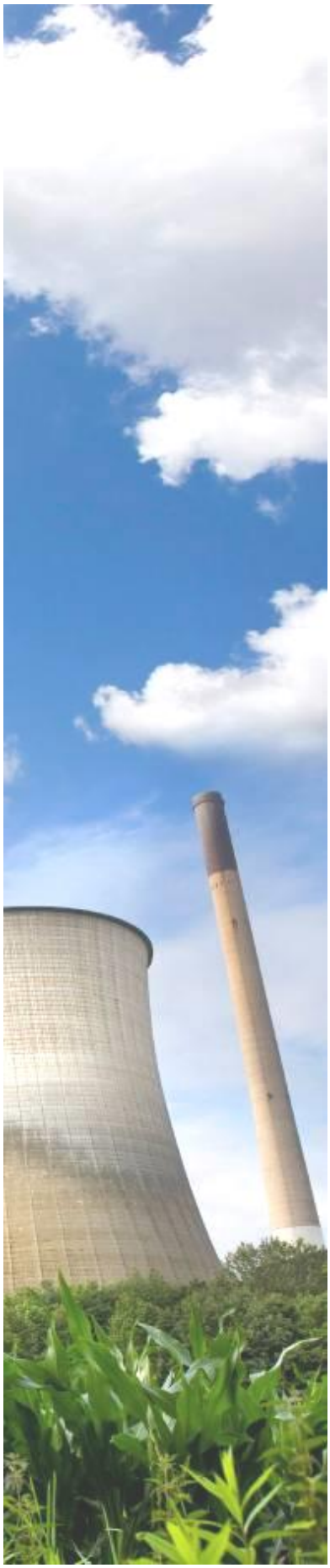
Resource & Environmental Consultants Ltd



MONITORING OF EMISSIONS FROM THE RANHEAT BOILER & WET SPRAYBOOTH PROCESSES

Prepared for Alan Nuttall Ltd

Installation: Dudley

Date of Monitoring Visit: 8-9 April, 2015

REC Report EM-02818p1r0

REC Environmental Monitoring

a CONCEPT LIFE SCIENCES company

Prepared for:

Alan Nuttall Ltd
National Works
Hall Street
Dudley
DY2 7DQ

Prepared by:

REC Ltd
Unit 19 Bordesley Trading Estate
Bordesley Green Road
Birmingham
B8 1BZ
Tel : 0121 326 7007
Fax : 0121 328 1689
E-mail : sales@recltd.co.uk
Web :www.recltd.co.uk

Issued : 12 May, 2015

Prepared by : _____
Michelle Edwards, Team Leader
MM05 659, MCERTS Level 2, TE1-4

Reviewed by : _____
Derek Myers, Operations Manager
MM02 115, MCERTS Level 2 TE1-4

CONTENTS **Page No.**

PART 1: EXECUTIVE SUMMARY

Objectives of Monitoring

Resource & Environmental Consultants (REC) Ltd was commissioned by Alan Nuttall Ltd to monitor emissions of pollutants from released from various process stacks at their site in Dudley.

The operations at Alan Nuttall Ltd are authorised under a Part B permit issued by the Local Authority under the Environmental Permitting Regulations, 2010. The site must demonstrate compliance with the emission limits stipulated in the site permit ref. PB/33.

Monitoring has been undertaken for the following parameters:-

Emission Parameter	Emission Point Identification	
	Wet Spray Booth	Ranheat Boiler
Total Particulate Matter	✓	✓
Hydrogen Chloride (as HCl)	-	✓
Formaldehyde	-	✓
Oxygen (O_2)	-	✓
Carbon Monoxide (CO)	-	✓
Total VOCs (as C)	-	✓
Hydrogen Cyanide	-	✓

Monitoring was undertaken during normal process operations.

Monitoring Results

Emission Point Reference	Parameter	Emission Limit	Monitoring Result	Uncertainty	Units	Reference conditions	Date of Sampling	Start & End Times	Reference Method	Accreditation Status[(1)]	Operating Status
Wet Spray Booth	Particulates	50	9.8	±1.4	mg/m^3	STP, Wet	08/04/15	11:14-11:54	BS EN 13284	B	Normal
Ranheat Boiler	Particulates	200	89.9	±3.8	mg/m^3	STP, Wet	09/04/15	12:35 – 13:05	BS EN 13284	B	Normal
	HCl	100	25.4	±3.1	mg/m^3	STP, Wet	09/04/15	12:35 – 13:05	BS EN 1911	B	Normal
	Formaldehyde	5	<0.07	±<0.01	mg/m^3	STP, Wet	09/04/15	13:46 – 14:16	US EPA M316A	B	Normal
	HCN	5	<0.1	N/A	mg/m^3	STP, Wet	09/04/15	13:31-14:11	US EPA CTM33	E	Normal
	CO	250	54.4	±2.2	mg/m^3	STP, Wet	09/04/15	12:35 – 13:35	BS EN 15058	A	Normal
	O_2	None Set	13.5	±0.4	%vol.	STP	09/04/15	12:35 – 13:35	BS EN 14789	A	Normal
	Total VOCs (as C)	20	12.3	±1.7	mg/m^3	STP, Wet	09/04/15	12:35 – 13:35	BS EN 12619	A	Normal

NOTE (1) : UKAS/MCERTS status:- (A) REC Ltd accredited for sampling and analysis. (B) REC Ltd accredited for sampling only, UKAS accredited analysis conducted by SAL or RPS. (E) REC Ltd not accredited for sampling, sub-contracted analysis conducted by SAL not UKAS accredited.

Operating Information

Emission Point Reference	Date	Process Type	Process Duration	Fuel Type	Feedstock	Load	Abatement Plant	Comparison of Operator CEMS and Periodic Monitoring Results			
								Substance	CEMS Results	Monitoring Results	Units
Wet Spray Booth	08/04/15	Spray Booth	Batch	Electricity	Furniture Fittings	Normal	None	N/A	N/A	N/A	N/A
Ranheat Boiler	09/04/15	Wood Burning Boiler	Continuous	Natural Gas	Laminated Scrap Wood	Normal	None	N/A	N/A	N/A	N/A

Monitoring Deviations

Emission Point Reference	Substance Deviations	Monitoring Deviations	Other Relevant Issues
Wet Spray Booth	None	None	The flow and temp variations were within requirements of EA TGN M1 Single four inch BSP socket was installed on the stack. EA TGN M1 requires 2 x 5 inch BSP sockets to be fitted at least 5 x hydraulic diameters from any flow disturbance both upstream and downstream of the sampling plane.
Ranheat Boiler	None	<95% of HCl detected in Impingers 1 & 2, probably due to very low concentration of target pollutant.	The flow and temp variations were within requirements of EA TGN M1. Only four inch BSP sockets were installed on the stack. EA TGN M1 requires 5 inch BSP sockets to be fitted at least 5 x hydraulic diameters from any flow disturbance both upstream and downstream of the sampling plane.

PART 2 SUPPORTING INFORMATION

APPENDIX 1

Sampling Personnel

Monitoring was conducted by the following REC Ltd permanent staff:-

- David Burns - Team Leader, MM05 579., MCERTS Level 2, TE1-4
- Michelle Edwards - Assistant, MM05 659, MCERTS Level 2, TE1-4

Method Details

The following table shows the reference methods used for the emissions monitoring survey:

Species	UKAS/ MCERTS Status	Method	Uncertainty ±%	Limit of Detection
Moisture	A	In house method MM0010 based on BS EN 14790	20	0.1%vol
Particulates	B	In house method MM0004 based on BS EN 13284	10	1 mg/m^3
Hydrogen Chloride	B	In house method MM0006 based on BS EN 1911	20	0.1 mg/m^3
Formaldehyde	B	In house method MM0015 based on US EPA M316A	20	0.1 mg/m^3
Hydrogen Cyanide	E	Based on US EPA CTM33	30	0.1 mg/m^3
Carbon Monoxide	A	In house method MM0002 based on BS EN 15058	10	1 mg/m^3
Oxygen	A	In house method MM0002 based on BS EN 14789	10	0.1%vol
Total VOCs (as C)	A	In house method MM0002 based on BS EN 12619	10	1 mg/m^3
Flows	A	In house method TPM01A based on EA MID BS EN 16911	10	5Pa

NOTE (1) : UKAS/MCERTS status:- (A) REC Ltd accredited for sampling and analysis. (B) REC Ltd accredited for sampling only, UKAS accredited analysis conducted by SAL or RPS. (E) REC Ltd not accredited for sampling, sub-contracted analysis conducted by SAL not UKAS accredited.

Monitoring Equipment

All monitoring equipment used at Alan Nuttall Ltd was calibrated before use either externally or in accordance with in house calibration procedures. The equipment used for the testing for each stack identified by its unique AQ No. is shown below.

Equipment	Identification	
Nozzle(s)	AQ	153
Probes(s)	No.	14
Pitot(s)	AQ	104
Timer	AQ	308
Glassware Set	Birmingham Set 1 & Mini Impingers	
Thermocouple(s)	AQ	148, 301
Temperature Indicator	AQ	126,163
Control Console	AQ	126
Manometer	AQ	126
Tape Measure	AQ	278
Balance	AQ	090
FID	AQ	270
Horiba	AQ	268
Cylinders		VC8179253 - Nitrogen VC10044 - Zero Air VCSMG5960 – O_2 & CO VCDY0207 –C_3H_8
DGM	AQ	199
Heated Line	AQ	315
Heated Line Controller	AQ	316b
Barometer	AQ	344

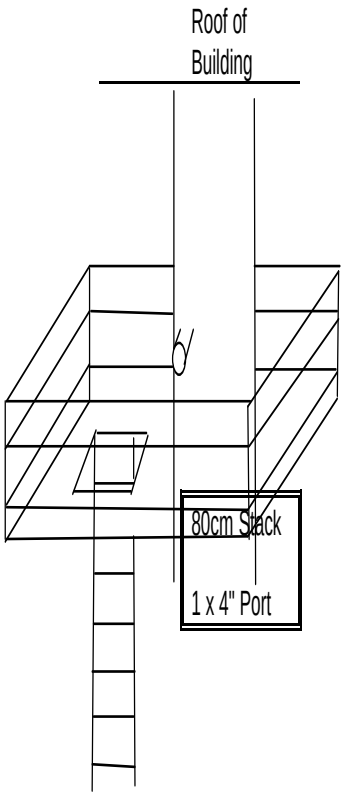
========== END OF REPORT ==========

APPENDIX 2

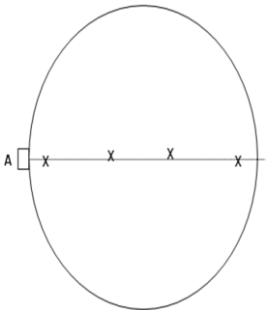
RANHEAT BOILER & WET SPRAY BOOTH

STACK DIAGRAMS & DESCRIPTION

Stack Ref	Wet Spray Booth



Sample Points



Stack Dimensions:

85cm Diameter

Sample Point Description

A single 4” BSP sampling port was installed on a horizontal plane. The sampling points provided were less than 4 x hydraulic diameters from any flow disturbance both upstream and downstream from the sampling plane.

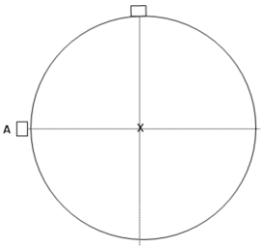
Due to the absence of a second sampling port, sampling could only be carried out across one sampling plane. The number of sampling points along this plane, were however doubled.

Access was via small temporary scaffolding.

Both the port size and sample planes do not fully meet the requirements stated in Environment Agency Technical Guidance Note M1.

Stack Ref	RANHEAT BOILER

Sample Points



Stack Dimensions:

22cm Diameter

Sample Point Description

On the Wood Burning Boiler stack 2 x 4” BSP sampling ports were installed at 90° to each other on a horizontal plane. The sampling points provided were less than 4 x hydraulic diameters from any flow disturbances both upstream and downstream from the sampling plane.

Due to access restrictions, only a single sampling plane could be utilised, However this was deemed suitable for the size of the ducting.

Access was via a temporary platform.

Both the port size and sample plane do not fully comply with the positional requirements of Environment Agency Technical Guidance Note M1 (EA TGN M1).

APPENDIX 3

RANHEAT BOILER & WET SPRAY BOOTH

FLOW DATA

APPENDIX 3.1

FLOW DATA

Stack Ref.	Stack Temp	Av Pitot ΔP	Duct Diam	X-Sect. Area	Velocity (actual)	Volume Flow (m^3/hr)	
	(^{0}C)	(Pa)	(cm)	(m^2)	(m/s)	(actual)	(@ ntp)
Wet Spray Booth	14	20	80	0.503	4.4	7,894	7,465
Ranheat Boiler	130	69	22	0.038	10.5	1,441	974

PRELIMINARY TRAVERSE DATA RECORDING SHEET (CIRCULAR DUCTS)

Site Reference	~~ATA~~ HB 6M-1P02818
Site Name	ALAN NUTTALS
Stack Reference	WOOD BURNER BOILER
Date	09/04/15
Time	08:58
Staff	AW/HB

Stack Diameter	0.22	m
Static pressure	-27	~~mmH2O~~ Pa
Barometric pressure	101.3	mbar
Pitot Cp	0.840 4	
Oxygen	—	%
Moisture	7.3	%

Stagnation Pressure Check (S Type Pitot) (Difference between Leg A and B must be < 10Pa or < 1mmH$_2$O)

Leg A	27	Pa			
Leg B	25	Pa	ΔP units	Pa	or ~~mmH2O~~

Velocity Traverse

Traverse Point	Traverse % Line A	Depth cm	ΔP,1	ΔP,2	ΔP,3	ΔP,ave	T,1 °C	T,2 °C	T,3 °C	T,ave °C	Angle °
1	2.1	0.5	/	/	/		130	/	/	/	/
2	6.7	1.5					130				
3	11.8	2.6					130				
4	17.7	3.9					130				
5	25	5.5	64	65	67	65.3	130	130	130	130	<15°
6	35.6	7.8	66	68	68	67.3	130	130	130	130	<15°
7	64.4	14.2	70	72	71	71.0	130	130	130	130	<15°
8	75	16.5	72	74	75	73.7	130	131	131	131	<15°
9	82.3	18.1	/	/	/		/	/	/	/	/
10	88.2	19.6									
11	93.3	20.5									
12	97.9	21.5									
Point	Line B	Depth	ΔP,1	ΔP,2	ΔP,3	ΔP,ave	T,1	T,2	T,3	T,ave	Angle
1	2.1										
2	6.7										
3	11.8							line			
4	17.7										
5	25										
6	35.6										
7	64.4										
8	75										
9	82.3										
10	88.2										
11	93.3										
12	97.9										

An electronic manometer was used to provide a direct reading of average differential pressure over at least 1 minute

Sampling plane requirements Re: BS EN 13284-1:2001 5.2

Angel of gas flow less than 15° with regard to duct axis	/
No local negative flow	/
Minimum pitot greater than 5Pa	/
Minimum local gas velocity	10.3
Maximum local gas velocity	10.9
Ratio of highest to lowest local gas velocity	1.06

Pitot	104
Manometer	126 PT03
Temperature ind.	148 ~~TM0~~ 126
Thermocouple	148
Barometer	344
Timer	308

BS EN 13284-1:2002 Sampling Points

Range of Sampling plain areas (m^2)	Range of Duct Diameters (m)	Minimum Number of Sampling lines (diameters)	Minimum Number of Sampling Points per plane
<0.1	0.35		1a
0.1 to 1.0	0.35 to 1.1	2	4
1.1 to 2.0	1.1 to 1.6	2	8
>2.0	>1.6	2	At least 12 and 4 per m^{2b}

[a] Using only one sampling point may give rise to errors greater than those specified in the method and the standard

[b] For Large ducts, a number of 20 sampling points is generally sufficient.

Tangential Rule Sampling Points

Sample Point Number	% Along Traverse			
	n=2	n=4	n=6	n=8
1	14.6	6.7	4.4	3.3
2	85.4	25	14.6	10.5
3		75	29.6	19.4
4		93.3	70.4	32.3
5			85.4	67.7
6			95.6	80.6
7				89.5
8				96.7

Sample Point Number	% Along Traverse			
	n=10	n=12	n=14	n=16
1	2.6	2.1	1.8	1.6
2	8.2	6.7	5.7	4.9
3	14.6	11.8	9.9	8.5
4	22.6	17.7	14.6	12.5
5	34.2	25	20.1	16.9
6	65.8	35.6	26.9	22
7	77.4	64.4	36.6	28.3
8	85.4	75	63.4	37.5
9	91.8	82.3	73.1	62.5
10	97.4	88.2	79.9	71.7
11		93.3	85.4	78
12		97.9	90.1	83.1
13			94.3	87.5
14			98.2	91.5
15				95.1
16				98.4

Sample Point Number	% Along Traverse			
	n=18	n=20	n=22	n=24
1	1.4	1.3	1.1	1.1
2	4.4	3.9	3.5	3.2
3	7.5	6.7	6	5.5
4	10.9	9.7	8.7	7.9
5	14.6	12.9	11.6	10.5
6	18.8	16.5	14.6	13.2
7	23.6	20.4	18	16.1
8	29.6	25	21.8	19.4
9	38.2	30.6	26.2	23
10	61.8	38.8	31.5	27.2
11	70.4	61.2	39.3	32.3
12	76.4	69.4	60.7	39.8
13	81.2	75	68.5	60.2
14	85.4	79.6	73.8	67.7
15	89.1	83.5	78.2	72.8
16	92.5	87.1	82	77
17	95.6	90.3	85.4	80.6
18	98.6	93.3	88.4	83.9
19		96.1	91.3	86.8
20		98.7	94	89.5
21			96.5	92.1
22			98.9	94.5
23				96.8
24				98.9

PRELIMINARY TRAVERSE DATA RECORDING SHEET (CIRCULAR DUCTS)

Site Reference	GM-IP02818
Site Name	ALAN NUTTALL
Stack Reference	SPRAY BOOTH
Date	08/04/15
Time	10:42
Staff	AW/HB

Stack Diameter	0.80	m
Static pressure	0	mmH_2O
Barometric pressure	100.7	mbar
Pitot Cp	0.8404	
Oxygen	–	%
Moisture	–	%

Stagnation Pressure Check (S Type Pitot) (Difference between Leg A and B must be < 10Pa or < 1mmH_2O)

Leg A	7	Pa
Leg B	5	Pa

ΔP units: Pa or ~~mmH_2O~~

Velocity Traverse

Traverse Point	Traverse % Line A	Depth cm	ΔP,1	ΔP,2	ΔP,3	ΔP,ave	T,1 °C	T,2 °C	T,3 °C	T,ave °C	Angle °
1	2.1	5.0	55	55	57	55.7	14	14	14	14	0
2	6.7	8.4	35	37	36	36.0	14	14	14	14	0
3	11.8	15.0	33	31	32	32	14	14	14	14	0
4	17.7	21.8	27	29	30	28.7	14	14	14	14	0
5	25	28.5	20	22	22	21.3	14	14	14	14	0
6	35.6	35.2	12	13	13	12.7	14	14	14	14	0
7	64.4	41.9	11	14	13	12.7	14	14	14	14	0
8	75	48.6	8	9	10	9.0	14	14	14	14	0
9	82.3	55.3	5	6	8	6.3	14	14	14	14	0
10	88.2	61.96	6	7	7	6.7	14	14	14	14	0
11	93.3	68.6	5	7	6	6.0	14	14	14	14	0
12	97.9	75.0	7	8	8	7.7	14	14	14	14	0
Point	Line B	Depth	ΔP,1	ΔP,2	ΔP,3	ΔP,ave	T,1	T,2	T,3	T,ave	Angle
1	2.1						Line.				
2	6.7										
3	11.8										
4	17.7										
5	25										
6	35.6										
7	64.4										
8	75										
9	82.3										
10	88.2										
11	93.3										
12	97.9										

An electronic manometer was used to provide a direct reading of average differential pressure over at least 1 minute

Sampling plane requirements Re: BS EN 13284-1:2001 5.2

Angel of gas flow less than 15° with regard to duct axis	✓
No local negative flow	✓
Minimum pitot greater than 5Pa	✓
Minimum local gas velocity	2.6
Maximum local gas velocity	7.9
Ratio of highest to lowest local gas velocity	3.05

Pitot	104
Manometer	PS03
Temperature ind.	126
Thermocouple	145
Barometer	344
Timer	705

BS EN 13284-1:2002 Sampling Points

Range of Sampling plain areas (m^2)	Range of Duct Diameters (m)	Minimum Number of Sampling lines (diameters)	Minimum Number of Sampling Points per plane
<0.1	0.35		1a
0.1 to 1.0	0.35 to 1.1	2	4
1.1 to 2.0	1.1 to 1.6	2	8
>2.0	>1.6	2	At least 12 and 4 per m^{2b}

[a] Using only one sampling point may give rise to errors greater than those specified in the method and the standard

[b] For Large ducts, a number of 20 sampling points is generally sufficient.

Tangential Rule Sampling Points

Sample Point Number	% Along Traverse			
	n=2	n=4	n=6	n=8
1	14.6	6.7	4.4	3.3
2	85.4	25	14.6	10.5
3		75	29.6	19.4
4		93.3	70.4	32.3
5			85.4	67.7
6			95.6	80.6
7				89.5
8				96.7

Sample Point Number	% Along Traverse			
	n=10	n=12	n=14	n=16
1	2.6	2.1	1.8	1.6
2	8.2	6.7	5.7	4.9
3	14.6	11.8	9.9	8.5
4	22.6	17.7	14.6	12.5
5	34.2	25	20.1	16.9
6	65.8	35.6	26.9	22
7	77.4	64.4	36.6	28.3
8	85.4	75	63.4	37.5
9	91.8	82.3	73.1	62.5
10	97.4	88.2	79.9	71.7
11		93.3	85.4	78
12		97.9	90.1	83.1
13			94.3	87.5
14			98.2	91.5
15				95.1
16				98.4

Sample Point Number	% Along Traverse			
	n=18	n=20	n=22	n=24
1	1.4	1.3	1.1	1.1
2	4.4	3.9	3.5	3.2
3	7.5	6.7	6	5.5
4	10.9	9.7	8.7	7.9
5	14.6	12.9	11.6	10.5
6	18.8	16.5	14.6	13.2
7	23.6	20.4	18	16.1
8	29.6	25	21.8	19.4
9	38.2	30.6	26.2	23
10	61.8	38.8	31.5	27.2
11	70.4	61.2	39.3	32.3
12	76.4	69.4	60.7	39.8
13	81.2	75	68.5	60.2
14	85.4	79.6	73.8	67.7
15	89.1	83.5	78.2	72.8
16	92.5	87.1	82	77
17	95.6	90.3	85.4	80.6
18	98.6	93.3	88.4	83.9
19		96.1	91.3	86.8
20		98.7	94	89.5
21			96.5	92.1
22			98.9	94.5
23				96.8
24				98.9

APPENDIX 4

RANHEAT BOILER & WET SPRAY BOOTH

PRELIMINARY GAS MEASUREMENTS & WATER VAPOUR RESULTS

APPENDIX 4.1

PRELIMINARY MOISTURE RESULTS

Sampling Data	Ranheat Boiler 10:15 - 10:55 (29/05/14)	Wet Spray Booth 11:54 - 12:34 (30/05/14)
Run Time (min)	40	40
Total mass H_2O collected (g)	27.6	7.6
Pitot tube constant, Cp	0.85	0.85
Dry gas meter (DGM) volume (m^3)	0.766	1.059
Temperature DGM (^oC)	17	22
Temperature stack (^oC)	143	31
Mean pitot tube pressure drop, delta P (mm H_2O)	8.5	2.4
Orifice meter pressure drop, delta H (mm H_2O)	34.3	54.6
Barometric Pressure (kPa)	98.9	99.9
X-sectional area of stack (m^2)	0.038	0.503
Nozzle size (mm)	7.01	10.09
Flow Data		
Velocity, actual (m/s)	12.2	5.5
Velocity, ntp (m/s)	7.9	4.9
Vol. Flow, actual (m^3/hr)	1,664	9,871
Vol. Flow, ntp (m^3/hr)	1,078	8,803
Volume sampled, ntp, dry gas (m^3)	0.691	0.963
Volume sampled, ntp, wet gas (m^3)	0.726	0.973
Emission Data		
H_2O (% vol)	4.7	1.0

APPENDIX 4.2

PRELIMINARY GAS MEASUREMENT RESULTS

Stack Ref	H_2O	O_2	CO		Total VOCs	
	(%vol)	(%vol)	ppm	mg/m^3	ppm	mg/m^3 (as C)
Ranheat Boiler	4.7	16.5	93.1	111.0	2.9	4.6
Uncertainty (±)	0.2	0.4		13.8		1.7

APPENDIX 5

RANHEAT BOILER

GAS ANALYSER CALIBRATION MEASUREMENTS

REC
Resource & Environmental Consultants Ltd

GAS SAMPLING WORKBOOK

GAS CALIBRATION CYLINDERS USED				Job No: 02818
Cylinder No	Contents	Concentration	Uncertainty	Client Site: Nuttalls
VC8177253	N_2	99.99%	N/A	Date: 09/4/15
VCSMG5960	CO	156.4ppm	1.008%	Sampling Team: AW/HB
VCSMG5960	O_2	12.03%	1.0 %	
VC10044	zero Air	0	~~1 ppm~~	
VCDY0207	C_3H_8	9.9ppm	2%	

GAS REGULATOR CHECKLIST		
H_2/He	AQ	
Acid Gas	AQ	
Other Gas	AQ	RRG38 RRG83
Other:	AQ	

Task	✓	X	Comments
Regulator has AQ No	✓		
Check Gauge Covers and Condition	✓		
Suitable presure range for work in hand	✓		
Inlet in good condition	✓		
Outlet in good condition	✓		
Leak check head on cylinder	✓		
Gauge reads zero OK	✓		
Gauge reads press OK	✓		
Pass/Fail	P		
Checked by	AWynne		
Date	9/4/15		

INSTRUMENT INFORMATION

Site	Alan Nuttall					
Job Number	02818					
Date	9/4/15					
Equipment Details:-	**AQ:**	**NO_x**	**CO**	**O_2**	**SO_2**	**CO_2**
Horiba	268	-	-	-	-	-
Range	-	—	0-200	0-25	—	—
Repeatability at Zero	-	0.43 → ~~0.45~~ 0.46		0.06 ~~0.05~~ 0.06		
Repeatability at Span	-		~~0.32~~	~~0.84~~		
	AQ:	**VOC**	**Comments**			
FID	270	-				
Range	-	0 – 10				
Repeatability at Zero	-	0.1				
Repeatability at Span	-	~~0.07~~ 0.05				
	AQ:	**Comments**				
Heated Line	315					
Heated Line Controller	316					
Heated Line						
Heated Line Controller						
Data Logger	Jumo Logger					
Data Logger						

PRE-CALIBRATION CHECKS

Parameter: NOx SO_2 CO O_2 (dry) VOCs	Job No: 02818
Instrument: Horiba AQ 341	Client Site: A. Nuttalo
Instrument: Bernet AQ 270	Date: 9/4/15
Atmospheric Pressure (kPa): 101.3	Data Saved as
Ambient Temperature °C: 23-5	FID:
Gas Conditioning Unit <4°C Yes / No	Horiba: 02815 -

NOTE: Instrument Span/Zero = back of instrument, System Span/Zero = end of line to allow leakage to be assessed

Pre Sampling Cal	Span/Zero Gas Ref	Gas Conc.	Time	T_{90} Value	Response Time T_{90}	Instrument Reading	Comment - (eg. zero deviation <2 X the repeatability at zero, system span <2% and zero <2% span gas value)
Instrument Zero	N_2	0	8.15			0	Set to ~~SGV~~ zero
Instrument Span	CO	156.4	8.21			156.4	Set to SGV
Instrument Zero Re-Check	N_2	0	8.27			0	< 2x repeatability
System Zero	N_2	0	9.00			0	< 2% SGV
System Span	CO	156.4	9.05	120.8	27	156.3	< 2% SGV
Instrument Zero	N_2	0	8.15			0	Set to zero
Instrument Span	O_2	12.03	8.21			12.03	Set to SGV
Instrument Zero Re-Check	N_2	0	8.27			0	< 2% repeatability
System Zero	N_2	0	9.00			0.01	< 2% SGV
System Span	O_2	12.03	9.05	13.2	25	12.04	< 2% SGV

PRE-CALIBRATION CHECKS

Parameter:	NOx	SO_2	CO	O_2 (dry)	Job No:	02818
	(VOCs)				Client Site:	A nuHolo
Instrument:	~~Hot~~	AQ			Date:	9/4/15
Instrument:	FID	AQ 270				
Atmospheric Pressure (kPa):	100.0				Data Saved as	
Ambient Temperature °C:					FID: See Page 3	
Gas Conditioning Unit <4°C	(Yes) / No				Horiba: See Page 3	

NOTE: Instrument Span/Zero = back of instrument, System Span/Zero = end of line to allow leakage to be assessed

Pre Sampling Cal	Span/Zero Gas Ref	Gas Conc.	Time	T_{90} Value	Response Time T_{90}	Instrument Reading	Comment - (eg. zero deviation <2 X the repeatability at zero, system span <2% and zero <2% span gas value)
Instrument Zero	~~Air~~ 9/4 N_2 Zero Air	0	8:33			0	adjusted to zero
Instrument Span	C_3H_8	9.9	8:38			9.9	adjusted to SGV
Instrument Zero Re-Check	Zero Air	0	8:43			0	< 2x repeatability at zero
System Zero	~~9/4 C_3H_8 Air~~ Zero Air	0	8:49			0	< 2% SGV
System Span	C_3H_8	9.9	8:55	~~23~~ 8.91	23	9.9	< 2% SGV
Instrument Zero							
Instrument Span							
Instrument Zero Re-Check							
System Zero							
System Span							

POST CALIBRATION CHECKS

Parameter: NO_x / VOCs SO_2 CO O_2 (dry) CO_2	Job No: 02818
Instrument: 341 AQ Horiba	Client Site: Alan Nuttall.
Instrument: 270 AQ Burnal	Date: 9/4/15
Atmospheric Pressure (kPa): 101.3	Data Saved as
Ambient Temperature °C: 23.7	FID: See Page 3
	Horiba: See Page 3

Post Sampling Cal	Span/Zero Gas Ref	Gas Conc.	Time	Response Time T_{90} (from Pre-Cal)	Instrument Reading	Comment - (eg. drift ≤2% - no correction, >2% ≤5% - correction applied or >5% measurement rejection)
Zero	N_2	0	14:33		0.12	< 2%. SGV
Span	O_2	12.03	14:40	25	12.02	< 2%. SGV
Zero	N_2	0	14:33		0.6	< 2%. SGV.
Span	CO	156.4	14:40	27	155.7	< 2%. SGV
Zero	Zero Air	0	14:44		0.02	< 2%. SGV
Span	C_3H_8	9.9	14:47	23	9.92	< 2%. SGV
Zero						
Span						
Zero						
Span						
Zero						
Span						

APPENDIX 6

RANHEAT BOILER

GAS ANALYSER RESULTS

APPENDIX 6.1

COMBUSTION GAS EMISSION DATA SUMMARY

Stack Ref	H_2O	O_2	CO	
	(%vol)	(%vol)	ppm	mg/m^3
Ranheat Boiler	4.2	13.5	45.4	54.4
Uncertainty (±)	0.1	0.4	-	2.2

APPENDIX 6.2

TOTAL VOC EMISSION DATA SUMMARY

Stack Ref	Total VOCs	
	ppm (as C_3H_8)	mg/m^3 as C
Ranheat Boiler	7.7	12.3
Uncertainty (±)	-	1.7

Fig 1: Combustion Gas Emission Data, Alan Nuttall Ltd, Ranheat Boiler, (09/04/15)

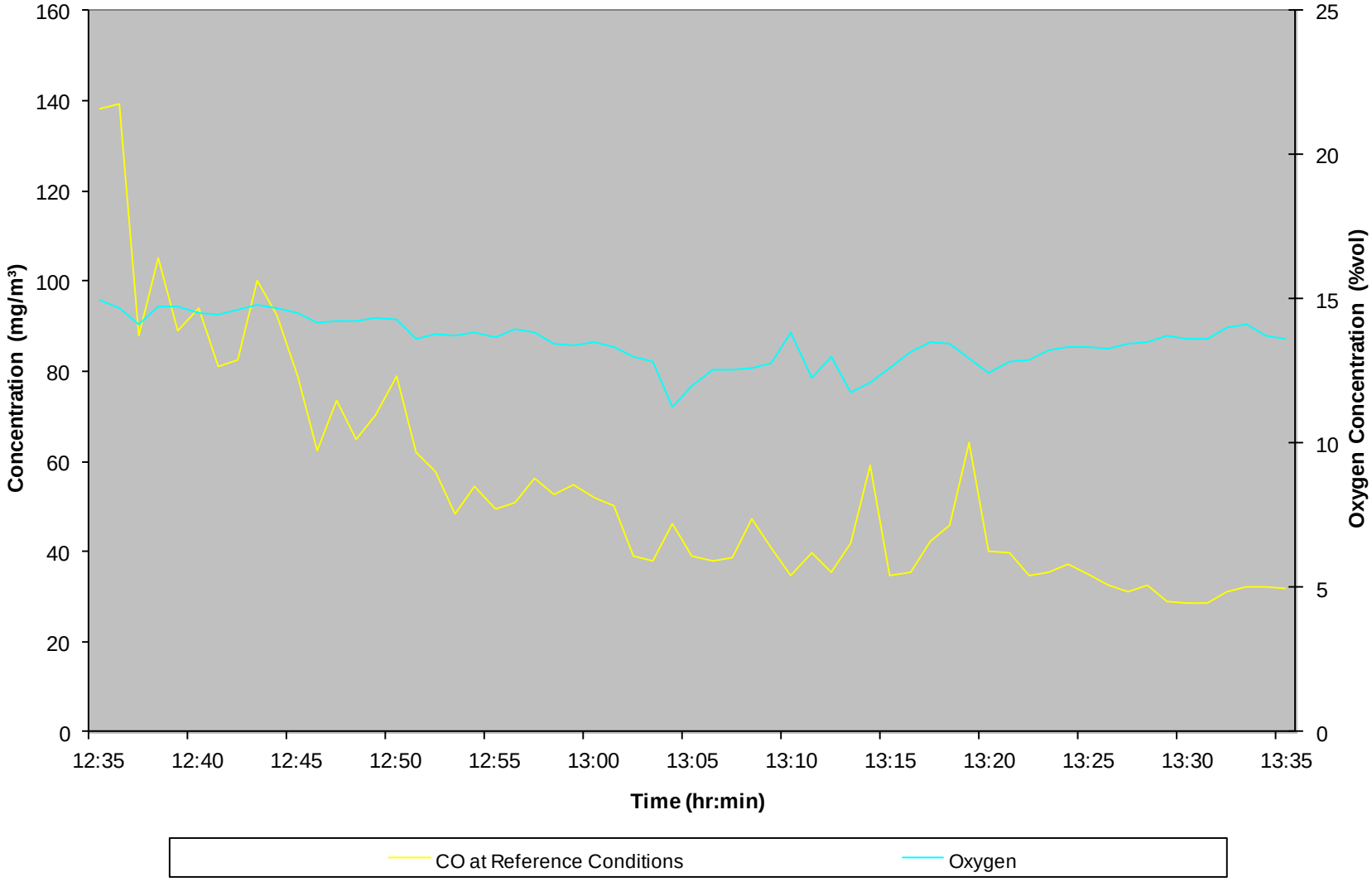
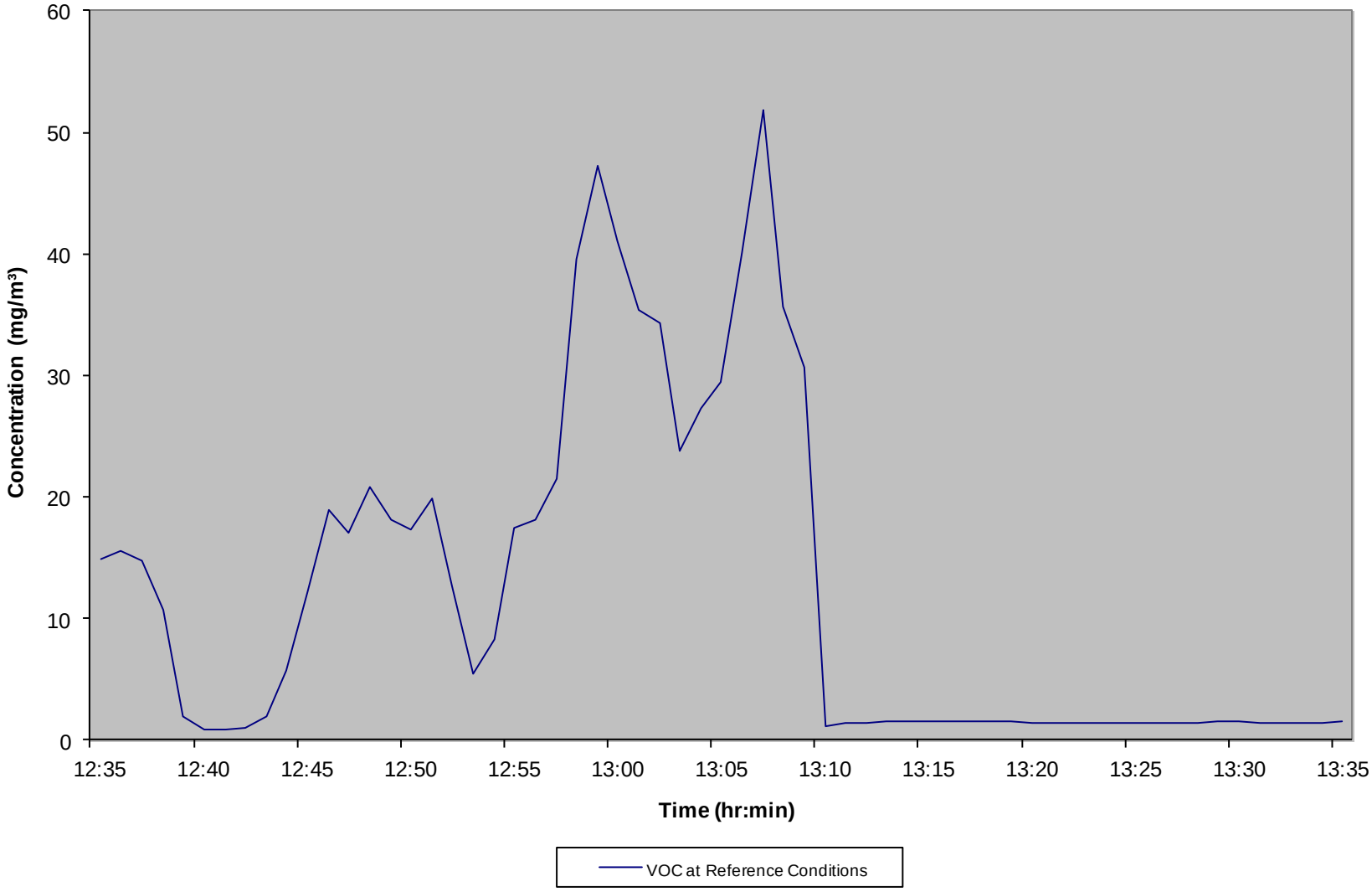


Fig 2: Total VOC Emission Data, Alan Nuttall Ltd, Ranheat Boiler, (09/04/15)



APPENDIX 7

RANHEAT BOILER & WET SPRAY BOOTH

LABORATORY CERTIFICATES OF ANALYSIS

Scientific Analysis Laboratories Ltd

a CONCEPT LIFE SCIENCES company

Scientific Analysis Laboratories is a limited company registered in England and Wales (No 2514788) whose address is at Hadfield House, Hadfield Street, Manchester M16 9FE

Hadfield House
Hadfield Street
Cornbrook
Manchester
M16 9FE
Tel : 0161 874 2400
Fax : 0161 874 2404

Scientific Analysis Laboratories Ltd

Certificate of Analysis

Report Number: 469275-1

Date of Report: 17-Apr-2015

Customer: REC Environmental Monitoring Ltd
10 Broad Lane
Moldgreen
Huddersfield
HD5 9BX

Customer Contact: The Emissions Group

Customer Job Reference: EM 1p02818
Date Job Received at SAL: 10-Apr-2015
Date Analysis Started: 14-Apr-2015
Date Analysis Completed: 17-Apr-2015

The results reported relate to samples received in the laboratory
Opinions and interpretations expressed herein are outside the scope of UKAS accreditation
This report should not be reproduced except in full without the written approval of the laboratory
Tests covered by this certificate were conducted in accordance with SAL SOPs
All results have been reviewed in accordance with QP22

UKAS TESTING
1549

Report checked and authorised by :
Michael Goodman
Project Management

Issued by :
Kayleigh McCann
Project Manager

Signature valid
Digitally signed by Kayleigh McCann
Date: 2015.04.17 16:44:14 BST
Reason: Issue
Location: SAL

SAL Reference: 469275
Customer Reference: EM 1p02818

Impinger(DI water) Analysed as Impinger(DI water)
Miscellaneous

				SAL Reference	469275 007	469275 010	469275 011
				Customer Sample Reference	EM-1p02818/7	EM-1p02818/10	EM-1p02818/11
				Test Sample	AR	AR	AR
				Date Sampled	09-APR-2015	09-APR-2015	09-APR-2015
Determinand	**Method**	**LOD**	**Units**	**Symbol**			
Hydrogen Chloride	IC	0.05	mg/l	U	(13) 1.1	(195,13) 79	(13) 1.3
Volume	Vol	1	ml	U	110	260	160

SAL Reference: 469275
Customer Reference: EM 1p02818

Impinger (sodium hydroxide) Analysed as Impinger (sodium hydroxide)
Miscellaneous

				SAL Reference	469275 012	469275 013
				Customer Sample Reference	EM-1p02818/12	EM-1p02818/13
				Test Sample	AR	AR
				Date Sampled	09-APR-2015	09-APR-2015
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Hydrogen Cyanide	Colorimetry	0.05	mg/l	N	<0.05	<0.05
Volume	Vol	1	ml	N	170	520

SAL Reference: 469275
Customer Reference: EM 1p02818

Wash(Acetone) Analysed as Wash(Acetone)
Miscellaneous

				SAL Reference	469275 001	469275 003	469275 005	469275 008
				Customer Sample Reference	EM-1p02818/1	EM-1p02818/3	EM-1p02818/5	EM-1p02818/8
				Test Sample	AR	AR	AR	AR
				Date Sampled	08-APR-2015	08-APR-2015	09-APR-2015	09-APR-2015
Determinand	**Method**	**LOD**	**Units**	**Symbol**				
Particulates (Total)	Grav	0.3	mg	U	0.4	2.8	0.6	9.6

SAL Reference: 469275
Customer Reference: EM 1p02818

Filter GFA 110mm Analysed as Filter GFA 110mm
Miscellaneous

				SAL Reference	469275 002	469275 004
				Customer Sample Reference	EM-1p02818/2	EM-1p02818/4
				Test Sample	AR	AR
				Date Sampled	08-APR-2015	08-APR-2015
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Particulates (Total)	Grav (5 Dec)	0.10	mg	U	0.92	4.8

SAL Reference: 469275
Customer Reference: EM 1p02818

Filter Quartz 85mm Analysed as Filter Quartz 85mm
Miscellaneous

				SAL Reference	469275 006	469275 009
				Customer Sample Reference	EM-1p02818/6	EM-1p02818/9
				Test Sample	AR	AR
				Date Sampled	09-APR-2015	09-APR-2015
Determinand	**Method**	**LOD**	**Units**	**Symbol**		
Particulates (Total)	Grav (5 Dec)	0.10	mg	U	<0.10	64

Index to symbols used in 469275-1

Value	Description
AR	As Received
195	Due to levels found in the sample that are outside of the normal calibration range of the instrument, analysis was conducted on a diluted sample
13	Results have been blank corrected.
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited

Test Certificate

Date 22/04/2015

Client	REC Ltd Unit 19 Bordesley Trading Estate Bordesley Green Rd Birmingham B8 1BZ	**Order No.**	0250 EM
		Certificate No.	**WK15-2001**
		Issue No.	1
Contact	Mr Derek Myers	**Date Received**	15/04/2015
Description	3 samples for formaldehyde in water	**Technique**	Wet Chemistry

Sample No.	**832192**	**EM-1p02818/14**		**Method**
Formaldehyde		<0.1 µg/ml	174 ml	M103(U)
Sample No.	**832193**	**EM-1p02818/15**		**Method**
Formaldehyde		<0.1 µg/ml	326 ml	M103(U)
Sample No.	**832194**	**EM-1p02818/16**		**Method**
Formaldehyde		<0.1 µg/ml	168 ml	M103(U)

RPS Laboratories Ltd. Unit 12. Waters Edge Business Park. Modwen Road. Salford. M5 3EZ
Tel: (0161) 872 2443 Fax: (0161) 877 3959

UKAS TESTING 0605

Test Certificate

Date 22/04/2015

Client REC Ltd

Certificate No. WK15-2001

Issue No. 1

Tested By Ashley Lunt Date 22/04/2015

Approved By  Date 22/04/2015

Lora McKerracher
Chemist

For and on authority of RPS Laboratories Ltd.

Method Symbols
(U) Analysis is UKAS Accredited
(N) Analysis is not UKAS Accredited

Concentration values (mg/m3 and ppm) are calculated on the basis of information provided by the customer.
Results stated as ml are refering to the sample volume.

RPS Laboratories terms and conditions apply - a copy is available on request.
Analysis carried out on samples 'as received'

RPS Laboratories Ltd. Unit 12. Waters Edge Business Park. Modwen Road. Salford. M5 3EZ
Tel: (0161) 872 2443 Fax: (0161) 877 3959

APPENDIX 8

RANHEAT BOILER & WET SPRAY BOOTH

MANUAL MONITORING RESULTS

APPENDIX 8.1

PARTICULATE EMISSION DATA SUMMARY- WET SPRAY BOOTH

DATE: 08/04/15 **11:14 - 11:54**

Sampling Data	
Run Time (min)	**40**
Total mass H_2O collected (g)	**3.9**
Pitot tube constant, Cp	**0.82**
Dry gas meter (DGM) volume (m^3)	**0.849**
Temperature DGM (^oC)	**17**
Temperature stack (^oC)	**23**
Mean pitot tube pressure drop, delta P (mm H_2O)	**2.7**
Orifice meter pressure drop, delta H (mm H_2O)	**45.5**
Barometric Pressure (kPa)	**100.7**
X-sectional area of stack (m^2)	**0.503**
Nozzle size (mm)	**8.98**
Flow Data	
Velocity, actual (m/s)	**5.5**
Velocity, ntp (m/s)	**5.1**
Vol. Flow, actual (m^3/hr)	**10,003**
Vol. Flow, ntp (m^3/hr)	**9,199**
Volume sampled, ntp, dry gas (m^3)	**0.770**
Volume sampled, ntp, wet gas (m^3)	**0.775**
Analytical Data	
Filter Weight Gain (mg)	**4.8**
Acetone Wash Residue Weight (mg)	**2.8**
Total Particulates (mg)	**7.6**
Partics Field Blank (mg)	**1.3**
Blank % of ELV	**0.9**
Emission Data	
H_2O (% vol)	**0.6**
Percentage Isokinetic	**100.4**
Particulates (mg/m^3)	**9.8**
Uncertainty (± mg/m^3)	**1.4**
Uncertainty (%ELV)	**0.7**

APPENDIX 8.2

PARTICULATE & HCl EMISSION DATA SUMMARY RANHEAT BOILER

DATE: 09/04/15 **12:35 - 13:05**

Sampling Data	
Run Time (min)	**30**
Total mass H_2O collected (g)	**27.7**
Pitot tube constant, Cp	**0.82**
Dry gas meter (DGM) volume (m^3)	**0.881**
Temperature DGM (^oC)	**25**
Temperature stack (^oC)	**131**
Mean pitot tube pressure drop, delta P (mm H_2O)	**7.2**
Orifice meter pressure drop, delta H (mm H_2O)	**80.6**
Barometric Pressure (kPa)	**101.3**
X-sectional area of stack (m^2)	**0.038**
Nozzle size (mm)	**8.98**
Flow Data	
Velocity, actual (m/s)	**10.6**
Velocity, ntp (m/s)	**7.1**
Vol. Flow, actual (m^3/hr)	**1,448**
Vol. Flow, ntp (m^3/hr)	**978**
Volume sampled, ntp, dry gas (m^3)	**0.784**
Volume sampled, ntp, wet gas (m^3)	**0.818**
Analytical Data	
Filter Weight Gain (mg)	**64.0**
Acetone Wash Residue Weight (mg)	**9.6**
Total Particulates (mg)	**73.6**
Partics Field Blank (mg)	**0.6**
Blank % of ELV	**0.3**
Mass HCl (ug)	**20748**
HCl Field Blank (mg/l)	**1.10**
Absorber Efficiency (%HCl in Impingers 1+2)	**99.0**
Emission Data	
H_2O (% vol)	**4.2**
Percentage Isokinetic	**100.5**
Particulates (mg/m^3)	**89.9**
Uncertainty (± mg/m^3)	**3.8**
Uncertainty (%ELV)	**1.9**
HCl (mg/m^3)	**25.4**
Uncertainty (± mg/m^3)	**3.1**
Uncertainty (%ELV)	**3.1**

APPENDIX 8.3

FORMALDEHYDE EMISSION DATA SUMMARY

DATE: 09/04/15 **13:46 - 14:16**

Sampling Data	
Run Time (min)	**30**
Total mass H_2O collected (g)	**23.5**
Pitot tube constant, Cp	**0.82**
Dry gas meter (DGM) volume (m^3)	**0.810**
Temperature DGM (^oC)	**29**
Temperature stack (^oC)	**133**
Mean pitot tube pressure drop, delta P (mm H_2O)	**6.6**
Orifice meter pressure drop, delta H (mm H_2O)	**74.2**
Barometric Pressure (kPa)	**101.3**
X-sectional area of stack (m^2)	**0.038**
Nozzle size (mm)	**8.98**
Flow Data	
Velocity, actual (m/s)	**10.2**
Velocity, ntp (m/s)	**6.8**
Vol. Flow, actual (m^3/hr)	**1,391**
Vol. Flow, ntp (m^3/hr)	**936**
Volume sampled, ntp, dry gas (m^3)	**0.710**
Volume sampled, ntp, wet gas (m^3)	**0.739**
Analytical Data	
Mass HCHO Imp 1+2 (ug)	**<49.4**
HCHO Field Blank (mg/l)	**<0.1**
Absorber Efficiency (%HCHO in Impinger 1)	**66.0**
Emission Data	
H_2O (% vol)	**4.0**
Percentage Isokinetic	**94.9**
HCHO (mg/m^3)	**<0.067**
Uncertainty (± mg/m^3)	**<0.010**

APPENDIX 8.4

HCN EMISSION DATA SUMMARY

Sampling Data	Ranheat Boiler
Start Time/Date	13:31, 09/04/15
End Time/Date	14:41, 09/04/15
Sampling Period (min)	40
DGM start (dry m^3)	52.229
DGM end (dry m^3)	52.295
Volume Sampled (dry m^3)	0.066
Ambient Temp (^oC)	23.5
Ambient Press (kPa)	100
Wt of Water (g)	3.8
Volume Water (m^3)	0.005
Volume Sampled, 273K, 101.3kPa (dry m^3)	0.060
Volume Sampled, 273K, 101.3kPa (wet m^3)	0.065
Volume NaOH Impinger 1+ 2 (ml)	520
Analytical Data	
HCN Blank (mg/l)	<0.05
HCN in NaOH Imp1+2(mg/l)	<0.05
total HCN (µg)	26
Emission Concentration Data	
Moisture (%vol)	7.3
HCN (mg/m^3)	<0.40

Resource & Environmental Consultants Ltd

ISOKINETIC SAMPLING WORKBOOK

Site	ALAN NUTTALS	
Stack	SPRAY BOOTH.	
Job Number	EM-1802818.	
Date	08/04/15	
Sampling Team	HB/AW	
Equipment Used:-	**MUST** enter AQ numbers below	
Nozzle(s)	**AQ**	153.
Probe(s)		14.
Pitot(s)	**AQ**	104.
Timer	**AQ**	308
Glassware Set		Bhem Set 1
Thermocouple(s)	**AQ**	146.
Temperature Indicator	**AQ**	126
Control Console	**AQ**	126
Digital Manometer	**AQ**	PI03 14/12/15
Tape Measure	**AQ**	26x
Balance	**AQ**	070

Workbook checked by:	M. Furmston

IMPORTANT!!!
ANY CROSSINGS OUT SHOULD BE MADE USING A SINGLE LINE AND INITIALLED
ALL SECTIONS TO BE COMPLETED AND SIGNED WHERE APPROPRIATE

SITE NOTES & BLANK(S) DETAILS - Please use this page to record site details, problems on site re access, non conforming work etc, pitot and DGM leak check results. For blank(s) details, include stack ref, substance, time taken, etc.

BSEN013284.

Blank completed 8/ 9-15

DIAGRAMS OF STACK

Plan of site layout including approx dimensions	Schematic diagram of the stack inc dimensions
	Stack Dimensions = cm (diameter) x cm (traverse 1st) Ø 0.80 -

Other Notes

LEAKAGE RATES FOR CONSOLE DRY GAS METERS

Leakage to be less than 2% of maximum nominal flowrate of meter

AQ140		
mm H_2O	l/min	2% leak l/min
5	8.1	0.16
10	9.8	0.20
15	12.3	0.25
20	14.1	0.28
25	16.0	0.32
30	17.4	0.35
35	18.8	0.38
40	19.6	0.39
45	21.4	0.43
50	22.2	0.44
55	23.7	0.47
60	24.5	0.49
65	25.5	0.51
70	27.0	0.54
75	27.8	0.56
80	28.8	0.58
85	29.6	0.59
90	30.4	0.61
95	31.2	0.62
100	32.2	0.64
110	33.8	0.68
120	35.2	0.70
130	36.7	0.73
140	37.8	0.76

AQ126		
mm H_2O	l/min	2% leak l/min
5	7.3	0.16
10	10.5	0.21
15	12.7	0.25
20	14.7	0.29
25	16.5	0.33
30	17.9	0.36
35	19.5	0.39
40	20.8	0.42
45	22.0	0.44
50	23.5	0.47
55	24.6	0.49
60	26.0	0.52
65	26.9	0.54
70	27.8	0.56
75	28.9	0.58
80	29.8	0.60
85	30.8	0.62
90	31.7	0.63
95	32.4	0.65
100	33.4	0.67
110	35.2	0.70
120	36.6	0.73
130	38.2	0.76
140	39.6	0.79

AQ002		
mm H_2O	l/min	2% leak l/min
5	7.7	0.15
10	10.3	0.21
15	12.6	0.25
20	14.2	0.28
25	15.4	0.31
30	16.4	0.33
35	17.9	0.36
40	18.9	0.38
45	20.1	0.40
50	21.2	0.42
55	22.1	0.44
60	23.2	0.46
65	24.1	0.48
70	24.9	0.50
75	25.7	0.51
80	26.5	0.53
85	27.1	0.54
90	27.9	0.56
95	28.7	0.57
100	29.5	0.59
110	30.9	0.62
120	32.1	0.64
130	33.1	0.66
140	34.5	0.69

AQ003		
mm H_2O	l/min	2% leak l/min
5	7.5	0.15
10	10.1	0.20
15	12.3	0.25
20	13.9	0.28
25	15.1	0.30
30	16.1	0.32
35	17.6	0.35
40	18.6	0.37
45	19.7	0.39
50	20.9	0.42
55	21.8	0.44
60	22.9	0.46
65	23.7	0.47
70	24.5	0.49
75	25.3	0.51
80	26.1	0.52
85	26.7	0.53
90	27.5	0.55
95	28.3	0.57
100	29.1	0.58
110	30.5	0.61
120	31.7	0.63
130	32.7	0.65
140	34.1	0.68

AQ325		
mm H_2O	l/min	2% leak l/min
5	8.2	0.16
10	11.6	0.23
15	13.8	0.28
20	15.1	0.30
25	16.8	0.34
30	18.1	0.36
35	19.3	0.39
40	20.9	0.42
45	22.0	0.44
50	23.3	0.47
55	24.4	0.49
60	25.8	0.52
65	26.4	0.53
70	27.0	0.54
75	28.2	0.56
80	29.4	0.59
85	30.2	0.60
90	30.8	0.62
95	31.7	0.63
100	32.0	0.64
110	34.9	0.70
120	35.0	0.70
130	36.7	0.73
140	38.2	0.76

AQ326		
mm H_2O	l/min	2% leak l/min
5	8.0	0.16
10	11.0	0.22
15	13.2	0.26
20	15.0	0.30
25	16.5	0.33
30	17.9	0.36
35	19.1	0.38
40	20.5	0.41
45	21.7	0.43
50	23.0	0.46
55	24.2	0.48
60	25.1	0.50
65	26.1	0.52
70	26.5	0.53
75	27.9	0.56
80	28.5	0.57
85	29.4	0.59
90	30.0	0.60
95	30.9	0.62
100	31.9	0.64
110	33.8	0.68
120	34.6	0.69
130	35.9	0.72
140	37.2	0.74

Site:	ALAN NUTTALS.		MOISTURE	Contents	Start Weight (g)	End Weight (g)	Gain (g)
Stack Description:	SPRAY BOOTH.		Impinger 1	$D.H_2O$.	599.2	590.4	~~9.8~~
Test No:	PARTIC		Impinger 2	$D.H_2O$.	669.9	673.3	3.4
Date:	08/04/15.		Impinger 3	BLK	666.1	667.4	1.3.
Filter No:	489.		Impinger 4	S.G.	807.8.	815.8.	8.0.
Site Team:	AW/HB		Impinger 5				3.9.
Start time	11:14.	hr:min	Impinger 6				
End time	11:54	hr:min	Impinger 7				
total time sampled	40	hr:min	Leak Check (see leakage rate conversions mmH_2O to l/min and 2% l/min values)				
Nozzle diameter:	~~8.997~~	mm	Max nominal flowrate - (from preliminary pitot traverse)	32.4)	l/min	Sampling flowrate - (from volume sampled/time)	28. l/min
K Factor:	16.84.		2% of max nominal flowrate - (from preliminary pitot traverse)	065	l/min	2% of sampling flowrate - (from volume sampled/time)	0.57. l/min
Stack Pres (with +/- above barometric if unknown enter zero)	0	mm H_2O	Actual pre-test leak check result + Vac Gauge Reading	0.4 l/min	18 "Hg	Actual post-test leak check result + Vac Gauge Reading	0.2 l/min −18 "Hg
Reference Standard (E.g BS EN 13284,USEPA M26a etc.)	BSEN 13284.		COMMENTS:				
Does test conform to standard (Y/N)	Y.		(E.g. Deviations from the Methods)				
Start volume reading	4.6007	m^3					
End volume reading	5.4494	m^3					
Barometric Pressure	100.7	kPa					
Reference O_2	N/A	%					
Ambient Temp	14.	°c					

16.84

16.84.

	Time Hr : Min	Sample Point	Time at each position min	ΔP mm H_2O	ΔH mm H_2O	Stack Temp °C	Probe Temp °C	Meter In °C	Meter Out °C	Oven Temp °C	Exit Temp °C	Cond. Temp °C	Vac. in Hg
1:	11:14	A1	5	5.0	84.2	15	160	15	15	160	12	—	-3.5
2:	19			5.0	84.2	17	160	16	16	160	14	—	-4.0
3:	24	A2		3.0	50.5	23	160	17	17	160	15	—	-3.0
4:	29			3.0	50.5	24	160	18	17	160	15	—	-3.0
5:	34	A3		1.8	30.3	26	160	18	18	160	16	—	-2.0
6:	39			1.8	30.3	25	160	18	18	160	16	—	-2.0
7:	44	A4		1.0	16.8	27	160	19	19	160	16	—	-1.0
8:	49			1.0	16.8	27	160	19	19	160	17		-1.0
9:	54	End											
10:													
11:													
12:													
13:													
14:													
15:													
16													
17:													
18:													
19:													
20:													
21:													
22:													
23:													
24:													
25:													
26:													
27:													
	Average values												

Resource & Environmental Consultants Ltd

ISOKINETIC SAMPLING WORKBOOK

Site	ALAN NUTTALS	
Stack	BOILER	
Job Number	EM-1P02818	
Date	09/04/15	
Sampling Team	AW/HB	
Equipment Used:-	**MUST** enter AQ numbers below	
Nozzle(s)	**AQ**	153.
Probe(s)		14.
Pitot(s)	**AQ**	104
Timer	**AQ**	308.
Glassware Set		Bhem Set 1.
Thermocouple(s)	**AQ**	147.
Temperature Indicator	**AQ**	126
Control Console	**AQ**	126.
Digital Manometer	**AQ**	126.
Tape Measure	**AQ**	268.
Balance	**AQ**	070.

Workbook checked by:	M Edwards

IMPORTANT!!!
ANY CROSSINGS OUT SHOULD BE MADE USING A SINGLE LINE AND INITIALLED
ALL SECTIONS TO BE COMPLETED AND SIGNED WHERE APPROPRIATE

SITE NOTES & BLANK(S) DETAILS - Please use this page to record site details, problems on site re access, non conforming work etc, pitot and DGM leak check results. For blank(s) details, include stack ref, substance, time taken, etc.

BSEN 13284 - Blank completed 9/4/15

BSEN 14791

USEPA m316 - blank completed 9/4/15

DIAGRAMS OF STACK

Plan of site layout including approx dimensions	Schematic diagram of the stack inc dimensions
	Stack Dimensions = cm (diameter) x cm (traverse 1st) Ø 22cm

Other Notes

LEAKAGE RATES FOR CONSOLE DRY GAS METERS

Leakage to be less than 2% of maximum nominal flowrate of meter

AQ140		
mm H_2O	l/min	2% leak l/min
5	8.1	0.16
10	9.8	0.20
15	12.3	0.25
20	14.1	0.28
25	16.0	0.32
30	17.4	0.35
35	18.8	0.38
40	19.6	0.39
45	21.4	0.43
50	22.2	0.44
55	23.7	0.47
60	24.5	0.49
65	25.5	0.51
70	27.0	0.54
75	27.8	0.56
80	28.8	0.58
85	29.6	0.59
90	30.4	0.61
95	31.2	0.62
100	32.2	0.64
110	33.8	0.68
120	35.2	0.70
130	36.7	0.73
140	37.8	0.76

AQ126		
mm H_2O	l/min	2% leak l/min
5	7.3	0.15
10	10.5	0.21
15	12.7	0.25
20	14.7	0.29
25	16.5	0.33
30	17.9	0.36
35	19.5	0.39
40	20.8	0.42
45	22.0	0.44
50	23.5	0.47
55	24.6	0.49
60	26.0	0.52
65	26.9	0.54
70	27.8	0.56
75	28.9	0.58
80	29.8	0.60
85	30.8	0.62
90	31.7	0.63
95	32.4	0.65
100	33.4	0.67
110	35.2	0.70
120	36.6	0.73
130	38.2	0.76
140	39.6	0.79

AQ002		
mm H_2O	l/min	2% leak l/min
5	7.7	0.15
10	10.3	0.21
15	12.6	0.25
20	14.2	0.28
25	15.4	0.31
30	16.4	0.33
35	17.9	0.36
40	18.9	0.38
45	20.1	0.40
50	21.2	0.42
55	22.1	0.44
60	23.2	0.46
65	24.1	0.48
70	24.9	0.50
75	25.7	0.51
80	26.5	0.53
85	27.1	0.54
90	27.9	0.56
95	28.7	0.57
100	29.5	0.59
110	30.9	0.62
120	32.1	0.64
130	33.1	0.66
140	34.5	0.69

AQ003		
mm H_2O	l/min	2% leak l/min
5	7.5	0.15
10	10.1	0.20
15	12.3	0.25
20	13.9	0.28
25	15.1	0.30
30	16.1	0.32
35	17.6	0.35
40	18.6	0.37
45	19.7	0.39
50	20.9	0.42
55	21.8	0.44
60	22.9	0.46
65	23.7	0.47
70	24.5	0.49
75	25.3	0.51
80	26.1	0.52
85	26.7	0.53
90	27.5	0.55
95	28.3	0.57
100	29.1	0.58
110	30.5	0.61
120	31.7	0.63
130	32.7	0.65
140	34.1	0.68

AQ325		
mm H_2O	l/min	2% leak l/min
5	8.2	0.16
10	11.6	0.23
15	13.8	0.28
20	15.1	0.30
25	16.8	0.34
30	18.1	0.36
35	19.3	0.39
40	20.9	0.42
45	22.0	0.44
50	23.3	0.47
55	24.4	0.49
60	25.8	0.52
65	26.4	0.53
70	27.0	0.54
75	28.2	0.56
80	29.4	0.59
85	30.2	0.60
90	30.8	0.62
95	31.7	0.63
100	32.0	0.64
110	34.9	0.70
120	35.0	0.70
130	36.7	0.73
140	38.2	0.76

AQ326		
mm H_2O	l/min	2% leak l/min
5	8.0	0.16
10	11.0	0.22
15	13.2	0.26
20	15.0	0.30
25	16.5	0.33
30	17.9	0.36
35	19.1	0.38
40	20.5	0.41
45	21.7	0.43
50	23.0	0.46
55	24.2	0.48
60	25.1	0.50
65	26.1	0.52
70	26.5	0.53
75	27.9	0.56
80	28.5	0.57
85	29.4	0.59
90	30.0	0.60
95	30.9	0.62
100	31.9	0.64
110	33.8	0.68
120	34.6	0.69
130	35.9	0.72
140	37.2	0.74

Site:	ALAN NUTTALS		MOISTURE	Contents	Start Weight (g)	End Weight (g)	Gain (g)
Stack Description:	WOOD BURNER BOILER		Impinger 1	D, H_2O	~~682.1~~ HB 644.6	648.1	3.5
Test No:	PARTIC/HC.		Impinger 2	D, H_2O	~~594.4~~ HB 660.4	670.1	9.7
Date:	09/04/15.		Impinger 3	D, H_2O	~~682.1~~ HB 729.5	733.4	3.9
Filter No:	~~492~~ HB 334		Impinger 4	Silica	~~660.4~~ HB 573.1	573.2	0.1
Site Team:	AW/HB		Impinger 5	S.G.	878.5	888.7	10.2
Start time	12:35	hr:min	Impinger 6				
End time	13:05	hr:min	Impinger 7				
total time sampled	00:30	hr:min	Leak Check (see leakage rate conversions mmH_2O to l/min and 2% l/min values)				
Nozzle diameter:	8.9 ~~8.7~~	mm	Max nominal flowrate - (from preliminary pitot traverse)	2.5	l/min	Sampling flowrate - (from volume sampled/time)	2.94 l/min
K Factor:	11.24		2% of max nominal flowrate - (from preliminary pitot traverse)	0.56	l/min	2% of sampling flowrate - (from volume sampled/time)	0.58 l/min
Stack Pres (with +/- above barometric if unknown enter zero)	-2.7	mm H20	Actual pre-test leak check result + Vac Gauge Reading	0.2 l/min	-16 "Hg	Actual post-test leak check result + Vac Gauge Reading	0.2 l/min -18 "Hg
Reference Standard (E.g BS EN 13284,USEPA M26a etc.)	BS EN 13284 BS EN 9111		COMMENTS: (E.g. Deviations from the Methods)				
Does test conform to standard (Y/N)	Y						
Start volume reading	~~6.9677~~ 3.0214	m^3					
End volume reading	3.9024	m^3					
Barometric Pressure	1003	kPa					
Reference O_2	—	%					
Ambient Temp	14	°c					

11.24

	Time Hr : Min	Sample Point	Time at each position min	ΔP mm H_2O	ΔH mm H_2O	Stack Temp °C	Probe Temp °C	Meter In °C	Meter Out °C	Oven Temp °C	Exit Temp °C	Cond. Temp °C	Vac. in Hg
1:	12:35	C.P.	5	8.0	89.9	130	160	27	21	160	14		-1.0
2:	40			7.0	78.7	130	160	28	17	160	14		-1.0
3:	45			7.0	78.7	130	160	29	19	160	15		-1.0
4:	50			7.0	78.7	131	160	30	21	160	16		-2.0
5:	55			7.0	78.7	132	160	30	22	160	17		-2.0
6:	13:00			7.0	78.7	134	160	31	24	160	17		-2.5
7:	13:05	END V											
8:													
9:													
10:													
11:													
12:													
13:													
14:													
15:													
16													
17:													
18:													
19:													
20:													
21:													
22:													
23:													
24:													
25:													
26:													
27:													
	Average values												

Site:	ALAN NUTTALS		MOISTURE	Contents	Start Weight (g)	End Weight (g)	Gain (g)
Stack Description:	BOILER		Impinger 1	D. H_2O	651.3	656.8	5.5
Test No:	FORMALDEHYDE.		Impinger 2	D. H_2O	688.1	695.9	7.8
Date:	09/04/15.		Impinger 3	D. H_2O	744.9	747.9	3.0
Filter No:	N/A.		Impinger 4	BLK	573.3	574.3	1.0
Site Team:	AW/HB		Impinger 5	S.G.	888.7	894.9	6.2
Start time	13:46	hr:min	Impinger 6				
End time	14:16	hr:min	Impinger 7				
total time sampled	00:30	hr:min	Leak Check (see leakage rate conversions mmH_2O to l/min and 2% l/min values)				
Nozzle diameter:	8.99	mm	Max nominal flowrate - (from preliminary pitot traverse)	0.54	l/min	Sampling flowrate - (from volume sampled/time)	26.97 l/min
K Factor:	11.24		2% of max nominal flowrate - (from preliminary pitot traverse)	0.18	l/min	2% of sampling flowrate - (from volume sampled/time)	0.54 l/min
Stack Pres (with +/- above barometric if unknown enter zero)	-22	mm H20	Actual pre-test leak check result + Vac Gauge Reading	0.4 l/min	-16 "Hg	Actual post-test leak check result + Vac Gauge Reading	0.2 l/min -18 "Hg
Reference Standard (E.g BS EN 13284,USEPA M26a etc.)	use M26		COMMENTS:				
Does test conform to standard (Y/N)	Y		(E.g. Deviations from the Methods)				
Start volume reading	39176.	m^3					
End volume reading	47274	m^3					
Barometric Pressure	101.3	kPa					
Reference O_2	—	%					
Ambient Temp	16.	°c					

	Time Hr : Min	Sample Point	Time at each position min	ΔP mm H_2O	ΔH mm H_2O	Stack Temp °C	Probe Temp °C	Meter In °C	Meter Out °C	Oven Temp °C	Exit Temp °C	Cond. Temp °C	Vac. in Hg
1:	13:46	C.P.		7.	78.7	132.	120	27	26	120	14		-1.0
2:	51			7	78.7	133	120	33	27	120	14		-1.0
3:	56			7	78.7	131	120	33	27	120	14		-1.0
4:	14:01			7	78.7	133	120	33	28	120	15		-2.0
5:	6.			7	78.7	134	120	32	28	120	16		-4.5
6:	11			4.6.	~~81.4~~ 81.7	134	120	31	28	120	17		-7.5
7:	16.		End.										
8:													
9:													
10:													
11:													
12:													
13:													
14:													
15:													
16													
17:													
18:													
19:													
20:													
21:													
22:													
23:													
24:													
25:													
26:													
27:													
	Average values												

REC
Resource & Environmental Consultants Ltd

NON-ISOKINETIC AND MOISTURE SAMPLING WORKSHEET

Client: A. Nuttal

Job No.: 02818

Date: 9/4/15

Sampling Operator: AW/HB

Test: HCN

Checked by/ Date: MC | 11/5/15

Sampling Location: Wood burning boiler outlet

Pump Ref AQ: ~~33~~ 199

DGM Ref AQ: ~~33~~ 199

Balance Ref AQ: 90

T/C + Reader AQ: 301 | 163

Start Leak Check: 0.0 L/min

End Leak Check: 0.0 L/min

Start Time: 13:31

End Time: 14:11

DGM Start (m^3): 52,229

DGM Start Temp (°C) 23

DGM End (m^3): 52.294

DGM End Temp (°C) 24.

Period Sampled (min): 40

Barometric Pressure (kPa): 100.0 AW

Impinger Ref	Contents	Start Weight (g)	End Weight (g)	Weight Gain (g)
1	0.1m NaOH	636.7	637.4	0.7
2	0.1m NaOH	752.4	753.6	1.2
3	Empty	395.1	395.7	0.6
4	Silica gel	640.2	641.5	1.3
			Total Gain (g)	3.8

APPENDIX 9

RANHEAT BOILER & WET SPRAY BOOTH

UNCERTAINTY CALCULATIONS

Uncertainty calculation for EN 13284 Determination of low range mass concentration of dust, Manual Gravimetric Method

Spreadsheet completed by:	**ME**	**Checked by:**	**DM**
Date:	**11/5/15**	**Date:**	**11/5/15**

Limit value	200	**mg.m^{-3}**	**Reference oxygen**	21.0	**% by volume**
Measured concentration	9.80	**mg.m^{-3}**			

Measurement Equation

$$c = \frac{m}{V} f_c$$

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at lv	Requirement of std
Sampled Volume	V_m	0.849	uV_m	0.001	**m^3**	0.12		<=2%
Sampled gas Temperature	T_m	290.4375	uTm	2	**K**	0.69		<=1%
Sampled gas Pressure	ρ_m	100.7	$u\rho_m$	1	**kPa**	0.99		<=1%
Sampled gas Humidity	H_m	0.626303678	uH_m	1	**% by volume**	159.67		<=1%
Oxygen content	$O_{2,m}$	21.0	$uO_{2,m}$	0.1	**% by volume**	0.48		<=5%
Mass particulate	m	7.6	um	0.522015325	**mg**	6.87	0.34	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	2			**%**	2.00		<=2%
Uncollected Mass (Instack filter - no rinse)	UCM	0			**mg**	0		<=10%

Intermediate calculations							
Factor for std conds	fs	0.929					
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**			
	ρ_m	0.009		0.009			
	H_m	0.009		0.009		$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$	
	T_m	0.003		0.006			
	ufs			0.015			1.57
Corrected volume	V	0.789	uV	0.012	**m^3**	$V = V_m f_s$	1.58
Factor for O2 correction	fc	1.00					
uncertainty components	symbol	**sensitivity coeff**		**u**			
	$O_{2,m}$	1.00		0.100		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
Factor for O2 Correction	ufc	1.00		0.100			10.00

Parameter	Uncertainty, Value		Units	Sensitivity coeff	Uncertainty in Result		Uncertainty as %	
Volume(standard conditions)	V	0.789	m^3	12.43	0.15	mg.m^{-3}	1.58	%
Mass	m	7.60	mg	1.29	0.67	mg.m^{-3}	6.87	
Factor for O2 Correction	fc	1.00		0.00	0.00	mg.m^{-3}	0.00	%
Leak	L	0.11	mg.m^{-3}	1.00	0.11	mg.m^{-3}		
Uncollected mass	UCM	0.00	mg	1.29	0.00	mg.m^{-3}		
Combined uncertainty					**0.70**	mg.m^{-3}		

Expanded uncertainty	**expressed with a level of confidence of 95%**	**14.28**	**%**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**1.40**	**mg.m^{-3}**
Expanded uncertainty as percentage of limit value		**0.7**	**% of ELV**

Uncertainty calculation for HCl Impingement Method

rec	**ME**	**Checked by:**	**DM**
Date:	**11/5/15**	**Date:**	**11/5/15**

Limit value	**100**	**mg.m^{-3}**	**Reference oxygen**	**21**	**% by volume**
Measured concentration	**25.35**	**mg.m^{-3}**			

Measurement Equation

$$c = \frac{m}{V} f_c$$

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**	**Uncertainty as percentage**	**Uncertainty at l**	**Requirement of std**
Sampled Volume	V_m	0.881	uV_m	0.001	**m^3**	0.11		<=2%
Sampled gas Temperature	T_m	297.9166667	uTm	2	k	0.67		<=1%
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	**kPa**	0.99		<=1%
Sampled gas Humidity	H_m	4.21	uH_m	1	**% by volume**	23.73		<=1%
Oxygen content	$O_{2,m}$	21	$uO_{2,m}$	0.1	**% by volume**	0.48		<=5%
Mass HCl	m	20748	um	1209.81	**ug**	5.83	1.48	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	2			**%**	2.00		<=2%
Uncollected Mass	UCM	0			**mg**	0		<=10%
Impinger Weight	Iw	1.3			**%**	1.3		<=5%

Intermediate calculations							
Factor for std conds	fs	0.88					
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**			
	ρ_m	0.009		0.009			
	H_m	0.009		0.009	$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$		
	T_m	0.003		0.006			
	ufs			0.014			1.59
Corrected volume	V	0.818	uV	0.012	**m^3**	$V = V_m f_s$	1.50
Factor for O2 correction	fc	1.00					
uncertainty components	symbol	**sensitivity coeff**		**u**			
	$O_{2,m}$	1.00		0.100	$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$		
Factor for O2 Correction	ufc	1.00		0.100			10.00

Parameter	**Uncertainty**	**Value**	**Units**	**Sensitivity coef**	**Uncertainty in Result**		**Uncertainty as %**	
Volume(standard conditions)	V	0.818	m^3	30.98	0.38	mg.m^{-3}	1.50	%
Mass HCl	m	20748.00	µg	1.00	1.48	mg.m^{-3}	5.83	%
Factor for O2 Correction	fc	1.00		0.00	0.00	mg.m^{-3}	0.00	%
Leak	L	0.29	mg.m^{-3}	1.00	0.29	mg.m^{-3}		
Uncollected mass	UCM	0.00	mg	1.00	0.00	mg.m^{-3}		
Impinger weight	I	0.19	mg.m^{-3}	1.00	0.19	mg.m^{-3}		
Combined uncertainty					**1.57**	**mg.m^{-3}**		

Expanded uncertainty	**expressed with a level of confidence of 95%**	**12.35**	**%**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**3.13**	**mg.m^{-3}**
Expanded uncertainty as percentage of limit value		**3.1**	**% of ELV**

Chloride Analysis Uncertainty

HCl Uncertainty	4.00	%
Volume Uncertainty	1	%
Uncertainty of HCl µg Calc	5.83	%

Uncertainty calculation for HCl Impingement Method

rec	**ME**	**Checked by:**	**DM**
Date:	**11/5/15**	**Date:**	**11/5/15**

Limit value	**100**	**mg.m^{-3}**	**Reference oxygen**	**21**	**% by volume**
Measured concentration	**25.35**	**mg.m^{-3}**			

Measurement Equation

$$c = \frac{m}{V} f_c$$

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**	**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume	V_m	0.881	uV_m	0.001	**m^3**	0.11		<=2%
Sampled gas Temperature	T_m	297.9166667	uTm	2	k	0.67		<=1%
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	**kPa**	0.99		<=1%
Sampled gas Humidity	H_m	4.21	uH_m	1	**% by volume**	23.73		<=1%
Oxygen content	$O_{2,m}$	21	$uO_{2,m}$	0.1	**% by volume**	0.48		<=5%
Mass HCl	m	20748	um	1209.81	**ug**	5.83	1.48	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	2			**%**	2.00		<=2%
Uncollected Mass	UCM	0			**mg**	0		<=10%
Impinger Weight	Iw	1.3			**%**	1.3		<=5%

Intermediate calculations						
Factor for std conds	fs	0.88				
uncertainty components	symbol	**sensitivity coeff**	**u (in units of fs)**			
	ρ_m	0.009	0.009			
	H_m	0.009	0.009	$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$		
	T_m	0.003	0.006			
	ufs		0.014			1.59
Corrected volume	V	0.818	uV 0.012	**m^3**	$V = V_m f_s$	1.50
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	**sensitivity coeff**	**u**			
	$O_{2,m}$	1.00	0.100		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
Factor for O2 Correction	ufc	1.00	0.100			10.00

Parameter	**Uncertainty, Value**		**Units**	**Sensitivity coeff**	**Uncertainty in Result**		**Uncertainty as %**
Volume(standard conditions)	V	0.818	m^3	30.98	0.38	mg.m^{-3}	1.50 %
Mass HCl	m	20748.00	µg	1.00	1.48	mg.m^{-3}	5.83 %
Factor for O2 Correction	fc	1.00		0.00	0.00	mg.m^{-3}	0.00 %
Leak	L	0.29	mg.m^{-3}	1.00	0.29	mg.m^{-3}	
Uncollected mass	UCM	0.00	mg	1.00	0.00	mg.m^{-3}	
Impinger weight	I	0.19	mg.m^{-3}	1.00	0.19	mg.m^{-3}	
Combined uncertainty					**1.57**	**mg.m^{-3}**	

Expanded uncertainty	**expressed with a level of confidence of 95%**	**12.35**	**%**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**3.13**	**mg.m^{-3}**
Expanded uncertainty as percentage of limit value		**3.1**	**% of ELV**

Chloride Analysis Uncertainty

HCl Uncertainty	4.00 %
Volume Uncertainty	1 %
Uncertainty of HCl µg Calc	5.83 %

Uncertainty calculation for EN 13284 Determination of low range mass concentration of dust, Manual Gravimetric Method

Spreadsheet completed by:	**ME**	**Checked by:**	**DM**
Date:	**11/5/15**	**Date:**	**11/5/15**

Limit value	200	**mg.m^{-3}**	**Reference oxygen**	21.0	**% by volume**
Measured concentration	89.93	**mg.m^{-3}**			

Measurement Equation

$$c = \frac{m}{V} f_c$$

Measured Quantities	Symbol	Value	Standard uncertainty		Units	Uncertainty as percentage	Uncertainty at lv	Requirement of std
Sampled Volume	V_m	0.881	uV_m	0.001	**m^3**	0.11		<=2%
Sampled gas Temperature	T_m	297.9166667	uTm	2	**K**	0.67		<=1%
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	**kPa**	0.99		<=1%
Sampled gas Humidity	H_m	4.214301132	uH_m	1	**% by volume**	23.73		<=1%
Oxygen content	$O_{2,m}$	21.0	$uO_{2,m}$	0.1	**% by volume**	0.48		<=5%
Mass particulate	m	73.6	um	0.522015325	**mg**	0.71	0.32	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	2			**%**	2.00		<=2%
Uncollected Mass (Instack filter - no rinse)	UCM	0			**mg**	0		<=10%

Intermediate calculations						
Factor for std conds	fs	0.878			$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$	
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**		
	ρ_m	0.009		0.009		
	H_m	0.009		0.009		
	T_m	0.003		0.006		
	ufs			0.014		1.59
Corrected volume	V	0.773	uV	0.012 **m^3**	$V = V_m f_s$	1.59
Factor for O2 correction	fc	1.00				
uncertainty components	symbol	**sensitivity coeff**		**u**		
	$O_{2,m}$	1.00		0.100	$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
Factor for O2 Correction	ufc	1.00		0.100		10.00

Parameter	Uncertainty, Value		Units	Sensitivity coeff	Uncertainty in Result		Uncertainty as %	
Volume(standard conditions)	V	0.773	m^3	116.30	1.43	mg.m^{-3}	1.59	%
Mass	m	73.60	mg	1.22	0.64	mg.m^{-3}	0.71	
Factor for O2 Correction	fc	1.00		0.00	0.00	mg.m^{-3}	0.00	%
Leak	L	1.04	mg.m^{-3}	1.00	1.04	mg.m^{-3}		
Uncollected mass	UCM	0.00	mg	1.22	0.00	mg.m^{-3}		
Combined uncertainty					**1.88**	mg.m^{-3}		

Expanded uncertainty	**expressed with a level of confidence of 95%**	**4.18**	**%**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**3.76**	**mg.m^{-3}**
Expanded uncertainty as percentage of limit value		**1.9**	**% of ELV**

Uncertainty calculation for Gaseous Measurement - VOCs

Completed by	**ME**	**11/5/15**		**Wood Burning Boiler**	**EM-02818**
Checked by	**DM**	**11/5/15**		**9/4/15**	**Alan Nuttall Ltd**
Limit value	100	**mg.m^{-3} (corrected) CO**	**Gas**	Propane CH3	
			Full Scale	10	**ppm**
Measured concentration	7.66	**ppm dry**	**Cal gas conc**	10	**ppm**
Measured concentration	12.31	**mg.m^{-3} (273K, 101.3kPa) CO**	**Conversion**	1.607142857	
			Full Scale	16.07142857	**mg.m^{-3} (CO)**
			Cal gas conc	15.91071429	**mg.m^{-3} (CO)**

Correction for reference conditions					
		O2, %	**Moisture, %**	**Pressure, KPa**	**Temperature, K**
	ref	21.00		101.30	**273.00**
	measured	21.00		101.30	**296.50**
Factors		1.00	1.00	1.00	1.09
Correction Factor		**1.09**			

Performance characteristics	**Value**			**specification**
Response time	23	seconds		180.000
Number of readings in measurement	61			
Repeatability at zero	0.1	% full scale		0.200
Repeatability at span level	0.1	% full scale		2.000
Deviation from linearity	1.0	% of value		2.000
Zero drift	0.2	% full scale		2.000
Span drift	0.2	% full scale		2.000
volume or pressure flow dependence	1.0	% of reading/10hPa		0.033
atmospheric pressure dependence	0.5	% of value/10hPa		0.750
ambient temperature dependence	2.0	% full scale/10K		0.300
NH3 (20 mg/m3)		mg/m3		
CO2 (15%)		% by vol		
H2O (30%)		% by vol		4.000
dependence on voltage	1.0	% full scale/10V		2%fs/10V
losses in the line (leak)	***1.5***	% of value		2% of value
Uncertainty of calibration gas	2.0	% of value		

Effect of drift	
0.06	mg/m3
0.46	% value

	ranges min	max	value at calib
flow	0.3	0.5	0.4
pressure	101.30	101.5	101.3
temp	283	289	283
NH3 range	0	0	0
CO2 range	0	0.5	0
H2O range	0	0.5	0
Instrument Voltage Rating			110
Voltage	104.5	115.5	110

Measurement performance related to stationary conditions

Performance characteristic		**Uncertainty**		**Value of uncertainty quantity**		
Standard deviation of repeatability at zero		u_{r0}		for mean		use rep at span
Standard deviation of repeatability at span level		u_{rs}		for mean		0.01
Lack of fit		u_{fit}				0.09
Drift		u_{0dr}				0.03
volume or pressure flow dependence		u_{spres}				0.00
atmopsheric pressure dependence		u_{apres}				0.01
ambient temperature dependence		u_{temp}				0.69
NH3 (20 mg/m3)		u_{interf}				0.00
CO2 (15%)						0.00
H2O (30%)						0.00
Dependence on voltage		u_{volt}				0.32
losses in the line (leak)		u_{leak}				0.11
Uncertainty of calibration gas		u_{calib}				0.14

Use largest negative or positive interferent effect	
0	0.00
0	0.00
0	0.00
0	0.00
Interference uncertainty	0.00

Measurement uncertainty		Result	12.31	mg/m^3
Combined uncertainty			0.79	mg/m^3
Expanded uncertainty	k =	2	1.58	mg/m^3
Uncertainty corrected to std conds			1.71	mg.m-3 (corrected)
Expanded uncertainty	**expressed with a level of confidence of 95%**		**1.71 % ELV**	
Expanded uncertainty	**expressed with a level of confidence of 95%**		**1.71 mg.m^{-3} at ELV**	

Uncertainty calculation for HCHO, DNPH Impingement Method

Spreadsheet completed by:	**ME**	**Checked by:**	**DM**
Date:	**11/5/15**	**Date:**	**11/5/15**

Limit value	**5**	**mg.m^{-3}**	**Reference oxygen**	**21**	**% by volume**
Measured concentration	**0.07**	**mg.m^{-3}**			

Measurement Equation

$$c = \frac{m}{V} f_c$$

Measured Quantities	**Symbol**	**Value**	**Standard uncertainty**		**Units**	**Uncertainty as percentage**	**Uncertainty at lv**	**Requirement of std**
Sampled Volume	V_m	0.8098	uV_m	0.001	**m^3**	0.12		<=2%
Sampled gas Temperature	T_m	302.4166667	uTm	2	k	0.66		<=1%
Sampled gas Pressure	ρ_m	101.3	$u\rho_m$	1	**kPa**	0.99		<=1%
Sampled gas Humidity	H_m	3.96	uH_m	1	**% by volume**	25.26		<=1%
Oxygen content	$O_{2,m}$	21	$uO_{2,m}$	0.1	**% by volume**	0.48		<=5%
Mass HCHO	m	49	um	3.55	**ug**	7.19	0.10	<5% of limit value
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	2			**%**	2.00		<=2%
Uncollected Mass	UCM	0			**mg**	0		<=10%
Impinger Weight	Iw	1.3			**%**	1.3		<=5%

Intermediate calculations							
Factor for std conds	fs	0.87					
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**			
	ρ_m	0.009		0.009			
	H_m	0.009		0.009	$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$		
	T_m	0.003		0.006			
	ufs			0.014			1.58
Corrected volume	V	0.739	uV	0.011	**m^3**	$V = V_m f_s$	1.51
Factor for O2 correction	fc	1.00					
uncertainty components	symbol	**sensitivity coeff**		**u**			
	$O_{2,m}$	1.00		0.100		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
Factor for O2 Correction	ufc	1.00		0.100			10.00

Parameter	**Uncertainty,**	**Value**	**Units**	**Sensitivity coeff**	**Uncertainty in Result**		**Uncertainty as %**	
Volume(standard conditions)	V	0.739	m^3	0.09	0.00	mg.m^{-3}	1.51	%
Mass HCHO	m	49.40	µg	1.00	0.00	mg.m^{-3}	7.19	%
Factor for O2 Correction	fc	1.00		0.00	0.00	mg.m^{-3}	0.00	%
Leak	L	0.00	mg.m^{-3}	1.00	0.00	mg.m^{-3}		
Uncollected mass	UCM	0.00	mg	1.00	0.00	mg.m^{-3}		
Impinger weight	I	0.00	mg.m^{-3}	1.00	0.00	mg.m^{-3}		
Combined uncertainty					**0.00**	**mg.m^{-3}**		

Expanded uncertainty	**expressed with a level of confidence of 95%**	**14.94**	**%**
Expanded uncertainty	**expressed with a level of confidence of 95%**	**0.01**	**mg.m^{-3}**

HCHO Analysis Uncertainty

HCHO mean	0.5017	mg/l (nominal 0.5 mg/l)
HCHO sd	0.0125	mg/l
HCHO Uncertainty	4.98	%
Volume Uncertainty	1	%
Uncertainty of HCHO µg Calc	7.19	%