STACK EMISSIONS MONITORING REPORT

2-4 Langlands Place
Kelvin South Business Park
East Kilbride
G75 0YF
Tel: 01355 246 730

Your contact at SOCOTEC LTD
David Hay Business Manager - North Tel: 01355 246 730 Email: david.hay@socotec.com

Operator & Address:
Medite Europe Limited Redmonstown, Clonmel, Co. Tipperary, Ireland

Permit Reference:
IE Licence: P0027-04

Release Point:
A2-21

Sampling Date(s):
27 November 2023

SOCOTEC Job Number:	LEK 14129 / Q4
Report Date:	09-Jan-24
Version:	1
Report By: MCERTS Number: MCERTS Level: Technical Endorsements:	Daniel Scully MM 19 1563 MCERTS Level 2 - Team Leader 1, 2, 3 & 4
Report Approved By: MCERTS Number: Business Title: Technical Endorsements: Signature:	Enda Flood MM 12 1170 MCERTS Level 2 - Team Leader 1, 2, 3 & 4 

UKAS TESTING
1015

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

CONTENTS

EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Medite Europe Limited operates a wood production/wood drier process at Clonmel which is subject to IE Licence P0027-04, under the EPA Act 1992.

SOCOTEC LTD were commissioned by Medite Europe Limited to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under normal operating conditions.

The results of these tests shall be used to demonstrate compliance with a set of emission limit values for prescribed pollutants as specified in the Plant's IE Licence, P0027-04.

Plant

A2-21

Operator

Medite Europe Limited
Redmonstown,
Clonmel,
Co. Tipperary,
Ireland

IE Licence: P0027-04

Stack Emissions Monitoring Test House

SOCOTEC - East Kilbride Laboratory
2-4 Langlands Place
Kelvin South Business Park
East Kilbride
G75 0YF
UKAS and MCERTS Accreditation Number: 1015

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.
The results of this testing relate only to the emission release point(s) listed in the report.
MCERTS accredited results will only be claimed where both the sampling and analytical stages are MCERTS accredited.

EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	**Units**	**Result**	**Calculated Uncertainty +/-**	**Emission Limit Value (ELV)**	**Accreditation**
Total Particulate Matter Particulate Emission Rate	mg/m³ g/hr	19.1 5014	0.65 170.5	20 -	MCERTS
Formaldehyde Formaldehyde Emission Rate	mg/m³ g/hr	2.5 670	0.27 71.0	15 -	MCERTS
Oxides of Nitrogen (as NO_2) Oxides of Nitrogen (as NO_2) Emission Rate	mg/m³ g/hr	70 23800	4.3 1460	110 -	MCERTS
Carbon Monoxide Carbon Monoxide Emission Rate	mg/m³ g/hr	7.31 2466.41	1.97 664.16	600 -	MCERTS
Moisture	%	12.64	0.34	-	MCERTS
Stack Gas Temperature	°C	55	-	-	MCERTS
Stack Gas Velocity	m/s	31.0	0.75	-	

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 flow data and not the above values.

Reference conditions are 273K, 101.3kPa, dry gas .

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	**Sampling Date(s)**	**Sampling Times**	**Sampling Duration**
Total Particulate Matter Run 1	27 November 2023	12:23 - 13:23	60 minutes
Formaldehyde Run 1	27 November 2023	12:23 - 13:23	60 minutes
Preliminary Stack Traverse	14 November 2023	11:48-12:16	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	wood Production/Wood Drier
Continuous or batch	Continuous
Product Details	Wood Drier
Part of batch to be monitored (if applicable)	N/A
Normal load, throughput or continuous rating	Normal Production
Fuel used during monitoring	N/A
Abatement	Cyclone
Plume Appearance	Heavy Plume visible

EXECUTIVE SUMMARY

Monitoring Methods

Declaration: Unless otherwise stated as a deviation, work has been completed to conform to the specific requirements of the Irish EPA's monitoring guidance notes; AG1, AG2, and the index of preferred methods.

MONITORING METHODS							
Species	**Method** Standard Reference Method / Alternative Method	**SOCOTEC Technical Procedure**	**UKAS Lab Number**	**Method Accreditation**	**Limit of Detection (LOD)**	**Calculated MU +/- % Result**	**Calculated MU +/- % ELV**
Total Particulate Matter	SRM - EN 13284-1	AE 104	1015	MCERTS	0.2 mg/m³	3.4%	3.28%
Formaldehyde	CEN/TS 17638	AE114	1015	MCERTS	0.012 mg/m³	10.6%	1.8%
Oxides of Nitrogen	SRM - EN 14792:2017	AE 102	1015	MCERTS	0.51 mg/m³	6.1%	3.93%
Carbon Monoxide	SRM - EN 15058:2017	AE 102	1015	MCERTS	0.28 mg/m³	26.9%	0.3%
Moisture	EN 14790	AE 105	1015	MCERTS	0.01%	2.7%	N/A - No ELV
Velocity	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	5 Pa	2.4%	N/A - No ELV
Volumetric Flow Rate	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	-	5.1%	9.95%
-	-	-	-	-	-	-	-

EXECUTIVE SUMMARY

Analytical Methods

The following tables list the analytical methods employed together with the custody details. Unless otherwise stated the samples are archived at the analysis lab location.

SAMPLING METHODS WITH SUBSEQUENT ANALYSIS							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	Analysis Accreditation	Analysis Lab	Analysis Report No. Date of Analyis	Archive Period
Total Particulate Matter	Gravimetric	AE 106	1015	MCERTS	SOCOTEC (East Kilbride)	N/A	8 Weeks
Formaldehyde	HPLC	M103(U)	0605	MCERTS	RPS	23-12810-0	8 Weeks
-	-	-	-	-	-	-	-

ON-SITE TESTING							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	Accreditation	Laboratory	Data Archive Location	Archive Period
Oxides of Nitrogen	Chemiluminescence	AE 102	1015	MCERTS	SOCOTEC (East Kilbride)	SOCOTEC (East Kilbride)	5 years
Carbon Monoxide	Non Dispersive Infra Red	AE 102	1015	MCERTS	SOCOTEC (East Kilbride)	SOCOTEC (East Kilbride)	5 years
Moisture	Gravimetric	AE 105	1015	MCERTS	SOCOTEC (East Kilbride)	-	-

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	**Value**	**Units**	**Requirement**	**Compliant**	**Method**
Lowest Differential Pressure	20	Pa	>= 5 Pa	Yes	EN 15259
Lowest Gas Velocity	11.6	m/s	-	-	-
Highest Gas Velocity	42.8	m/s	-	-	-
Ratio of Gas Velocities	3.7	: 1	< 3 : 1	No	EN 15259
Mean Velocity	31.0	m/s	-	-	-
Maximum angle of flow with regard to duct axis	<15	°	< 15°	Yes	EN 15259
No local negative flow	Yes	-	-	Yes	EN 15259

DUCT CHARACTERISTICS		
	Value	**Units**
Shape	Circular	-
Depth	2.30	m
Width	-	m
Area	4.16	m^2
Port Depth	90	mm

SAMPLING LINES & POINTS		
	Isokinetic	**Non-Iso & Gases**
Sample port size	4" BSP	4" BSP
Number of lines used	2	1
Number of points / line	9	1
Duct orientation	Vertical	Vertical
Filtration	In Stack	Out Stack
Filtration for TPM	In Stack	-

SAMPLING PLATFORM	
General Platform Information	
Permanent / Temporary Platform / Ground level / Floor Level / Roof	Permanent
Inside / Outside	Out side

AG1 Platform requirements	
Is there a sufficient working area so work can be performed in a compliant manner	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	Yes
Handrail / obstructions do not hamper insertion of sampling equipment	N/A
Depth of Platform = >Stack depth / diameter + wall and port thickness + 1.5m	Yes

Sampling Platform Improvement Recommendations (if applicable)

0

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

Velcoity Profile

As this sampling location shows high levels of turbulence throughout the results from the standard flow traverse are indicative. In the past, reports detailing the volumetric flow rate according to fan rating have been used to calculate mass emission rates for this stack.

Sample Line & Sample point

Only one sampling line will be accessed safely, therefore the other samlpling line will not be accessed due to excessive probe overhang. it is only possible to sample from one representative sampling point for all isokinetic monitoring due to a number of factors, including excessivley high flows close to the stack edge, swirl being greater than 15° & negative flow.]

Sampling Nozzle

Due to high flows in the stack, a nozzle smaller than the recommended minimum of 6mm was used to ensure isokintic sampling rate could be met

Maximum Uncertainty

Uncertainity of CO exceeded the maximum percentage specifed in the EPA's AG2 guidance document. This is typicla with concnetraion levels are low or close to zero.

APPENDICES

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APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

MONITORING SCHEDULE					
Species	**Method** Standard Reference Method / Alternative Method	**SOCOTEC Technical Procedure**	**UKAS Lab Number**	**MCERTS Accredited Method**	**Number of Samples**
Total Particulate Matter	SRM - EN 13284-1	AE 104	1015	MCERTS	1
Formaldehyde	CEN/TS 17638	AE114	1015	MCERTS	1
Oxides of Nitrogen	SRM - EN 14792:2017	AE 102	1015	MCERTS	1
Carbon Monoxide	SRM - EN 15058:2017	AE 102	1015	MCERTS	1
Oxygen	SRM - EN 14789:2017	AE 102	1015	MCERTS	1
Moisture	EN 14790	AE 105	1015	MCERTS	1
Velocity	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	1

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

CALIBRATEABLE EQUIPMENT CHECKLIST					
Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	Equipment I.D.	Equipment	Equipment I.D.	Equipment	Equipment I.D.
Control Box DGM	LEK 9.47	Horiba PG-250 Analyser	LEK 12.15	Laboratory Balance	LEK 15.21
Box Thermocouples	LEK 9.48	FT-IR	-	Tape Measure	LEK 20.16
Meter In Thermocouple	LEK 9.48	FT-IR Oven Box	-	Stopwatch	-
Meter Out Thermocouple	LEK 9.48	Bernath 3006 FID	-	Protractor	-
Control Box Timer	LEK 17.26	Signal 3030 FID	-	Barometer	LEK 16.8
Oven Box	-	Servomex	-	Digital Micromanometer	LEK 1.20
Probe	LEK 6.53	JCT Heated Head Filter	LEK 13.21b	Digital Temperature Meter	LEK 2.20
Probe Thermocouple	-	Thermo FID	-	Stack Thermocouple	-
Probe	-	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	LEK 6.53	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	LEK 23.12	Chiller (JCT/MAK 10)	LEK 12.16	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	LEK 8.53	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	LEK 8.21	10m Heated Line (1)	-
Callipers	LEK 15.1F	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-			15m Heated Line (1)	LEK 8.21
Heater Controller	-			20m Heated Line (1)	LEK 8.531
Inclinometer (Swirl Device)	LEK 24.10			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 (traceable to ISO 17025)	Cylinder I.D Number	Supplier	ppm	%	Analytical Tolerance +/- %
Oxygen	-	BOC	-	20.95	-
Nitric Oxide	LEK 325	BOC	200	-	2.0
Carbon Monoxide	LEK 325	BOC	164	-	2.0
Carbon Dioxide	LEK 325	BOC	-	16.03	2.0
-	-	-	-	-	-

STACK EMISSIONS MONITORING TEAM

MONITORING TEAM								
Personnel	MCERTS Number	MCERTS		TE / H&S Qualifications and Expiry Date				
		Level	Expiry	TE1	TE2	TE3	TE4	H&S
Enda Flood	MM 12 1170	MCERTS Level 2	Mar-24	Mar-24	Mar-24	May-28	Nov-28	Mar-28
Daniel Scully	MM 19 1563	MCERTS Level 2	Oct-24	Nov-26	Nov-28	Mar-28	Jul-27	Oct-24

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER SUMMARY					
Parameter	**Sampling Times**	**Concentration mg/m³**	**Uncertainty mg/m³**	**ELV mg/m³**	**Emission Rate g/hr**
Run 1	12:23 - 13:23 27 November 2023	19.07	0.66	20	5014
Blank	-	0.20	-	-	-

Reference conditions are 273K, 101.3kPa, dry gas .

Acetone Blank Value mg/l	Acceptable Value mg/l
0.3	10

FILTER INFORMATION

SAMPLES								
Test	Filter & Probe Rinse Number	Filter Start Weight g	Filter End Weight g	Mass Gained on Filter g	Probe Rinse Start Weight g	Probe Rinse End Weight g	Mass Gained on Probe g	Combined Total Mass Gained g
Run 1	AC 3875	0.09874	0.11407	0.01533	56.55168	56.55310	0.00142	0.01675

If total mass gained is less than the LOD then the LOD is reported

BLANKS								
Test	Filter & Probe Number	Filter Start Weight g	Filter End Weight g	Mass Gained Filter g	Probe Start Weight g	Probe End Weight g	Mass Gained Probe g	Combined Total Mass Gained g
Run 1	AC 3873	0.09729	0.09730	0.00001	53.75583	53.75596	0.00013	0.00018

If total mass gained is less than the LOD then the LOD is reported

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 1 — TPM

Absolute pressure of stack gas, P_s		
Barometric pressure, P_b	Kpa	100.5
Stack static pressure, P_{static}	pa	-265.0
$P_s = P_b + P_{static}$	Kpa	100.2
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	102.0
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.127092
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.956
Gas meter correction factor, Y_d		0.964
Mean dry gas meter temperature, T_m		285
Mean pressure drop across orifice, DH	mmH_2O	23.957
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.878
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	1.0056
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		19.9
% oxygen reference condition		21
O_2 Reference Factor O_2 Ref = $\frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$		No O2 Ref
$V_{mstd@X\%oxygen} = (V_{mstd})(O_{2\,Ref})$	m^3	No O2 Ref
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.1264
	%	12.64
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.95
Mean of velocity heads, DP_{avg}	Pa	347.08
Mean stack gas temperature, T_s	K	340
Gas density $_{(wet,\ ambient)}$, p		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	0.973
Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	25.34

Molecular weight of dry gas, M_d		
CO_2	%	0.03
O_2	%	19.92
Total	%	19.95
N_2 (100 -Total)	%	80.05
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.80
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	27.44
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	4.16
$Q_a = (60)(A_s)(V_s)$	m^3/min	6317.0
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	Dry	4383.0
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	5017.10
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	3.98
Nozzle area, A_n	mm^2	12.42
Total sampling time, q	min	60
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	111.7
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.01533
Mass collected in probe, M_p	g	0.00142
Total mass collected, M_n	g	0.01675
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	16.657
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	19.067
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		5014.18

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	15.36	0.10	-	-533.4	0.31	Yes

In BS EN 13284-1:2017 a post sampling leak check is not required.

ISOKINETICITY		
Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	111.74	Yes

Acceptable isokinetic range 95% to 115%

WEIGHING BALANCE UNCERTAINTY			
Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.20	1.0	Yes

The above is based on both the Filter and rinse uncertainty

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	0.20	20	2.0	Yes

FILTERS					
Run	Filter Material	Filter Size mm	Max Filtration Temperature °C	Pre-use Filter Conditioning Temperature °C	Post-use Filter Conditioning Temperature °C
Run 1	Glass Fibre	47	67	180	160

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

FORMALDEHYDE SUMMARY					
Test	Sampling Times	Concentration mg/m³	LOD mg/m³	ELV mg/m³	Emission Rate g/hr
Run 1	12:23 - 13:23 27 November 2023	2.55	0.012	15	670
Field Blank	-	0.029	-	-	-

Reference conditions are 273K, 101.3kPa, dry gas .

FORMALDEHYDE QUALITY ASSURANCE CHECKLIST

	Barometric Pressure Kpa	Average Oxygen Value for Referencing %	Total Sample Volume @ ref Conditions m³	Mean Sampling Rate l/min	Pre Sampling Leak Rate l/min	Post Sampling Leak Rate l/min	Acceptable Leak Rate l/min	Leak Tests Acceptable?
Run 1	100.5	-	0.878	15.4	0.10	-	0.31	Yes

	Filter Material	Filter Size mm	Max. Filtration Temp. °C	Temperature during storage / transit <25°C	Type of Absorbers	Absorption Solutions
Run 1	QF	47	67	N/A	PE	HPLC Water / DNPH derivatization

FORMALDEHYDE ABSORPTION EFFICIENCY

Parameter	Total ug	IMP C ug	Absorption Efficiency %	Acceptable Absorption Efficiency %	Absorption Efficiency Acceptable ?
Run 1	2237.8	257.5	88	95	N/A - <30% ELV

ND - None Detected

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS 1 — Formaldehyde

Absolute pressure of stack gas, P_s			**Velocity of stack gas, V_s**		
Barometric pressure, P_b	kPa	101	Velocity pressure coefficient, C_p		0.951
Stack static pressure, P_{static}	Pa	-265	Mean of velocity heads, DP_{avg}	Pa	347.08
$P_s = P_b + (P_{static})$	kPa	100.24	Mean stack gas temperature, T_s	K	340.00
			Gas density $_{(wet, ambient)}$, p		
Vol. of water vapour collected, V_{wstd}			p=(Ms*Ps)/(8.314*Ts)	kg/m^3	0.973
Moisture trap weight increase,Vlc	g	-	Stack Velocity, Vs		
$V_{wstd} = (0.001246)(V_{lc})$	m^3	-	$V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	25.34
Volume of gas metered dry, V_{mstd}			**Actual flow of stack gas, Q_a**		
Volume of gas sample through gas meter, V_m	m^3	0.9558	Area of stack, A_s	m^2	4.16
Gas meter correction factor, Y_d		0.9643	$Q_a = (60)(A_s)(V_s)$	m^3/min	6317
Mean dry gas meter temperature, T_m	K	284.71	**Dry total flow of stack gas, Q_{std}**		
Mean pressure drop across orifice, DH	mmH_2O	23.96	Conversion factor (K/mm.Hg)		0.3592
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.88	$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	m^3/min	4383
Volume of gas metered wet, V_{mstw}			**Wet total flow of stack gas, Q_{stw}**		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	1.0056	$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	m^3/min	5017
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$			**Dry total flow of stack gas at X% O_2, Q_{stdO2}**		
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No	$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	m^3/min	No O2 Ref
% oxygen measured in gas stream, act%O_2		19.92	**Percent isokinetic, %I**		
% oxygen reference condition		21	Nozzle diameter, D_n	mm	3.98
O_2 Reference Factor $\frac{O2\ Ref = 21.0 - act\%O2}{21.0 - ref\%O2}$		No O2 Ref	Nozzle area, A_n	mm^2	12.42
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	No O2 Ref	Total sampling time, q	min	60
Moisture content, B_{wo}			$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	112
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.1264			
	%	12.64	Acceptable isokinetic range 95% to 115%		Yes
Moisture by FTIR	%	-	**Formaldehyde Concentration, C**		
Molecular weight of dry gas, M_d			Mass collected , M	ug	2238
CO_2		0.03	$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	2.225
O_2		19.92			
Total		19.95	$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	2.547
N_2 (100 -Total)		80.05			
			$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.80			
Molecular weight of wet gas, M_s			**Formaldehyde Emission Rates, E**		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	27.4	$E = [(C_{wet})(Q_{stw})(60)] / 1000$	g/hr	669.89

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

COMBUSTION GASES SUMMARY

Test	Sampling Time and Date	Concentration mg/m³	LOD mg/m³	ELV mg/m³	Emission Rate g/hr
Oxides of Nitrogen	12:33 - 13:33 27 November 2023	70.5	0.51	110	23800
Carbon Monoxide	12:33 - 13:33 27 November 2023	7.3	0.28	600	2466.41

Test	Sampling Time and Date	Concentration %	LOD %
Oxygen	12:33 - 13:33 27 November 2023	19.92	0.01

Reference conditions are 273K, 101.3kPa, dry gas .

PRE-SAMPLING CALIBRATION DATA

Date	27 November 2023
Start Time	11:41
End Time	12:03

Chiller Temperature (°C)	2.5
Requirement	< 4°C
Compliant	Yes

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 %
Nitric Oxide	250	0.00	199.3	0.07	0.00	198/2	40	#VALUE!
Carbon Monoxide	200	0.00	164.0	0.33	0.90	163.6	40	0.26
Oxygen	25	0.00	20.99	0.10	0.16	20.78	40	1.03

POST-SAMPLING CALIBRATION DATA

Date	27 November 2023
Start Time	13:50
End Time	14:02

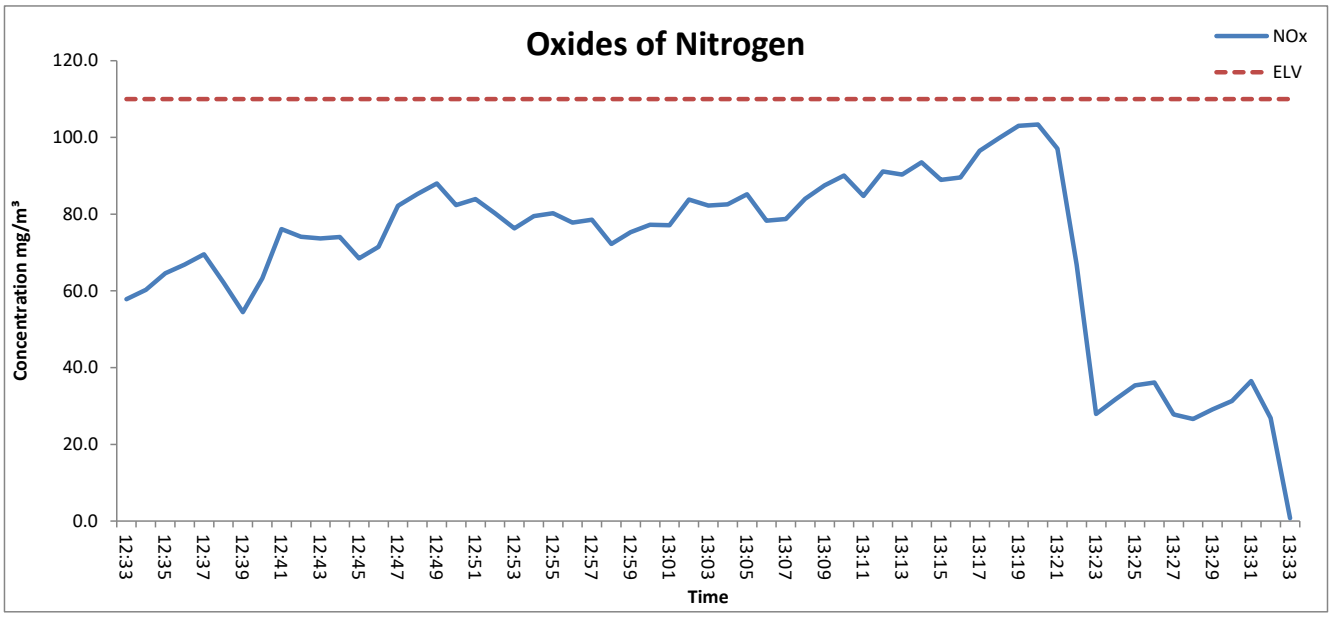
Chiller Temperature (°C)	2.5
Requirement	< 4°C
Compliant	Yes

Gas	Zero Check at Analyser	Span Check at Analyser	Zero Drift (%)	Span Drift (%)	Corrected for Zero Drift	Corrected for Span Drift	Corrected Values ppm / %
Nitric Oxide	0.03	196.8	-0.02	-1.23	×	×	N/A - not corrected
Carbon Monoxide	0.43	161.2	0.07	-1.77	×	×	N/A - not corrected
Oxygen	0.04	21.00	-0.30	0.33	×	×	N/A - not corrected

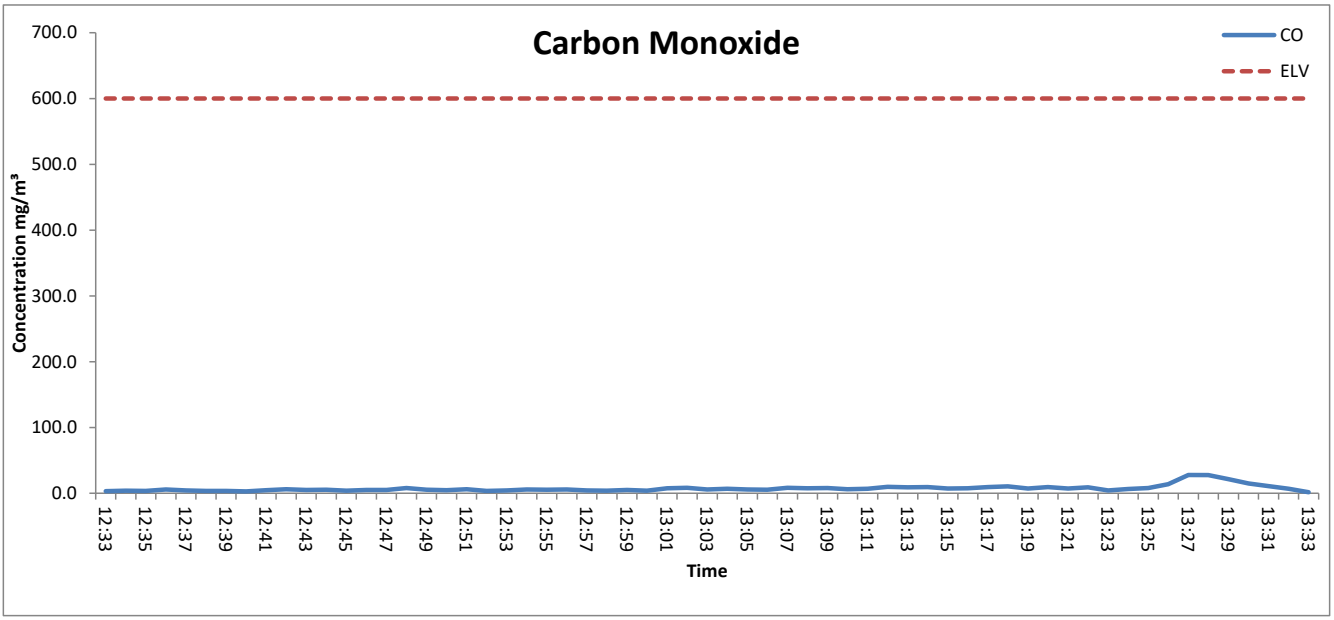
#VALUE!

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

OXIDES OF NITROGEN (as NO_2) EMISSIONS CHART

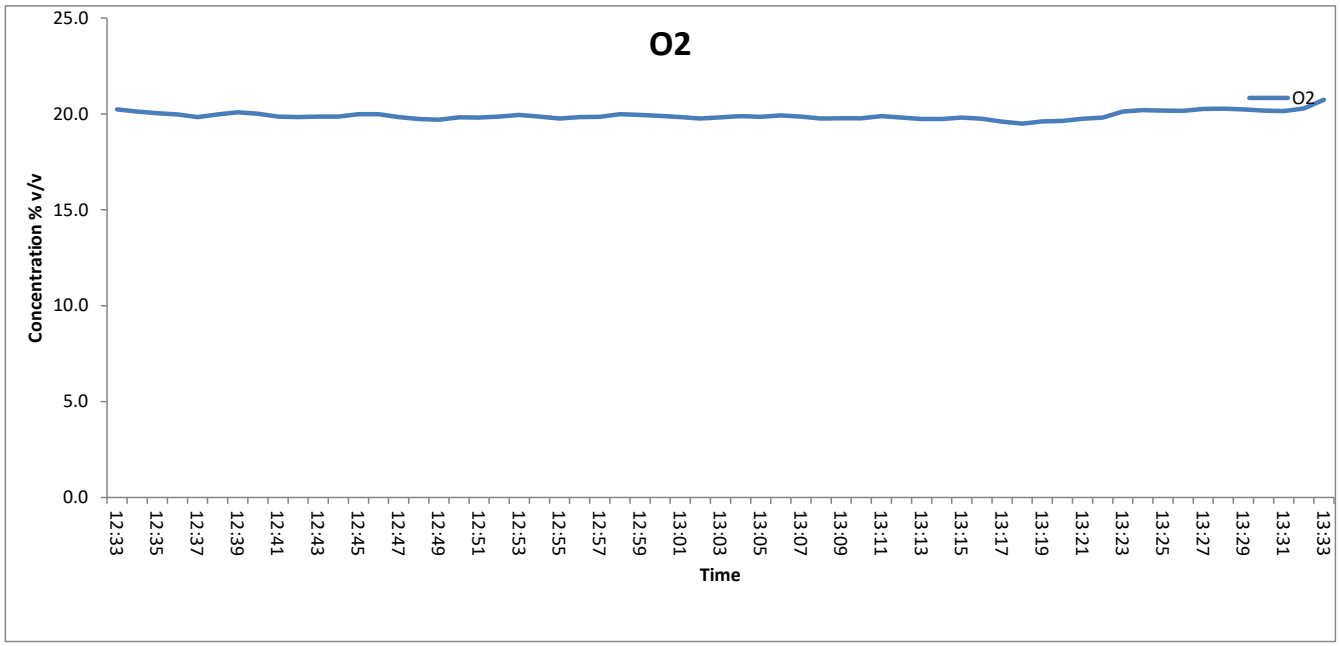


CARBON MONOXIDE EMISSIONS CHART



APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

OXYGEN EMISSIONS CHART



APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

MOISTURE CALCULATIONS

Moisture Determination - Isokinetic							
Test Number	Sampling Time and Date	Start Weight kg	End Weight kg	Total gain kg	Concentration %	LOD %	Uncertainty %
Run 1	12:23 - 13:23 27 November 2023	1.6590	1.7610	0.1020	12.6	0.01	2.7

Moisture Quality Assurance							
Test Number	Sampling Duration mins	Total Volume Sampled l	Sampling Rate l/min	Start Leak Rate l/min	End Leak Rate l/min	Acceptable Leak Rate l/min	Leak Tests Acceptable?
Run 1	60	1006	15.4	0.10	-	0.31	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	2.30	m
Stack Width, W	-	m
Stack Area, A	4.16	m^2
Average stack gas temperature	55	°C
Stack static pressure	0.353	kPa
Barometric Pressure	101	kPa

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	0.028571	0.000286	0.000561	0.024960	0.000250	0.000490
O_2	32	1.427679	19.921831	0.199218	0.284420	17.403986	0.174040	0.248473
N_2	28	1.249219	80.049598	0.800496	0.999995	69.932434	0.699324	0.873609
H_2O	18	0.803070	-	-	-	12.638620	0.126386	0.101497

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

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2850	kg/m^3
Wet Density (STP), P_{STW}	1.2241	kg/m^3
Dry Density (Actual), P_{Actual}	1.0701	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.019	kg/m^3

Where:

P_{STD} = sum of component concentrations, kg/m^3 (not including water vapour)

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

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

$P_{ActualW} = P_{STW}$ x (Ts / Ps) x (Pa / Ta)

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY

TRAVERSE 1

Date of Survey	14 November 2023
Time of Survey	11:48-12:16
Velocity Measurement Device:	S-Type Pitot

Sampling Line A								
Traverse Point	Distance into duct (m)	*DP* pt Pa (average of 3 readings)	*DP* pt mmH_2O (average of 3 readings)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m^3/s	O_2 % Vol	Angle of Swirl °
1	0.06	1097.6	112.0	55	39.5	164.1	-	<15
2	0.19	1244.6	127.0	55	42.0	174.7	-	<15
3	0.34	999.6	102.0	55	37.7	156.6	-	<15
4	0.52	872.2	89.0	55	35.2	146.3	-	<15
5	0.79	950.6	97.0	55	36.7	152.7	-	<15
6	1.51	441.0	45.0	55	25.0	104.0	-	<15
7	1.78	372.4	38.0	55	23.0	95.6	-	<15
8	1.96	186.2	19.0	55	16.3	67.6	-	<15
9	2.11	764.4	78.0	55	33.0	136.9	-	<15
10	2.24	1029.0	105.0	55	38.2	158.9	-	<15
Mean	-	795.8	81.2	55	32.7	135.7	-	-

Sampling Line B								
Traverse Point	Distance into duct (m)	*DP* pt Pa (average of 3 readings)	*DP* pt mmH_2O (average of 3 readings)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m^3/s	O_2 % Vol	Angle of Swirl °
1	0.06	1290.3	131.7	55	42.8	177.9	-	<15
2	0.19	1290.3	131.7	55	42.8	177.9	-	<15
3	0.34	1009.4	103.0	55	37.9	157.3	-	<15
4	0.52	614.1	62.7	55	29.5	122.7	-	<15
5	0.79	917.9	93.7	55	36.1	150.0	-	<15
6	1.51	176.4	18.0	55	15.8	65.8	-	<15
7	1.78	516.1	52.7	55	27.1	112.5	-	<15
8	1.96	94.7	9.7	55	11.6	48.2	-	<15
9	2.11	323.4	33.0	55	21.4	89.1	-	<15
10	2.24	581.5	59.3	55	28.7	119.4	-	<15
Mean	-	681.4	69.5	55	29.4	122.1	-	-

PRELIMINARY STACK SURVEY QUALITY ASSURANCE CHECKLIST

PITOT LEAK CHECK								
Run	Pre Traverse Leak Rate				Post Traverse Leak Rate			
	Start Value mmH2O	End Value mmH2O	Difference %	Outcome	Start Value mmH2O	End Value mmH2O	Difference %	Outcome
Run 1	112	107	4.5	Pass	124	122	1.6	Pass

To complete a compliant pitot leak check a pressure of over 80 mmH_2O (or 800 Pa) is applied and the pressure drop monitored over 5 mins. A drop of less than 5% must be observed.

S-Type Pitot Stagnation Check				
Run	Stagnation (Pa)	Reference (Pa)	Difference (Pa)	Outcome (Permitted +/- 10 Pa)
Run 1	368	359	9.0	Pass

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY (CONTINUED)

Sampling Plane Validation Criteria				
EA Technical Guidance Note (Monitoring) M1	Result	Units	Requirement	Compliant
Lowest Average Differential Pressure	95	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	11.6	m/s	-	-
Highest Gas Velocity	42.8	m/s	-	-
Ratio of Gas Velocities	3.7	-	< 3 : 1	No
Maximum angle of flow with regard to duct axis	<15	°	< 15°	Yes
No local negative flow	Yes	-	-	Yes

Calculation of Stack Gas Velocity, V		
Velocity at Traverse Point, V = K_{pt} x (1-e) * Ö(2 * DP_{pt} / $P_{ActualW}$)		
Where: K_{pt} = Pitot tube calibration coefficient (1-e) = Compressibility correction factor, assumed at a constant 0.998		
Average Stack Gas Velocity, Va	**31.0**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	55	0	°C
Total Pressure	101.353	101.3	kPa
Oxygen	19.9	21	%
Moisture	12.64	0.00	%
Pitot tube calibration coefficient, K_{pt}	0.85		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	31.02	m/s
Stack Area (A)	4.16	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	464054.52	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	386442.58	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	337601.57	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	337601.57	m^3/hr

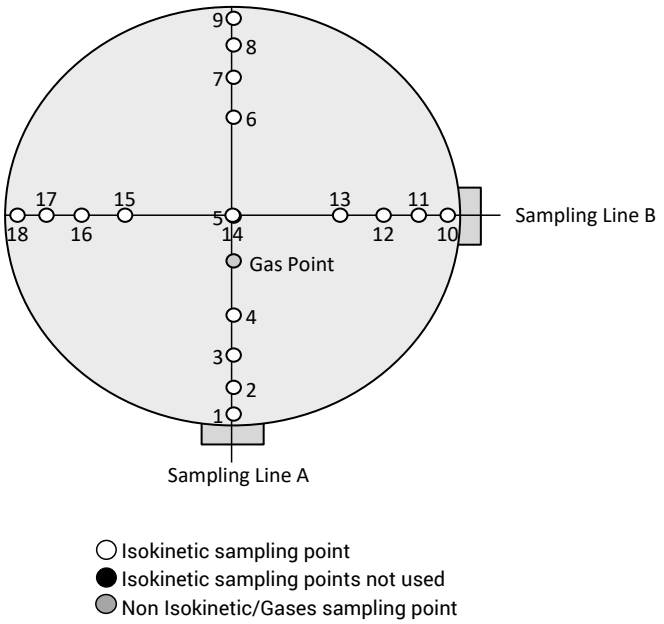
Where:
Q_{Actual} = Va x A x 3600
Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps) x 3600
$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma)) x 3600
Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((21 - O_2a) / (21 - O_2s))

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK DIAGRAM

	Value	Units
Stack Depth	2.30	m
Stack Width	-	m
Area	4.16	m^2



Non-Isokinetic/Gases Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack	Units
A	0.3	0.01	m

Isokinetic Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	2.9	0.07	< 15
2	9.2	0.21	< 15
3	16.7	0.38	< 15
4	26.4	0.61	< 15
5	50.0	1.15	< 15
6	73.6	1.69	< 15
7	83.3	1.92	< 15
8	90.8	2.09	< 15
9	97.1	2.23	< 15
10	2.9	0.07	< 15
11	9.2	0.21	< 15
12	16.7	0.38	< 15
13	26.4	0.61	< 15
14	50.0	1.15	< 15
15	73.6	1.69	< 15
16	83.3	1.92	< 15
17	90.8	2.09	< 15
18	97.1	2.23	< 15
-	-	-	-
-	-	-	-

SAMPLING LOCATION

APPENDIX 3 - 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	0.002	2.0	0.50	1.0	N/A	0.1800	-	-
as a %	0.20	0.59	0.50	1.0	N/A	1.02448	0.65	0.001
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**	**Yes**

Run	Volume (STP)	Mass of particulate	O_2 Correction	Leak	Uncollected Mass	Combined uncertainty
	m^3	mg	-	mg/m^3	mg	
Run 1	0.70	16.7500	1.0	0.0717	0.0001	-
MU as mg/m^3	0.25	0.2049	-	0.0717	0.0001	**0.33**
MU as %	1.29	1.0746	-	0.376	0.0006	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.66**	**mg/m^3**	**3.44**	**% Result**	**3.28**	**% ELV**

(k is a coverage factor which gives a 95% confidence in the quoted figures)
Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - ISOKINETIC FORMALDEHYDE

Run	Sampled Volume	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Limit of Detection	Leak
	m^3	K	kPa	% by volume	% by volume	% by mass	%
MU required	**<=2%**	**<2.5 k**	**<=1%**	**<=1%**	**<=5%**	**≤ 5% of ELV**	**<=2%**
Run 1	0.878	285	97.85	1.0	-	3.7	-
as a %	0.11	0.70	0.51	1.0	-	0.19	0.65
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**

Run	Volume (STP)	Mass of Formaldehyde	O2 Correction	Leak	Lab Uncertainty	Combined uncertainty
	m^3	mg	-	mg/m^3	mg	
Run 1	0.8137	3.6660	-	0.0096	-	-
MU as mg/m^3	0.0339	0.0279	-	0.0096	0.1274	**0.1351**
MU as %	1.3303	1.0943	-	0.3759	5.0	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.27**	**mg/m^3**	**10.60**	**% Result**	**1.80**	**% ELV**

(k is a coverage factor which gives a 95% confidence in the quoted figures)
Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - 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	0.001756985	2.0	0.50	1.0	N/A	-
as a %	0.20	0.59	0.50	1.0	N/A	0.65
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**

Run	Volume (STP) m^3	Mass Gained mg	O_2 Correction -	Leak mg/m^3	Uncollected Mass mg	Combined uncertainty
Run 1	0.70	102000	1.0	436.41	58	-
MU as % v/v	0.19	0.01	-	0.05	0.008	**0.20**
MU as %	1.29	0.10	-	0.38	0.06	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.39**	**% v/v**	**2.69**	**%**

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXIDES OF NITROGEN

Limit value	110	mg/m^3
Concentration @ Ref conditions	70.5	mg/m^3
Cal gas conc	410	mg/m^3
Analyser Full Scale	513	mg/m^3

	Value	Units	specification	MU Met?
Response time	40	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.11	% full scale	<1 % range	Yes
Repeatability at span level	0.1	% full scale	<2 % range	Yes
Deviation from linearity	-0.40	% of value	<2 % range	Yes
Zero drift	-0.02	% full scale	<5% range / 24hr	Yes
Span drift	-1.23	% full scale	<5% range / 24hr	Yes
volume or pressure flow dependence	0.25	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.25	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence zero / span	0.00	% full scale/10K	<3% range / 10 K	Yes
Combined interference	-0.01	% range	<4% of Range	Yes
dependence on voltage	0.03	% full scale/10V	< 0.1%vol /10 volt	Yes
Influence of Vibration	N/A	% of upper limit of Cal range	<2%	-
losses in the line (leak)	0.03	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.0037
lack of fit	U_{lof}	-0.2309
short term zero drift	$U_{d,z}$	-0.0097
short term span drift	$U_{d,s}$	-0.7119
influence of Ambient Temp at Zero	$U_{t,z}$	0.0000
influence of Ambient Temp at Span	$U_{t,s}$	0.5196
influence of sample gas pressure	U_p	-0.0192
influence of sample gas flow	U_{fit}	0.1732
influence of supply voltage	U_v	0.0759
Combined Interfence	U_i	-0.0018
Uncertainty of Cal gas	U_{adj}	2.0000

Measurement uncertainty (Concentration Measured)	70.50	mg/m^3
Combined uncertainty	2.21	mg/m^3
Expanded at a 95% confidence interval	4.32	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**3.93**	**% ELV**

Expanded uncertainty expressed with a level of confidence of 95%	**4.3**	**mg/m^3**

Expanded uncertainty expressed with a level of confidence of 95%	**6.1**	**% value**

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - CARBON MONOXIDE

Limit value	600	mg/m^3
Concentration @ Ref conditions	7.3	mg/m^3
Cal gas conc	205.0	mg/m^3
Analyser Full Scale	250	mg/m^3

Performance characteristics	Value	Units	specification	MU Met?
Response time	40	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.1	% full scale	<1 % range	Yes
Repeatability at span level	0.2	% full scale	<2 % range	Yes
Deviation from linearity	0.61	% of value	<2 % range	Yes
Zero drift	0.07	% full scale	<5% range / 24hr	Yes
Span drift	-1.77	% full scale	<5% range / 24hr	Yes
volume or pressure flow dependence	0.2	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.44	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence zero / span	-0.8	% full scale/10K	<3% range / 10 K	Yes
Combined interference	-0.01	% of Range	<4% of Range	Yes
dependence on voltage	-0.06	% full scale/10V	< 0.1%vol /10 volt	Yes
Influence of Vibration	N/A	% of upper limit of Cal range	<2%	N/A
losses in the line (leak)	0.00	% of value	< 2% of value	Yes
Uncertainty of calibration gas	1.00	% of value	< 2% of value	Yes

N/A - Horiba's are not effected by Vibration

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.003
lack of fit	U_{lof}	0.12
short term zero drift	$U_{d,z}$	0.35
short term span drift	$U_{d,s}$	0.04
influence of Ambient Temp zero	$U_{t,z}$	-0.04
influence of Ambient Temp span	$U_{t,s}$	0.04
influence of sample gas pressure	U_p	0.06
influence of sample gas flow	U_{fit}	0.14
influence of supply voltage	U_v	-0.09
Combined Interfence	U_i	-0.40
Uncertainty of Cal gas	U_{adj}	0.82

Measurement uncertainty (Concentration Measured)	7.3	mg/m^3
Combined uncertainty	1.0	mg/m^3
Expanded uncertainty	2.0	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**0.3**	**% ELV**
Expanded uncertainty expressed with a level of confidence of 95%	**2.0**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**26.9**	**% value**

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXYGEN

Reference	N/A	%vol
Reported Concentration	19.92	%vol
Calibration gas	20.95	%vol
Analyser Full Scale	25	%vol

	Value	Units	specification	MU Met?
Response time	40	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	0.13	% of value	<2 % range	Yes
Zero drift	-0.30	% full scale	<5% range / 24hr	Yes
Span drift	0.33	% full scale	<5% range / 24hr	Yes
volume or pressure flow dependence	0.03	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.05	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	-0.05	% full scale/10K	<3% range / 10 K	Yes
Combined interference	0.01	% range	<4% of Range	Yes
dependence on voltage	0.00	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	0.01	% of value	< 2% of value	Yes
Uncertainty of calibration gas	0.0	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.0083
lack of fit	U_{lof}	0.0751
short term zero drift	$U_{d,z}$	-0.1744
short term span drift	$U_{d,s}$	0.1929
influence of Ambient Temp at Zero	$U_{t,z}$	-0.0008
influence of Ambient Temp at Span	$U_{t,s}$	-0.0116
influence of sample gas pressure	U_p	-0.0037
influence of sample gas flow	U_{fit}	0.0173
influence of supply voltage	U_v	0.0001
Combined Interfence	U_i	0.0017
Uncertainty of Cal gas	U_{adj}	0.1048

Measurement uncertainty (Concentration Measured)	19.92	%
Combined uncertainty	0.29	%
Expanded uncertainty	0.57	%

Expanded uncertainty expressed with a level of confidence of 95%	**0.6**	**%**
Expanded uncertainty expressed with a level of confidence of 95%	**2.86**	**% vol**

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	31.0	m/s
Measured Volumetric Flow rate at Actual Conditions	464055	m³/hr

Performance Characteristics & Source of Value	Units	Values	Requirement	Compliant
Uncertainty of Local Gas Velocity Determination				
Uncertainty of pitot tube coefficient	-	0.010		
Uncertainty of mean local dynamic pressures	-	5.54		
Factor loading, function of the number of measurements.	3 readings	0.591	minimum 3	Yes
Range of measurment device	pa	1000		
Resolution	pa	1.00		
Calibration uncertainty	pa	108.36	<1% of Value or 20 Pa whichever is greater	Yes
Drift	% range	0.10		
Linearity	% range	0.06	<2% of value	Yes
Uncertainty of gas density determination				
Uncertainty of molar mass determination	kg/mol	0.00002		
Uncertainty of temperature measurement	K	1.67	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	517		
Uncertainty associated with the calculation of density	kg/m3	0.008		
Uncertainty associated with the measurement of local velocity	-	0.0001		
Uncertainty associated with the measurement of mean velocity	-	0.0002		

Measurement Uncertainty - Velocity	m/s
Combined uncertainty	0.38
Expanded uncertainty at a 95% Confidence Interval	0.75

Note - The expanded uncertainty uses a coverage factor of k = 2.

Expanded Measurement Uncertainty of Velocity at a 95% Confidence Interval	%
Expressed as a % of the Measured Velocity	1.2
Expanded uncertainty at a 95% Confidence Interval	2.4

Measurement Uncertainty Volumetric Flow Rate	m³/hr
Combined uncertainty	12147
Expanded uncertainty at a 95% Confidence Interval	23808

Note - The expanded uncertainty uses a coverage factor of k = 2.

Expanded Measurement Uncertainty of Volumetric Flow Rate at a 95% Confidence Interval	%
Expressed as a % of the Measured Volumetric Flow Rate	2.6
Expanded uncertainty at a 95% Confidence Interval	5.1

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

END OF REPORT

Thank you for choosing SOCOTEC for your environmental monitoring needs. We hope our services have met your requirements and that you are fully satisfied with your experience of working with us, we really do value your custom and would welcome your feedback. We would appreciate it if you could take a moment to complete a short online questionnaire so that we can improve our operations and address any areas that have not met with your expectations, by clicking on the following

https://www.surveymonkey.co.uk/r/CAE_customer_feedback_weblink