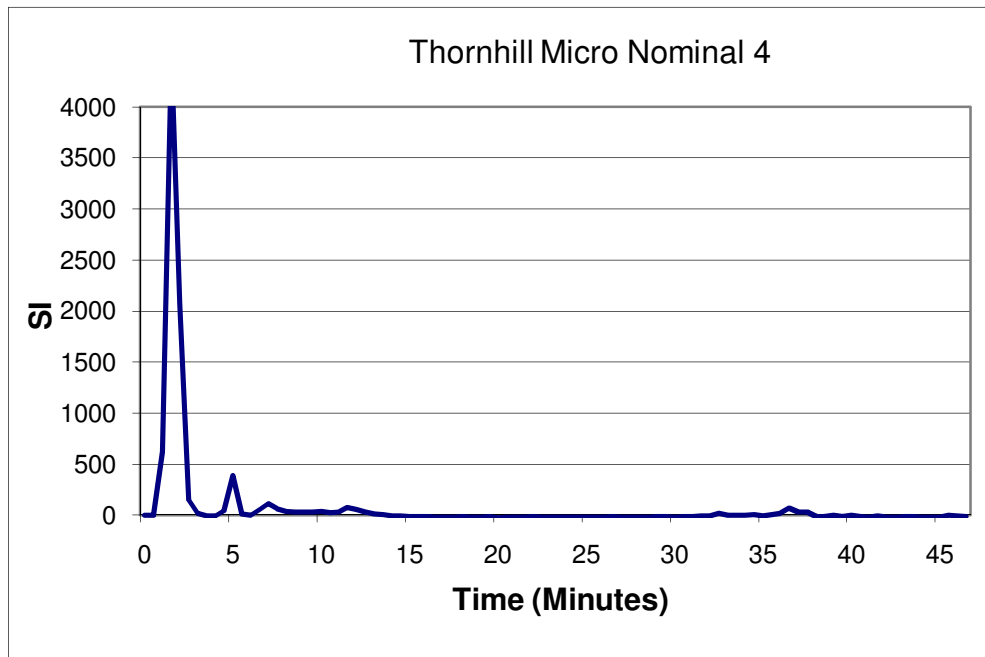
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 0% (maximum permitted; 10%)

### Graph A-04

Condition	Nominal heat output
Test number	4 of 6
Setting of: - controller	"2"



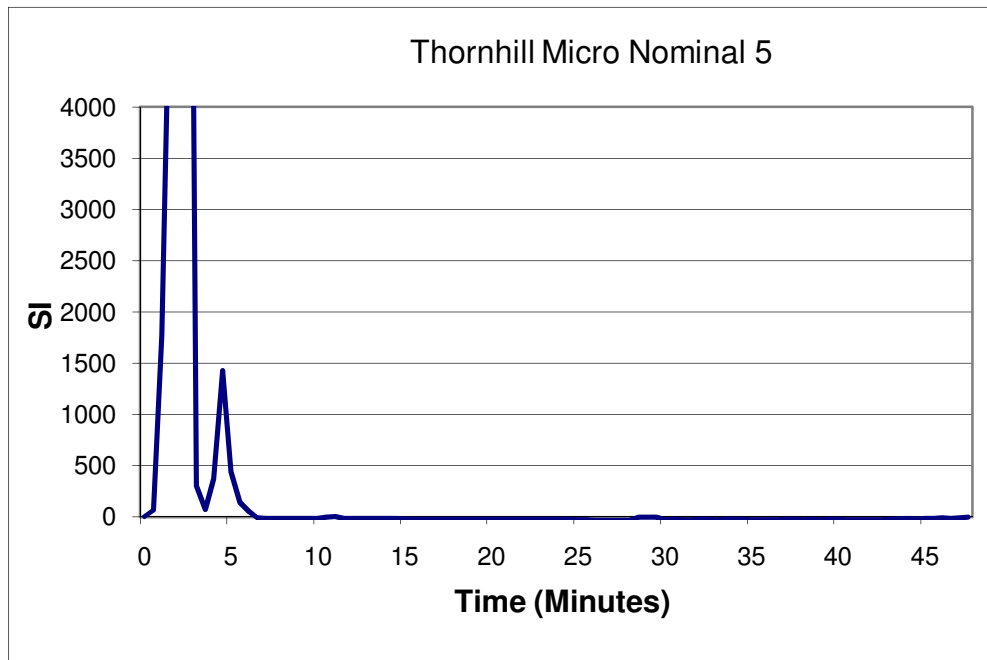
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 1% (maximum permitted; 10%)

## Graph A-05

Condition	Nominal heat output
Test number	5 of 6
Setting of: - controller	"2"



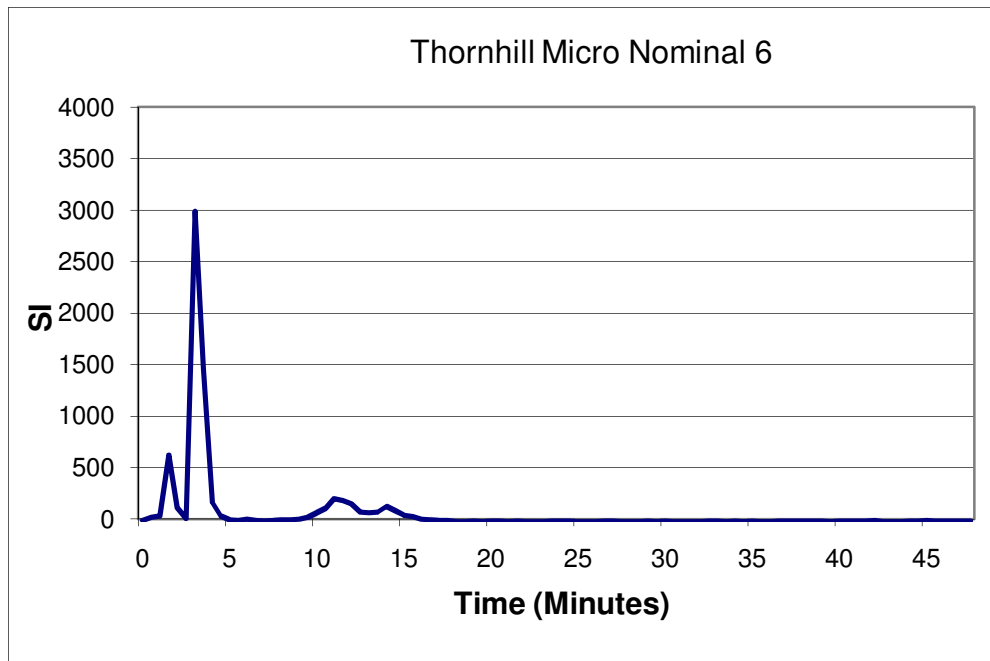
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 3% (maximum permitted; 10%)

### Graph A-06

Condition	Nominal heat output
Test number	6 of 6
Setting of: - controller	"2"



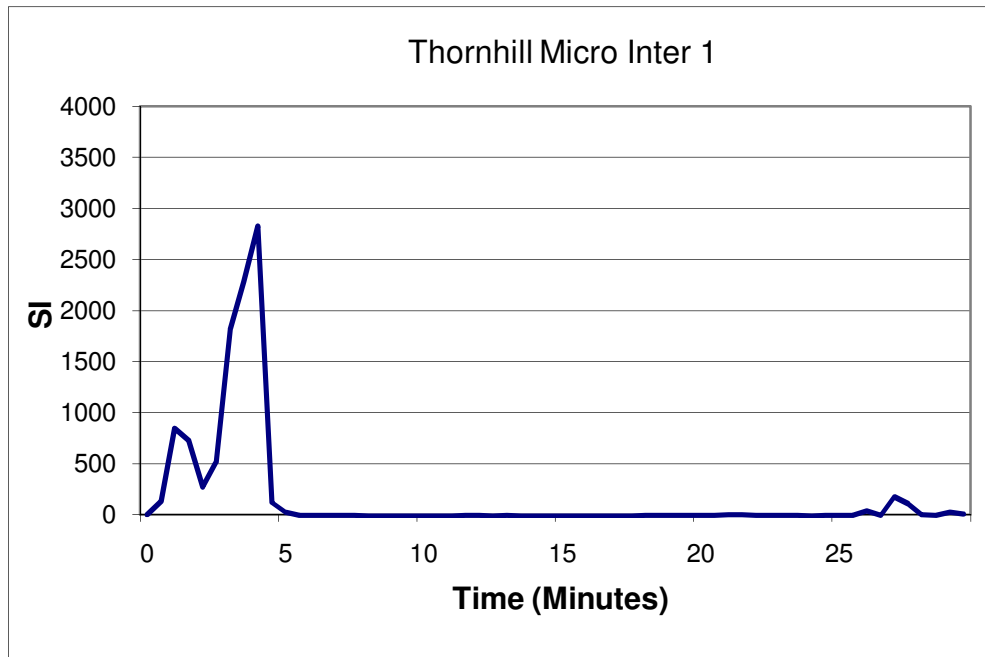
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 0% (maximum permitted; 10%)

### Graph A-07

Condition	Intermediate heat output
Test number	1 of 3
Setting of: - controller	"3.5"



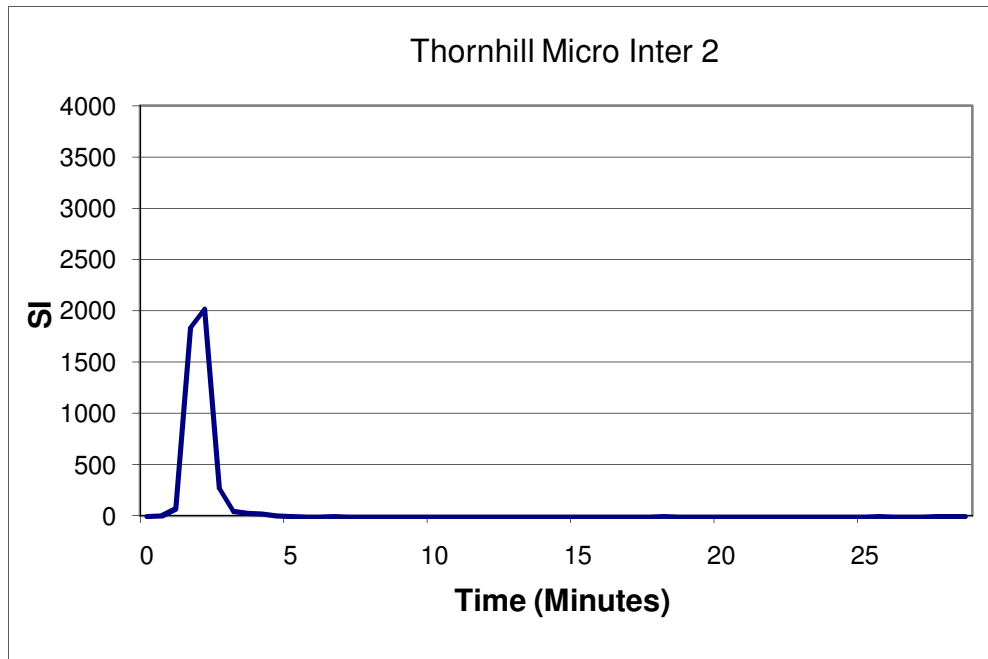
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 0% (maximum permitted; 10%)

### Graph A-08

Condition	Intermediate heat output
Test number	2 of 3
Setting of: - controller	"3.5"



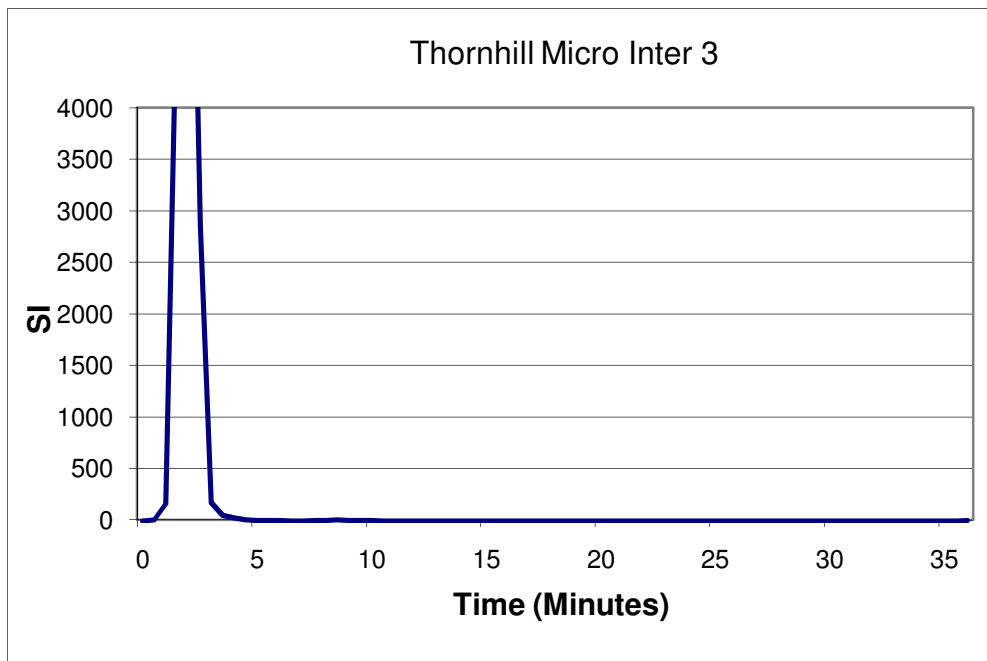
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 0% (maximum permitted; 10%)

### Graph A-09

Condition	Intermediate heat output
Test number	3 of 3
Setting of: - controller	"3.5"



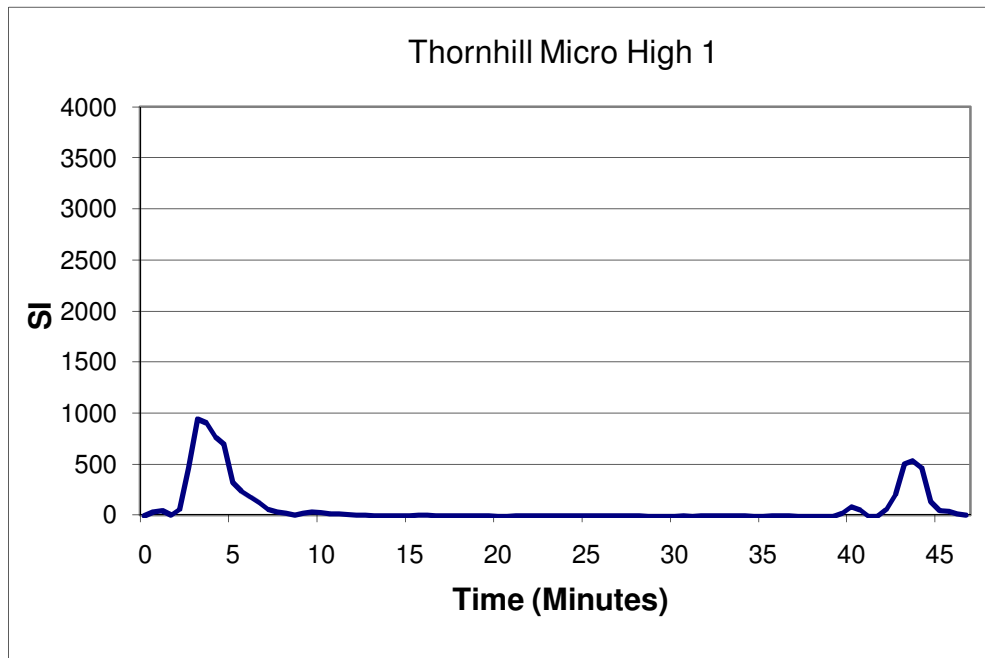
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 3% (maximum permitted; 10%)

### Graph A-10

Condition	High heat output
Test number	1 of 5
Setting of: - controller	"5"



The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

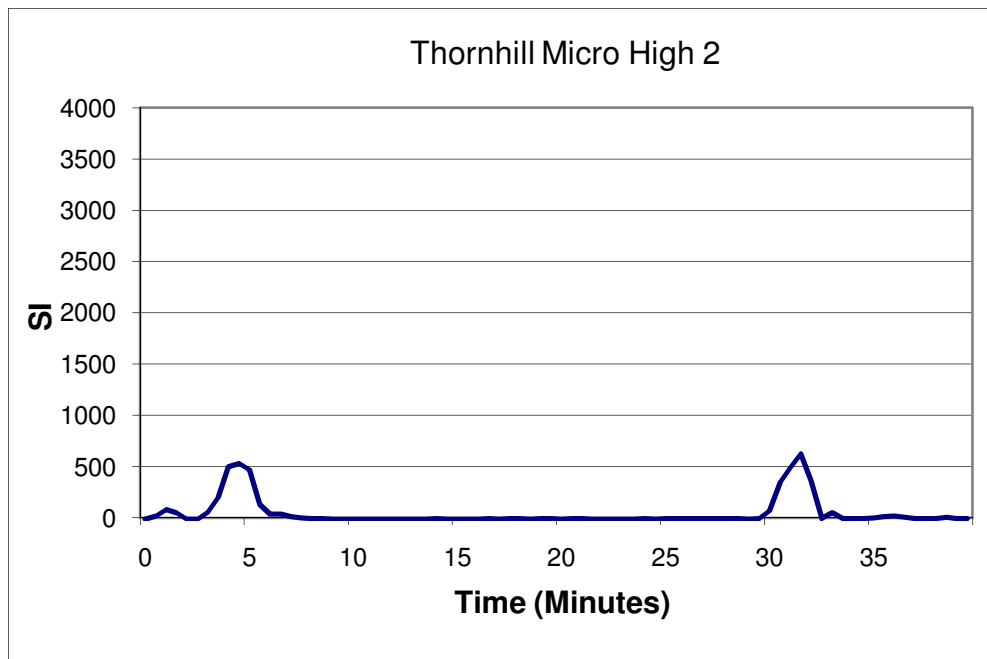
SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 0% (maximum permitted; 10%)



### Graph A-11

Condition	High heat output
Test number	2 of 5
Setting of: - controller	"5"



The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

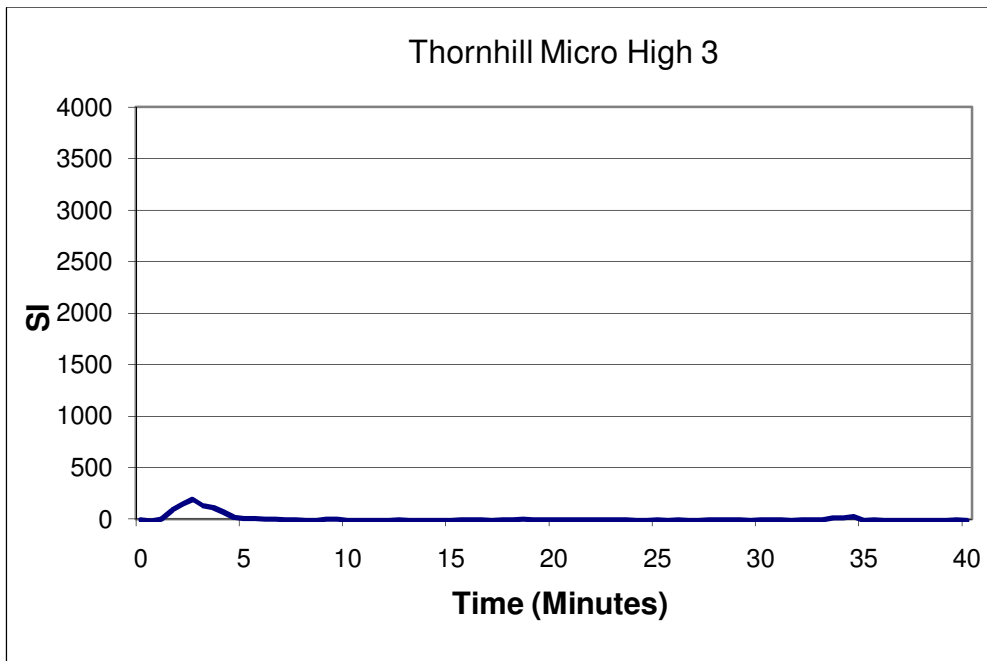
SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 0% (maximum permitted; 10%)



## Graph A-12

Condition	High heat output
Test number	3 of 5
Setting of: - controller	"5"



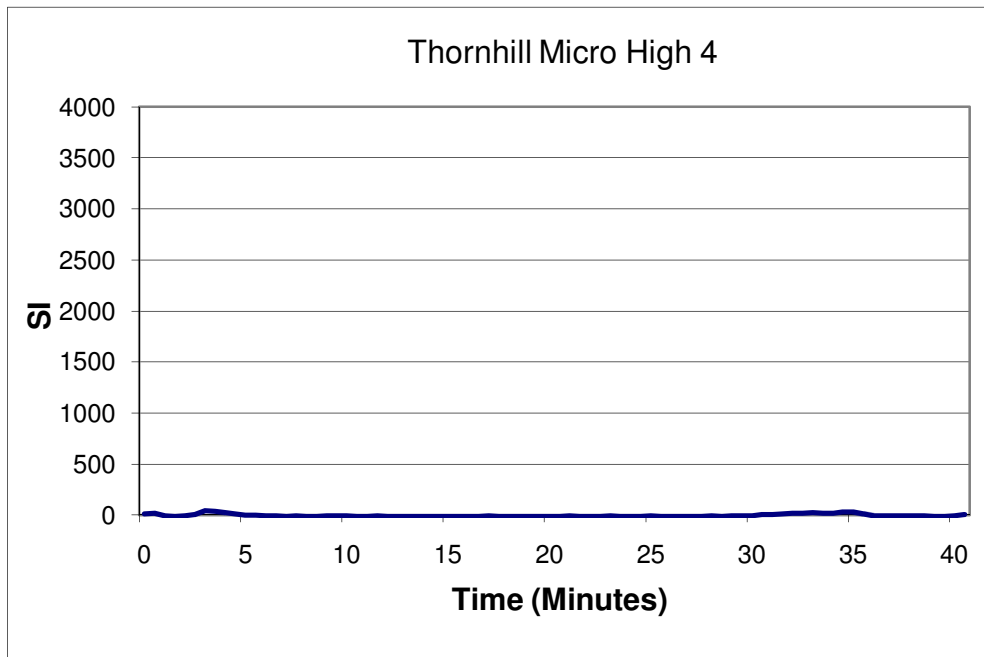
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 0% (maximum permitted; 10%)

### Graph A-13

Condition	High heat output
Test number	4 of 5
Setting of: - controller	"5"



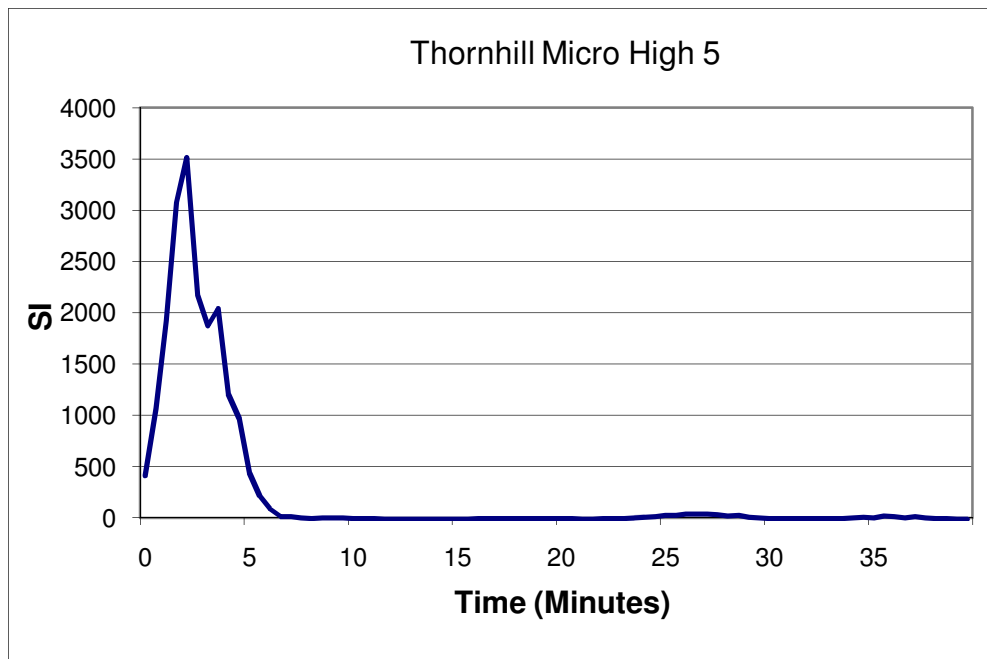
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 0% (maximum permitted; 10%)

### Graph A-14

Condition	High heat output
Test number	5 of 5
Setting of: - controller	"5"



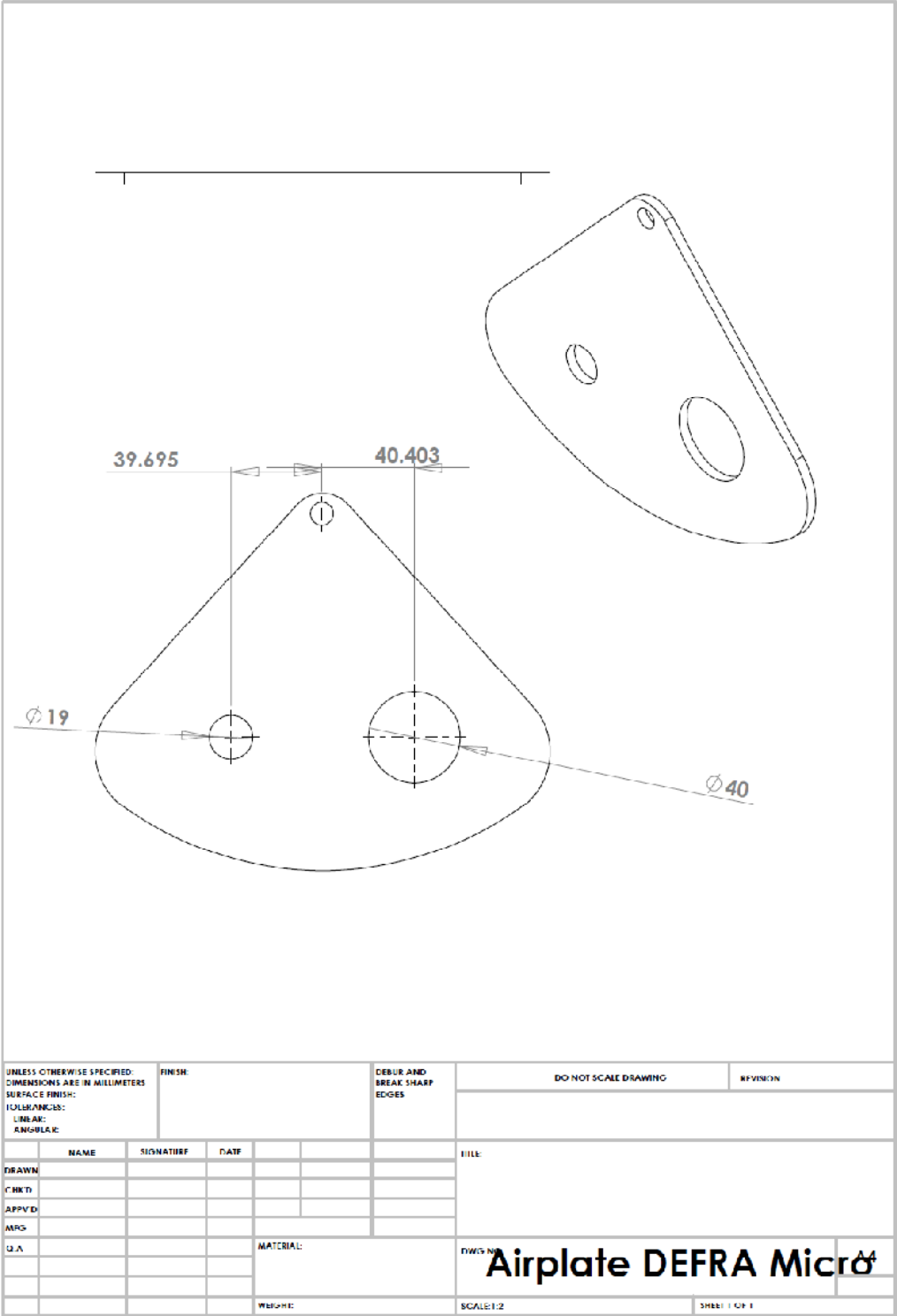
The output of optical instrument type Dust Hunter of Sick Maihak (SI, no dimension) is related to the optical density as described in the table below.

SI	Observation	Ringelmann (-)
<400	Not clearly visible	0
1.000	20% obscuration	1
4.000	40% obscuration	2

% of time above Ringelmann 2 = 0% (maximum permitted; 10%)

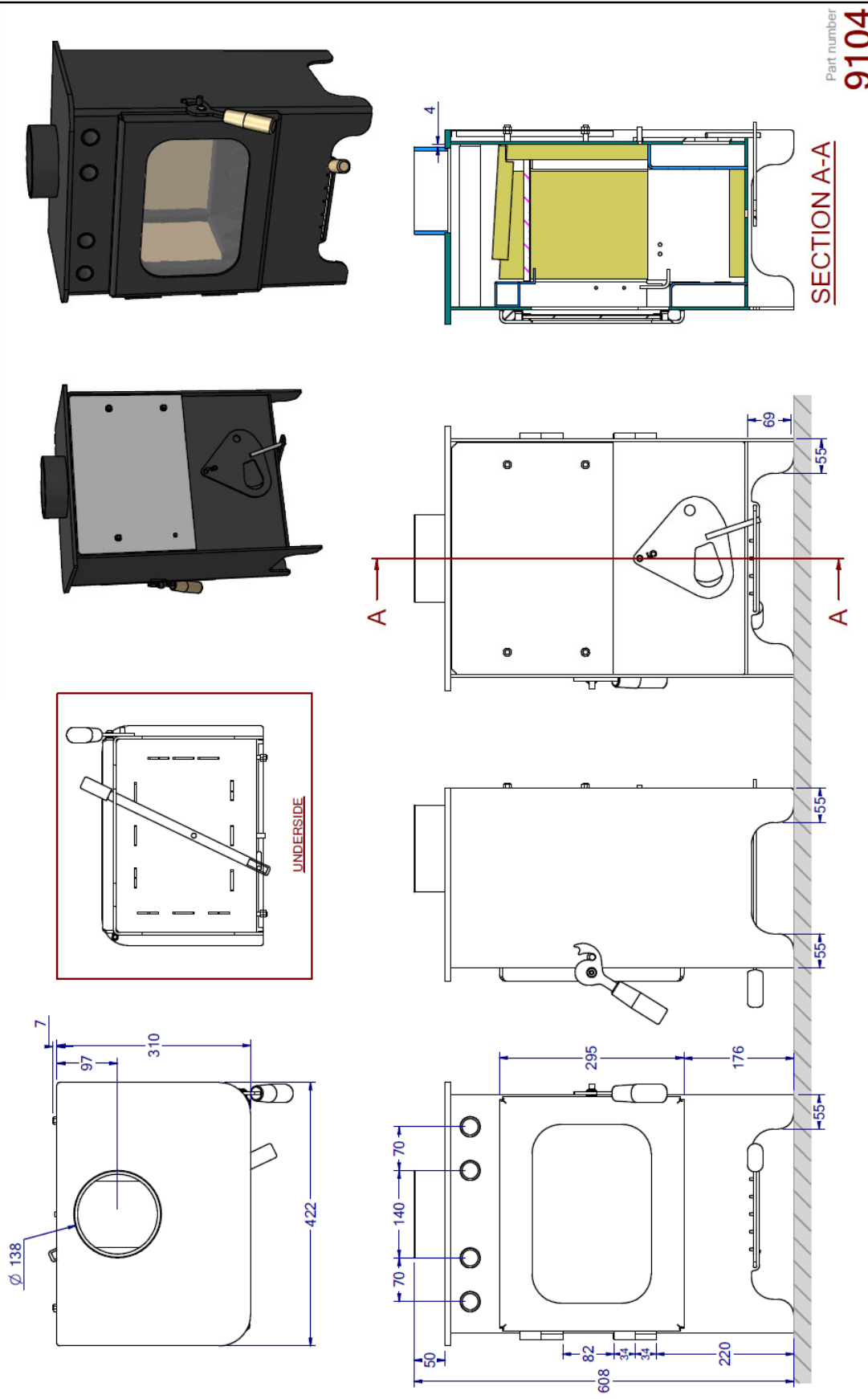
**Annex B**

**Drawings of the appliance**



All dimensions in mm. DO NOT SCALE.

File: 9104-001-A Main assembly.dft



Part number  
**9104**

**SECTION A-A**

Created by: JJA 04/07/2011  
Drawing reference - Issue  
**9104-001-A**

Drawing title / Project  
**9104 main assembly**  
Burley - 9104 Micro wood burning stove



General tolerances  
**+/- 0.5mm**  
**+/- 1°**  
Unless otherwise stated

Issue	Brief description of revision	Date	CAR
-	-	-	-
A	-	-	-

This drawing is confidential - the contents may not be reproduced or used without the prior written permission of Burley Appliances // www.burley.co.uk // Contact: (+44) 0 1572 756956 // info@burley.co.uk

## Annex C

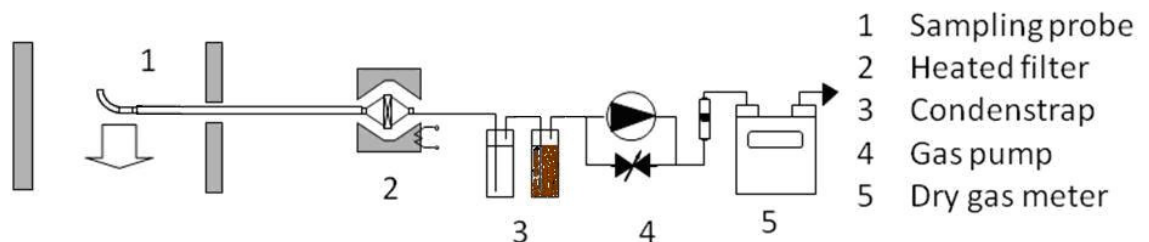
### Brief description of dust measurement method

#### Before sampling:

Sampling is being done on a quartz fiber plane filter with a pore size of  $0.2\ \mu\text{m}$  and a diameter of 47 mm. The quartz filter is dried at  $180\ ^\circ\text{C}$  for approx. 1 h, weighed on a micro scale with an accuracy of  $\pm 0.05\ \text{mg}$  and stored in an identical numbered container. Just before sampling starts the filter is placed in the stainless steel filter holder using a pair of tweezers.

The flue gas static and dynamic pressure is measured by a pitot tube and a micro manometer. The retrieved data is used to calculate the iso kinetic sampling velocity.

The sampling point is situated at the centre point of the flue gas channel. The filter holder is heated to  $70\ ^\circ\text{C}$ . This temperature is maintained during the sampling. The probe is positioned in the flue gas channel in such a way that the nozzle is at the centre point of the flue gas channel. The nozzle is pointed in the opposite direction of the flue gas stream. See figure.



The setup is tested for any leakage by blocking the nozzle and measuring the sample flow at  $-0.8\ \text{bar}$  suction pressure. The setup is considered leak tight when the flow rate is less than  $0.03\ \text{l/min}$ .

#### Sampling:

The volume reading on the gas meter and the start time is noted. The sampling is started directly after loading of the woodstove. The gas pump suction speed is set according to the calculated isokinetic flue gas velocity by means of a flow regulator. During the sampling the gas meter temperature is noted.

Sampling ends when the basic fire bed has been reached. Volume reading on the gas meter is noted.

#### After sampling:

The filter is removed from its holder and temporarily kept in a glass container. In an analytical laboratory the filter is dried again at  $160\ ^\circ\text{C}$  for approx. 1 h and weighed on a micro scale. The sampled dry volume is calculated by taking the start and end volume readings and corrected to standard conditions ( $273.15\ \text{K}$ ,  $1013\ \text{hPa}$ ). The sampled volume is also corrected with a calibration factor, which is determined every year with a calibrated precision gas flow meter.

The amount of sampled dust is calculated by extracting the start weight of the filter from the end weight of the filter.

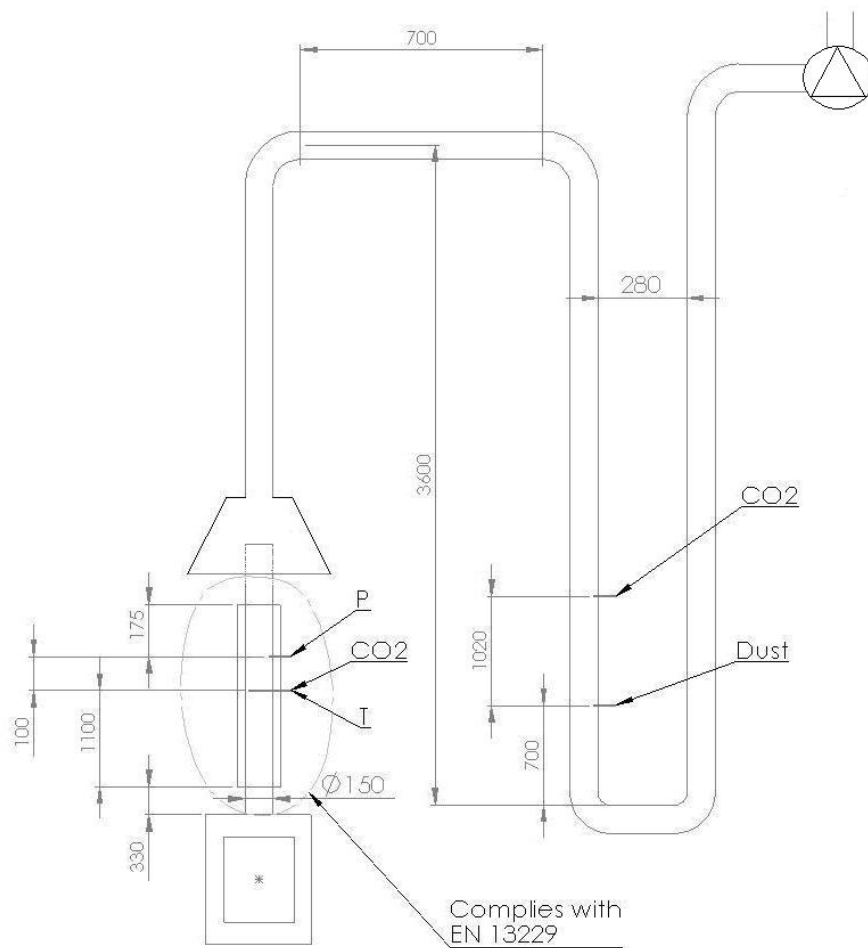
#### Determination of the dilution factor:

The dilution factor is measured using 2 infrared continuous  $\text{CO}_2$  analyzers with range  $0 - 25\ \text{vol}\%$  and  $0 - 5\ \%$  respectively. Prior to, and after, the measurements both analyzers are calibrated and adjusted using certified gas mixtures. The flue gas from the diluted and non-diluted flue gas stream is simultaneously sampled, dried by a cool trap and led through the analyzer.

The  $\text{CO}_2$  concentration is continuously monitored and the data is automatically stored on a computer every 20 seconds. Afterwards the dilution factor is calculated by dividing the average concentrations upon each other.

## Annex D

### Drawing of the test rig including dilution tunnel





## Annex E

### Measurements uncertainties

Sampling/analysis methods used, measuring standards and uncertainties. All measurements mentioned in this table are covered by EN-ISO 17025 certification. Measurements marked with an asterisk are also accredited by RvA Testing under no. L-092.

No.	Component	SGS Procedure/Standard	Uncertainties <sup>1)</sup>
	Determination of the particulate concentration (gravimetric)	ENVI/L/05, dilution tunnel	< ± 14% of measured value higher than 5 mg/m <sup>3</sup> , when fluctuations in gas flow > 10% may occur < ± 30%.
*	Determination of the CO <sub>2</sub> concentration (nondispersive infrared)	EMM-006, 007, 030 conform NEN-ISO 12039	< ± 8%.
*	Determination of the CO concentration (nondispersive infrared)	EMM-006, 008, 009, 013, 030 conform NEN-EN 15058	< ± 8%.
*	Determination of the gas temperature (thermocouple)	ENVI/L/03 conform ISO 8756, VDI/VDE 3511, VDI/VDE 3512 Blatt 2	< ± 0.75% of the measured value or ± 1.5 °C (largest value)

*1) The stated uncertainties refer to the 95% confidence interval (2 sigma). The stated percentages are related to the actual measurement results, unless indicated otherwise.*