

AIR & EMISSIONS TESTING GROUP

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Stack Emissions Testing Report


Operator / Company
Wood Waste Technology Ltd

Site:
Stafford

Release Point:
Wood Burner (Low Fire)

Sampling Date/s:
17th November 2010

Job Number:
LAB 9746

Report Date:	25th November 2010
Version:	1
Report By:	Mark Woodruff
MCERTS Number:	MM 03 164
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Report Approved By:	Andrew Palliser
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Signature:	

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EXECUTIVE SUMMARY

Stack Emissions Monitoring Objectives

Wood Waste Technology Ltd operates a wood burner at Stafford

Environmental Scientifics Group Limited were commissioned by Wood Waste Technology Ltd to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under low fire operating conditions.

Plant

Wood Burner (Low Fire)

Operator

Wood Waste Technology Ltd
Units 1, 2 & 3
Drummond Road
Astonfields Industrial Estate
Stafford
ST16 3HJ

Stack Emissions Monitoring

Environmental Scientifics Group Limited - Stockport Laboratory
52 Offerton Industrial Estate
Hempshaw Lane
Stockport
SK2 5TJ
UKAS and MCERTS Accreditation Number: 1015

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EXECUTIVE SUMMARY

Emissions Summary

Parameter	Units	Result	Uncertainty +/-	Limit
Total Particulate Matter	mg/m ³	126	4.7	-
Particulate Emission Rate	g/hr	94	3.5	-
Volatile Organic Compounds	mg/m ³	ND	-	-
Volatile Organic Compounds Emission Rate	g/hr	-	-	-
Carbon Monoxide	mg/m ³	131	11	-
Carbon Monoxide Emission Rate	g/hr	106	8.6	-
Carbon Dioxide	% v/v	8.91	0.71	-
Oxygen	% v/v	10.7	0.4	-
Moisture	%	1.6	0.15	-
Stack Gas Temperature	°C	347.0	-	-
Stack Gas Velocity	m/s	7.1	-	-
Gas Volumetric Flow Rate (Actual)	m ³ /hr	1817	-	-
Gas Volumetric Flow Rate (STP, Wet)	m ³ /hr	798	-	-
Gas Volumetric Flow Rate (STP, Dry)	m ³ /hr	785	-	-
Gas Volumetric Flow Rate (@ref conditions)	m ³ /hr	808	-	-

ND = None Detected,

Results at or below the limit of detection are highlighted by bold italic text.

The above volumetric flow rate is calculated using data from the preliminary survey. Mass emissions for non isokinetic tests are calculated using these values. For all isokinetic testing the mass emission is calculated using test specific values.

Reference conditions are 273K, 101.3kPa, dry gas, 11% Oxygen.

EXECUTIVE SUMMARY

Monitoring Times

Parameter	Sampling Date	Sampling Times	Sampling Duration
Total Particulate Matter Run 1	17 November 2010	11:20 - 11:50	30 minutes
Total Particulate Matter Run 2	17 November 2010	11:55 - 12:25	30 minutes
Total Particulate Matter Run 3	17 November 2010	12:26 - 12:56	30 minutes
Volatile Organic Compounds Run 1	17 November 2010	11:20 - 12:45	85 minutes
Combustion Gases	17 November 2010	11:20 - 12:45	85 minutes

EXECUTIVE SUMMARY

Process Details

Parameter	Process Details
Process Status	Low Fire
Continuous or Batch Process	Batch
Feedstock (if applicable)	MDF/Chipboard
Abatement System	Cyclone
Abatement System Running Status	On
Fuel	N/A
Plume Appearance	Very slight plume visible

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard methods employed by Environmental Scientifics Group Limited is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency Technical Guidance Document (Monitoring) M2. i.e. CEN, ISO, BS, US EPA etc.

The tables below summarise the monitoring methods, techniques and technical procedures employed, and details any deviations from the aforementioned hierarchy:

Sampling Methods with Subsequent Analysis

Species	Standard Method	ESG Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Limit of Detection (LOD)	MU of Method +/- %	MU +/- %
TPM	BS ISO 9096	AE 006	1015	Yes	0.6 mg/m ³	30%	3.7 %

On-Site Testing

Species	Standard Method	ESG Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Limit of Detection (LOD)	MU of Method +/- %	MU +/- %
VOCs	BS EN 13526	AE 056	1015	Yes	0.4 mg/m ³	20%	N/A
CO	BS EN 15058	AE 007 / AE 015	1015	Yes	0.2 mg/m ³	25%	8.1%
CO ₂	BS ISO 12039	AE 007 / AE 015	1016	Yes	0.002 mg/m ³	10%	7.9%
O ₂	BS EN 14789	AE 007 / 015	1015	Yes	0.01%	10%	3.76%
H ₂ O	BS EN 14790	AE 004	1015	Yes	0.0005 %	10%	9.4%

EXECUTIVE SUMMARY

Analytical Methods

The following tables list the analytical methods employed together with the custody and archiving details:

Sampling Methods with Subsequent Analysis

Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	UKAS Accredited Analysis	Laboratory	Sample Archive Location	Archive Period
TPM	Gravimetric	AE 006	1015	Yes	Stockport	Stockport	3 months

On-Site Testing

Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	MCERTS Accredited Analysis	Laboratory	Sample Archive Location	Span Gas
VOCs	Flame Ionisation Detection	AE 056	1015	Yes	Stockport	N/A	9.9 ppm
CO	Non Dispersive Infra Red	AE 007 / AE 015	1015	Yes	Stockport	N/A	168.95 ppm
CO ₂	Non Dispersive Infra Red	AE 007 / AE 015	1015	Yes	Stockport	N/A	7.79
O ₂	Zirconia Cell	AE 007 / 015	1015	Yes	Stockport	N/A	20.95 %
H ₂ O	Gravimetric	AE 004	1015	Yes	Stockport	N/A	N/A

BS EN 14790 has been validated over a range of 4 - 40%. It is however the preferred method of the Environment Agency for concentrations below 4%

EXECUTIVE SUMMARY

Sampling Location

Sampling Plane Validation Criteria	Value	Units	Requirement	Compliance	Method
Lowest Differential Pressure	20	Pa	≥ 5 Pa	Yes	BS EN 13284 - 1
Lowest Gas Velocity	6.79	m/s	-	-	-
Highest Gas Velocity	7.44	m/s	-	-	-
Ratio of Above	1.10	: 1	$< 3 : 1$	Yes	BS EN 13284 - 1
Mean Velocity	7.14	m/s	-	-	-
Angle of flow with regard to duct axis	0	°	$< 15^\circ$	Yes	BS EN 13284 - 1
No local negative flow	-	-	-	Yes	BS EN 13284 - 1

Duct Characteristics

	Value	Units
Type	Circular	-
Depth	0.30	m
Width	-	m
Area	0.07	m ²
Port Depth	0	mm

Sampling Lines & Sample Points

	Isokinetic (CEN Methods)	Isokinetic (ISO Methods)	Non-Iso & Gases
Sample Port Size	-	4 inch	4 inch
Number Used	-	1	1
Orientation	-	Horizontal	Horizontal
Number Points / Line	-	1	1
Filtration for TPM	-	Out Stack	-

Sampling Platform

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

M1 Platform requirements	
Minimum Platform Area 5 m ²	Yes
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	Yes
Platform has vertical base boards (approximately 0.25 m high)	Yes
Platform has removable chains / self closing gates at the top of ladders	No
Handrail / obstructions do not hamper insertion of sampling equipment	Yes
Depth of Platform = Minimum of 2m or Probe Length + 1m	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements as specified in EA Guidance Note M1.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

In this instance there were no deviations from the sampling methods employed.

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APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER SUMMARY

Test	Sampling Times	Concentration mg/m ³	LOD mg/m ³	Limit mg/m ³	Emission Rate g/hr
Run 1	11:20 - 11:50 17 November 2010	131	0.61	-	99
Run 2	11:55 - 12:25 17 November 2010	128	0.61	-	93
Run 3	12:26 - 12:56 17 November 2010	119	0.58	-	89
Blank	-	3.9	-	-	-

Reference conditions are 273K, 101.3kPa, dry gas, 11% Oxygen.

Acetone Blank Value mg/l	Acceptable Value mg/l
5.00	10

ISOKINETIC SAMPLING EQUATIONS- RUN 1

TPM

Absolute pressure of stack gas, P_s			Molecular weight of dry gas, M_d	
Barometric pressure, P _b	mm Hg	757.51	CO ₂	% 8.92
Stack static pressure, P _{static}	mm H ₂ O	1.02	O ₂	% 11.00
$P_s = \frac{P_b + (P_{static})}{13.6}$	mm Hg	757.58	Total	% 19.92
Vol. of water vapour collected, V_{wstd}			N ₂ (100 -Total)	% 80.08
Moisture trap weight increase, V _{lc}	g	2.7	M _d = 0.44(%CO ₂)+0.32(%O ₂)+0.28(%N ₂)	29.87
V _{wstd} = (0.001246)(V _{lc})	m ³	0.003	Molecular weight of wet gas, M_s	
Volume of gas metered dry, V_{mstd}			M _s = M _d (1 - B _{wo}) + 18(B _{wo})	g/gmol 29.68
Volume of gas sample through gas meter, V _m		0.233	Actual flow of stack gas, Q_a	
Gas meter correction factor, Y _d		0.930	Area of stack, A _s	m ² 0.07
Mean dry gas meter temperature, T _m		13.333	Q _a = (60)(A _s)(V _s)	m ³ /min 28.8
Mean pressure drop across orifice, ΔH mmH ₂ O		5.494	Total flow of stack gas, Q	
$V_{mstd} = \frac{(0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)}{T_m + 273}$		0.206	Conversion factor (K/mm.Hg)	0.3592
Volume of gas metered wet, V_{mstw}			Q _{std} = $\frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s) + 273}$	Dry 12.5
V _{mstw} = V _{mstd} + V _{wstd}	m ³	0.2093	Q _{stdO2} = $\frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s) + 273}$	@O2ref 12.54
Vol. of gas metered at O₂ Ref. Cond., V_{mstd@X%O2}			Q _{stw} = $\frac{(Q_a)P_s(0.3592)}{(T_s) + 273}$	Wet 12.75
Is the process burning hazardous waste? (If yes, no favourable oxygen correction)		No	Percent isokinetic, %	
% oxygen measured in gas stream, act%O ₂		11.0	Nozzle diameter, D _n	mm 7.00
% oxygen reference condition		11	Nozzle area, A _n	mm ² 38.49
O ₂ Reference O ₂ Ref = 21.0 - act%O ₂		1.00	Total sampling time, θ	min 30
Factor $\frac{21.0 - ref\%O_2}{21.0 - act\%O_2}$			%I = $\frac{(4.6398E6)(T_s+273)(V_{mstd})}{(P_s)(V_s)(A_n)(\theta)(1-B_{wo})}$	% 100.5
V _{mstd@X%oxygen} = (V _{mstd}) (O ₂ Ref)	m ³	0.2060	Acceptable isokinetic range 95% to 115%	Yes
Moisture content, B_{wo}			Particulate Concentration, C	
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$	%	1.61	Mass collected on filter, M _f	g 0.02564
Moisture by FTIR			Mass collected in probe, M _p	g 0.00139
	%	-	Total mass collected, M _n	g 0.0270
Velocity of stack gas, V_s			C _{wet} = $\frac{M_n}{V_{mstw}}$	mg/m ³ 129.117
Pitot tube velocity constant, K _p		34.97	C _{dry} = $\frac{M_n}{V_{mstd}}$	mg/m ³ 131.225
Velocity pressure coefficient, C _p		0.83	C _{dry@X%O2} = $\frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m ³ 131.225
Mean of velocity heads, ΔP _{avg}	mm H ₂ O	2.00	Particulate Emission Rates, E	
Mean square root of velocity heads, √ΔP		1.41	E = [(C _{wet})(Q _{stw})(60)] / 1000	98.76
Mean stack gas temperature, T _s	°C	341		
$V_s = \frac{(K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})}{(M_s)(P_s)}$	m/s	6.79		

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 2

TPM

Absolute pressure of stack gas, P_s			Molecular weight of dry gas, M_d	
Barometric pressure, P _b	mm Hg	757.51	CO ₂	% 8.92
Stack static pressure, P _{static}	mm H ₂ O	1.02	O ₂	% 11.00
$P_s = \frac{P_b + (P_{static})}{13.6}$	mm Hg	757.58	Total	% 19.92
			N ₂ (100 -Total)	% 80.08
Vol. of water vapour collected, V_{wstd}			$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	29.87
Moisture trap weight increase, V _{lc}	g	2.7	Molecular weight of wet gas, M_s	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.0033642	$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol 29.68
Volume of gas metered dry, V_{mstd}			Actual flow of stack gas, Q_a	
Volume of gas sample through gas meter, V _m		0.235	Area of stack, A _s	m ² 0.07
Gas meter correction factor, Y _d		0.930	$Q_a = (60)(A_s)(V_s)$	m ³ /min 28.1
Mean dry gas meter temperature, T _m		15.500	Total flow of stack gas, Q	
Mean pressure drop across orifice, ΔH	mmH ₂ O	5.143	Conversion factor (K/mm.Hg)	0.3592
$V_{mstd} = \frac{(0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)}{T_m + 273}$		0.206	$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s) + 273}$	Dry 12.1
Volume of gas metered wet, V_{mstw}			$Q_{stdO_2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s) + 273}$	@O2ref 12.09
$V_{mstw} = V_{mstd} + V_{wstd}$	m ³	0.2095	$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s) + 273}$	Wet 12.29
Vol. of gas metered at O₂ Ref. Cond., V_{mstd@X%O₂}			Percent isokinetic, %I	
Is the process burning hazardous waste? (If yes, no favourable oxygen correction)		No	Nozzle diameter, D _n	mm 7.00
% oxygen measured in gas stream, act%O ₂		11	Nozzle area, A _n	mm ² 38.49
% oxygen reference condition		11	Total sampling time, θ	min 30
O ₂ Reference O ₂ Ref = 21.0 - act%O ₂		1.00	$\%I = \frac{(4.6398E6)(T_s + 273)(V_{mstd})}{(P_s)(V_s)(A_n)(\theta)(1 - B_{wo})}$	% 104.4
Factor 21.0 - ref%O ₂			Acceptable isokinetic range 95% to 115%	Yes
$V_{mstd@X\%oxygen} = (V_{mstd}) (O_2 Ref)$	m ³	0.2062	Particulate Concentration, C	
Moisture content, B_{wo}			Mass collected on filter, M _f	g 0.0251
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$	%	1.61	Mass collected in probe, M _p	g 0.00136
Moisture by FTIR			Total mass collected, M _n	g 0.02646
	%	-	$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m ³ 126.27
Velocity of stack gas, V_s			$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m ³ 128.33
Pitot tube velocity constant, K _p		34.97	$C_{dry@X\%O_2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m ³ 128.33
Velocity pressure coefficient, C _p		0.83	Particulate Emission Rates, E	
Mean of velocity heads, ΔP _{avg}	mm H ₂ O	1.88	E = [(C _{wet})(Q _{stw})(60)] / 1000	
Mean square root of velocity heads, √ΔP		1.37		
Mean stack gas temperature, T _s	°C	350		
$V_s = \frac{(K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})}{(M_s)(P_s)}$	m/s	6.63		

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 3

TPM

Absolute pressure of stack gas, P_s			Molecular weight of dry gas, M_d	
Barometric pressure, P _b	mm Hg	757.51	CO ₂	% 8.92
Stack static pressure, P _{static}	mm H ₂ O	1.02	O ₂	% 11.00
$P_s = \frac{P_b + (P_{static})}{13.6}$	mm Hg	757.58	Total	% 19.92
Vol. of water vapour collected, V_{wstd}			N ₂ (100 -Total)	% 80.08
Moisture trap weight increase, V _{lc}	g	2.7	$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	29.87
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.0033642	Molecular weight of wet gas, M_s	
Volume of gas metered dry, V_{mstd}			$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol 29.69
Volume of gas sample through gas meter, V _m		0.250	Actual flow of stack gas, Q_a	
Gas meter correction factor, Y _d		0.930	Area of stack, A _s	m ² 0.07
Mean dry gas meter temperature, T _m		17.500	$Q_a = (60)(A_s)(V_s)$	m ³ /min 28.9
Mean pressure drop across orifice, ΔH mmH ₂ O		5.511	Total flow of stack gas, Q	
$V_{mstd} = \frac{(0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)}{T_m + 273}$		0.218	Conversion factor (K/mm.Hg)	0.3592
Volume of gas metered wet, V_{mstw}			$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s) + 273}$	Dry 12.5
$V_{mstw} = V_{mstd} + V_{wstd}$	m ³	0.2212	$Q_{stdO_2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s) + 273}$	@O2ref 12.48
Vol. of gas metered at O₂ Ref. Cond., V_{mstd@X%O₂}			$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s) + 273}$	Wet 12.67
Is the process burning hazardous waste? (If yes, no favourable oxygen correction)		No	Percent isokinetic, %I	
% oxygen measured in gas stream, act%O ₂		11	Nozzle diameter, D _n	mm 7.00
% oxygen reference condition		11	Nozzle area, A _n	mm ² 38.49
O ₂ Reference O ₂ Ref = 21.0 - act%O ₂		1.00	Total sampling time, θ	min 30
Factor $\frac{21.0 - ref\%O_2}{21.0 - act\%O_2}$			$\%I = \frac{(4.6398E6)(T_s + 273)(V_{mstd})}{(P_s)(V_s)(A_n)(\theta)(1 - B_{wo})}$	% 106.8
$V_{mstd@X\%oxygen} = (V_{mstd})(O_2 Ref)$	m ³	0.2178	Acceptable isokinetic range 95% to 115%	Yes
Moisture content, B_{wo}			Particulate Concentration, C	
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0152	Mass collected on filter, M _f	g 0.02466
	%	1.52	Mass collected in probe, M _p	g 0.00134
Moisture by FTIR			Total mass collected, M _n	g 0.02600
	%	-	$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m ³ 117.54
Velocity of stack gas, V_s			$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m ³ 119.35
Pitot tube velocity constant, K _p		34.97	$C_{dry@X\%O_2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m ³ 119.35
Velocity pressure coefficient, C _p		0.83	Particulate Emission Rates, E	
Mean of velocity heads, ΔP _{avg} mm H ₂ O		2.00	$E = \frac{[(C_{wet})(Q_{stw})(60)]}{1000}$	
Mean square root of velocity heads, √ΔP		1.41		
Mean stack gas temperature, T _s °C		348		
$V_s = \frac{(K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})}{(M_s)(P_s)}$	m/s	6.82		

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER QUALITY ASSURANCE CHECKLIST

Leak Rate

Run	Mean Sampling Rate litre/min	Pre-sampling Leak Rate litre/min	Post-sampling Leak Rate litre/min	Maximum Vacuum mm Hg	Acceptable Leak Rate litre/min	Leak Tests Acceptable?
Run 1	7.22	0.12	0.12	-10	0.14	Yes
Run 2	7.28	0.13	0.12	-10	0.15	Yes
Run 3	7.75	0.12	0.12	-10	0.15	Yes

Isokineticity

Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	100.53	Yes
Run 2	104.39	Yes
Run 3	106.85	Yes

Acceptable Isokinetic rate 95 -115%

Blank Value

Run	Overall Blank Value mg/m ³	Daily Emission Limit Value mg/m ³	Acceptable Blank Value mg/m ³	Overall Blank Acceptable mg/m ³
Blank 1	3.90	-	-	Yes

Filters

Run	Filter Material	Filter Size mm	Max Filtration Temperature °C	Pre-conditioning Filter Temperature °C	Post conditioning Filtration Temperature °C
Run 1	GF	47	160	180	160
Run 2	GF	47	160	180	160
Run 3	GF	47	160	180	160

GF = Glass Fibre

QF = Quartz Fibre

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

VOLATILE ORGANIC COMPOUNDS SUMMARY

Test	Sampling Times	Concentration mg/m ³	LOD mg/m ³	Limit mg/m ³	Emission Rate g/hr
Run 1	11:20 - 12:45 17 November 2010	ND	0.40	-	-

Reference conditions are 273K, 101.3kPa, dry gas, 11% Oxygen.

INSTRUMENTAL SPAN & ZERO CHECKS

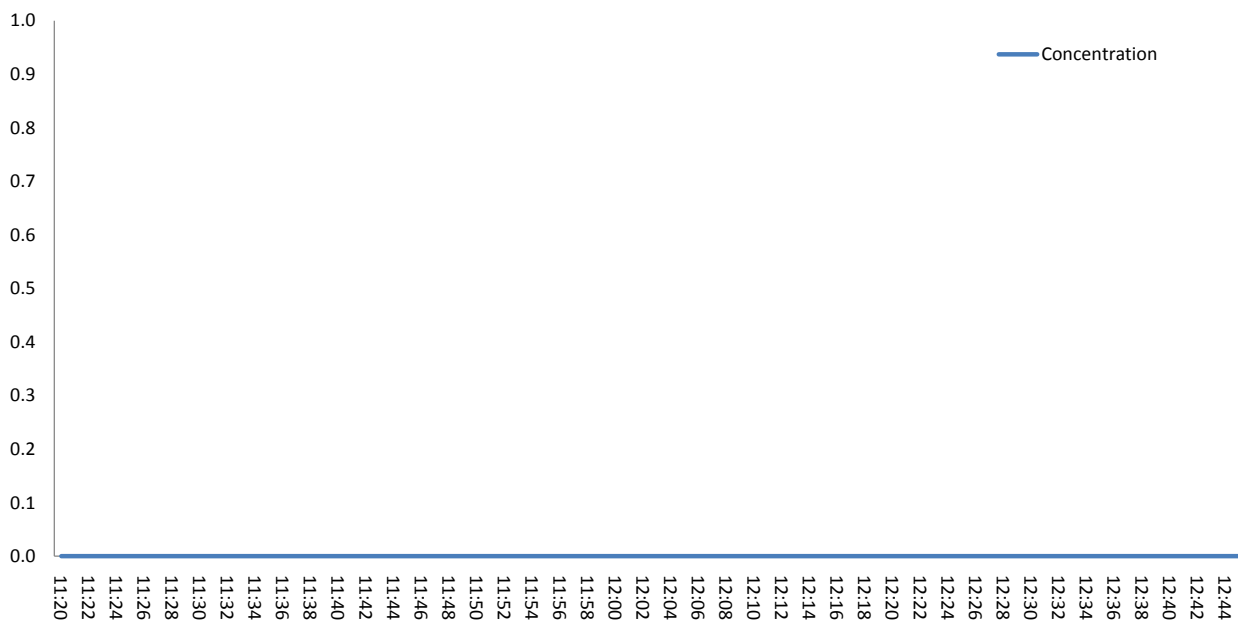
PRE-SAMPLING CALIBRATION CHECKS

Gas	Cylinder Ref No	Gas Conc (ppm)	Start Time	End Time	Range	Instrument Zero Reading	Instrument Span Reading	Span down line reading
Propane	HPC 512	9.9	10:00	10:10	100	0	9.9	9.88

POST-SAMPLING CALIBRATION CHECKS

Gas	Start Time	End Time	Instrument Zero Reading	Zero Drift (%)	Instrument Span Reading	Span Drift (%)	Span down line reading	Zero Drift ppm
Propane	15:50	15:55	0.1	0.1	9.88	-0.12	9.86	-0.1

VOLATILE ORGANIC COMPOUNDS EMISSIONS CHART



Reference conditions are 273K, 101.3kPa, dry gas, 11% Oxygen.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

COMBUSTION GASES SUMMARY

Test	Sampling Times	Concentration mg/m ³	LOD mg/m ³	Limit mg/m ³	Emission Rate g/hr
CO	11:20 - 12:45 17 November 2010	131	0.35	-	106

Test	Sampling Times	Concentration %	LOD %
CO ₂	11:20 - 12:45 17 November 2010	8.9	0.002
O ₂	11:20 - 12:45 17 November 2010	10.7	0.003

Reference conditions are 273K, 101.3kPa, dry gas, 11% Oxygen.

PRE-SAMPLING CALIBRATION DATA

Date	17 November 2010
Start Time	10:00
End Time	10:10

Cooler Temp. (°C)	2.2
-------------------	-----

(should be < 4°C)

Gas	Range (ppm)	Zero Reading at analyser	Span Reading at analyser	Zero Check at analyser	Zero Check down line	Span Check down line	Response Time (Secs)	Leak Rate %
CO	200	0	169	0.1	0.1	169.1	20	0.06
CO ₂	20	0.1	7.81	0.1	0.09	7.82	23	0.13
O ₂	25	0.03	20.96	0.05	0.09	20.96	23	0.00

POST-SAMPLING CALIBRATION DATA

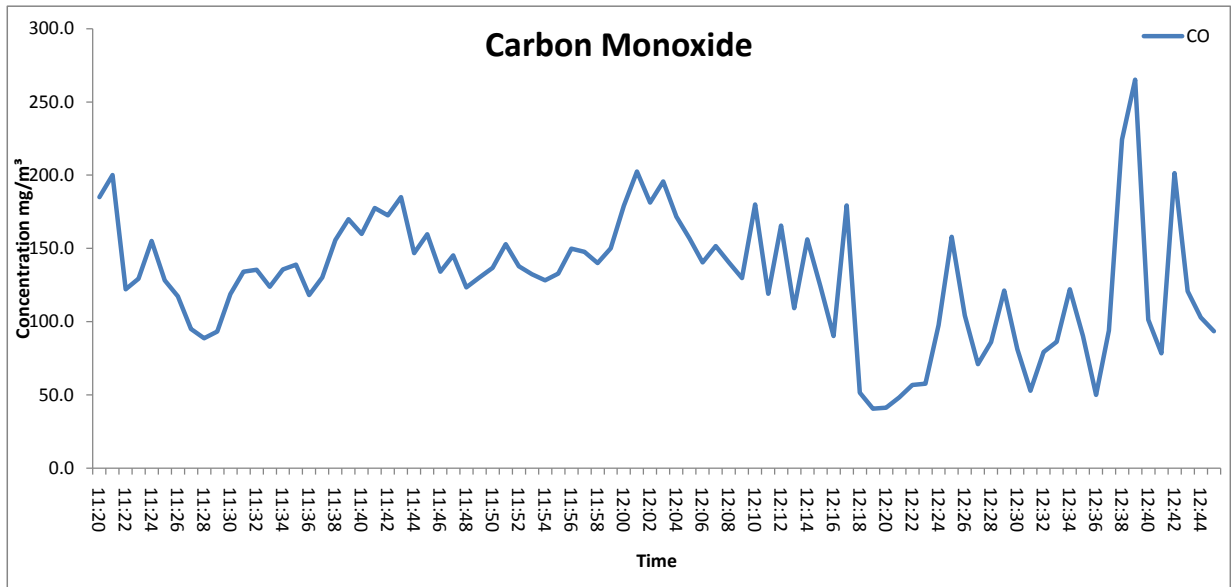
Date	17 November 2010
Start Time	15:00
End Time	15:06

Cooler Temp. (°C)	2.2
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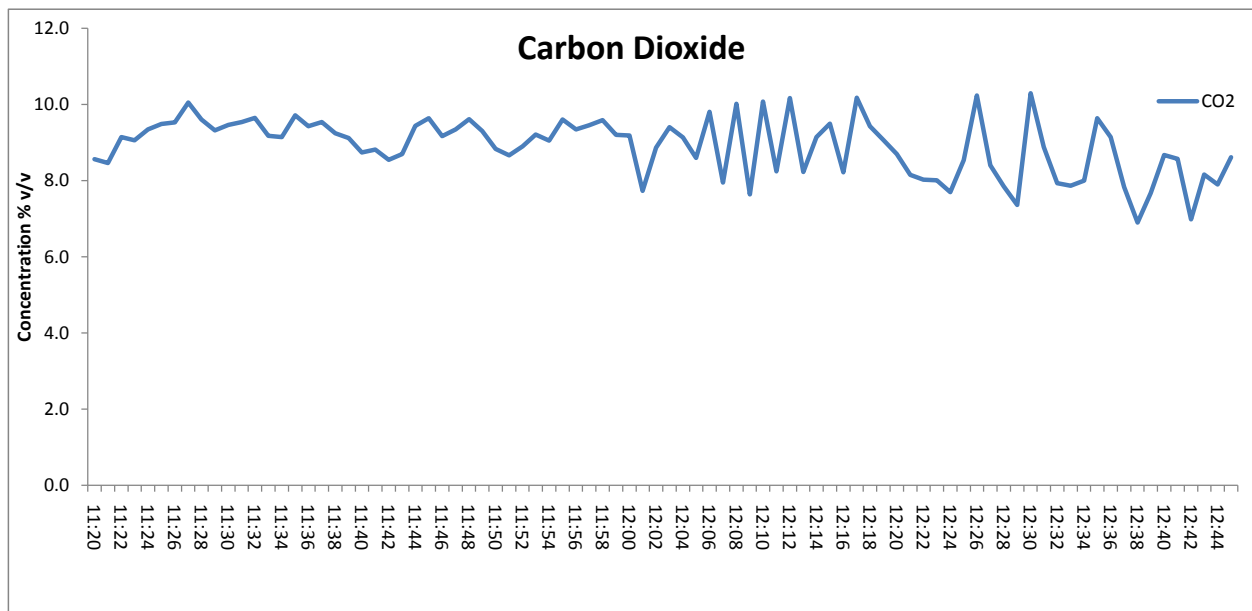
(should be < 4°C)

Gas	Zero Check down line	Span Check down line	Zero Drift (%)	Span Drift (%)
CO	0.12	169.3	0.01	0.12
CO ₂	0.11	7.85	0.10	0.39
O ₂	0.11	20.98	0.08	0.10

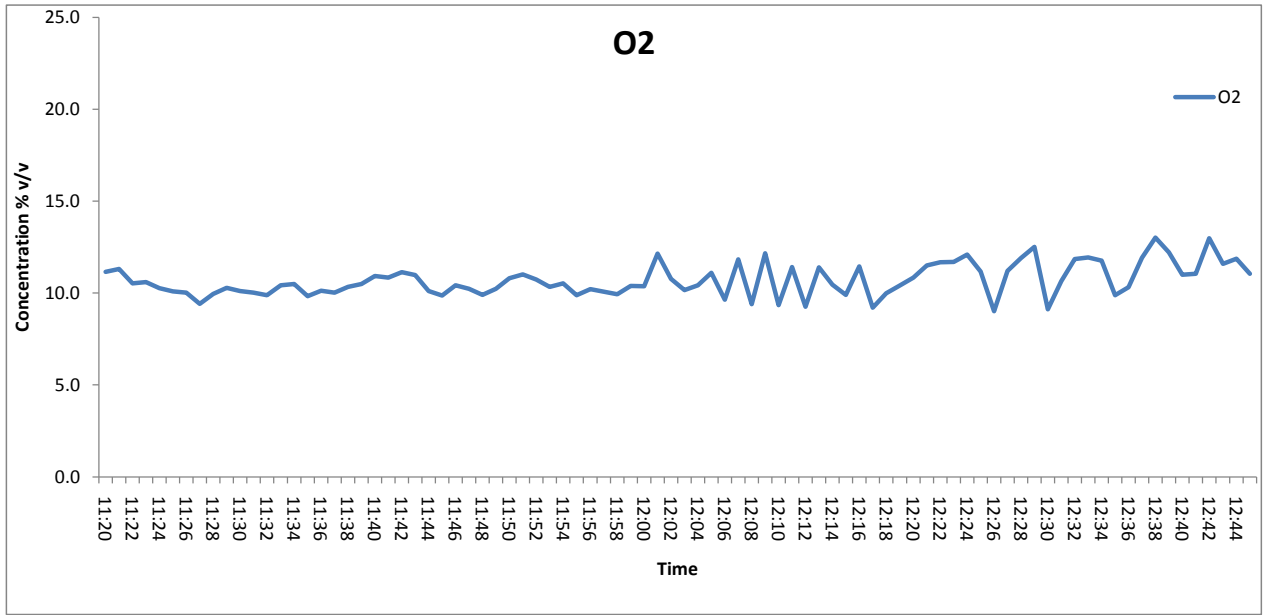
CARBON MONOXIDE EMISSIONS CHART



CARBON DIOXIDE EMISSIONS CHART



OXYGEN EMISSIONS CHART



APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY

Stack Diameter / Depth, D	0.30	m
Stack Width, W	-	m
Stack Area, A	0.07	m ²
Average stack gas temperature	347	°C
Pitot static pressure	0.01	kPa
Barometric Pressure	101	kPa
Pitot tube calibration coefficient, K_{pt}	0.83	-

Stack Gas Composition & Molecular Weights

Component	Molar Mass M	Density kg/m ³ ρ	Conc Dry % Vol	Dry Volume Fraction r	Dry Conc kg/m ³ pi	Conc Wet % Vol	Wet Volume Fraction r	Wet Conc kg/m ³ pi
CO ₂	44	1.963059	9.000000	0.090000	0.176675	8.858000	0.088580	0.173888
O ₂	32	1.427679	10.800000	0.108000	0.154189	10.629600	0.106296	0.151757
N ₂	28	1.249219	80.200000	0.802000	1.001874	78.934624	0.789346	0.986067
H ₂ O	18	0.803070	-	-	-	1.577775	0.015778	0.012671

Where:

$$\rho = M / 22.41$$

$$p_i = r \times p$$

Calculation of Stack Gas Densities

Determinand	Result	Units
Dry Density (STP), P_{STD}	1.3327	kg/m ³
Wet Density (STP), P_{STW}	1.3244	kg/m ³
Dry Density (Actual), P_{Actual}	0.5852	kg/m ³
Average Wet Density (Actual), $P_{ActualW}$	0.581	kg/m ³

PRELIMINARY STACK SURVEY**TRAVERSE 1**

Date of Survey	17 November 2010
Time of Survey	10:00
Velocity Measurement Device:	S-Type

Sampling Line A							
Traverse Point	Distance into duct (m)	ΔP_{pt} mmH ₂ O	ΔP_{pt} Pa	Temp °C	Velocity m/s	O ₂ % Vol	Angle of Swirl °
1	0.02	2.2	22	347	7.13	10.8	0
2	0.05	2.1	21	347	6.96	10.8	0
3	0.08	2.2	22	347	7.13	10.8	0
4	0.11	2.2	22	347	7.13	10.8	0
5	0.14	2.3	23	347	7.29	10.8	0
6	0.17	2.4	24	347	7.44	10.8	0
7	0.20	2.4	24	347	7.44	10.8	0
8	0.23	2.2	22	347	7.13	10.8	0
9	0.26	2.1	21	347	6.96	10.8	0
10	0.29	2.0	20	347	6.79	10.8	0
Mean	-	2.2	22	347	7.14	10.8	

Sampling Line B							
Traverse Point	Distance into duct (m)	ΔP_{pt} mmH ₂ O	ΔP_{pt} Pa	Temp °C	Velocity m/s	O ₂ % Vol	Angle of Swirl °
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
Mean	-	-	-	-	-	-	

PRELIMINARY STACK SURVEY (CONTINUED)

TRAVERSE 1 CONTINUED

Sampling Line C							
Traverse Point	Distance into duct (m)	ΔP_{pt} mmH ₂ O	ΔP_{pt} Pa	Temp °C	Velocity m/s	O ₂ % Vol	Angle of Swirl °
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
Mean	-	-	-	-	-	-	-
Sampling Line D							
Traverse Point	Distance into duct (m)	ΔP_{pt} mmH ₂ O	ΔP_{pt} Pa	Temp °C	Velocity m/s	O ₂ % Vol	Angle of Swirl °
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
Mean	-	-	-	-	-	-	-

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY (CONTINUED)

Sampling Plane Validation Criteria

EA Technical Guidance Document (Monitoring) M1	Result	Units	Requirement	Compliant
Lowest Differential Pressure	19.6	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	6.79	m/s	-	-
Highest Gas Velocity	7.44	m/s	-	-
Ratio of Above	1.10	-	< 3 : 1	Yes
Angle of flow with regard to duct axis	0	°	< 15°	Yes
No local negative flow	-	-	-	Yes

Other Sampling Method Criteria	Result	Units	Requirement	Compliant
Mean Velocity	7.14	m/s	-	-
Standard Deviation of Velocity from Mean	2.91	%	< 10%	Yes
Mean Oxygen	10.80	%	-	-
Standard Deviation of Oxygen from Mean	0.00	%	< 15%	-
Homogeneous flow stream / gas velocity	-	-	-	Yes

Where:

P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)

$P_{STW} = (P_{STD} + p_i \text{ of } H_2O) / (1 + (p_i \text{ of } H_2O / 0.8036))$

$P_{Actual} = P_{STD} \times (T_s / P_s) \times (P_a / T_a)$

$P_{ActualW} \text{ (at each sampling point)} = P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Velocity, V

Velocity at Traverse Point, $V = K_{pt} \times (1-\epsilon) \times \sqrt{(2 \times \Delta P_{pt} / P_{ActualW})}$

Where:

K_{pt} = Pitot tube calibration coefficient

(1-ε) = Compressibility correction factor, assumed at a constant 0.998

Average Stack Gas Velocity, V_a

7.14

m/s

PRELIMINARY STACK SURVEY (CONTINUED)**Calculation of Stack Gas Volumetric Flowrate, Q****Sampling plane reference conditions**

Duct gas flow conditions	Actual	Reference	Units
Temperature	347	0	°C
Total Pressure	101.01	101.3	kPa
Oxygen	11	11	%
Moisture	1.61	0.00	%

Gas Volumetric Flowrate	Result	Units
Gas Volumetric Flowrate (Actual), Q_{Actual}	1817	m ³ /hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	798	m ³ /hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	785	m ³ /hr
Gas Volumetric Flowrate (REF), Q_{Ref}	808	m ³ /hr

Where:

$$Q_{Actual} = V_a \times A \times 3600$$

$$Q_{STP} = Q (Actual) \times (T_s / T_a) \times (P_a / P_s) \times 3600$$

$$Q_{STP,Dry} = Q (STP) / (100 - (100 / Ma)) \times 3600$$

$$Q_{Ref} = Q (STP) \times ((100 - Ma) / (100 - Ms)) \times ((20.9 - O_{2a}) / (20.9 - O_{2s}))$$

Nomenclature:

T_s = Absolute Temperature, Standard Conditions, 273 K

P_s = Absolute Pressure, Standard Conditions, 101.3 kPa

T_a = Absolute Temperature, Actual Conditions, K

P_a = Absolute Pressure, Actual Conditions, kPa

Ma = Water vapour, Actual Conditions, % Vol

Ms = Water vapour, Reference Conditions, % Vol

O_{2a} = Oxygen, Actual Conditions, % Vol

O_{2s} = Oxygen, Reference Conditions, % Vol

APPENDIX 3 - Calibrateable Equipment Checklist & Calibration Gases

CALIBRATEABLE EQUIPMENT CHECKLIST

Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	Equipment I.D.	Equipment	Equipment I.D.	Equipment	Equipment I.D.
Control Box DGM	LAB 13-04	Horiba PG-250 Analyser	LAB 0944	Laboratory Balance	-
Box Thermocouples	LAB 03-04	JCT JCC P-1 Cooler	LAB 0928	Tape Measure	-
Meter In Thermocouple	LAB 10-04a	MAK 10 Cooler	-	Stopwatch	LAB 2306
Meter Out Thermocouple	LAB 10-04b	FT-IR	-	Protractor	LAB 1718
Control Box Timer	LAB 17-04	FT-IR Oven Box	-	Barometer	-
Oven Box	-	Bernath 3006 FID	-	Digital Micromanometer	-
Probe	-	Signal 3030 FID	-	Digital Temperature Meter	-
Probe Thermocouple	-	Servomex	-	Stack Thermocouple	-
Probe	LAB 1299	JCT Heated Head Filter	-	Mass Flow Controller	-
Probe Thermocouple	-	Thermo FID	LAB 1211	Mass Flow Control Box	-
S-Pitot	LAB 0726	Stackmaster	-	1m Heated Line (1)	-
L-Pitot	-	FTIR Heater Box for Heated Line	-	1m Heated Line (2)	-
Site Balance	LAB 1410		-	1m Heated Line (3)	-
Last Impinger Arm	-		-	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-		-	10m Heated Line (1)	-
Callipers	LAB 3106		-	10m Heated Line (2)	-
Small DGM	-		-	15m Heated Line (1)	-
Heater Controller	-		-	20m Heated Line (1)	LAB 1802
			-	20m Heated Line (2)	-

NOTE: If the equipment I.D is represented by a dash (-), then this piece of equipment has not been used for this test.

CALIBRATION GASES

Gas	Cylinder I.D. Number	Supplier	ppm	%	Analytical Tolerance +/- %
Oxygen	-	Fresh Air	-	20.95	-
Propane	HPC 512	Cryoservice	9.9	-	2
Carbon Monoxide	HPC 537	Cryoservice	168.95	-	2
Carbon Dioxide	HPC 407	Cryoservice	-	7.79	2

All the above gases are traceable to ISO 17025.

APPENDIX 4 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - TOTAL PARTICULATE MATTER

Run	Sampled Volume	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Limit of Detection	Leak	Uncollected Mass
	m ³	K	kPa	% by volume	% by volume	% by mass	%	mg
MU required	≤ 2%	≤ 2%	≤ 1%	≤ 1%	≤ 10%	≤ 5% of ELV	≤ 2%	≤ 10% of ELV
Run 1	0.001	2	0.5	1	0.1	0.1265	-	-
as a %	0.49	0.70	0.50	1.00	0.91	N/A	1.66	N/A
compliant?	Yes	Yes	Yes	Yes	Yes	N/A	Yes	N/A
Run 2	0.001	2	0.5	1.00	0.1	0.126	-	-
as a %	0.49	0.69	0.50	1.00	0.91	N/A	1.65	N/A
compliant?	Yes	Yes	Yes	Yes	Yes	N/A	Yes	N/A
Run 3	0.001	2	0.5	1	0.1	0.1265	-	-
as a %	0.46	0.69	0.50	1.00	0.91	N/A	1.55	N/A
compliant?	Yes	Yes	Yes	Yes	Yes	N/A	Yes	N/A

Run	Volume (STP)	Mass of particulate	O2 Correction	Leak	Uncollected Mass	Combined uncertainty
	m ³	mg	-	mg/m ³	mg	
Run 1	0.20	27.0300	1.00	1.259	0.00	-
MU as mg/m ³	1.85	0.6141	1.31	1.259	0.00	2.67
MU as %	1.41	0.4680	-	0.959	0.00	-
Run 2	0.19	26.4600	1.00	1.221	0.00	-
MU as mg/m ³	1.81	0.6135	0.00	1.221	0.00	2.27
MU as %	1.4	0.4780	-	0.951	0.00	-
Run 3	0.20	26.0000	1.00	1.067	0.00	-
MU as mg/m ³	1.67	0.5807	0.00	1.067	0.00	1.73
MU as %	1.40	0.4865	-	0.894	0.002	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	5.34	mg/m³	4.07	%
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R2 - Uncertainty expressed at a 95% confidence level (where k = 2)	4.54	mg/m³	3.53	%
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R3 - Uncertainty expressed at a 95% confidence level (where k = 2)	4.13	mg/m³	3.46	%
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(k is a coverage factor which gives a 95% confidence in the quoted figures)

Developed for the STA by R Robinson, NPL

APPENDIX 4 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - MOISTURE

Run	Sampled Volume m ³	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Leak %
MU required	≤ 2%	≤ 2%	≤ 1%	≤ 1%	≤ 10%	≤ 2%
Run 1	0.001	2	0.5	1	0.1	-
as a %	0.49	0.70	0.50	1.00	0.91	1.66
compliant?	Yes	Yes	Yes	Yes	Yes	Yes
Run 2	0.001	2	0.5	1	0.1	-
as a %	0.49	0.69	0.50	1.00	0.91	1.65
compliant?	Yes	Yes	Yes	Yes	Yes	Yes
Run 3	0.001	2	0.5	1	0.1	-
as a %	0.46	0.69	0.50	1.00	0.91	1.55
compliant?	Yes	Yes	Yes	Yes	Yes	Yes
Run	Volume (STP) m ³	Mass Gained mg	O2 Correction -	Leak mg/m ³	Uncollected Mass mg	Combined uncertainty
Run 1	0.20	2700.00	1.00	125.76	57.74	-
MU as % v/v	0.02	0.06	0.02	0.02	0.035	0.08
MU as %	1.41	3.70	1.00	0.96	2.14	-
Run 2	0.19	2700.00	1.00	124.57	57.74	-
MU as % v/v	0.02	0.06	0.02	0.02	0.04	0.08
MU as %	1.41	3.70	1.00	0.95	2.14	-
Run 3	0.20	2700.00	1.00	110.82	57.74	-
MU as % v/v	0.02	0.06	0.02	0.01	0.03	0.07
MU as %	1.40	3.70	0.95	0.89	2.14	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	0.16	% v/v	9.42	%
R2 - Uncertainty expressed at a 95% confidence level (where k = 2)	0.16	% v/v	9.42	%
R3 - Uncertainty expressed at a 95% confidence level (where k = 2)	0.15	% v/v	9.39	%

APPENDIX 4 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VOLATILE ORGANIC COMPOUNDS RUN 1

Measured Concentration	ND	mg/m ³
Limit	-	mg/m ³
Calibration Gas Concentration	15.84	mg/m ³
Range	160	mg/m ³

Performance characteristics	Value	Units	specification	MU Met?
Response time	35	seconds	<180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	85	minutes	-	-
Number of readings in measurement	85	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.70	% of value	<2 % range	Yes
Zero drift	0.10	% full scale	<2% range / 24hr	Yes
Span drift	-0.12	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	0.02	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.80	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	0.01	% full scale/10K	<3% range / 10 K	Yes
dependence on voltage	0.10	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	-0.20	% of value	< 2% of span gas value	Yes
Uncertainty of calibration gas	2.0	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	ur0	0.02
Standard deviation of repeatability at span level	urs	0.02
Lack of fit	ufit	N/A
Drift	u0dr	N/A
volume or pressure flow dependence	uspres	N/A
atmospheric pressure dependence	uapres	N/A
ambient temperature dependence	utemp	N/A
Dependence on voltage	uvolt	N/A
losses in the line (leak)	uleak	N/A
Uncertainty of calibration gas	ucalib	N/A
Uncertainty in factor	uf	N/A

Measurement uncertainty Measured Concentration	ND	mg/m ³
Combined uncertainty	-	mg/m ³
Expanded uncertainty	-	mg/m ³

Expanded uncertainty expressed with a level of confidence of 95%	-	% ELV
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Expanded uncertainty expressed with a level of confidence of 95%	-	mg/m³
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Expanded uncertainty expressed with a level of confidence of 95%	-	% value
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Developed for the STA by R Robinson, NPL

APPENDIX 4 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - CARBON MONOXIDE

Limit value	-	mg/m ³
Measured concentration	130.7	mg/m ³
Cal gas conc	211	mg/m ³
Full Scale	250	mg/m ³

Performance characteristics	Value	Units	specification	MU Met?
Response time	20	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	85	minutes	-	-
Number of readings in measurement	85	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.7	% of value	<2 % range	Yes
Zero drift	0.01	% full scale	<2% range / 24hr	Yes
Span drift	0.118	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	0.02	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.80	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	0.01	% full scale/10K	<3% range / 10 K	Yes
dependence on voltage	0.10	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	0.06	% of value	< 2% of value	Yes
Uncertainty of calibration gas	2	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	ur0	0.02
Standard deviation of repeatability at span level	urs	0.02
Lack of fit	ufit	1.01
Drift	u0dr	0.05
volume or pressure flow dependence	uspres	0.00
atmospheric pressure dependence	uapres	0.06
ambient temperature dependence	utemp	0.00
Dependence on voltage	uvolt	0.22
losses in the line (leak)	uleak	0.04
Uncertainty of calibration gas	ucalib	1.51
Uncertainty in factor	uf	4.96

Measurement uncertainty (Concentration Measured)	130.7	mg/m ³
Combined uncertainty	5.3	mg/m ³
Expanded uncertainty	10.6	mg/m ³

Expanded uncertainty expressed with a level of confidence of 95%	-	% ELV
Expanded uncertainty expressed with a level of confidence of 95%	10.58	mg/m³
Expanded uncertainty expressed with a level of confidence of 95%	8.10	% value

Developed for the STA by R Robinson, NPL

APPENDIX 4 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - CARBON DIOXIDE

Limit value	-	%vol
Measured concentration	8.91	%vol
Calibration gas	7.79	%vol
Full Scale	20	%vol

Performance characteristics	Value	Units	specification	MU Met?
Response time	23	seconds	< 200 s	Yes
Logger sampling interval	60	seconds	0	-
Measurement period	85	minutes	0	-
Number of readings in measurement	85	-	0	-
Repeatability at zero	0.015	% by volume	<0.2 % range	Yes
Repeatability at span level	0.014	% by volume	<0.4 % range	Yes
Deviation from linearity	0.13	% vol	<0.3 % volume	Yes
Zero drift (during measurement period)	0.1	% vol at zero level	<2% of volume / 24hr	Yes
Span drift (during measurement period)	0.39	% vol at span level	<2% volume/24hr	Yes
volume or pressure flow dependence	0.02	% of fs / 10l/h	<1% range	Yes
atmospheric pressure dependence	0.8	% of fs/kPa	< 1.5 % range	Yes
ambient temperature dependence	0.01	% by volume /10K	<0.3% volume 10 K	Yes
Combined interference	0.56	% range	<2% range	No
Dependence on voltage	0.1	% by volume /10V	< 0.1%vol /10 volt	Yes
Losses in the line (leak)	0.13	% of value	< 2% of value	Yes
Uncertainty of calibration gas	2	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	ur0	-
Standard deviation of repeatability at span level	urs	0.0015
Lack of fit	ufit	0.0751
Drift	u0dr	0.3120
volume or pressure flow dependence	uspres	0.0000
atmospheric pressure dependence	uapres	0.0098
ambient temperature dependence	utemp	0.0005
Combined interference (from mcerts)	-	0.0647
dependence on voltage	uvolt	0.0862
losses in the line (leak)	uleak	0.0066
Uncertainty of calibration gas	ucalib	0.1029

Measurement uncertainty (Concentration Measured)	8.91	%vol
Combined uncertainty	0.35	%vol
% of value	3.97	%

Expanded uncertainty expressed with a level of confidence of 95%	7.95	% of value
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Expanded uncertainty expressed with a level of confidence of 95%	0.71	% vol
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Developed for the STA by R Robinson, NPL

APPENDIX 4 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXYGEN

Reference	11	%vol
Measured concentration	10.70	%vol
Calibration gas	20.95	%vol
Full Scale	25	%vol

Performance characteristics	Value	Units	specification	MU Met?
Response time	23	seconds	< 200 s	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	85	minutes	-	-
Number of readings in measurement	85	-	-	-
Repeatability at zero	0.015	% by volume	<0.2 % range	Yes
Repeatability at span level	0.014	% by volume	<0.4 % range	Yes
Deviation from linearity	0.13	% vol	<0.3 % volume	Yes
Zero drift (during measurement period)	0.08	% vol at zero level	<2% of volume / 24hr	Yes
Span drift (during measurement period)	0.10	% vol at span level	<2% volume/24hr	Yes
volume or pressure flow dependence	0.02	% of fs / 10l/h	<1% range	Yes
atmospheric pressure dependence	0.80	% of fs/kPa	< 1.5 % range	Yes
ambient temperature dependence	0.01	% by volume /10K	<0.3% volume 10 K	Yes
Combined interference	0.14	% range	<2% range	Yes
Dependence on voltage	0.10	% by volume /10V	< 0.1%vol /10 volt	Yes
Losses in the line (leak)	0.00	% of value	< 2% of value	Yes
Uncertainty of calibration gas	2.00	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	ur0	-
Standard deviation of repeatability at span level	urs	0.0015
Lack of fit	ufit	0.0751
Drift	u0dr	0.0743
volume or pressure flow dependence	uspres	0.00003
atmospheric pressure dependence	uapres	0.0122
ambient temperature dependence	utemp	0.0005
Combined interference (from mcerts)	-	0.0808
dependence on voltage	uvolt	0.0862
losses in the line (leak)	uleak	0.0000
Uncertainty of calibration gas	ucalib	0.1236

Measurement uncertainty (Concentration Measured)	10.70	%vol
Combined uncertainty	0.20	%vol
% of value	1.88	%

Expanded uncertainty expressed with a level of confidence of 95%	3.76	% of value
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Expanded uncertainty expressed with a level of confidence of 95%	0.403	% vol
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Developed for the STA by R Robinson, NPL

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