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**Stack Emissions Testing Report Commissioned by**  
Alan Nuttall Partnership Ltd

**Installation Name & Address**  
Alan Nuttall Partnership Ltd  
National Works  
Hall Street  
Dudley  
West Midlands  
DY2 7DQ

PPC Permit: PB/23 Dudley MBC

**Stack Reference**  
Ranheat Wood Burning Boiler

**Dates of the Monitoring Campaign**  
12th October 2017

**Job Reference Number**  
CAT-3673

<b>Report Written by</b>
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<b>Report Approved by</b>
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<b>Report Date</b>
7th November 2017

<b>Version</b>
Version 1

<b>Signature of Report Approver</b>

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## Executive Summary

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### MONITORING OBJECTIVES

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler  
12th October 2017

#### Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by Alan Nuttall Partnership Ltd to carry out stack emissions testing on the Ranheat Wood Burning Boiler at West Midlands .

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Permit.

#### Special Requirements

There were no special requirements.

#### Target Parameters

Total Particulate Matter, Hydrogen Chloride, Hydrogen Cyanide, Formaldehyde, Total VOCs (as Carbon), Carbon Monoxide

## Executive Summary

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### MONITORING RESULTS

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler  
12th October 2017

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total Particulate Matter	<sup>1</sup> mg/m <sup>3</sup>	47.8	2.5	200	g/hr	58.0	4.9	-
Hydrogen Chloride	<sup>1</sup> mg/m <sup>3</sup>	2.3	0.16	100	g/hr	2.8	0.27	-
Hydrogen Cyanide	<sup>1</sup> mg/m <sup>3</sup>	< 0.16	0.03	5	g/hr	< 0.19	0.03	-
Formaldehyde	<sup>1</sup> mg/m <sup>3</sup>	< 0.06	0.01	5	g/hr	< 0.08	0.01	-
Total VOCs (as Carbon)	<sup>1</sup> mg/m <sup>3</sup>	1.8	0.41	20	g/hr	2.2	0.52	-
Carbon Monoxide	<sup>1</sup> mg/m <sup>3</sup>	162	4.6	250	g/hr	196	14.3	-
Water Vapour	% v/v	4.9	0.24					
Stack Gas Temperature	°C	113						
Stack Gas Velocity	m/s	12.8	0.64					
Volumetric Flow Rate (ACTUAL)	m <sup>3</sup> /hr	1755	118					
Volumetric Flow Rate (REF)	<sup>1</sup> m <sup>3</sup> /hr	1214	81.5					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM AN AVERAGE OF ALL OF THE ISOKINETIC RUNS.

<sup>1</sup> Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

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### MONITORING DATE(S) & TIMES

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler  
12th October 2017

Parameter	Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins	
Total Particulate Matter	R1	mg/m <sup>3</sup>	47.8	g/hr	58.0	12/10/2017	10:52 - 11:22	30
Hydrogen Chloride	R1	mg/m <sup>3</sup>	2.3	g/hr	2.8	12/10/2017	10:52 - 11:22	30
Hydrogen Cyanide	R1	mg/m <sup>3</sup>	< 0.16	g/hr	< 0.19	12/10/2017	12:17 - 12:57	30
Formaldehyde	R1	mg/m <sup>3</sup>	< 0.06	g/hr	< 0.08	12/10/2017	11:36 - 12:06	30
Total VOCs (as Carbon)	R1	mg/m <sup>3</sup>	1.8	g/hr	2.2	12/10/2017	10:50 - 11:50	60
Carbon Monoxide	R1	mg/m <sup>3</sup>	162	g/hr	196.5	12/10/2017	10:50 - 11:50	60
Velocity & Volumetric Flow Rate	R1				12/10/2017	09:48 - 10:00		

All results are expressed at the respective reference conditions.

## Executive Summary

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### PROCESS DETAILS

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler  
12th October 2017

#### Standard Operating Conditions

Parameter	Value
Process Status	Operational
Capacity (of 100%) and Tonnes / Hour	Normal Operation
Continuous or Batch Process	Continuous
Feedstock (if applicable)	Scrap Wood
Abatement System	None
Abatement System Running Status	N/A
Fuel	Natural Gas
Plume Appearance	Black Haze

## Executive Summary

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### MONITORING & ANALYTICAL METHODS

Alan Nuttall Partnership Ltd, West Midlands

Ranheat Wood Burning Boiler

12th October 2017

Parameter	Monitoring				Analysis				MCERTS Testing	LOD (Average)
	Standard	Technical Procedure	ISO 17025 Testing	Testing Lab	Analytical Procedure	Analytical Technique	ISO 17025 Analysis	Analysis Lab		
Total Particulate Matter	EN 13284-1	CAT-TP-01	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.32 mg/m <sup>3</sup>
Hydrogen Chloride	EN 1911	CAT-TP-11	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.04 mg/m <sup>3</sup>
Hydrogen Cyanide	US EPA OTM29	CAT-TP-12	Yes	CAT	W4	WC	Yes	RPS	Yes	0.16 mg/m <sup>3</sup>
Formaldehyde	US EPA M316	CAT-TP-19	Yes	CAT	CAT-AP-05	Vis-Spec	Yes	CAT	Yes	0.06 mg/m <sup>3</sup>
Water Vapour	EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.10 % v/v
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20	Yes	CAT	Flame Ionisation Detection by Sick 3006 FID				Yes	0.42 mg/m <sup>3</sup>
Carbon Monoxide	EN 15058	CAT-TP-39	Yes	CAT	NDIR by Horiba PG-350E				Yes	0.42 mg/m <sup>3</sup>
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	Yes	CAT	Pitot Tube and Thermocouple				Yes	1.2 m/s

### ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Exova Catalyst (CAT)	ISO 17025 Accreditation Number: 4279
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

### SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All Parameters	All	There are no deviations associated with the sampling employed.

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### SUITABILITY OF SAMPLING LOCATION

#### Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.22
Width	m	-
Area	m <sup>2</sup>	0.04
Port Depth	cm	9
Orientation of Duct	-	Vertical
Number of Ports	-	2
Sample Port Size	-	4" BSP

#### Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Temporary
Inside / Outside	Inside

#### Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	Yes
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

#### Sampling Location / Platform Improvement Recommendations

All platforms should be designed in accordance with the requirements in the Environment Agency's Technical Guidance Note M1 and EN 15259.

#### EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

#### Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	104.0	> 5 Pa	Yes
Mean Velocity	m/s	12.51	-	-
Lowest Gas Velocity	m/s	12.51	-	-
Highest Gas Velocity	m/s	12.51	-	-
Ratio of Above	: 1	1.00	< 3 : 1	Yes
Maximum Angle of Swirl	°	0	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes



# Executive Summary

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## PLANT PHOTOS

Photo 1



Photo 2



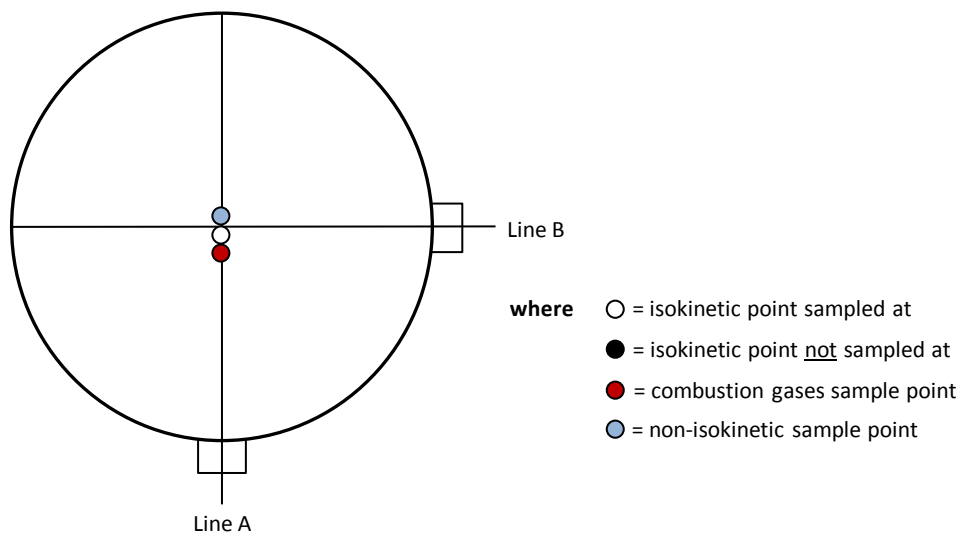
Photo 3



Photo 4



## SAMPLE POINTS



## APPENDICES

### APPENDIX CONTENTS

APPENDIX 1 - Stack Emissions Monitoring Personnel, List of Equipment & Methods and Technical Procedures Used

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

**STACK EMISSIONS MONITORING PERSONNEL**

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	David Burns	MCERTS Level 2	MM 05 579	TE1 TE2 TE3 TE4
Team Leader	Bill Trueman	MCERTS Level 1	MM 06 753	None

**LIST OF EQUIPMENT**

Extractive Sampling		Instrumental Analysers		Miscellaneous Items	
Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.
Control Box DGM (1)	CAT 7.58	Horiba PG-350E	CAT 39.11	Digital Manometer (1)	CAT 3.143
Control Box DGM (2)	-	Horiba PG-250	-	Digital Manometer (2)	CAT 3.145
Box Thermocouples (1)	CAT 3.148	Servomex 4900	-	Digital Temperature Meter	-
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 14.86
Umbilical (1)	CAT 3.148	ABB AO2020-URAS26	-	Barometer	CAT 13.41
Umbilical (2)	-	Servomex 5200MP	-	Stack Thermocouple (1)	CAT 4.846
Oven Box (1)	CAT 12.201	Ankersmid APS 313	CAT 4.848	Stack Thermocouple (2)	CAT 4.849
Oven Box (2)	-	Gasmex DX4000	-	Stack Thermocouple (3)	CAT 4.016
Heated Probe (1)	CAT 5.129	Gasmex Sampling System	-	1m Heated Line (1)	-
Heated Probe (2)	CAT 5.130	Bernath 3006 FID	CAT 8.32	1m Heated Line (2)	-
Heated Probe (3)	CAT 5.131	M&C PSS	CAT 12.108	1m Heated Line (3)	-
S-Pitot (1)	CAT 21P.97	Mass Flow Controller (1)	CAT 6.63	5m Heated Line (1)	-
S-Pitot (2)	CAT 21S.56	Mass Flow Controller (2)	CAT 6.64	15m Heated Line (1)	-
L-Pitot	-	Mass View (1)	CAT 25.61	20m Heated Line (1)	CAT 20.119
Site Balance	CAT 17.38	Mass View (2)	CAT 25.62	20m Heated Line (2)	-
500g / 1Kg Check Weights	CAT 17.38	Hioki 5043 (V)	CAT 11.70	Dual Channel Heater Controller	CAT 3.002
Last Impinger Arm	CAT 4.902/4.903	Easylogger EN-EL-12 Bit	-	Single Channel Heater Controller	CAT 20.119
Callipers	CAT 23.41	Bioaerosols Temperature Logger	-	Laboratory Balance	CAT 1.18 / 1.18a
Tubes Kit Thermocouple	-	Electronic Refrigerator	-	Tape Measure	CAT 16.49

**METHODS & TECHNICAL PROCEDURES USED**

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	CAT-TP-01
Hydrogen Chloride	EN 1911	CAT-TP-11
Hydrogen Cyanide	US EPA OTM29	CAT-TP-12
Formaldehyde	US EPA M316	CAT-TP-19
Water Vapour	EN 14790	CAT-TP-05
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20
Carbon Monoxide	EN 15058	CAT-TP-39
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

## PRELIMINARY STACK SURVEY: CALCULATIONS

### General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.22
Stack Width, W	m	-
Stack Area, A	m <sup>2</sup>	0.04
Average Stack Gas Temperature, T <sub>a</sub>	°C	102.0
Average Stack Gas Pressure	Pa	104.0
Average Stack Static Pressure, P <sub>static</sub>	kPa	0.088
Average Barometric Pressure, P <sub>b</sub>	kPa	99.1
Average Pitot Tube Calibration Coefficient, C <sub>p</sub>	-	0.83

### Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m <sup>3</sup> p	Conc kg/m <sup>3</sup> p <sub>i</sub>
CO <sub>2</sub> (Estimated)	-	3.70	3.52	0.0370	44.01	1.9635	0.07265
O <sub>2</sub> (Estimated)	-	17.00	16.16	0.1700	32.00	1.4277	0.24271
N <sub>2</sub>	-	79.30	75.39	0.7930	28.01	1.2498	0.99113
Moisture (H <sub>2</sub> O)	-	-	4.93	0.0493	18.02	0.8037	0.03960

Where:  $p = M / 22.41$   
 $p_i = r \times p$

### Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P <sub>STD</sub>	kg/m <sup>3</sup>	1.306
Wet Density (STP), P <sub>STW</sub>	kg/m <sup>3</sup>	1.282
Dry Density (Actual), P <sub>Actual</sub>	kg/m <sup>3</sup>	0.931
Average Wet Density (Actual), P <sub>ActualW</sub>	kg/m <sup>3</sup>	0.914

Where: P<sub>STD</sub> = sum of component concentrations, kg/m<sup>3</sup> (not including water vapour)  
P<sub>STW</sub> = sum of all wet concentrations / 100 x density, kg/m<sup>3</sup> (including water vapour)  
 $P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$   
 $P_{ActualW} \text{ (at each sampling point)} = P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

### Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF <sup>1</sup>
Temperature	°C	102.0	0.0
Total Pressure	kPa	99.2	101.3
Moisture	%	4.93	4.93

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m <sup>3</sup> /hr	1713
Gas Volumetric Flowrate (STP, Wet)	m <sup>3</sup> /hr	1221
Gas Volumetric Flowrate (STP, Dry)	m <sup>3</sup> /hr	1161
Gas Volumetric Flowrate REF <sup>1</sup>	m <sup>3</sup> /hr	1221

**PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)**

(1 of 1)

Parameter	Units	Value
Date of Survey	-	12/10/2017
Time of Survey	-	09:48 - 10:00
Atmospheric Pressure	kPa	99.1
Average Stack Static Pressure	Pa	88
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 210 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C <sub>p</sub>	-	0.83
Number of Lines Available	-	2
Number of Lines Used	-	1

Sampling Line A							Sampling Line B - Not required				
Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m <sup>3</sup>	Velocity m/s	Swirl °	ΔP	Temp °C	Wet Density kg/m <sup>3</sup>	Velocity m/s	Swirl °
<i>STATIC (Units: Pa)</i>		88.0									
<b>Mean</b>		<b>104.0</b>	<b>102.0</b>	<b>0.914</b>	<b>12.51</b>						
1	0.11	104.0	102.0	0.914	12.51	0.0					

**PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY**

(1 of 1)

<b>Performance characteristics (Uncertainty Components)</b>	<b>Uncertainty</b>	<b>Value</b>	<b>Units</b>
Standard Uncertainty on the coefficient of the Pitot Tube	$u(k)$	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	$u(\Delta p_i)$	2.014	Pa
- Resolution	$u(res)$	0.00087	
- Calibration	$u(cal)$	1.126	
- Drift	$u(drift)$	0.083	
- Lack of Fit	$u(fit)$	1.845	
- Overall corrections to dynamic measurements	$u(C_f)$	3.055	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00004	-
- $\varphi_{O_2,w}$	-	16.162	
- $\varphi_{CO_2,w}$	-	3.518	
- Oxygen, dry	$u(\phi_{O_2,d})$	0.520	
- Carbon Dioxide, dry	$u(\phi_{CO_2,d})$	0.113	
- Water Vapour	$u(\phi_{H_2O})$	0.251	
- Oxygen, wet	$u(\phi_{O_2,w})$	0.497	
- Carbon Dioxide, wet	$u(\phi_{CO_2,w})$	0.108	
Standard uncertainty associated with the stack temperature	$u(T_c)$	1.913	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.704	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	2.014	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00493	-
Standard uncertainty associated with the local velocities	$u(v_i)$	0.316	Pa
Standard uncertainty associated with the mean velocity	$u(\underline{v})$	0.316	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	0.620	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	4.95	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV,w)$	114.9	m <sup>3</sup> /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00117	
- $u^2(qV,w)$	-	3438	
- $u(qV,w)$	-	58.6	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV,w)$	6.71	%

**TOTAL PARTICULATE MATTER: RESULTS SUMMARY**

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler

**Sample Runs**

Parameter	Units	Run 1	Mean
Concentration	mg/m <sup>3</sup>	47.8	47.8
Uncertainty	±mg/m <sup>3</sup>	2.5	2.5
Mass Emission	g/hr	58.0	58.0
Uncertainty	±g/hr	4.9	4.9

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	4.7	4.7
Uncertainty	±% v/v	0.24	0.24

**Blank Runs**

Parameter	Units	Blank 1	Maximum
Concentration	mg/m <sup>3</sup>	0.48	0.48

**General Sampling Information**

Parameter	Value
Standard	EN 13284-1
Technical Procedure	CAT-TP-01
Probe Material	Titanium
Filter Housing Material	Titanium
Positioning of Filter	In Stack
Filter Size and Material	47mm Glass Fibre
Number of Sampling Lines Used	1 / 1
Number of Sampling Points Used	1 / 1
Sample Point I.D.'s	A1

FORMAT: Number Used / Number Required

**Reference Conditions**

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

**TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS**

Test	Units	Run 1	
<b>Absolute pressure of stack gas, P<sub>s</sub></b>			
Barometric pressure, P <sub>b</sub>	mmHg	743.3	
Stack static pressure, P <sub>static</sub>	mmH <sub>2</sub> O	9.0	
P <sub>s</sub> = (P <sub>b</sub> + (P <sub>static</sub> / 13.6))	mmHg	743.9	
<b>Volume of water vapour collected, V<sub>wstd</sub></b>			
Total mass collected in impingers (liquid trap)	g	12.4	
Total mass collected in impingers (silica trap)	g	4.2	
Total mass of liquid collected, V <sub>lc</sub>	g	16.6	
V <sub>wstd</sub> = (0.001246)(V <sub>lc</sub> )	m <sup>3</sup>	0.0207	
<b>Volume of gas metered dry, V<sub>mstd</sub></b>			
Volume of gas sample through gas meter, V <sub>m</sub>	m <sup>3</sup>	0.4520	
Gas meter correction factor, Y <sub>d</sub>	-	1.0030	
Average dry gas meter temperature, T <sub>m</sub>	°C	13.5	
Average pressure drop across orifice, ΔH	mmH <sub>2</sub> O	26.6	
V <sub>mstd</sub> = ((0.3592)(V <sub>m</sub> )(P <sub>b</sub> + (ΔH/13.6))(Y <sub>d</sub> )) / (T <sub>m</sub> + 273)	m <sup>3</sup>	0.4236	
<b>Moisture content, B<sub>wv</sub> &amp; R<sub>wv</sub></b>			
B <sub>wv</sub> = V <sub>wstd</sub> / (V <sub>mstd</sub> + V <sub>wstd</sub> )	m <sup>3</sup>	0.0466	
B <sub>wv</sub> as a percentage	% v/v	4.66	
Reported Water Vapour, checked with Tables in EN 14790, R <sub>wv</sub>	% v/v	4.66	
<b>Volume of gas metered wet, V<sub>mstw</sub></b>			
V <sub>mstw</sub> = (V <sub>mstd</sub> )(100/(100 - R <sub>wv</sub> ))	m <sup>3</sup>	0.4443	
<b>Volume of gas metered at Oxygen Reference Conditions, V<sub>mstd@X%O<sub>2</sub></sub> &amp; V<sub>mstw@X%O<sub>2</sub></sub></b>			
IED & Incinerates Hazardous Material? (Yes = no positive O <sub>2</sub> correction)	-	No	
% wet oxygen measured in gas stream, ACT%O <sub>2w</sub>	% v/v	N/A	
% dry oxygen measured in gas stream, ACT%O <sub>2d</sub>	% v/v	N/A	
% oxygen reference condition, REF%O <sub>2</sub>	% v/v	N/A	
O <sub>2</sub> Reference Factor wet (O <sub>2REFw</sub> ) = (21 - REF%O <sub>2</sub> ) / (21 - ACT%O <sub>2w</sub> )	-	N/A	
O <sub>2</sub> Reference Factor dry (O <sub>2REFd</sub> ) = (21 - REF%O <sub>2</sub> ) / (21 - ACT%O <sub>2d</sub> )	-	N/A	
V <sub>mstw@X%oxygen</sub> = (V <sub>mstw</sub> ) / (O <sub>2REFw</sub> )	m <sup>3</sup>	N/A	
V <sub>mstd@X%oxygen</sub> = (V <sub>mstd</sub> ) / (O <sub>2REFd</sub> )	m <sup>3</sup>	N/A	
<b>Molecular weight of dry gas stream, M<sub>d</sub></b>			
CO <sub>2</sub> (Estimated)	% v/v	3.70	
O <sub>2</sub> (Estimated)	% v/v	17.00	
Total	% v/v	20.70	
N <sub>2</sub>	% v/v	79.30	
M <sub>d</sub> = 0.44(%CO <sub>2</sub> )+0.32(%O <sub>2</sub> )+0.28(%N <sub>2</sub> )	g/gmol	29.27	
<b>Molecular weight of stack gas (wet), M<sub>s</sub></b>			
M <sub>s</sub> = M <sub>d</sub> (1 - (R <sub>wv</sub> /100)) + 18(R <sub>wv</sub> /100)	g/gmol	28.75	
<b>Velocity of stack gas, V<sub>s</sub></b>			
Pitot tube velocity constant, K <sub>p</sub>	-	34.97	
Velocity pressure coefficient, C <sub>p</sub>	-	0.84	
Average of velocity heads, ΔP <sub>avg</sub>	mmH <sub>2</sub> O	10.45	
Average square root of velocity heads, √ΔP	√mmH <sub>2</sub> O	3.23	
Average stack gas temperature, T <sub>s</sub>	°C	113.3	
V <sub>s</sub> = ((K <sub>p</sub> )(C <sub>p</sub> )(√ΔP)(√T <sub>s</sub> + 273)) / (√(M <sub>s</sub> )(P <sub>s</sub> ))	m/s	12.82	
<b>Total flow of stack gas: Actual (Q<sub>a</sub>), Wet (Q<sub>stw</sub>), Dry (Q<sub>std</sub>), Wet@O<sub>2REF</sub> (Q<sub>stwO<sub>2</sub></sub>), Dry@O<sub>2REF</sub> (Q<sub>stdO<sub>2</sub></sub>)</b>			
Area of stack, A <sub>s</sub>	m <sup>2</sup>	0.04	
Q <sub>a</sub> = (60)(A <sub>s</sub> )(V <sub>s</sub> )	m <sup>3</sup> /min	29.3	
Conversion factor (K/mm.Hg), C <sub>f</sub>	-	0.3592	
Q <sub>stw</sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )) / ((T <sub>s</sub> + 273))	m <sup>3</sup> /min	20.2	
Q <sub>std</sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )(1 - (R <sub>wv</sub> /100))) / ((T <sub>s</sub> + 273))	m <sup>3</sup> /min	19.3	
Q <sub>stwO<sub>2</sub></sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )) / ((T <sub>s</sub> + 273)) / (O <sub>2REFw</sub> )	m <sup>3</sup> /min	N/A	
Q <sub>stdO<sub>2</sub></sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )(1 - (R <sub>wv</sub> /100))) / ((T <sub>s</sub> + 273)) / (O <sub>2REFd</sub> )	m <sup>3</sup> /min	N/A	
<b>Percent isokinetic, %I</b>			
Nozzle diameter, D <sub>n</sub>	mm	5.95	
Nozzle area, A <sub>n</sub>	mm <sup>2</sup>	27.78	
Total sampling time, q	min	30	
%I = (4.6398E <sup>6</sup> )(T <sub>s</sub> +273)(V <sub>mstd</sub> ) / (P <sub>s</sub> )(V <sub>s</sub> )(A <sub>n</sub> )(q)(1 - (R <sub>wv</sub> /100))	%	100.2	



**TOTAL PARTICULATE MATTER: SAMPLING DETAILS**

**Sample Runs**

Parameter	Units	Run 1
Sampling Times	-	10:52 - 11:22
Sampling Dates	-	12/10/2017
Sampling Device	-	ISO
Volume Sampled (REF)	m <sup>3</sup>	0.4443
Filter I.D. Number	-	47-41441
Start Filter Mass	g	0.15431
End Filter Mass	g	0.17366
Total Mass on Filter	g	0.01935
Probe Rinse I.D. Number	-	PR-47-41441
Start Probe Rinse Mass	g	2.84894
End Probe Rinse Mass	g	2.85082
Total Mass in Probe Rinse	g	0.00187
Total Mass Collected	mg	21.22
Calculated Concentration	mg/m <sup>3</sup>	47.76
Balance Uncertainty / LOD	mg/m <sup>3</sup>	0.32

**Where:** ISO stands for Manual Isokinetic Sampling Train

**Blank Runs**

Parameter	Units	Blank 1
Blank Dates	-	12/10/2017
Average Volume Sampled (REF)	m <sup>3</sup>	0.4443
Filter I.D. Number	-	47-41440
Start Filter Mass	g	0.15493
End Filter Mass	g	0.15495
Total Mass on Filter	g	0.00002
Probe Rinse I.D. Number	-	PR-47-41440
Start Probe Rinse Mass	g	2.83718
End Probe Rinse Mass	g	2.83738
Total Mass in Probe Rinse	g	0.00019
Total Mass Collected	mg	0.21
Calculated Concentration	mg/m <sup>3</sup>	0.48
Balance Uncertainty / LOD	mg/m <sup>3</sup>	0.32

**TOTAL PARTICULATE MATTER: QUALITY ASSURANCE**

(PAGE 1 OF 2)

**Sample Runs**

<b>Leak Test Results</b>	<b>Units</b>	<b>Run 1</b>	
Mean Sampling Rate	l/min	15.11	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.30	
Leak Test Acceptable	-	Yes	

<b>Water Droplets</b>	<b>Units</b>	<b>Run 1</b>	
Are Water Droplets Present	-	No	

<b>MU (Concurrent Water Vapour)</b>	<b>Units</b>	<b>Run 1</b>	
Measurement Uncertainty (MU)	%	5.2	
Allowable MU	%	20	
MU Acceptable	%	Yes	

<b>Silica Gel (Concurrent Water Vapour)</b>	<b>Units</b>	<b>Run 1</b>	
Less than 50% Faded	%	Yes	

<b>Isokinetic Criterion Compliance</b>	<b>Units</b>	<b>Run 1</b>	
Isokinetic Variation	%	100.2	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

<b>Weighing Uncertainty Criteria</b>	<b>Units</b>	<b>Run 1</b>	
Overall Weighing Uncertainty	± mg	0.25	
Overall Weighing Uncertainty	± mg/m <sup>3</sup>	0.57	
ELV [Daily ELV for IED]	mg/m <sup>3</sup>	200.00	
Allowable Weighing Uncertainty	mg/m <sup>3</sup>	10.00	
Weighing Uncertainty Acceptable	-	Yes	

<b>Filter Temperatures</b>	<b>Units</b>	<b>Run 1</b>	
Pre-Conditioning Temperature	°C	180	
Post-Conditioning Temperature	°C	160	
Maximum Filter Temperature	°C	130	

<b>Test Conditions</b>	<b>Units</b>	<b>Run 1</b>	
Ambient Temperature Recorded?	-	Yes	

**TOTAL PARTICULATE MATTER: QUALITY ASSURANCE**

(PAGE 2 OF 2)

**Blank Runs**

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	20.00	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.40	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m <sup>3</sup>	20.0	
Blank Acceptable	-	Yes	

Acetone / Water Rinse Blank	Units	Blank
Acetone / Water Rinse Value	mg/l	2.7
Allowable Blank	mg/l	10
Blank Acceptable	-	Yes

**Method Deviations**

Nature of Deviation	Run Number
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1
There are no deviations associated with the sampling employed.	wx

**TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS**

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V <sub>m</sub>	0.4520		uV <sub>m</sub>	m <sup>3</sup>	0.0090	
Sampled Gas Temperature	T <sub>m</sub>	286.5		uT <sub>m</sub>	K	2.0	
Sampled Gas Pressure	p <sub>m</sub>	99.2		up <sub>m</sub>	kPa	0.5	
Sampled Gas Humidity	H <sub>m</sub>	0.0		uH <sub>m</sub>	% v/v	1.0	
Leak	L	0.00		uL	%	-	
Mass of Particulate	m	21.22		um	mg	0.14	
Uncollected Mass	UCM	0.21		uUCM	mg	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.70		≤1%
Sampled Gas Pressure	%	0.50		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.00		≤2%
Mass of Particulate	%	0.16		<5% of ELV
Uncollected Mass	%	-		-

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V <sub>m</sub>	m <sup>3</sup>	0.4236		112.76	
Leak	L	mg/m <sup>3</sup>	0.000		1.00	
Mass of Particulate	L <sub>r</sub>	mg	21.220		2.25	
Uncollected Mass	UCM	mg	0.12		2.25	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m <sup>3</sup>	1.199	
Leak	mg/m <sup>3</sup>	0.0000	
Mass of Particulate	mg/m <sup>3</sup>	0.3151	
Uncollected Mass	mg/m <sup>3</sup>	0.2772	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O <sub>2</sub> Correction Factor	-	N/A	
Stack Gas O <sub>2</sub> Content	% v/v	N/A	
MU for O <sub>2</sub> Correction	-	N/A	
Overall MU For O <sub>2</sub> Measurement	%	N/A	

Parameter	Units	Run 1	
Combined uncertainty	mg/m <sup>3</sup>	1.27	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m <sup>3</sup>	2.49	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m <sup>3</sup>	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m <sup>3</sup>	2.49	
Reported Uncertainty	mg/m <sup>3</sup>	2.49	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	5.2	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	5.2	
Reported Uncertainty	%	5.2	

## HYDROGEN CHLORIDE: RESULTS SUMMARY

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler

### Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m <sup>3</sup>	2.3	2.3
Uncertainty	±mg/m <sup>3</sup>	0.16	0.16
Mass Emission	g/hr	2.8	2.8
Uncertainty	±g/hr	0.27	0.27

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	4.7	4.7
Uncertainty	±% v/v	0.24	0.24

### Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m <sup>3</sup>	2.3	2.3

### General Sampling Information

Parameter	Value	
Standard	EN 1911	
Technical Procedure	CAT-TP-11	
Name of Analytical Laboratory	CAT	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	18/10/2017	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Polyethylene	
Absorption Solution	HPLC Grade Water	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Glass Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

### Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

**HYDROGEN CHLORIDE: ISOKINETIC SAMPLING CALCULATIONS**

Test	Units	Run 1	
<b>Absolute pressure of stack gas, P<sub>s</sub></b>			
Barometric pressure, P <sub>b</sub>	mmHg	743.3	
Stack static pressure, P <sub>static</sub>	mmH <sub>2</sub> O	9.0	
P <sub>s</sub> = (P <sub>b</sub> + (P <sub>static</sub> / 13.6))	mmHg	743.9	
<b>Volume of water vapour collected, V<sub>wstd</sub></b>			
Total mass collected in impingers (liquid trap)	g	12.4	
Total mass collected in impingers (silica trap)	g	4.2	
Total mass of liquid collected, V <sub>lc</sub>	g	16.6	
V <sub>wstd</sub> = (0.001246)(V <sub>lc</sub> )	m <sup>3</sup>	0.0207	
<b>Volume of gas metered dry, V<sub>mstd</sub></b>			
Volume of gas sample through gas meter, V <sub>m</sub>	m <sup>3</sup>	0.4520	
Gas meter correction factor, Y <sub>d</sub>	-	1.0030	
Average dry gas meter temperature, T <sub>m</sub>	°C	13.5	
Average pressure drop across orifice, ΔH	mmH <sub>2</sub> O	26.6	
V <sub>mstd</sub> = ((0.3592)(V <sub>m</sub> )(P <sub>b</sub> + (ΔH/13.6))(Y <sub>d</sub> )) / (T <sub>m</sub> + 273)	m <sup>3</sup>	0.4236	
<b>Moisture content, B<sub>wv</sub> &amp; R<sub>wv</sub></b>			
B <sub>wv</sub> = V <sub>wstd</sub> / (V <sub>mstd</sub> + V <sub>wstd</sub> )	m <sup>3</sup>	0.0466	
B <sub>wv</sub> as a percentage	% v/v	4.66	
Reported Water Vapour, checked with Tables in EN 14790, R <sub>wv</sub>	% v/v	4.66	
<b>Volume of gas metered wet, V<sub>mstw</sub></b>			
V <sub>mstw</sub> = (V <sub>mstd</sub> )(100/(100 - R <sub>wv</sub> ))	m <sup>3</sup>	0.4443	
<b>Volume of gas metered at Oxygen Reference Conditions, V<sub>mstd@X%O<sub>2</sub></sub> &amp; V<sub>mstw@X%O<sub>2</sub></sub></b>			
IED & Incinerates Hazardous Material? (Yes = no positive O <sub>2</sub> correction)	-	No	
% wet oxygen measured in gas stream, ACT%O <sub>2w</sub>	% v/v	N/A	
% dry oxygen measured in gas stream, ACT%O <sub>2d</sub>	% v/v	N/A	
% oxygen reference condition, REF%O <sub>2</sub>	% v/v	N/A	
O <sub>2</sub> Reference Factor wet (O <sub>2REFw</sub> ) = (21 - REF%O <sub>2</sub> ) / (21 - ACT%O <sub>2w</sub> )	-	N/A	
O <sub>2</sub> Reference Factor dry (O <sub>2REFd</sub> ) = (21 - REF%O <sub>2</sub> ) / (21 - ACT%O <sub>2d</sub> )	-	N/A	
V <sub>mstw@X%oxygen</sub> = (V <sub>mstw</sub> ) / (O <sub>2REFw</sub> )	m <sup>3</sup>	N/A	
V <sub>mstd@X%oxygen</sub> = (V <sub>mstd</sub> ) / (O <sub>2REFd</sub> )	m <sup>3</sup>	N/A	
<b>Molecular weight of dry gas stream, M<sub>d</sub></b>			
CO <sub>2</sub> (Estimated)	% v/v	3.70	
O <sub>2</sub> (Estimated)	% v/v	17.00	
Total	% v/v	20.70	
N <sub>2</sub>	% v/v	79.30	
M <sub>d</sub> = 0.44(%CO <sub>2</sub> )+0.32(%O <sub>2</sub> )+0.28(%N <sub>2</sub> )	g/gmol	29.27	
<b>Molecular weight of stack gas (wet), M<sub>s</sub></b>			
M <sub>s</sub> = M <sub>d</sub> (1 - (R <sub>wv</sub> /100)) + 18(R <sub>wv</sub> /100)	g/gmol	28.75	
<b>Velocity of stack gas, V<sub>s</sub></b>			
Pitot tube velocity constant, K <sub>p</sub>	-	34.97	
Velocity pressure coefficient, C <sub>p</sub>	-	0.84	
Average of velocity heads, ΔP <sub>avg</sub>	mmH <sub>2</sub> O	10.45	
Average square root of velocity heads, √ΔP	√mmH <sub>2</sub> O	3.23	
Average stack gas temperature, T <sub>s</sub>	°C	113.3	
V <sub>s</sub> = ((K <sub>p</sub> )(C <sub>p</sub> )(√ΔP)(√T <sub>s</sub> + 273)) / (√(M <sub>s</sub> )(P <sub>s</sub> ))	m/s	12.82	
<b>Total flow of stack gas: Actual (Q<sub>a</sub>), Wet (Q<sub>stw</sub>), Dry (Q<sub>std</sub>), Wet@O<sub>2REF</sub> (Q<sub>stwO<sub>2</sub></sub>), Dry@O<sub>2REF</sub> (Q<sub>stdO<sub>2</sub></sub>)</b>			
Area of stack, A <sub>s</sub>	m <sup>2</sup>	0.04	
Q <sub>a</sub> = (60)(A <sub>s</sub> )(V <sub>s</sub> )	m <sup>3</sup> /min	29.3	
Conversion factor (K/mm.Hg), C <sub>f</sub>	-	0.3592	
Q <sub>stw</sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )) / ((T <sub>s</sub> + 273)	m <sup>3</sup> /min	20.2	
Q <sub>std</sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )(1 - (R <sub>wv</sub> /100))) / ((T <sub>s</sub> + 273)	m <sup>3</sup> /min	19.3	
Q <sub>stwO<sub>2</sub></sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )) / ((T <sub>s</sub> + 273) / (O <sub>2REFw</sub> ))	m <sup>3</sup> /min	N/A	
Q <sub>stdO<sub>2</sub></sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )(1 - (R <sub>wv</sub> /100))) / ((T <sub>s</sub> + 273) / (O <sub>2REFd</sub> ))	m <sup>3</sup> /min	N/A	
<b>Percent isokinetic, %I</b>			
Nozzle diameter, D <sub>n</sub>	mm	5.95	
Nozzle area, A <sub>n</sub>	mm <sup>2</sup>	27.78	
Total sampling time, q	min	30	
%I = (4.6398E <sup>6</sup> )(T <sub>s</sub> +273)(V <sub>mstd</sub> ) / (P <sub>s</sub> )(V <sub>s</sub> )(A <sub>n</sub> )(q)(1 - (R <sub>wv</sub> /100))	%	100.2	

## HYDROGEN CHLORIDE: SAMPLING DETAILS

### Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	10:52 - 11:22	
Sampling Dates	-	12/10/2017	
Sampling Device	-	ISO	
Volume Sampled (REF)	m <sup>3</sup>	0.4443	
Laboratory Result for Front Impingers	µg/ml	1.22	
Laboratory Result for Back Impinger	µg/ml	0.44	
Volume in Front Impingers	ml	256.0	
Volume in Back Impinger	ml	122.0	
Mass in Front Impingers	µg	312.3	
Mass in Back Impinger	µg	53.7	
Total Mass Collected	µg	366.0	
Calculated Concentration	mg/m <sup>3</sup>	0.82	

**Where:** ISO stands for Manual Isokinetic Sampling Train

### Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	12/10/2017	
Average Volume Sampled (REF)	m <sup>3</sup>	0.4443	
Laboratory Result for Impingers	µg/ml	2.71	
Volume in Impingers	ml	377.0	
Total Mass Collected	µg	1021.7	
Calculated Concentration	mg/m <sup>3</sup>	2.30	

**HYDROGEN CHLORIDE: QUALITY ASSURANCE**

(PAGE 1 OF 2)

**Sample Runs**

<b>Leak Test Results</b>	<b>Units</b>	<b>Run 1</b>	
Mean Sampling Rate	l/min	15.11	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.30	
Leak Test Acceptable	-	Yes	

<b>Absorption Efficiency</b>	<b>Units</b>	<b>Run 1</b>	
Absorption Efficiency	%	85.3	
Allowable Absorption Efficiency	%	N/A <sup>1</sup>	
Absorption Efficiency Acceptable	-	N/A <sup>1</sup>	

<sup>1</sup> The concentration in the last absorber was less than 5 times the analytical detection limit.

<b>Water Droplets</b>	<b>Units</b>	<b>Run 1</b>	
Are Water Droplets Present	-	No	

<b>MU (Concurrent Water Vapour)</b>	<b>Units</b>	<b>Run 1</b>	
Measurement Uncertainty (MU)	%	5.2	
Allowable MU	%	20	
MU Acceptable	%	Yes	

<b>Silica Gel (Concurrent Water Vapour)</b>	<b>Units</b>	<b>Run 1</b>	
Less than 50% Faded	%	Yes	

<b>Isokinetic Criterion Compliance</b>	<b>Units</b>	<b>Run 1</b>	
Isokinetic Variation	%	100.2	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

<b>Filter Temperatures</b>	<b>Units</b>	<b>Run 1</b>	
Maximum Filter Temperature	°C	113	

<b>Test Conditions</b>	<b>Units</b>	<b>Run 1</b>	
Ambient Temperature Recorded?	-	Yes	



**HYDROGEN CHLORIDE: QUALITY ASSURANCE**

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**Blank Runs**

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	20.00	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.40	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m <sup>3</sup>	10.0	
Blank Acceptable	-	Yes	

**Method Deviations**

Nature of Deviation	Run Number
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1
There are no deviations associated with the sampling employed.	wx

**HYDROGEN CHLORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS**

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V <sub>m</sub>	0.4520		uV <sub>m</sub>	m <sup>3</sup>	0.0090	
Sampled Gas Temperature	T <sub>m</sub>	286.5		uT <sub>m</sub>	K	2.0	
Sampled Gas Pressure	p <sub>m</sub>	99.2		up <sub>m</sub>	kPa	0.5	
Sampled Gas Humidity	H <sub>m</sub>	0.0		uH <sub>m</sub>	% v/v	1.0	
Leak	L	0.00		uL	%	-	
Laboratory Result	L <sub>r</sub>	2.50		uL <sub>r</sub>	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.70		≤1%
Sampled Gas Pressure	%	0.50		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.00		≤2%
Laboratory Result	%	2.50		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V <sub>m</sub>	m <sup>3</sup>	0.4236		5.43	
Leak	L	mg/m <sup>3</sup>	0.0000		1.00	
Laboratory Result	L <sub>r</sub>	mg/m <sup>3</sup>	0.057		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m <sup>3</sup>	0.0577	
Leak	mg/m <sup>3</sup>	0.000	
Laboratory Result	mg/m <sup>3</sup>	0.057	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O <sub>2</sub> Correction Factor	-	N/A	
Stack Gas O <sub>2</sub> Content	% v/v	N/A	
MU for O <sub>2</sub> Correction	-	N/A	
Overall MU For O <sub>2</sub> Measurement	%	N/A	

Parameter	Units	Run 1	
Combined uncertainty	mg/m <sup>3</sup>	0.08	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m <sup>3</sup>	0.16	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m <sup>3</sup>	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m <sup>3</sup>	0.16	
Reported Uncertainty	mg/m <sup>3</sup>	0.16	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	6.9	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	6.9	
Reported Uncertainty	%	6.9	

## HYDROGEN CYANIDE: RESULTS SUMMARY

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler

### Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m <sup>3</sup>	< 0.16	< 0.16
Uncertainty	±mg/m <sup>3</sup>	0.03	0.03
Mass Emission	g/hr	< 0.19	< 0.19
Uncertainty	±g/hr	0.03	0.03

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	6.5	6.5
Uncertainty	±% v/v	0.28	0.28

### Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m <sup>3</sup>	< 0.11	< 0.11

### General Sampling Information

Parameter	Value
Standard	US EPA OTM29
Technical Procedure	CAT-TP-12
Name of Analytical Laboratory	RPS
Analytical Laboratory's Procedure	W4
ISO 17025 Accredited Analysis?	Yes
Date of Sample Analysis	24/10/2017
Probe Material	Titanium
Filter Housing Material	Titanium
Impinger Material	Polyethylene
Absorption Solution	1.0 mol/l Sodium Hydroxide
Positioning of Filter	In Stack
Filter Size and Material	47mm Quartz Fibre
Number of Sampling Lines Used	1 / 1
Number of Sampling Points Used	1 / 1
Sample Point I.D.'s	A1

FORMAT: Number Used / Number Required

### Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

**HYDROGEN CYANIDE: SAMPLING DETAILS**

**Sample Runs**

Parameter	Units	Run 1	
Sampling Times	-	12:17 - 12:57	
Sampling Dates	-	12/10/2017	
Sampling Device	-	MFC / MV	
Duration	mins	30	
Volume Sampled (STP, Dry)	m <sup>3</sup>	0.2871	
Volume Sampled (STP, Wet)	m <sup>3</sup>	0.3071	
Volume Sampled (REF)	m <sup>3</sup>	0.3071	
Sample Flow Rate	l/min	9.45	
Laboratory Result for Front Impingers	µg/ml	< 0.10	
Laboratory Result for Back Impinger	µg/ml	< 0.10	
Volume in Front Impingers	ml	327.3	
Volume in Back Impinger	ml	162.0	
Mass in Front Impingers	µg	< 32.7	
Mass in Back Impinger	µg	< 16.2	
Total Mass Collected	µg	< 48.9	
Calculated Concentration	mg/m <sup>3</sup>	< 0.16	
Liquid Trap Start Mass	g	1534.8	
Liquid Trap End Mass	g	1548.6	
Silica Trap Start Mass	g	1448.6	
Silica Trap End Mass	g	1450.8	
Total Mass Of Water Vapour	g	16.0	
Calculated Water Vapour	% v/v	6.49	

**Where:** MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

**Blank Runs**

Parameter	Units	Blank 1	
Blank Dates	-	12/10/2017	
Average Volume Sampled (REF)	m <sup>3</sup>	0.3071	
Laboratory Result for Impingers	µg/ml	< 0.10	
Volume in Impingers	ml	333.7	
Total Mass Collected	µg	< 33.4	
Calculated Concentration	mg/m <sup>3</sup>	< 0.11	

## HYDROGEN CYANIDE: QUALITY ASSURANCE

### Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	9.45	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.19	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	100.0	
Allowable Absorption Efficiency	%	N/A	
Absorption Efficiency Acceptable	-	N/A	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	4.3	
Allowable MU	%	20	
MU Acceptable	%	Yes	

Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

### Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	9.50	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.19	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m <sup>3</sup>	0.5	
Blank Acceptable	-	Yes	

### Method Deviations

Nature of Deviation	Run Number
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1
There are no deviations associated with the sampling employed.	wx

**HYDROGEN CYANIDE: MEASUREMENT UNCERTAINTY CALCULATIONS**

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (STP)	V <sub>m</sub>	0.2871		uV <sub>m</sub>	m <sup>3</sup>	0.0057	
Leak	L	0.00		uL	%	-	
Laboratory Result	L <sub>r</sub>	8.00		uL <sub>r</sub>	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	0.00		≤2%
Laboratory Result	%	8.00		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V <sub>m</sub>	m <sup>3</sup>	0.2871		0.55	
Leak	L	mg/m <sup>3</sup>	0.000		1.00	
Laboratory Result	L <sub>r</sub>	mg/m <sup>3</sup>	0.013		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m <sup>3</sup>	0.0032	
Leak	mg/m <sup>3</sup>	0.0000	
Laboratory Result	mg/m <sup>3</sup>	0.0127	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O <sub>2</sub> Correction Factor	-	N/A	
Stack Gas O <sub>2</sub> Content	% v/v	N/A	
MU for O <sub>2</sub> Correction	-	N/A	
Overall MU For O <sub>2</sub> Measurement	%	N/A	

Parameter	Units	Run 1	
Combined uncertainty	mg/m <sup>3</sup>	0.01	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m <sup>3</sup>	0.03	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m <sup>3</sup>	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m <sup>3</sup>	0.03	
Reported Uncertainty	mg/m <sup>3</sup>	0.03	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	16.2	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	16.2	
Reported Uncertainty	%	16.2	

**FORMALDEHYDE: RESULTS SUMMARY**

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler

**Sample Runs**

Parameter	Units	Run 1	Mean
Concentration	mg/m <sup>3</sup>	< 0.06	< 0.06
Uncertainty	±mg/m <sup>3</sup>	0.01	0.01
Mass Emission	g/hr	< 0.08	< 0.08
Uncertainty	±g/hr	0.01	0.01

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	3.9	3.9
Uncertainty	±% v/v	0.18	0.18

**Blank Runs**

Parameter	Units	Blank 1	Maximum
Concentration	mg/m <sup>3</sup>	< 0.06	< 0.06

**General Sampling Information**

Parameter	Value	
Standard	US EPA M316	
Technical Procedure	CAT-TP-19	
Name of Analytical Laboratory	CAT	
Analytical Laboratory's Procedure	CAT-AP-05	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	17/10/2017	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Polyethylene	
Absorption Solution	HPLC Grade Water	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

**Reference Conditions**

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

**FORMALDEHYDE: SAMPLING DETAILS**

**Sample Runs**

Parameter	Units	Run 1	
Sampling Times	-	11:36 - 12:06	
Sampling Dates	-	12/10/2017	
Sampling Device	-	MFC / MV	
Duration	mins	30	
Volume Sampled (STP, Dry)	m <sup>3</sup>	0.2883	
Volume Sampled (STP, Wet)	m <sup>3</sup>	0.3001	
Volume Sampled (REF)	m <sup>3</sup>	0.3001	
Sample Flow Rate	l/min	9.49	
Laboratory Result for Front Impingers	µg/ml	< 0.05	
Laboratory Result for Back Impinger	µg/ml	< 0.05	
Volume in Front Impingers	ml	260.3	
Volume in Back Impinger	ml	127.4	
Mass in Front Impingers	µg	< 13.0	
Mass in Back Impinger	µg	< 6.4	
Total Mass Collected	µg	< 19.4	
Calculated Concentration	mg/m <sup>3</sup>	< 0.06	
Liquid Trap Start Mass	g	1533.9	
Liquid Trap End Mass	g	1542.4	
Silica Trap Start Mass	g	1447.7	
Silica Trap End Mass	g	1448.6	
Total Mass Of Water Vapour	g	9.4	
Calculated Water Vapour	% v/v	3.90	

**Where:** MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

**Blank Runs**

Parameter	Units	Blank 1	
Blank Dates	-	12/10/2017	
Average Volume Sampled (REF)	m <sup>3</sup>	0.3001	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	337.2	
Total Mass Collected	µg	< 16.9	
Calculated Concentration	mg/m <sup>3</sup>	< 0.06	



**FORMALDEHYDE: QUALITY ASSURANCE**

**Sample Runs**

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	9.49	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.19	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	100.0	
Allowable Absorption Efficiency	%	N/A	
Absorption Efficiency Acceptable	-	N/A	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	4.6	
Allowable MU	%	20	
MU Acceptable	%	Yes	

Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

**Blank Runs**

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	9.50	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.19	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m <sup>3</sup>	0.5	
Blank Acceptable	-	Yes	

**Method Deviations**

Nature of Deviation	Run Number
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1
There are no deviations associated with the sampling employed.	wx

**FORMALDEHYDE: MEASUREMENT UNCERTAINTY CALCULATIONS**

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (STP)	V <sub>m</sub>	0.2883		uV <sub>m</sub>	m <sup>3</sup>	0.0058	
Leak	L	0.00		uL	%	-	
Laboratory Result	L <sub>r</sub>	7.50		uL <sub>r</sub>	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	0.00		≤2%
Laboratory Result	%	7.50		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V <sub>m</sub>	m <sup>3</sup>	0.2883		0.22	
Leak	L	mg/m <sup>3</sup>	0.000		1.00	
Laboratory Result	L <sub>r</sub>	mg/m <sup>3</sup>	0.005		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m <sup>3</sup>	0.0013	
Leak	mg/m <sup>3</sup>	0.0000	
Laboratory Result	mg/m <sup>3</sup>	0.0048	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O <sub>2</sub> Correction Factor	-	N/A	
Stack Gas O <sub>2</sub> Content	% v/v	N/A	
MU for O <sub>2</sub> Correction	-	N/A	
Overall MU For O <sub>2</sub> Measurement	%	N/A	

Parameter	Units	Run 1	
Combined uncertainty	mg/m <sup>3</sup>	0.005	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m <sup>3</sup>	0.010	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m <sup>3</sup>	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m <sup>3</sup>	0.010	
Reported Uncertainty	mg/m <sup>3</sup>	0.010	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	15.2	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	15.2	
Reported Uncertainty	%	15.2	

**TOTAL VOCs (as CARBON): RESULTS SUMMARY**

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler

**Sample Runs**

Parameter	Units	Run 1	Mean
Concentration	mg/m <sup>3</sup>	1.8	1.8
Uncertainty	±mg/m <sup>3</sup>	0.41	0.41
Mass Emission	g/hr	2.2	2.2
Uncertainty	±g/hr	0.52	0.52

**General Sampling Information**

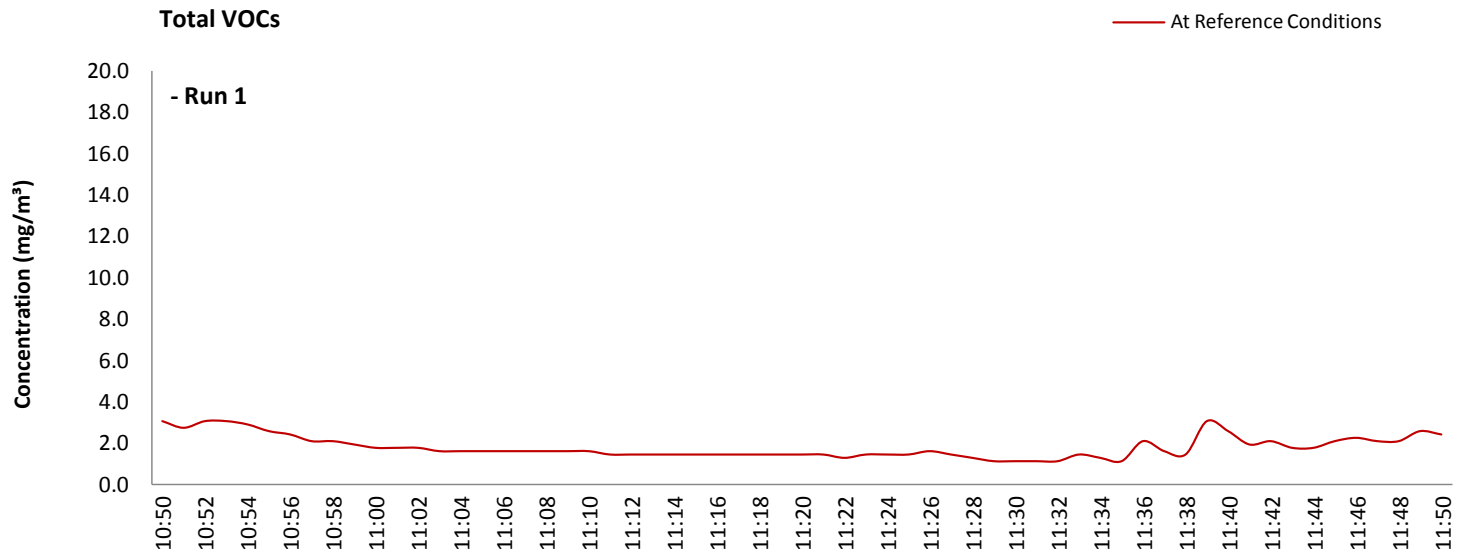
Parameter	Value	
Standard	EN 12619:2013	
Technical Procedure	CAT-TP-20	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Propane In Synthetic Air (5 Grade)	
Span Gas Reference Number	CYL 1.0246a	
Span Gas Expiry Date	10/09/2021	
Span Gas Start Pressure (bar)	30	
Gas Cylinder Concentration (ppm)	80.1	
Span Gas Set Point (ppm)	80.10	
Span Gas Uncertainty (%)	N/A	
Zero Gas Type	Synthetic Air (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

**Reference Conditions**

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

### TOTAL VOCs (as CARBON): DATA TREND

#### Graphical Trend of Data



**TOTAL VOCs (as CARBON): SAMPLING DETAILS & QUALITY ASSURANCE**

**Sampling Details**

Parameter	Units	Run 1	
Sampling Times	-	10:50 - 11:50	
Sampling Dates	-	12/10/2017	
Instrument Range	ppm	100	
Span Gas Value	ppm	80.1	

**Quality Assurance**

	Zero Drift	Units	Run 1	
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.00	
	Zero Down Sampling Line (Post)	ppm	0.00	
	Zero Drift	ppm	0.00	
	Allowable Zero Drift	± ppm	4.01	
	Zero Drift Acceptable	-	Yes	

	Span Drift	Units	Run 1	
CAL 1	Span Down Sampling Line (Pre)	ppm	80.00	
	Span Down Sampling Line (Post)	ppm	80.00	
	Span Drift	ppm	0.00	
	Allowable Span Drift	± ppm	4.01	
	Span Drift Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Run Ambient Temperature Range	°C	12 - 15	

**Method Deviations**

Nature of Deviation	Run Number	
	(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x	

**TOTAL VOCs (as CARBON): MEASUREMENT UNCERTAINTY CALCULATIONS**

Performance characteristics	RUN 1	Units
Limit value	20.0	mg/m <sup>3</sup> (REF)
TGN M2 Allowable MU	15.0	%
Measured concentration	1.90	mg/m <sup>3</sup> (STP, dry)
Range Used	100.0	ppm
Range Used [A]	160.6	mg/m <sup>3</sup>
Cal gas conc.	80.1	ppm
Conversion	1.61	ppm to mg/m <sup>3</sup>
MCERTS Range [B]	15.0	mg/m <sup>3</sup>
Lower of [A] or [B]	15.0	mg/m <sup>3</sup>
Cal gas conc.	128.7	mg/m <sup>3</sup>

Performance characteristics	RUN 1	Units
Response time	45	seconds
Number of readings in measurement	60	-
Repeatability at zero	2.00	% full scale
Repeatability at span level	0.00	% full scale
Deviation from linearity	0.39	% of value
Zero drift	0.00	% full scale
Span drift	0.00	% full scale
Volume or pressure flow dependence	1.60	% of full scale
Atmospheric pressure dependence	0.30	% of value/kPa
Ambient temperature dependence	1.40	% full scale/10K
Combined interference	0.45	% range
Dependence on voltage	0.50	% full scale/10V
Losses in the line (leak)	0.12	% of value
Uncertainty of calibration gas	2.00	% of value

Performance characteristic	RUN 1	Units
Standard deviation of repeatability at zero	use rep at span	mg/m <sup>3</sup>
Standard deviation of repeatability at span level	0.00	mg/m <sup>3</sup>
Lack of fit	0.03	mg/m <sup>3</sup>
Drift	0.00	mg/m <sup>3</sup>
Volume or pressure flow dependence	0.00	mg/m <sup>3</sup>
Atmospheric pressure dependence	0.01	mg/m <sup>3</sup>
Ambient temperature dependence	0.20	mg/m <sup>3</sup>
Combined interference (from MCERTS Certificate)	0.04	mg/m <sup>3</sup>
Dependence on voltage	0.06	mg/m <sup>3</sup>
Losses in the line (leak)	0.00	mg/m <sup>3</sup>
Uncertainty of calibration gas	0.02	mg/m <sup>3</sup>

Measurement uncertainty	Result	RUN 1	Units
Combined uncertainty		1.90	mg/m <sup>3</sup>
Expanded uncertainty		0.22	mg/m <sup>3</sup>
Expanded uncertainty	k = 1.96	0.43	mg/m <sup>3</sup>
Uncertainty corrected to std conds. (O <sub>2</sub> )		0.43	mg/m <sup>3</sup> (REF)

	RUN 1	Units
Expanded uncertainty (no O <sub>2</sub> ) - at 95% Confidence	22.84	% of Value
Expanded uncertainty (no O <sub>2</sub> ) - at 95% Confidence	2.17	% at ELV
Overall Allowable uncertainty (no O <sub>2</sub> ) - at 95% Confidence	15.0	% at ELV
<b>Result of Compliance with Uncertainty Requirement in M2</b>	COMPLIANT	-

	RUN 1	Units
Expanded uncertainty (with O <sub>2</sub> ) - at 95% Confidence	N/A	% of Value
Expanded uncertainty (with O <sub>2</sub> ) - at 95% Confidence	N/A	% at ELV
Overall Allowable uncertainty (with O <sub>2</sub> ) - at 95% Confidence	N/A	% at ELV
<b>Result of Compliance with Uncertainty Requirement in M2</b>	N/A	-

Requirement for SRM is that Uncertainty should be <15% of the value at the ELV, on a dry gas basis, or if O<sub>2</sub> correction is applied less than 15% + the uncertainty associated with the O<sub>2</sub> correction (using sqrt of sum squares to add uncertainty components). Ref EA TGN M2.

### CARBON MONOXIDE: RESULTS SUMMARY

Alan Nuttall Partnership Ltd, West Midlands  
Ranheat Wood Burning Boiler

#### Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m <sup>3</sup>	162	162
Uncertainty	±mg/m <sup>3</sup>	4.6	4.6
Mass Emission	g/hr	196	196
Uncertainty	±g/hr	14.3	14.3

#### General Sampling Information

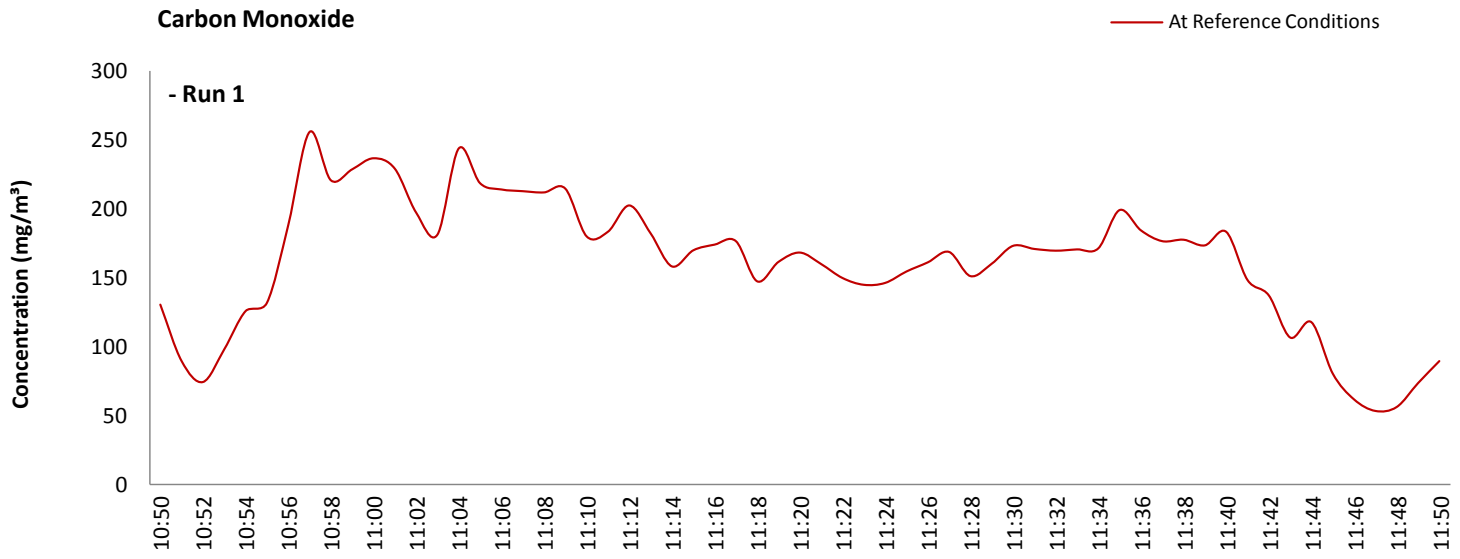
Parameter	Value	
Standard	EN 15058	
Technical Procedure	CAT-TP-39	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Carbon Monoxide	
Span Gas Reference Number	CYL 12.0100	
Span Gas Expiry Date	13/07/2019	
Span Gas Start Pressure (bar)	160	
Gas Cylinder Concentration (ppm)	409.4	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

#### Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

### CARBON MONOXIDE: DATA TREND

Graphical Trend of Data





**CARBON MONOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE**

**Sampling Details**

Parameter	Units	Run 1	
Sampling Times	-	10:50 - 11:50	
Sampling Dates	-	12/10/2017	
Instrument Range	ppm	500	
Span Gas Value	ppm	200.1	

**Quality Assurance**

Conditioning Unit Temperature	Units	Run 1	
Average Temperature	°C	2.0	
Allowable Temperature	< °C	4.0	
Temperature Acceptable	-	Yes	

Zero Drift	Units	Run 1		
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.10	
	Zero Down Sampling Line (Post)	ppm	0.00	
	Zero Drift	ppm	-0.10	
	Allowable Zero Drift	± ppm	10.01	
	Zero Drift Acceptable	-	Yes	

Span Drift	Units	Run 1		
CAL 1	Span Down Sampling Line (Pre)	ppm	199.20	
	Span Down Sampling Line (Post)	ppm	199.00	
	Span Drift	ppm	-0.20	
	Allowable Span Drift	± ppm	10.01	
	Span Drift Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Run Ambient Temperature Range	°C	12 - 15	

**Method Deviations**

Nature of Deviation	Run Number	
(x = deviation applies to the associated run)	1	
There are no deviations associated with the sampling employed.	x	

**CARBON MONOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS**

Performance characteristics	RUN 1	Units
Limit value	250.0	mg/m <sup>3</sup> (REF)
TGN M2 Allowable MU	6.0	%
Measured concentration	170.24	mg/m <sup>3</sup> (STP, dry)
Range Used	500.0	ppm
Range Used [A]	624.6	mg/m <sup>3</sup>
Cal gas conc.	200.1	ppm
Conversion	1.25	ppm to mg/m <sup>3</sup>
MCERTS Range [B]	75.0	mg/m <sup>3</sup>
Lower of [A] or [B]	75.0	mg/m <sup>3</sup>
Cal gas conc.	250.0	mg/m <sup>3</sup>

Performance characteristics	RUN 1	Units
Response time	28	seconds
Number of readings in measurement	60	-
Repeatability at zero	0.10	% full scale
Repeatability at span level	0.20	% full scale
Deviation from linearity	0.41	% of value
Zero drift	-0.05	% full scale
Span drift	-0.10	% full scale
Volume or pressure flow dependence	0.10	% of full scale
Atmospheric pressure dependence	0.22	% of value/kPa
Ambient temperature dependence	-0.20	% full scale/10K
Combined interference	-0.48	% range
Dependence on voltage	-0.35	% full scale/10V
Losses in the line (leak)	0.45	% of value
Uncertainty of calibration gas blending	1.40	% of value
Uncertainty of calibration gas	2.00	% of value

Performance characteristic	RUN 1	Units
Standard deviation of repeatability at zero	use rep at span	mg/m <sup>3</sup>
Standard deviation of repeatability at span level	0.03	mg/m <sup>3</sup>
Lack of fit	0.18	mg/m <sup>3</sup>
Drift	-0.17	mg/m <sup>3</sup>
Volume or pressure flow dependence	0.00	mg/m <sup>3</sup>
Atmospheric pressure dependence	0.05	mg/m <sup>3</sup>
Ambient temperature dependence	-0.03	mg/m <sup>3</sup>
Combined interference (from MCERTS Certificate)	-0.21	mg/m <sup>3</sup>
Dependence on voltage	-0.04	mg/m <sup>3</sup>
Losses in the line (leak)	0.44	mg/m <sup>3</sup>
Uncertainty of calibration gas blending	1.38	mg/m <sup>3</sup>
Uncertainty of calibration gas	1.97	mg/m <sup>3</sup>

Measurement uncertainty	Result	RUN 1	Units
Combined uncertainty		170.24	mg/m <sup>3</sup>
Expanded uncertainty		2.47	mg/m <sup>3</sup>
Expanded uncertainty	k = 1.96	4.84	mg/m <sup>3</sup>
Uncertainty corrected to std conds. (O <sub>2</sub> )		4.84	mg/m <sup>3</sup> (REF)

	RUN 1	Units
Expanded uncertainty (no O <sub>2</sub> ) - at 95% Confidence	2.84	% of Value
Expanded uncertainty (no O <sub>2</sub> ) - at 95% Confidence	1.94	% at ELV
Overall Allowable uncertainty (no O <sub>2</sub> ) - at 95% Confidence	6.0	% at ELV
<b>Result of Compliance with Uncertainty Requirement in M2</b>	<b>COMPLIANT</b>	-

	RUN 1	Units
Expanded uncertainty (with O <sub>2</sub> ) - at 95% Confidence	N/A	% of Value
Expanded uncertainty (with O <sub>2</sub> ) - at 95% Confidence	N/A	% at ELV
Overall Allowable uncertainty (with O <sub>2</sub> ) - at 95% Confidence	N/A	% at ELV
<b>Result of Compliance with Uncertainty Requirement in M2</b>	<b>N/A</b>	-

Requirement for SRM is that Uncertainty should be <6% of the value at the ELV, on a dry gas basis, or if O<sub>2</sub> correction is applied less than 6% + the uncertainty associated with the O<sub>2</sub> correction (using sqrt of sum squares to add uncertainty components). Ref EA TGN M2.