AIR & EMISSIONS TESTING GROUP

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Stack Emissions Testing Report

Operator / Company
Wood Waste Technology Ltd

Site:
Stafford

Release Point:
Wood Burner (High Fire)

Sampling Date/s:
17th November 2010

Job Number:
LAB 9746

Report Date: Version:	25th November 2010 1
Report By: MCERTS Number: MCERTS Level: Technical Endorsements:	Mark Woodruff MM 03 164 MCERTS Level 2 - Team Leader 1, 2, 3 & 4
Report Approved By: MCERTS Number: Business Title: Technical Endorsements: Signature:	Andrew Palliser MM 03 161 MCERTS Level 2 - Business Manager 1, 2, 3 & 4 

UKAS TESTING 1015

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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 high fire operating conditions.

Plant

Wood Burner (High 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

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

EXECUTIVE SUMMARY

Emissions Summary

Parameter	Units	Result	Uncertainty +/-	Limit
Total Particulate Matter	mg/m³	161	5.8	-
Particulate Emission Rate	g/hr	124	4.5	-
Volatile Organic Compounds	mg/m³	0.81	1.3	-
Volatile Organic Compounds Emission Rate	g/hr	0.72	1.2	-
Carbon Monoxide	mg/m³	64	4.8	-
Carbon Monoxide Emission Rate	g/hr	57	4.2	-
Carbon Dioxide	% v/v	9.6	0.74	-
Oxygen	% v/v	9.8	0.39	-
Moisture	%	0.89	0.14	-
Stack Gas Temperature	°C	347	-	-
Stack Gas Velocity	m/s	7.1	-	-
Gas Volumetric Flow Rate (Actual)	m³/hr	1817	-	-
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	798	-	-
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	791	-	-
Gas Volumetric Flow Rate (@ref conditions)	m³/hr	882	-	-

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	13:16 - 13:46	30 minutes
Total Particulate Matter Run 2	17 November 2010	13:50 - 14:20	30 minutes
Total Particulate Matter Run 3	17 November 2010	14:23 - 14:53	30 minutes
Volatile Organic Compounds Run 1	17 November 2010	13:50 - 14:50	60 minutes
Combustion Gases	17 November 2010	13:16 - 14:53	97 minutes

EXECUTIVE SUMMARY

Process Details

Parameter	Process Details
Process Status	High Fire
Percentage of capacity or Tonnes / Hour	70 kg/hr
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	0.58 mg/m³	30%	3.6 %

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/m³	20%	163.9 %
CO	BS EN 15058	AE 007 / AE 015	1015	Yes	0.2 mg/m³	25%	7.4%
CO_2	BS ISO 12039	AE 007 / AE 015	1016	Yes	0.002 mg/m³%	10%	7.7%
O_2	BS EN 14789	AE 007 / 015	1015	Yes	0.01%	10%	4.0%
H_2O	BS EN 14790	AE 004	1015	Yes	0.0005 %	10%	15.9%

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_2O	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 prefered 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	^{o}	< 15^{o}	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	N/A
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.

APPENDICES

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APPENDICES

STACK EMISSIONS MONITORING TEAM

Team Leader	Ivan Hernandez MCERTS Level 2, Technical Endorsements 1, 2, 3 & 4 MM 06 696
Technician	Lawrence Mason MCERTS Level 2, Technical Endorsements 1 & 4 MM 07 849

TOTAL PARTICULATE MATTER SUMMARY

Test	Sampling Times	Concentration mg/m³	LOD mg/m³	Limit mg/m³	Emission Rate g/hr
Run 1	13:16 - 13:46 17 November 2010	172	0.58	-	136
Run 2	13:50 - 14:20 17 November 2010	171	0.61	-	127
Run 3	14:23 - 14:53 17 November 2010	141	0.56	-	110
Blank	-	0.74	-	-	-

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		
Barometric pressure, P_b	mm Hg	757.51
Stack static pressure, P_{static}	mm H_2O	1.02
$P_s = \frac{P_b + (P_{static})}{13.6}$	mm Hg	757.58
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	1.5
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.001869
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.240
Gas meter correction factor, Y_d		0.930
Mean dry gas meter temperature, T_m		17.583
Mean pressure drop across orifice, ΔH	mmH_2O	5.497
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(\Delta H/13.6))(Y_d)}{T_m + 273}$		0.209
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.2109
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$		
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No
% oxygen measured in gas stream, act%O_2		10.5
% oxygen reference condition		11
O_2 Reference Factor $O2\ Ref = \frac{21.0 - act\%O2}{21.0 - ref\%O2}$		1.05
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	0.2195
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0089
	%	0.89
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Pitot tube velocity constant, K_p		34.97
Velocity pressure coefficient, C_p		0.83
Mean of velocity heads, ΔP_{avg}	mm H_2O	2.00
Mean square root of velocity heads, $\sqrt{\Delta P}$		1.41
Mean stack gas temperature, T_s	^oC	350
$V_s = \frac{(K_p)(C_p)(\sqrt{\Delta P})(\sqrt{(T_s + 273)})}{(M_s)(P_s)}$	m/s	6.81

Molecular weight of dry gas, M_d		
CO_2	%	9.65
O_2	%	10.50
Total	%	20.15
N_2 (100 -Total)	%	79.85
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.96
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	29.86
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.07
$Q_a = (60)(A_s)(V_s)$	m^3/min	28.9
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s) +273}$	Dry	12.5
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s) +273}$	@O2ref	13.13
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s) +273}$	Wet	12.62
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	7.00
Nozzle area, A_n	mm^2	38.49
Total sampling time, θ	min	30
$\%I = \frac{(4.6398E6)(T_s+273)(V_{mstd})}{(P_s)(V_s)(A_n)(\theta)(1-B_{wo})}$	%	102.3
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.02774
Mass collected in probe, M_p	g	0.01011
Total mass collected, M_n	g	0.0379
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	179.438
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	181.043
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	172.422
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		135.89

ISOKINETIC SAMPLING EQUATIONS - RUN 2

TPM

Absolute pressure of stack gas, P_S		
Barometric pressure, P_b	mm Hg	757.51
Stack static pressure, P_{static}	mm H_2O	1.02
$P_s = \frac{P_b + (P_{static})}{13.6}$	mm Hg	757.58
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	1.5
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.001869
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.229
Gas meter correction factor, Y_d		0.930
Mean dry gas meter temperature, T_m		18.250
Mean pressure drop across orifice, ΔH	mmH_2O	4.888
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(\Delta H/13.6))(Y_d)}{T_m + 273}$		0.199
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.2009
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$		
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No
% oxygen measured in gas stream, act%O_2		10.5
% oxygen reference condition		11
O_2 Reference Factor $O2\ Ref = \frac{21.0 - act\%O2}{21.0 - ref\%O2}$		1.05
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	0.2090
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0093
	%	0.93
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Pitot tube velocity constant, K_p		34.97
Velocity pressure coefficient, C_p		0.83
Mean of velocity heads, ΔP_{avg}	mm H_2O	1.80
Mean square root of velocity heads, $\sqrt{\Delta P}$		1.34
Mean stack gas temperature, T_s	^oC	359
$V_s = \frac{(K_p)(C_p)(\sqrt{\Delta P})(\sqrt{(T_s + 273)})}{(M_s)(P_s)}$	m/s	6.51

Molecular weight of dry gas, M_d		
CO_2	%	9.65
O_2	%	10.50
Total	%	20.15
N_2 (100 -Total)	%	79.85
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.96
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	29.85
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.07
$Q_a = (60)(A_s)(V_s)$	m^3/min	27.6
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s) +273}$	Dry	11.8
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s) +273}$	@O2ref	12.37
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s) +273}$	Wet	11.89
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	7.00
Nozzle area, A_n	mm^2	38.49
Total sampling time, θ	min	30
$\%I = \frac{(4.6398E6)(T_s+273)(V_{mstd})}{(P_s)(V_s)(A_n)(\theta)(1-B_{wo})}$	%	103.4
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.02611
Mass collected in probe, M_p	g	0.00952
Total mass collected, M_n	g	0.03563
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	177.36
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	179.03
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	170.51
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		126.52

ISOKINETIC SAMPLING EQUATIONS - RUN 3

TPM

Absolute pressure of stack gas, P_S		
Barometric pressure, P_b	mm Hg	757.51
Stack static pressure, P_{static}	mm H_2O	1.02
$P_s = \frac{P_b + (P_{static})}{13.6}$	mm Hg	757.58
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	1.5
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.001869
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.246
Gas meter correction factor, Y_d		0.930
Mean dry gas meter temperature, T_m		18.333
Mean pressure drop across orifice, ΔH	mmH_2O	5.378
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(\Delta H/13.6))(Y_d)}{T_m + 273}$		0.214
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.2156
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$		
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No
% oxygen measured in gas stream, act%O_2		10.5
% oxygen reference condition		11
O_2 Reference Factor $O2\ Ref = \frac{21.0 - act\%O2}{21.0 - ref\%O2}$		1.05
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	0.2244
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$	%	0.0087 0.87
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Pitot tube velocity constant, K_p		34.97
Velocity pressure coefficient, C_p		0.83
Mean of velocity heads, ΔP_{avg}	mm H_2O	2.00
Mean square root of velocity heads, $\sqrt{\Delta P}$		1.41
Mean stack gas temperature, T_s	^oC	365
$V_s = \frac{(K_p)(C_p)(\sqrt{\Delta P})(\sqrt{(T_s + 273)})}{(M_s)(P_s)}$	m/s	6.89

Molecular weight of dry gas, M_d		
CO_2	%	9.65
O_2	%	10.50
Total	%	20.15
N_2 (100 -Total)	%	79.85
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.96
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	29.86
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.07
$Q_a = (60)(A_s)(V_s)$	m^3/min	29.2
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s) +273}$	Dry	12.4
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s) +273}$	@O2ref	12.98
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s) +273}$	Wet	12.47
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	7.00
Nozzle area, A_n	mm^2	38.49
Total sampling time, θ	min	30
$\%I = \frac{(4.6398E6)(T_s+273)(V_{mstd})}{(P_s)(V_s)(A_n)(\theta)(1-B_{wo})}$	%	105.9
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.02325
Mass collected in probe, M_p	g	0.00847
Total mass collected, M_n	g	0.03172
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	147.12
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	148.41
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	141.34
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		110.07

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	7.44	0.12	0.12	-10	0.15	Yes
Run 2	7.10	0.13	0.12	-10	0.14	Yes
Run 3	7.62	0.12	0.11	-10	0.15	Yes

Isokineticity

Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	102.32	Yes
Run 2	103.44	Yes
Run 3	105.86	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	0.74	-	-	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	0	180	160
Run 2	GF	47	0	180	160
Run 3	GF	47	0	180	160

GF = Glass Fibre

QF = Quartz Fibre

VOLATILE ORGANIC COMPOUNDS SUMMARY

Test	Sampling Times	Concentration mg/m³	LOD mg/m³	Limit mg/m³	Emission Rate g/hr
Run 1	13:50 - 14:50 17 November 2010	0.81	0.40	-	0.72

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

INSTRUMENTAL SPAN & ZERO CHECKS

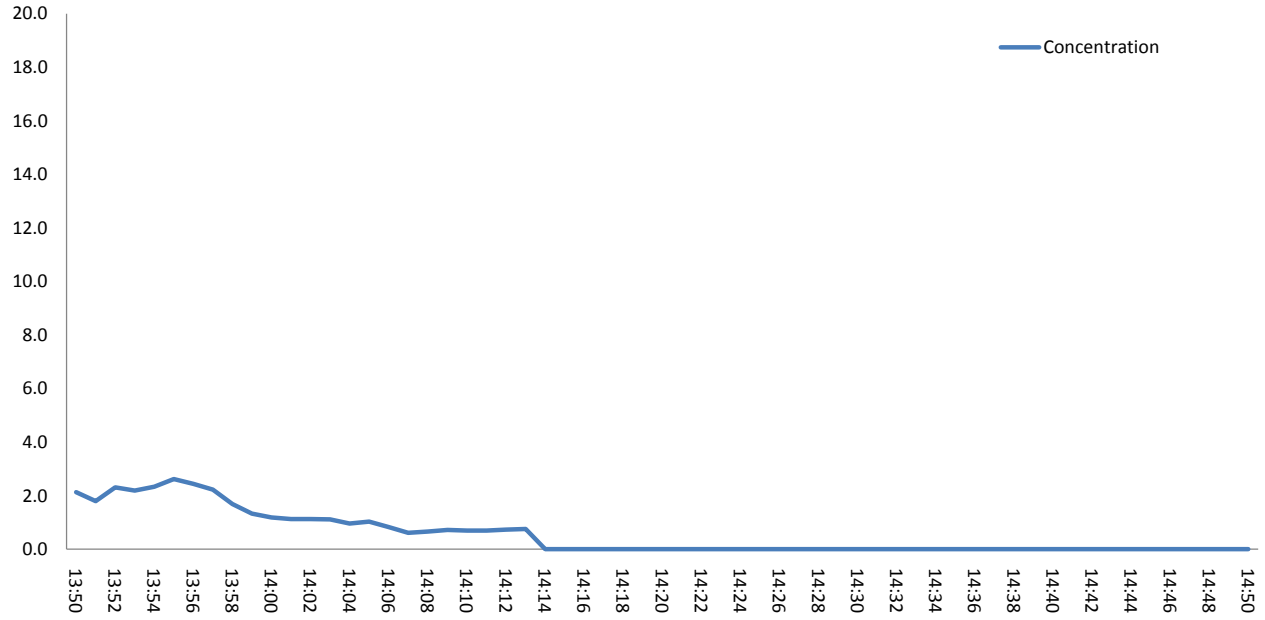
PRE-SAMPLING CALIBRATION CHECKS

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/m³	LOD mg/m³	Limit mg/m³	Emission Rate g/hr
CO	13:16 - 14:53 17 November 2010	64	0.35	-	57

Test	Sampling Times	Concentration %	LOD %
CO_2	13:16 - 14:53 17 November 2010	9.63	0.002
O_2	13:16 - 14:53 17 November 2010	9.84	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)	2.3

(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
CO2	20	0.1	7.81	0.1	0.09	7.82	23	0.13
O2	25	0.03	20.96	0.05	0.09	20.96	23	0.00

POST-SAMPLING CALIBRATION DATA

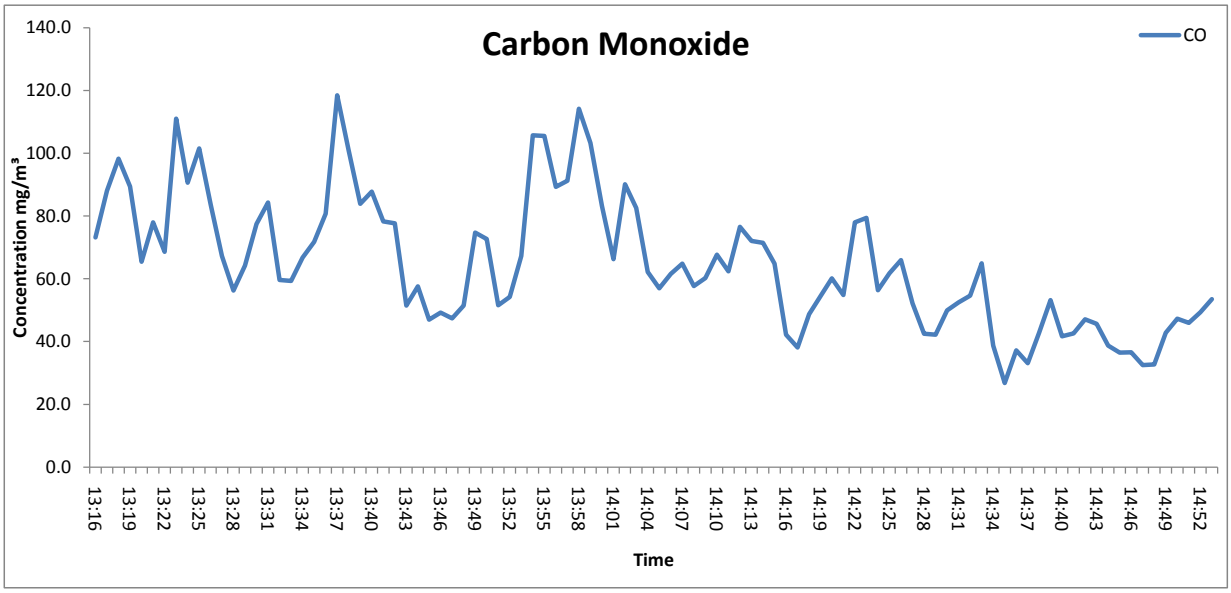
Date	17 November 2010
Start Time	15:00
End Time	15:06

Cooler Temp. (°C)	2.2

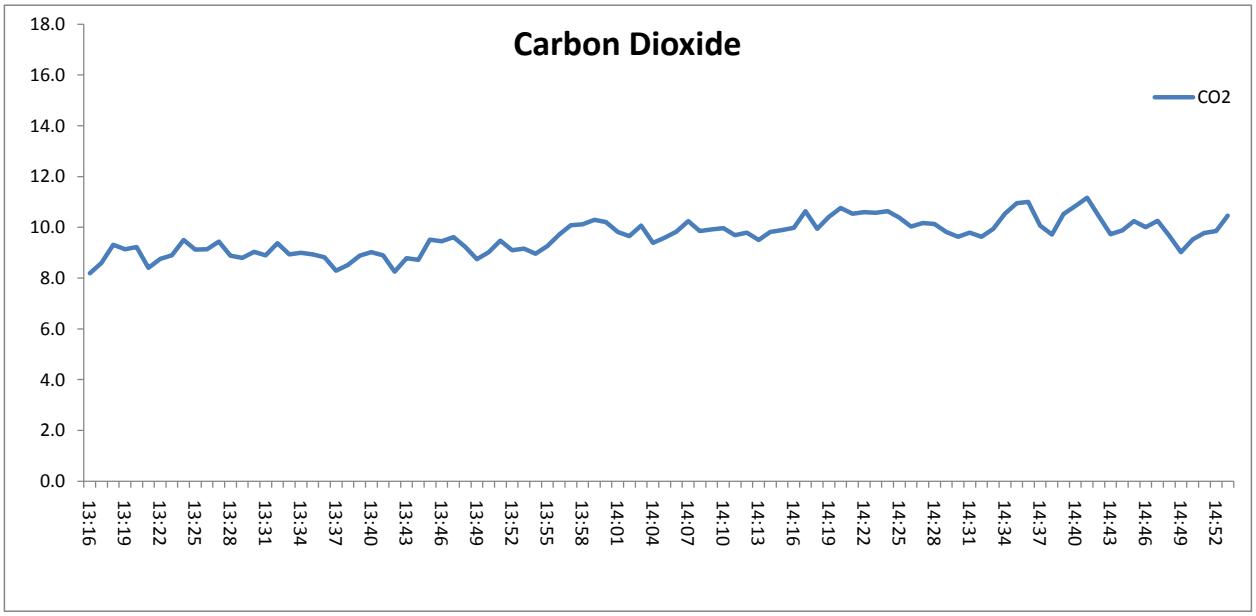
(should be < 4°C)

Gas	Zero Check down line	Span Check down line	Zero Drift (%)	Span Drift (%)
CO	0.12	169.3	0.01	0.12
CO2	0.11	7.85	0.10	0.39
O2	0.11	20.98	0.08	0.10

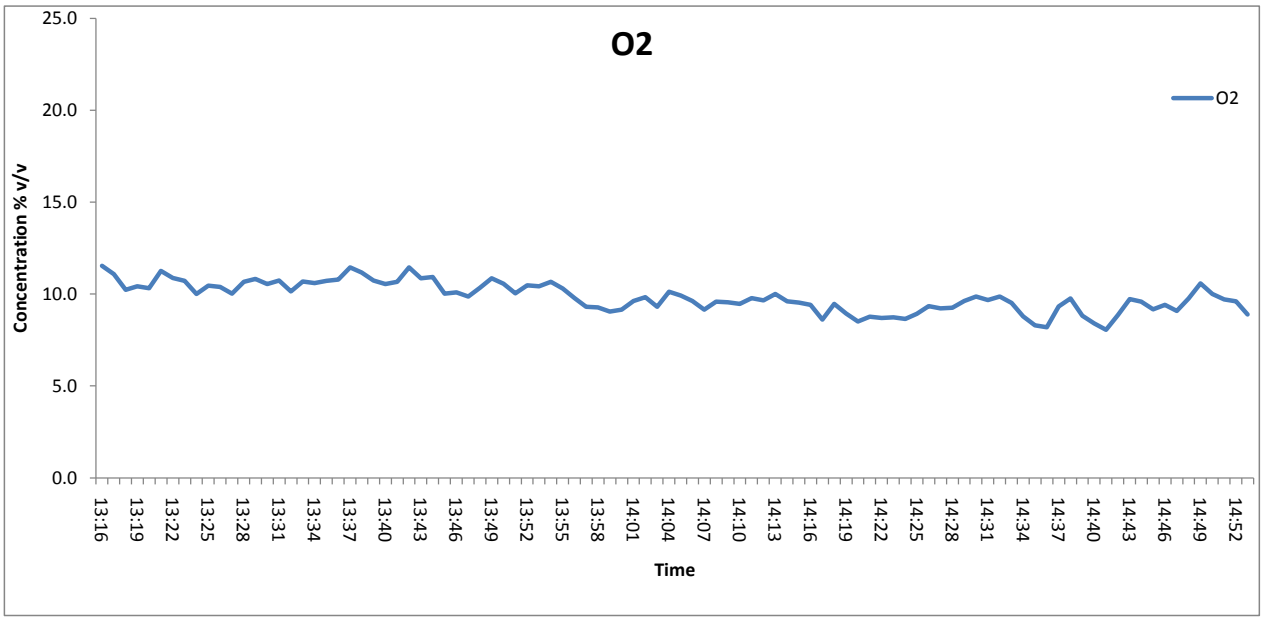
CARBON MONOXIDE EMISSIONS CHART



CARBON DIOXIDE EMISSIONS CHART



OXYGEN EMISSIONS CHART



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	^oC
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 p	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	8.919501	0.089195	0.175095
O_2	32	1.427679	10.800000	0.108000	0.154189	10.703402	0.107034	0.152810
N_2	28	1.249219	80.200000	0.802000	1.001874	79.482669	0.794827	0.992913
H_2O	18	0.803070	-	-	-	0.894428	0.008944	0.007183

Where:
p = M / 22.41
p*i* = r x p

Calculation of Stack Gas Densities

Determinand	Result	Units
Dry Density (STP), P_{STD}	1.3327	kg/m^3
Wet Density (STP), P_{STW}	1.3280	kg/m^3
Dry Density (Actual), P_{Actual}	0.5852	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	0.583	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_2O	ΔP pt Pa	Temp ^oC	Velocity m/s	O_2 % Vol	Angle of Swirl ^{o}
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_2O	ΔP pt Pa	Temp ^oC	Velocity m/s	O_2 % Vol	Angle of Swirl ^{o}
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_2O	ΔP pt Pa	Temp ^{o}C	Velocity m/s	O_2 % Vol	Angle of Swirl ^{o}
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
Mean	-	-	-	-	-	-	

Sampling Line D							
Traverse Point	Distance into duct (m)	ΔP pt mmH_2O	ΔP pt Pa	Temp ^{o}C	Velocity m/s	O_2 % Vol	Angle of Swirl ^{o}
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
Mean	-	-	-	-	-	-	

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	^{o}	< 15^{o}	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/m^3 (not including water vapour)

P_{STW} = (P_{STD} + p*i* of H_2O) / (1 + (p*i* of H_2O / 0.8036))

P_{Actual} = P_{STD} x (Ts / Ps) x (Pa / Ta)

$P_{ActualW}$ (at each sampling point) = P_{STW} x (Ts / Ps) x (Pa / Ta)

Calculation of Stack Gas Velocity, V

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

Where:

K_{pt} = Pitot tube calibration coefficient

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

Average Stack Gas Velocity, Va **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	^{o}C
Total Pressure	101.01	101.3	kPa
Oxygen	10	11	%
Moisture	0.89	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), $Q_{STP,Dry}$	791	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	882	m^3/hr

Where:

Q_{Actual} = Va x A x 3600

Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps) x 3600

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

Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((20.9 - O_2a) / (20.9 - O_2s))

Nomenclature:

Ts = Absolute Temperature, Standard Conditions, 273 K

Ps = Absolute Pressure, Standard Conditions, 101.3 kPa

Ta = Absolute Temperature, Actual Conditions, K

Pa = Absolute Pressure, Actual Conditions, kPa

Ma = Water vapour, Actual Conditions, % Vol

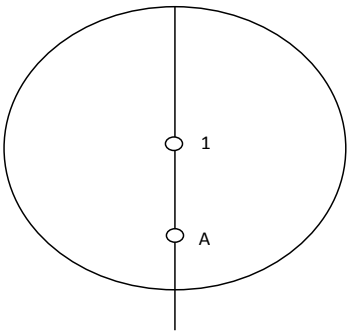
Ms = Water vapour, Reference Conditions, % Vol

O_2a = Oxygen, Actual Conditions, % Vol

O_2s = Oxygen, Reference Conditions, % Vol

STACK DIAGRAM

	Value	Units
Stack Depth	0.30	m
Stack Width	-	m
Area	0.07	m^2



Sampling Line

Non-Isokinetic Sampling

Sampling Point	Distance (% of Depth)	Distance into Stack	Units
A	10	0.03	m

Isokinetic Sampling ISO Methods

Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl º
1	50.0	0.15	0
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

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	-
Umbilical	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

All the above gases are traceable to ISO 17025.

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 %	0.46	0.69	0.50	1.00	0.95	N/A	1.61	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 %	0.48	0.69	0.50	1.00	0.95	N/A	1.69	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 %	0.45	0.69	0.50	1.00	0.95	N/A	1.44	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	0.21	37.8500	0.95	1.606	0.0001	-
MU as mg/m^3	2.41	0.5762	1.64	1.606	0.0004	**3.38**
MU as %	1.40	0.3342	-	0.931	0.0002	-
Run 2	0.20	35.6300	0.95	1.664	0.0001	-
MU as mg/m^3	2.40	0.6053	0.00	1.664	0.0004	**2.98**
MU as %	1.4	0.3550	-	0.976	0.0003	-
Run 3	0.21	31.7200	0.95	1.177	0.0001	-
MU as mg/m^3	1.97	0.5636	0.00	1.177	0.0004	**1.67**
MU as %	1.39	0.3988	-	0.833	0.0003	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**6.76**	**mg/m^3**	**3.92**	**%**
R2 - Uncertainty expressed at a 95% confidence level (where k = 2)	**5.96**	**mg/m^3**	**3.50**	**%**
R3 - Uncertainty expressed at a 95% confidence level (where k = 2)	**4.73**	**mg/m^3**	**3.34**	**%**

(k is a coverage factor which gives a 95% confidence in the quoted figures)

Developed for the STA by R Robinson, NPL

MEASUREMENT UNCERTAINTY BUDGET - MOISTURE

Run	Sampled Volume	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Leak
	m^3	K	kPa	% by volume	% by volume	%
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 2%**
Run 1	0.001	2	0.5	1	0.1	-
as a %	0.46	0.69	0.50	1.00	0.95	1.61
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Run	Volume (STP)	Mass Gained	O2 Correction	Leak	Uncollected Mass	Combined uncertainty
	m^3	mg	-	mg/m^3	mg	
Run 1	0.21	1500.00	0.95	63.64	57.74	-
MU as % v/v	0.01	0.06	0.01	0.01	0.033	**0.07**
MU as %	1.40	6.67	0.95	0.93	3.85	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.14**	**% v/v**	**15.87**	**%**

APPENDIX 4 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VOLATILE ORGANIC COMPOUNDS RUN 1

Measured Concentration	0.8	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	60	minutes	-	-
Number of readings in measurement	60	-	-	-
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	0.65
Drift	u0dr	0.05
volume or pressure flow dependence	uspres	0.00
atmopsheric pressure dependence	uapres	0.04
ambient temperature dependence	utemp	0.00
Dependence on voltage	uvolt	0.14
losses in the line (leak)	uleak	0.00
Uncertainty of calibration gas	ucalib	0.01
Uncertainty in factor	uf	0.02

Measurement uncertainty Measured Concentration	0.81	mg/m^3
Combined uncertainty	0.67	mg/m^3
Expanded uncertainty	1.33	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**-**	**% ELV**
Expanded uncertainty expressed with a level of confidence of 95%	**1.33**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**163.91**	**% value**

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	64.4	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	97	minutes	-	-
Number of readings in measurement	97	-	-	-
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	0.12	% 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)	0.06	% 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	0.03
volume or pressure flow dependence	uspres	0.00
atmopsheric pressure dependence	uapres	0.06
ambient temperature dependence	utemp	0.00
Dependence on voltage	uvolt	0.22
losses in the line (leak)	uleak	0.02
Uncertainty of calibration gas	ucalib	0.74
Uncertainty in factor	uf	2.01

Measurement uncertainty (Concentration Measured)	64.4	mg/m^3
Combined uncertainty	2.4	mg/m^3
Expanded uncertainty	4.8	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**-**	**% ELV**
Expanded uncertainty expressed with a level of confidence of 95%	**4.76**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**7.40**	**% 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	9.6	%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	-	-
Measurement period	97	minutes	-	-
Number of readings in measurement	97	-	-	-
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	0.16	% range	<2% range	Yes
Dependence on voltage	0.1	% by volume /10V	< 0.1%vol /10 volt	Yes
Losses in the line (leak)	0.127877238	% 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	0.00142
Lack of fit	ufit	0.07506
Drift	u0dr	0.33268
volume or pressure flow dependence	uspres	0.00002
atmospheric pressure dependence	uapres	0.00978
ambient temperature dependence	utemp	0.00050
Combined interference (from mcerts)	-	0.01848
dependence on voltage	uvolt	0.08622
losses in the line (leak)	uleak	0.00711
Uncertainty of calibration gas	ucalib	0.11123

Measurement uncertainty (Concentration Measured)	9.63	%vol
Combined uncertainty	0.37	%vol
% of value	3.84	%

Expanded uncertainty expressed with a level of confidence of 95%	**7.67**	**% of value**

Expanded uncertainty expressed with a level of confidence of 95%	**0.74**	**% vol**

Developed for the STA by R Robinson, NPL

APPENDIX 4 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXYGEN

Reference	11	%vol
Measured concentration	9.84	%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	97	minutes	-	-
Number of readings in measurement	97	-	-	-
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	0.0014
Lack of fit	ufit	0.0751
Drift	u0dr	0.0721
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	0.1137

Measurement uncertainty (Concentration Measured)	9.84	%vol
Combined uncertainty	0.19	%vol
% of value	1.98	%

Expanded uncertainty expressed with a level of confidence of 95%	**3.95**	**% of value**

Expanded uncertainty expressed with a level of confidence of 95%	**0.389**	**% vol**

Developed for the STA by R Robinson, NPL

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