STACK EMISSIONS MONITORING REPORT

2-4 Langlands Place
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East Kilbride
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Operator & Address:
Medite Europe Limited Redmonstown, Clonmel, Co. Tipperary, Ireland

Permit Reference:
IE Licence: P0027-04

Release Point:
A2-5

Sampling Date(s):
25-27th August 2025

SOCOTEC Job Number:	LIR 1288 / Q3
Report Date:	02-Oct-25
Version:	1
Report By:	Stuart Gordon
MCERTS Number:	MM 22 1745
MCERTS Level:	MCERTS Level 1 Technician
Technical Endorsements:	1, 3 & 4
Report Approved By:	Enda Flood
MCERTS Number:	MM 12 1170
Business Title:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Signature:	

1015

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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 UK 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

A2-5

Operator

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

IE Licence: P0027-04

Stack Emissions Monitoring Test House

SOCOTEC UK LTD - 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 A2-5					
Parameter	**Units**	**Result**	**Calculated Uncertainty +/-**	**Emission Limit Value (ELV)**	**Accreditation**
Total Particulate Matter	mg/m³	16.8	0.50	20	MCERTS
Particulate Emission Rate	g/hr	3043	91	-	
Dioxins & Furans - UPPER Limits					
Dioxins & Furans (NATO I-TEQ)	ng/m³	0.0025	0.0005	-	MCERTS
Dioxins & Furans (NATO I-TEQ) Emission Rate	µg/hr	0.4249	0.0888	-	
Dioxins & Furans (WHO TEQ Humans / Mammals)	ng/m³	0.0026	0.0005	-	MCERTS
Dioxins & Furans (WHO TEQ H / M) Emission Rate	µg/hr	0.4422	0.0924	-	
Dioxins & Furans (WHO TEQ Fish)	ng/m³	0.0027	0.0006	-	MCERTS
Dioxins & Furans (WHO TEQ Fish) Emission Rate	µg/hr	0.4735	0.0990	-	
Dioxins & Furans (WHO TEQ Birds)	ng/m³	0.0057	0.0012	-	MCERTS
Dioxins & Furans (WHO TEQ Birds) Emission Rate	µg/hr	0.9926	0.2074	-	
Dioxins & Furans - LOWER Limits					
Dioxins & Furans (NATO I-TEQ)	ng/m³	0.0023	0.0005	-	MCERTS
Dioxins & Furans (NATO I-TEQ) Emission Rate	µg/hr	0.4014	0.0839	-	
Dioxins & Furans (WHO TEQ Humans / Mammals)	ng/m³	0.0024	0.0005	-	MCERTS
Dioxins & Furans (WHO TEQ H / M) Emission Rate	µg/hr	0.4187	0.0875	-	
Dioxins & Furans (WHO TEQ Fish)	ng/m³	0.0026	0.0005	-	MCERTS
Dioxins & Furans (WHO TEQ Fish) Emission Rate	µg/hr	0.4500	0.0940	-	
Dioxins & Furans (WHO TEQ Birds)	ng/m³	0.0056	0.0012	-	MCERTS
Dioxins & Furans (WHO TEQ Birds) Emission Rate	µg/hr	0.9691	0.2025	-	
Formaldehyde	mg/m³	8.6	2.06	15	MCERTS
Formaldehyde Emission Rate	g/hr	1564	373.9	-	
Total Volatile Organic Compounds	mg/m³	68.24	1.8	120	MCERTS
Total Volatile Organic Compounds Emission Rate	g/hr	21003.86	546.10	-	
Oxides of Nitrogen (as NO_2)	mg/m³	10	6.4	110	MCERTS
Oxides of Nitrogen (as NO_2) Emission Rate	g/hr	3228	1972	-	
Carbon Monoxide	mg/m³	489.28	2.27	600	MCERTS
Carbon Monoxide Emission Rate	g/hr	150585.98	697.23	-	
Oxygen	% v/v	19.7	0.238	-	MCERTS
Moisture	%	8.56	0.25	-	MCERTS
Stack Gas Temperature	°C	51	-	-	MCERTS
Stack Gas Velocity	m/s	26.8	0.65	-	

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	26 August 2025	10:10 - 11:10	60 minutes
Dioxins & Furans Run 1	25 August 2025	11:30 - 10:00	360 minutes
Formaldehyde Run 1	26 August 2025	10:10 - 11:10	60 minutes
Total Volatile Organic Compounds Run 1	26 August 2025	14:40 - 15:40	60 minutes
Combustion Gases	25 August 2025	14:50 - 15:50	60 minutes
Preliminary Stack Traverse	25 August 2025	10:56	-

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	0.05 mg/m³	3%	2.52%
Dioxins & Furans	SRM - EN 1948 - Part 1	AE 109	1015	MCERTS	0.0004 ng/m³	20.9%	N/A - No ELV
Formaldehyde	CEN/TS 17638	AE114	1015	MCERTS	0.014 mg/m³	23.9%	13.76%
Total Volatile Organic Compounds	SRM - EN 12619:2013	AE 102	1015	MCERTS	0.3 mg/m³	2.6%	1.5%
Oxides of Nitrogen	SRM - EN 14792:2017	AE 102	1015	MCERTS	0.51 mg/m³	61.1%	5.82%
Carbon Monoxide	SRM - EN 15058:2017	AE 102	1015	MCERTS	0.28 mg/m³	0.5%	0.4%
Oxygen	SRM - EN 14789:2017	AE 102	1015	MCERTS	0.01%	1.2%	N/A - No ELV
Moisture	EN 14790	AE 105	1015	MCERTS	0.01%	3.0%	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%	9.08%
-	-	-	-	-	-	-	-

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
Dioxins and Furans	Gas Chromatography - High Resolution Mass Spectometry	2002a	1668	MCERTS	Marchwood	567822-567824 12 Sep 2025	8 Weeks
Formaldehyde	Spectrophotometric	M103	0605	MCERTS	RPS	25-07365-1	8 Weeks
-	-	-	-	-	-	-	-

ON-SITE TESTING							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	Accreditation	Laboratory	Data Archive Location	Archive Period
Total Volatile Organic Compounds	Flame Ionisation Detection	AE 102	1015	MCERTS	SOCOTEC (East Kilbride)	SOCOTEC (East Kilbride)	5 years
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
Oxygen	Paramagnetism	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	39	Pa	>= 5 Pa	Yes	EN 15259
Lowest Gas Velocity	7.3	m/s	-	-	-
Highest Gas Velocity	39.5	m/s	-	-	-
Ratio of Gas Velocities	5.4	: 1	< 3 : 1	No	EN 15259
Mean Velocity	26.8	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	1	1
Duct orientation	Vertical	1
Filtration	Select	Out stack
Filtration for TPM	Select	-

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	No

Sampling Platform Improvement Recommendations (if applicable)

Although the sampling platform does not meet the requirements of AG1, in its current state it is acceptable due to use of deviations form SRM's

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

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
Dioxins & Furans	SRM - EN 1948 - Part 1	AE 109	1015	MCERTS	1
Formaldehyde	CEN/TS 17638	AE114	1015	MCERTS	1
Total Volatile Organic Compounds	SRM - EN 12619:2013	AE 102	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

CALIBRATABLE EQUIPMENT CHECKLIST					
Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	**Equipment I.D.**	**Equipment**	**Equipment I.D.**	**Equipment**	**Equipment I.D.**
Control Box DGM	LIR 9.47 / 9.44	Horiba PG-250 Analyser	LIR 12.15	Laboratory Balance	LIR 15.21
Box Thermocouples	LIR 9.48 / 9.46	FT-IR	-	Tape Measure	LIR 20.19
Meter In Thermocouple	LIR 9.48 / 9.46	FT-IR Oven Box	-	Stopwatch	-
Meter Out Thermocouple	LIR 9.48 / 9.46	Bernath 3006 FID	-	Protractor	-
Control Box Timer	LIR 17.26 / 27.25	Signal 3030 FID	-	Barometer	LIR 16.8
Oven Box	-	Servomex	-	Digital Micromanometer	LIR 1.20
Probe	LIR 6.11 / 6.7	JCT Heated Head Filter	-	Digital Temperature Meter	LIR 2.20
Probe Thermocouple	-	Thermo FID	LIR 8.44	Stack Thermocouple	-
Probe	-	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	LIR 6.11/ 6.7	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	LIR 23.12	Chiller (JCT/MAK 10)	LIR 12.19	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	LIR 8.56	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	LIR 8.77	10m Heated Line (1)	-
Callipers	LIR 15.1F	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-		-	15m Heated Line (1)	-
Heater Controller	-		-	20m Heated Line (1)	LIR 8.77
Inclinometer (Swirl Device)	LIR 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	Fresh Ir	BOC	-	20.95	1
Propane	LEK 391	BOC	82.8	-	2.0
Nitric Oxide	LEK 396	BOC	209.8	-	2.0
Carbon Monoxide	LEK 396	BOC	169.4	-	2.0

Note: Span gases may be diluted to an appropriate range with a gas divider.

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-28	Mar-29	Mar-29	Jun-28	Nov-28	Mar-28
Aidan Whitney	MM 20 1603	MCERTS Level 2	Nov-26	Nov-26	Apr-29	Mar-28	Apr-27	Sep-30
Aisling Brophy	MM 25 1882	MCERTS Trainee	Apr-30	-	-	-	-	Apr-30

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	10:10 - 11:10 26 August 2025	16.80	0.50	20	3043
Blank	-	0.05	-	-	-

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

Acetone Blank Value mg/l	Acceptable Value mg/l
0.3	1.0

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	IAC 315	0.10132	0.11561	0.01429	55.93806	55.94321	0.00515	0.01944

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	IAC 310	0.10103	0.10095	-0.00008	55.31776	55.31777	0.00001	0.00006

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	101.3
Stack static pressure, P_{static}	pa	-276.0
$P_s = P_b + P_{static}$	Kpa	101.0
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	86.9
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.1082774
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		1.280
Gas meter correction factor, Y_d		0.975
Mean dry gas meter temperature, T_m		296
Mean pressure drop across orifice, DH	mmH_2O	41.327
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	1.157
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	1.2655
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		19.7
% 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}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0856
	%	8.56
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.85
Mean of velocity heads, DP_{avg}	Pa	178.24
Mean stack gas temperature, T_s	K	324
Gas density $_{(wet,\ ambient)}$, ρ p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.046
Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	15.76

Molecular weight of dry gas, M_d		
CO_2	%	0.21
O_2	%	19.75
Total	%	19.96
N_2 (100 -Total)	%	80.04
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.82
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	27.90
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	3929.9
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	Dry	3018.7
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	3301.14
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	5.93
Nozzle area, A_n	mm^2	27.62
Total sampling time, q	min	60
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	96.1
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.01429
Mass collected in probe, M_p	g	0.00515
Total mass collected, M_n	g	0.01944
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m³	15.362
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m³	16.799
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m³	No O2 Ref
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		3042.71

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	20.80	0.25	-	-812.8	0.42	Yes

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

ISOKINETICITY		
Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	96.11	Yes

Acceptable isokinetic range 95% to 115%

WEIGHING BALANCE UNCERTAINTY			
Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.05	1.0	Yes

The above is based on both the Filter and rinse uncertainty

BLANK VALUE				
Run	Overall Blank Value mg/m^3	Daily Limit Value mg/m^3	Acceptable Blank Value mg/m^3	Overall Blank Acceptable
Blank 1	0.05	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	51	180	160

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS SUMMARY - UPPER LIMIT

NATO I-TEQ					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	11:30 - 10:00 25 August 2025	0.0025	0.0004	-	0.42
Field Blanks Run 1	-	0.000435	0.00035	-	-

WHO TEQ (Humans / Mammals)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	11:30 - 10:00 25 August 2025	0.0026	0.0005	-	0.44
Field Blanks Run 1	-	0.00051	0.00043	-	-

WHO TEQ (Fish)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	11:30 - 10:00 25 August 2025	0.0027	0.0006	-	0.47
Field Blanks Run 1	-	0.00049	0.00045	-	-

WHO TEQ (Birds)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	11:30 - 10:00 25 August 2025	0.0057	0.0008	-	0.99
Field Blanks Run 1	-	0.00132	0.00065	-	-

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS SUMMARY - LOWER LIMIT

NATO I-TEQ					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	11:30 - 10:00 25 August 2025	0.0023	-	-	0.40
Field Blanks Run 1	-	0.0001071	-	-	-

WHO TEQ (Humans / Mammals)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	11:30 - 10:00 25 August 2025	0.0024	-	-	0.42
Field Blanks Run 1	-	0.00010280	-	-	-

WHO TEQ (Fish)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	11:30 - 10:00 25 August 2025	0.0026	-	-	0.45
Field Blanks Run 1	-	0.000049781	-	-	-

WHO TEQ (Birds)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	11:30 - 10:00 25 August 2025	0.0056	-	-	0.97
Field Blanks Run 1	-	0.00086055	-	-	-

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS ANALYSIS SUMMARY - RUN 1

NATO I-TEQ & WHO TEQ (Humans / Mammals)							
Congener	Result	NATO I-TEQ	WHO TEQ Humans / Mammals	Extraction Recovery		Sampling Recovery	
				Actual	Permitted	Actual	Permitted
	ng	ng	ng	%	%	%	%
Dioxins							
2,3,7,8 Tetra CDD	< 0.00062	0.0006	0.0006	105	50% - 130%		
1,2,3,7,8 Penta CDD	0.00397	0.0020	0.0040	87	50% - 130%		
1,2,3,4,7,8 Hexa CDD	0.00295	0.0003	0.0003	111	50% - 130%		
1,2,3,6,7,8 Hexa CDD	0.0066	0.0007	0.0007	106	50% - 130%		
1,2,3,7,8,9 Hexa CDD	0.00428	0.0004	0.0004		-		
1,2,3,4,6,7,8 Hepta CDD	0.0277	0.0003	0.0003	91	40% - 130%		
OCDD Octa CDD	0.0404	0.0000	0.00001	82	40% - 130%		
Total -Dioxins	**0.08652**	**0.0043**	**0.0063**				
Furans							
2,3,7,8 Tetra CDF	0.0122	0.0012	0.0012	96	50% - 130%		
1,2,3,7,8 Penta CDF	0.00347	0.0002	0.0001		-	77	>=50
2,3,4,7,8 Penta CDF	0.00714	0.0036	0.0021	95	50% - 130%		
1,2,3,4,7,8 Hexa CDF	0.00532	0.0005	0.0005	102	50% - 130%		
1,2,3,6,7,8 Hexa CDF	0.00606	0.0006	0.0006	103	50% - 130%		
2,3,4,6,7,8 Hexa CDF	0.00606	0.0006	0.0006	101	50% - 130%		
1,2,3,7,8,9 Hexa CDF	0.00047	0.0000	0.0000		-	86	>=50
1,2,3,4,6,7,8 Hepta CDF	0.013	0.0001	0.0001	86	40% - 130%		
1,2,3,4,7,8,9 Hepta CDF	0.00147	0.00001	0.00001		-	94	>=50
OCDF Octa CDF	0.00337	0.00000	0.00000	76	40% - 130%		
Total -Furans	**0.05856**	**0.0069**	**0.0054**				
Mean Recoveries (%)				**95**		**86**	
Total Isomers	**0.14508**	**0.0112**	**0.0117**				
Total ITEQ (<LOD = 0)		**0.0106**	**0.0110**				

NOTE: The Total Isomers result includes all isomers below the limit of detection. This gives a "worst case" Dioxins & Furans result.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS ANALYSIS SUMMARY - RUN 1

WHO TEQ (Fish) & WHO TEQ (Birds)							
Congener	Result	WHO TEQ Fish	WHO TEQ Birds	Extraction Recovery		Sampling Recovery	
				Actual	Permitted	Actual	Permitted
	ng	ng	ng	%	%	%	%
Dioxins							
2,3,7,8 Tetra CDD	< 0.00062	0.0006	0.0006	105	50% - 130%		
1,2,3,7,8 Penta CDD	0.00397	0.0040	0.0040	87	50% - 130%		
1,2,3,4,7,8 Hexa CDD	0.00295	0.0015	0.0001	111	50% - 130%		
1,2,3,6,7,8 Hexa CDD	0.0066	0.0001	0.0001	106	50% - 130%		
1,2,3,7,8,9 Hexa CDD	0.00428	0.0000	0.0000		-		
1,2,3,4,6,7,8 Hepta CDD	0.0277	0.00003	0.00003	91	40% - 130%		
OCDD Octa CDD	0.0404	-	-	82	40% - 130%		
Total -Dioxins	**0.08652**	**0.0062**	**0.0049**				
Furans							
2,3,7,8 Tetra CDF	0.0122	0.0006	0.0122	96	50% - 130%		
1,2,3,7,8 Penta CDF	0.00347	0.0002	0.0000		-	77	>=50
2,3,4,7,8 Penta CDF	0.00714	0.0036	0.0071	95	50% - 130%		
1,2,3,4,7,8 Hexa CDF	0.00532	0.0005	0.0005	102	50% - 130%		
1,2,3,6,7,8 Hexa CDF	0.00606	0.0006	0.0006	103	50% - 130%		
2,3,4,6,7,8 Hexa CDF	0.00606	0.0006	0.0006	101	50% - 130%		
1,2,3,7,8,9 Hexa CDF	0.00047	0.0000	0.0000		-	86	>=50
1,2,3,4,6,7,8 Hepta CDF	0.013	0.0001	0.0001	86	40% - 130%		
1,2,3,4,7,8,9 Hepta CDF	0.00147	0.00001	0.00001		-	94	>=50
OCDF Octa CDF	0.00337	0.00000	0.00000	76	40% - 130%		
Total -Furans	**0.05856**	**0.0063**	**0.0213**				
Mean Recoveries (%)				**95**		**86**	
Total Isomers	**0.14508**	**0.0125**	**0.0262**				
Total ITEQ (<LOD = 0)		**0.0119**	**0.0256**				

NOTE: The Total Isomers result includes all isomers below the limit of detection. This gives a "worst case" Dioxins & Furans result.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS ANALYSIS SUMMARY - FIELD BLANK RUN 1

NATO I-TEQ & WHO TEQ (Humans / Mammals)							
Congener	Result	NATO I-TEQ	WHO TEQ Humans / Mammals	Extraction Recovery		Sampling Recovery	
				Actual	Permitted	Actual	Permitted
	ng	ng	ng	%	%	%	%
Dioxins							
2,3,7,8 Tetra CDD	< 0.00055	0.000550	0.000550	101	50% - 130%		
1,2,3,7,8 Penta CDD	< 0.00092	0.000460	0.000920	85	50% - 130%		

1,2,3,4,7,8 Hexa CDD	< 0.00032	0.000032	0.000032	103	50% - 130%		
1,2,3,6,7,8 Hexa CDD	< 0.00033	0.000033	0.000033	99	50% - 130%		
1,2,3,7,8,9 Hexa CDD	< 0.00034	0.000034	0.000034		-		
1,2,3,4,6,7,8 Hepta CDD	0.00436	0.000044	0.000044	92	40% - 130%		
OCDD Octa CDD	0.0247	0.000025	0.000007	89	40% - 130%		
TOTAL 2,3,7,8-Dioxins	**0.03152**	**0.0012**	**0.0016**				
Furans							
2,3,7,8 Tetra CDF	0.0039	0.000390	0.000390	89	50% - 130%		
1,2,3,7,8 Penta CDF	< 0.00046	0.000023	0.000014		-	85	>=50
2,3,4,7,8 Penta CDF	< 0.00046	0.000230	0.000138	91	50% - 130%		
1,2,3,4,7,8 Hexa CDF	< 0.00033	0.000033	0.000033	98	50% - 130%		
1,2,3,6,7,8 Hexa CDF	< 0.00032	0.000032	0.000032	99	50% - 130%		
2,3,4,6,7,8 Hexa CDF	< 0.00034	0.000034	0.000034	98	50% - 130%		
1,2,3,7,8,9 Hexa CDF	< 0.00035	0.000035	0.000035		-	88	>=50
1,2,3,4,6,7,8 Hepta CDF	0.00278	0.000028	0.000028	87	40% - 130%		
1,2,3,4,7,8,9 Hepta CDF	< 0.00042	0.000004	0.000004		-	94	>=50
OCDF Octa CDF	0.00328	0.000003	0.000001	85	40% - 130%		
TOTAL 2,3,7,8-Furans	**0.01264**	**0.0008**	**0.0007**				
Mean Recoveries (%)				**93**		**89**	
Total Isomers	**0.04416**	**0.0020**	**0.0023**				
Total ITEQ (<LOD = 0)		**0.0004894**	**0.0004698**				

NOTE: The Total Isomers result includes all isomers below the limit of detection. This gives a "worst case" Dioxins & Furans result.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS ANALYSIS SUMMARY - FIELD BLANK RUN 1

WHO TEQ (Fish) & WHO TEQ (Birds)							
Congener	Result	WHO TEQ Fish	WHO TEQ Birds	Extraction Recovery		Sampling Recovery	
				Actual	Permitted	Actual	Permitted
	ng	ng	ng	%	%	%	%
Dioxins							
2,3,7,8 Tetra CDD	< 0.00055	0.000550	0.000550	101	50% - 130%		
1,2,3,7,8 Penta CDD	< 0.00092	0.000920	0.000920	85	50% - 130%		
1,2,3,4,7,8 Hexa CDD	< 0.00032	0.000160	0.000016	103	50% - 130%		
1,2,3,6,7,8 Hexa CDD	< 0.00033	0.000003	0.000003	99	50% - 130%		
1,2,3,7,8,9 Hexa CDD	< 0.00034	0.000003	0.000003		-		
1,2,3,4,6,7,8 Hepta CDD	0.00436	0.000004	0.000004	92	40% - 130%		
OCDD Octa CDD	0.0247	-	-	89	40% - 130%		
TOTAL 2,3,7,8-Dioxins	**0.03152**	**0.0016**	**0.0015**				
Furans							
2,3,7,8 Tetra CDF	0.0039	0.000195	0.003900	89	50% - 130%		
1,2,3,7,8 Penta CDF	< 0.00046	0.000023	0.000005		-	85	>=50
2,3,4,7,8 Penta CDF	< 0.00046	0.000230	0.000460	91	50% - 130%		
1,2,3,4,7,8 Hexa CDF	< 0.00033	0.000033	0.000033	98	50% - 130%		
1,2,3,6,7,8 Hexa CDF	< 0.00032	0.000032	0.000032	99	50% - 130%		
2,3,4,6,7,8 Hexa CDF	< 0.00034	0.000034	0.000034	98	50% - 130%		
1,2,3,7,8,9 Hexa CDF	< 0.00035	0.000035	0.000035		-	88	>=50
1,2,3,4,6,7,8 Hepta CDF	0.00278	0.000028	0.000028	87	40% - 130%		

1,2,3,4,7,8,9 Hepta CDF	< 0.00042	0.000004	0.000004		-	94	>=50
OCDF Octa CDF	0.00328	0.000000	0.000000	85	40% - 130%		
TOTAL 2,3,7,8-Furans	**0.01264**	**0.0006**	**0.0045**				
Mean Recoveries (%)				**93**		**89**	
Total Isomers	**0.04416**	**0.0023**	**0.0060**				
Total ITEQ (<LOD = 0)		**0.0002275**	**0.0039325**				

NOTE: The Total Isomers result includes all isomers below the limit of detection. This gives a "worst case" Dioxins & Furans result.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 1 — Dioxins & Furans

Absolute pressure of stack gas, P_s		
Barometric pressure, P_b	kPa	101.10
Stack static pressure, P_{static}	Pa	-276.00
$P_s = P_b + (P_{static})$	kPa	100.82
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	533.3
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.6645
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m	m	5.33
Gas meter correction factor, Y_d		0.93
Mean dry gas meter temperature, T_m		295.06
Mean pressure drop across orifice, DH	mmH_2O	18.57
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m + 273}$	m^3	4.57
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	5.2343
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		19.75
% oxygen reference condition		21
O_2 Reference Factor $\frac{O2\ Ref = 21.0 - act\%O2}{21.0 - ref\%O2}$		No O2 Ref
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	No O2 Ref
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.1270
	%	12.70
Moisture by FTIR	%	-

Molecular weight of dry gas, M_d		
CO_2	%	0.21
O_2	%	19.75
Total	%	19.96
N_2 (100 -Total)	%	80.04
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.82
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	27.45
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.843
Mean of velocity heads, DP_{avg}	Pa	182.28
Mean stack gas temperature, T_s	K	324.61
Gas density $_{(wet, ambient)}$, p		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.025
Stack Velocity, Vs $V_{s=} \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	15.85
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	3952.0
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(Ts)}$	Dry	2887.1
$Q_{std02} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(Ts)}$	@O2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(Ts)}$	Wet	3307
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	4.9
Nozzle area, A_n	mm^2	19.1
Total sampling time, q	min	360.0
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	95.4
Acceptable isokinetic range 95% to 115%		Yes

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS QUALITY ASSURANCE CHECKLIST

Leak Test Results	Mean Sampling Rate litre/min	Pre-sampling Leak Rate litre/min	Post-sampling Leak Rate litre/min	Maximum Vacuum mm Hg	Leak Tests Acceptable litre/min	Acceptable Leak Rate litre/min	Leak Tests Acceptable litre/min
Run 1	13.73	0.10	0.10	-660.4	Yes	0.69	Yes

Isokinetic Criterion Compliance	Isokinetic Variation %	Acceptable Isokineticity %
Run 1	95.4	Yes

Acceptable isokinetic range 95% to 115%

Filtration	Filter Material	Filter Size mm	Maximum Filtration Temperature °C
Run 1	Glass Fibre	47	120

Critical Sampling Requirement	Maximum Temperature at Condenser / Adsorber °C	Acceptable Temperature?	Temperature during storage / transit <25°C
Run 1	16	Yes	Yes
Acceptance Criteria	< 20°C	-	< 25°C

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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	10:10 - 11:10 26 August 2025	8.64	0.014	15	1564
Field Blank	-	0.026	-	-	-

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	101.3	-	1.157	20.8	0.25	-	0.42	Yes

	Filter Material	Filter Size mm	Max. Filtration Temp. °C	Temperature during storage / transit <25°C	Type of Absorbers	Absorption Solutions
Run 1	Glass Fibre	47	51	25-07365-1	PTFE	Analytical Grade Water

FORMALDEHYDE ABSORPTION EFFICIENCY

Parameter	Total ug	IMP C ug	Absorption Efficiency %	Acceptable Absorption Efficiency %	Absorption Efficiency Acceptable ?
Run 1	9995.6	195.6	98	95	Yes

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		0.854
Stack static pressure, P_{static}	Pa	-276	Mean of velocity heads, DP_{avg}	Pa	178.24
$P_s = P_b + (P_{static})$	kPa	101.02	Mean stack gas temperature, T_s	K	324.00
			Gas density $_{(wet, ambient)}$, p		
Vol. of water vapour collected, V_{wstd}			p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.046
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	15.76
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	1.2804	Area of stack, A_s	m^2	4.16
Gas meter correction factor, Y_d		0.9747	$Q_a = (60)(A_s)(V_s)$	m^3/min	3930
Mean dry gas meter temperature, T_m	K	295.50	**Dry total flow of stack gas, Q_{std}**		
Mean pressure drop across orifice, DH	mmH_2O	41.33	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	1.16	$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	m^3/min	3019
Volume of gas metered wet, V_{mstw}			**Wet total flow of stack gas, Q_{stw}**		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	1.2655	$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	m^3/min	3301
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		19.75	**Percent isokinetic, %I**		
% oxygen reference condition		21	Nozzle diameter, D_n	mm	5.93
O_2 Reference Factor $\frac{O2\ Ref = 21.0 - act\%O2}{21.0 - ref\%O2}$		No O2 Ref	Nozzle area, A_n	mm^2	27.62
$V_{mstd@X\%oxygen} = (V_{mstd})(O_{2\ Ref})$	m^3	No O2 Ref	Total sampling time, q	min	60
Moisture content, B_{wo}			$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	96
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0856			
	%	8.56	Acceptable isokinetic range 95% to 115%		Yes
Moisture by FTIR	%	-	**Formaldehyde Concentration, C**		
Molecular weight of dry gas, M_d			Mass collected , M	ug	9996
CO_2		0.21	$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	7.899
O_2		19.75			
Total		19.96	$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	8.638
N_2 (100 -Total)		80.04			
			$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.82			
Molecular weight of wet gas, M_s			**Formaldehyde Emission Rates, E**		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	27.9	$E = [(C_{wet})(Q_{stw})(60)] / 1000$	g/hr	1564.49

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL VOLATILE ORGANIC COMPOUNDS SUMMARY

Test	Sampling Times	Concentration mg/m³	LOD mg/m³	ELV mg/m³	Emission Rate g/hr
Run 1	14:40 - 15:40 26 August 2025	68.2	0.30	120	21003.86

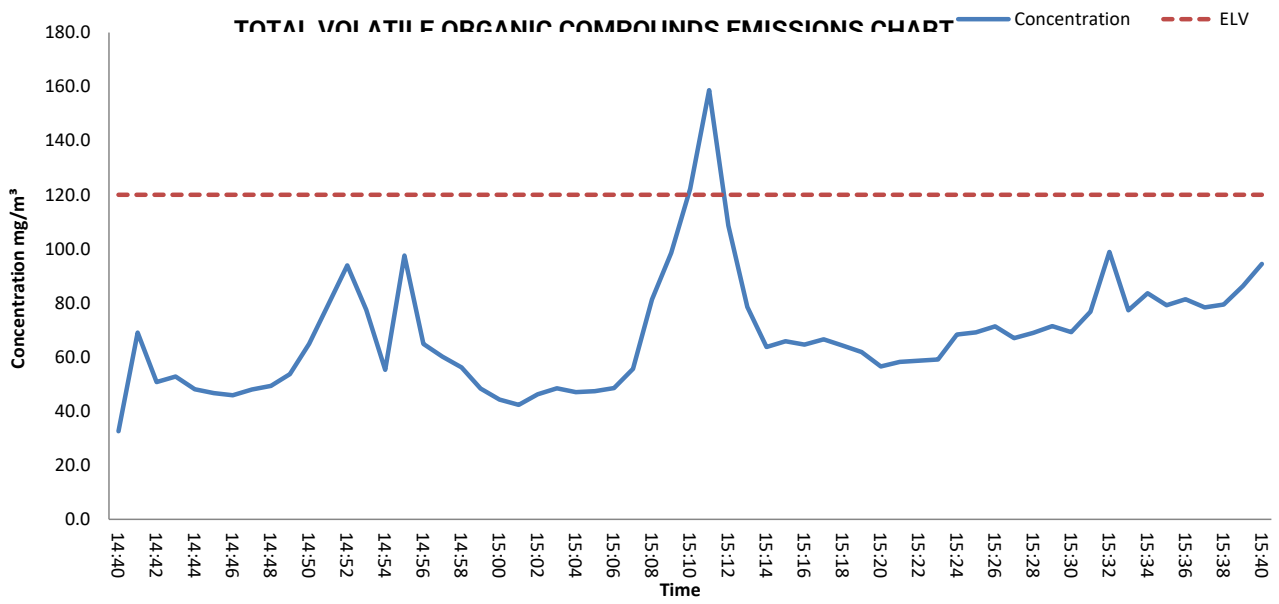
Reference conditions are 273K, 101.3kPa, dry gas .

INSTRUMENTAL SPAN & ZERO CHECKS

PRE-SAMPLING CALIBRATION CHECKS								
Date	26 August 2025							
Start Time	11:53							
End Time	12:05							
Gas	Span Conc (ppm)	Analyser Range	Instrument Zero Reading	Instrument Span Reading	Instrument Zero Reading	Zero Down line reading	Span down line reading	Leak Rate (%)
Propane	82.8	100	-0.12	82.7	-0.80	0.40	81.9	0.98

Zero and Span gas contained 20% Oxygen

POST-SAMPLING CALIBRATION CHECKS								
Date	26 August 2025							
Start Time	17:20							
End Time	17:30							
Gas	Mean Raw Value ppm	Zero down line reading	Span down line reading	Zero Drift (%)	Span Drift (%)	Corrected for Zero Drift	Corrected for Span Drift	Corrected Values ppm / %
Propane	38.83	1.02	81.1	0.75	-1.67	×	×	N/A - not corrected



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

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	14:50 - 15:50 25 August 2025	10.5	0.51	110	3228
Carbon Monoxide	14:50 - 15:50 25 August 2025	489.3	0.28	600	150585.98

Test	Sampling Time and Date	Concentration %	LOD %
Oxygen	14:50 - 15:50 25 August 2025	19.75	0.01

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

PRE-SAMPLING CALIBRATION DATA

Date	25 August 2025
Start Time	12:44
End Time	13:06

Chiller Temperature (°C)	2.9
Requirement	< 4°C
Compliant	Yes

Gas	Analyser 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	0.10	210.3	0.03	0.07	206.7	40	1.71
Carbon Monoxide	200	-0.20	169.5	0.30	0.33	168.8	40	0.43
Oxygen	25	0.01	21.00	0.07	0.08	20.83	25	0.78

POST-SAMPLING CALIBRATION DATA

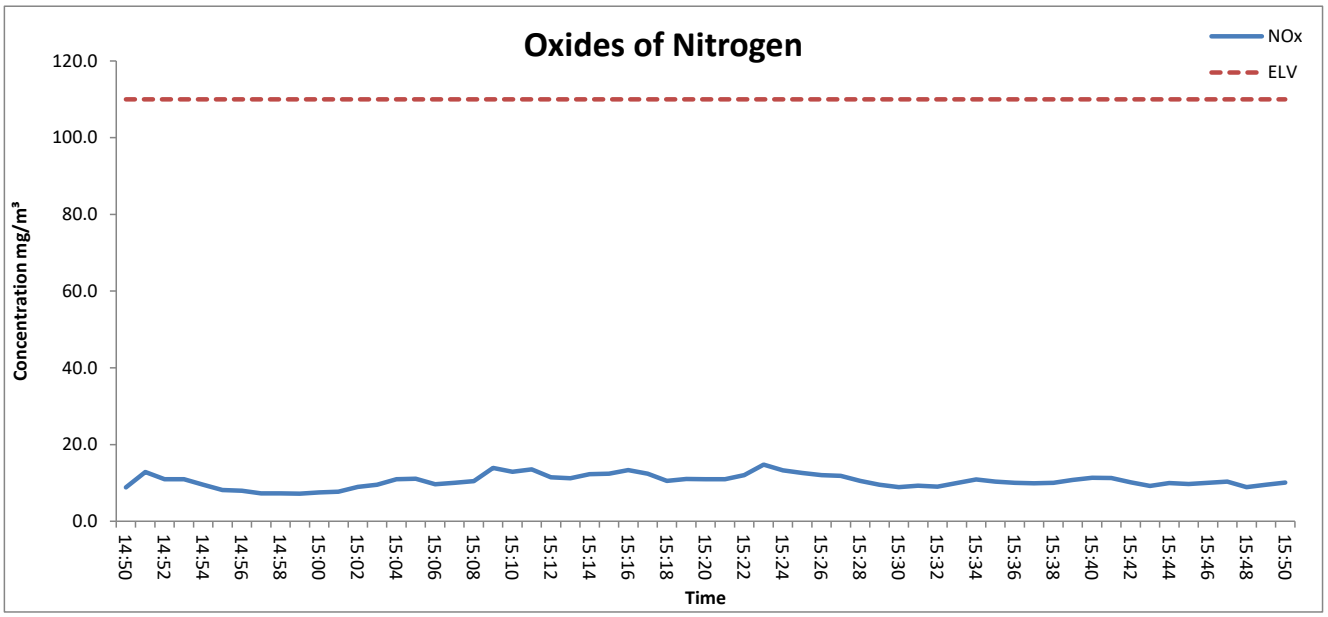
Date	25 August 2025
Start Time	16:50
End Time	16:58

Chiller Temperature (°C)	2.9
Requirement	< 4°C
Compliant	Yes

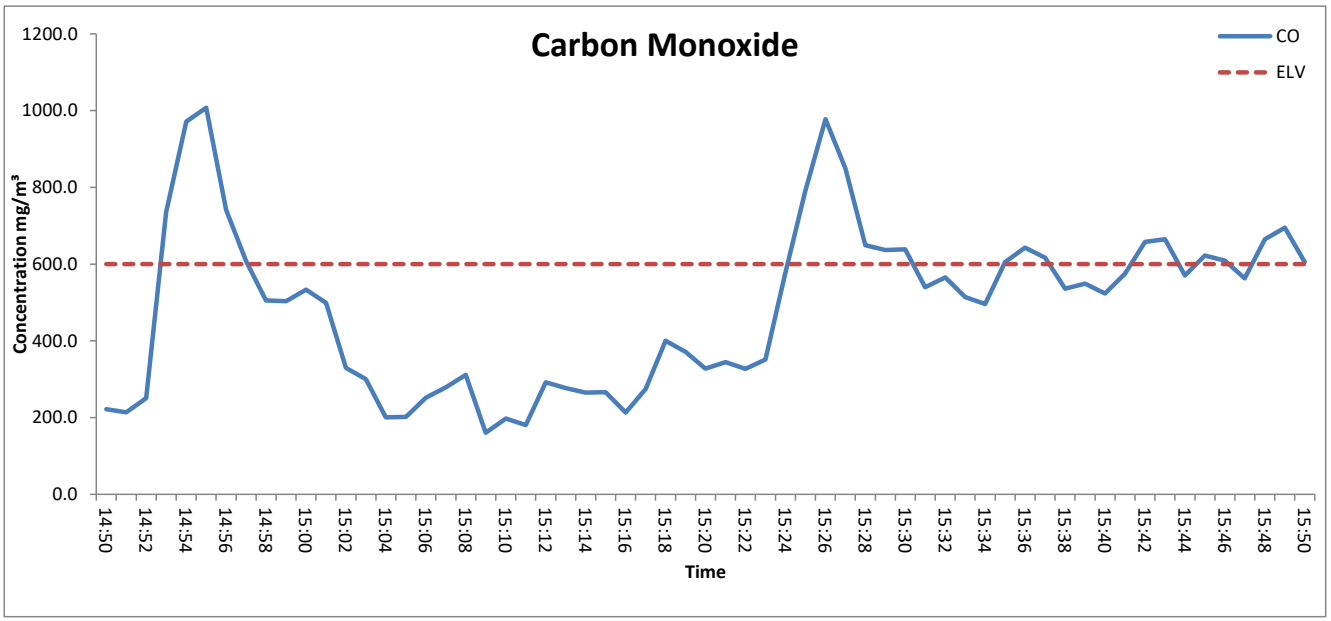
Gas	Zero Check at Analyser	Span Check at Analyser	Zero Drift (% of Span Gas)	Span Drift (% of Span Gas)	Corrected for Zero Drift	Corrected for Span Drift	Corrected Values ppm / %
Nitric Oxide	0.00	209.3	-0.02	-0.47	×	×	N/A - not corrected
Carbon Monoxide	1.00	168.0	0.42	-1.30	×	×	N/A - not corrected
Oxygen	0.01	20.93	-0.30	-0.03	×	×	N/A - not corrected

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

OXIDES OF NITROGEN (as NO_2) EMISSIONS CHART

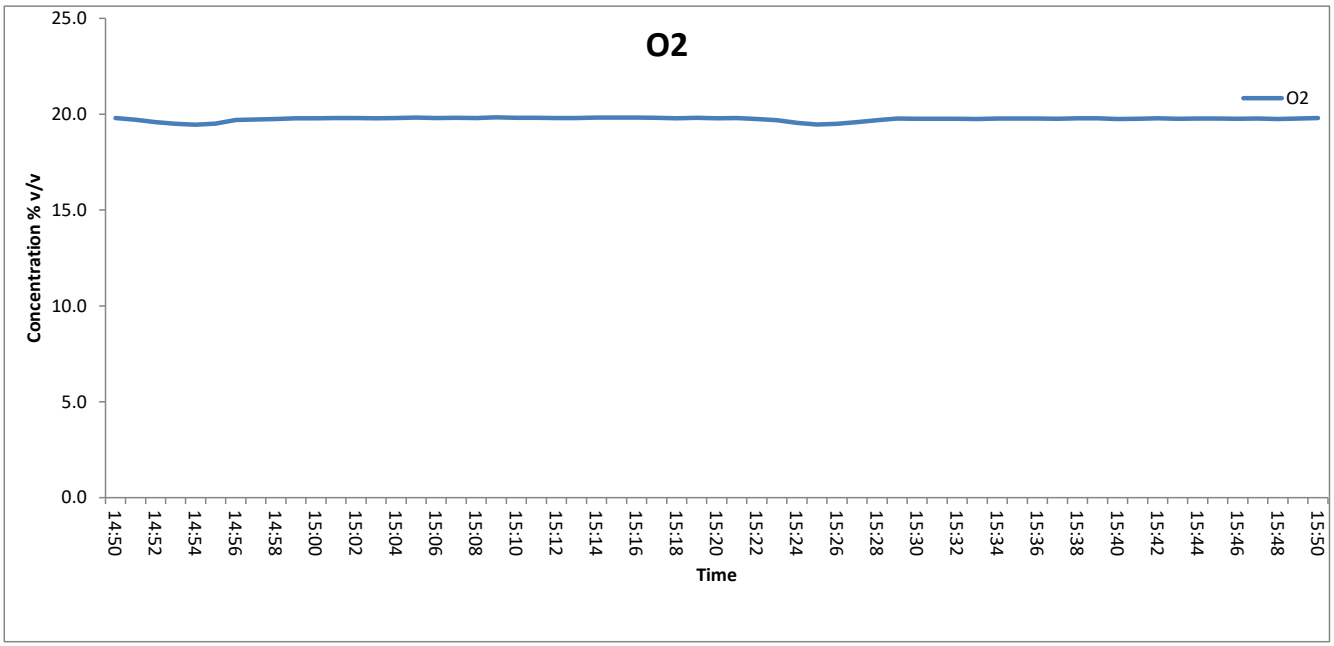


CARBON MONOXIDE EMISSIONS CHART



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	10:10 - 11:10 26 August 2025	2.3538	2.4407	0.0869	8.6	0.01	3.0

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	1265	20.8	0.25	-	0.42	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	51	^oC
Stack static pressure	-0.276	kPa
Barometric Pressure	101.1	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	0.210476	0.002105	0.004132	0.192467	0.001925	0.003778
O_2	32	1.427679	19.745055	0.197451	0.281896	18.055603	0.180556	0.257776
N_2	28	1.249219	80.044469	0.800445	0.999931	73.195602	0.731956	0.914374
H_2O	18	0.803070	-	-	-	8.556328	0.085563	0.068713

Where: p = M / 22.41 pi = r x p

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2860	kg/m^3
Wet Density (STP), P_{STW}	1.2446	kg/m^3
Dry Density (Actual), P_{Actual}	1.0777	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.043	kg/m^3

Where:

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

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

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

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY

TRAVERSE 1

Date of Survey	25 August 2025
Time of Survey	10:56
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	0.07	147.0	15.0	51	14.2	58.8	-	<15
2	0.21	225.4	23.0	51	17.5	72.8	-	<15
3	0.38	744.8	76.0	51	31.9	132.4	-	<15
4	0.61	960.4	98.0	51	36.2	150.3	-	<15
5	1.15	147.0	15.0	51	14.2	58.8	-	<15
6	1.69	39.2	4.0	51	7.3	30.4	-	<15
7	1.92	646.8	66.0	51	29.7	123.3	-	<15
8	2.09	1019.2	104.0	51	37.3	154.8	-	<15
9	2.23	1146.6	117.0	51	39.5	164.2	-	<15
-	-	-	-	-	-	-	-	-
Mean	-	564.0	57.6	51	25.3	105.1	-	-

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	0.07	333.2	34.0	51	21.3	88.5	-	<15
2	0.21	421.4	43.0	51	24.0	99.6	-	<15
3	0.38	960.4	98.0	51	36.2	150.3	-	<15
4	0.61	656.6	67.0	51	29.9	124.3	-	<15
5	1.15	529.2	54.0	51	26.8	111.6	-	<15
6	1.69	215.6	22.0	52	17.1	71.2	-	<15
7	1.92	764.4	78.0	52	32.3	134.1	-	<15
8	2.09	1068.2	109.0	52	38.1	158.5	-	<15
9	2.23	656.6	67.0	52	29.9	124.3	-	<15
-	-	-	-	-	-	-	-	-
Mean	-	622.8	63.6	51	28.4	118.0	-	-

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	152	153	-0.7	Pass	157	155	1.3	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 15 seconds. 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	176	178	-2.0	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	39	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	7.3	m/s	-	-
Highest Gas Velocity	39.5	m/s	-	-
Ratio of Gas Velocities	5.4	-	< 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, $V = K_{pt} \times (1\text{-}e) * \sqrt{(2 * DP_{pt} / P_{ActualW})}$		
Where: K_{pt} = Pitot tube calibration coefficient (1-e) = Compressibility correction factor, assumed at a constant 0.998		
Average Stack Gas Velocity, Va	**26.8**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	51	0	°C
Total Pressure	100.824	101.3	kPa
Oxygen	19.7	21	%
Moisture	8.56	0.00	%
Pitot tube calibration coefficient, K_{pt}	0.84		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	26.85	m/s
Stack Area (A)	4.16	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	401608.46	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	336571.39	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	307773.24	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	307773.24	m^3/hr

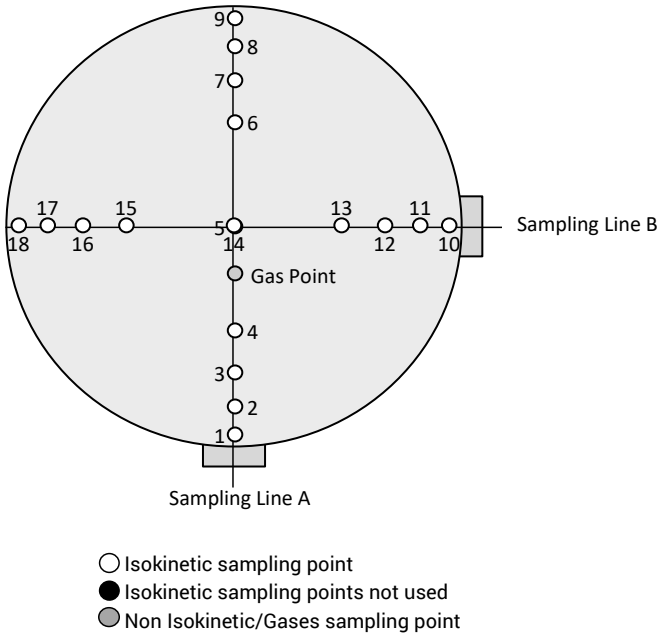
Where:
Q_{Actual} = Va x A x 3600
Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps)
$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma))
Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((21 - O_2a) / (21 - O_2s))

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	30	0.69	m

Isokinetic Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	-	-	< 15
2	-	-	< 15
3	-	-	< 15
4	-	-	< 15
5	-	-	< 15
6	-	-	< 15
7	-	-	< 15
8	-	-	< 15
9	-	-	< 15
10	-	-	< 15
11	-	-	< 15
12	-	-	< 15
13	-	-	< 15
14	-	-	< 15
15	-	-	< 15
16	-	-	< 15
17	-	-	< 15
18	-	-	< 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	0.06	-	-
as a %	0.20	0.62	0.49	1.0	N/A	0.26	1.20	0.000
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	0.98	19.4400	1.0	0.1166	0.0000	-
MU as mg/m^3	0.2178	0.0518	-	0.1166	0.0000	**0.25**
MU as %	1.30	0.3086	-	0.694	0.0002	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.50**	**mg/m^3**	**3.01**	**% Result**	**2.52**	**% 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 - DIOXINS & FURANS

Run	Sampled Volume m³	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Leak %	Uncollected Mass ng/m^3
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 5%**	**≤ 10% ELV**
Run 1	0.009	2.0	0.50	1.0	N/A	-	0.00044
as a %	0.20	0.7	0.49	1.0	N/A	0.73	N/A
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**N/A**

Run	Volume (STP) m³	O2 Correction -	Mass of Dioxin & Furan ng	Leak ng/m³	Uncollected Mass ng/m^3	Laboratory analysis -	Combined uncertainty
Run 1	4.2198	1.0	0.1451	0.00001	0.00025	-	-
MU as ng/m^3	0.0000	-	0.0001	0.00001	0.0000258	0.0002	**0.0003**
MU as %	1.3232	-	5.6796	0.4206	1.0504	8.60	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.0005**	**ng/m³**	**20.9**	**% Result**	**N/A**	**% 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%**	**<=10%**	**≤ 5% of ELV**	**<=2%**
Run 1	1.157	296	98.54	1.0	-	16.8	-
as a %	0.09	0.68	0.51	1.0	-	0.20	1.20
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	1.0399	16.8096	-	0.0599	-	-
MU as mg/m^3	0.1134	0.0298	-	0.0599	1.0236	**1.0320**
MU as %	1.3133	0.3449	-	0.6939	11.9	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**2.06**	**mg/m^3**	**23.90**	**% Result**	**13.76**	**% 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	0.0023	2.0	0.50	1.0	N/A	-
as a %	0.20	0.62	0.49	1.0	N/A	1.20
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	0.98	86900	1.0	521.11	58	-
MU as % v/v	0.123	0.011	-	0.066	0.006	**0.140**
MU as %	1.30	0.12	-	0.69	0.07	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.28**	**% v/v**	**2.95**	**%**

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VOLATILE ORGANIC COMPOUNDS RUN 1

Measured Concentration	68.2	mg/m^3
Limit	120	mg/m^3
Calibration Gas Concentration	132.48	mg/m^3
Range	160	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	0.25	% 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	0.75	% full scale	<5% range / 24hr	Yes
Span drift	-1.67	% full scale	<5% 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)	0.98	% of value	< 2% of span gas value	Yes
Uncertainty of calibration gas	1.0	% 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	-0.06
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	0.39
Uncertainty of calibration gas	ucalib	0.39
Uncertainty in factor	uf	0.21

Measurement uncertainty Measured Concentration	68.24	mg/m^3
Combined uncertainty	0.89	mg/m^3
Expanded uncertainty	1.74	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**1.45**	**% ELV**
Expanded uncertainty expressed with a level of confidence of 95%	**1.74**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**2.55**	**% value**

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXIDES OF NITROGEN

Limit value	110	mg/m^3
Concentration @ Ref conditions	10.5	mg/m^3
Cal gas conc	430	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	-0.47	% 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	0.00	% 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)	0.00	% 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	$U_{d,z}$	-0.0091
short term span drift	$U_{d,s}$	-0.2735
influence of Ambient Temp at Zero	$U_{t,z}$	0.0000
influence of Ambient Temp at Span	$U_{t,s}$	2.4750
influence of sample gas pressure	U_p	0.0000
influence of sample gas flow	U_{fit}	0.1732
influence of supply voltage	U_v	0.0113
Combined Interfence	U_i	-0.0018
Uncertainty of Cal gas	U_{adj}	2.0980

Measurement uncertainty (Concentration Measured)	10.49	mg/m^3
Combined uncertainty	3.27	mg/m^3
Expanded at a 95% confidence interval	6.41	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**5.82**	**% ELV**
Expanded uncertainty expressed with a level of confidence of 95%	**6.4**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**61.1**	**% value**

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - CARBON MONOXIDE

Limit value	600	mg/m^3
Concentration @ Ref conditions	489.3	mg/m^3
Cal gas conc	211.8	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	0.42	% full scale	<5% range / 24hr	Yes
Span drift	-1.30	% 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	$U_{d,s}$	0.24
influence of Ambient Temp zero	$U_{t,z}$	-0.44
influence of Ambient Temp span	$U_{t,s}$	0.20
influence of sample gas pressure	U_p	0.00
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}	0.85

Measurement uncertainty (Concentration Measured)	489.3	mg/m^3
Combined uncertainty	1.2	mg/m^3
Expanded uncertainty	2.3	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**0.4**	**% ELV**
Expanded uncertainty expressed with a level of confidence of 95%	**2.3**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**0.5**	**% 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	19.75	%vol
Calibration gas	20.95	%vol
Analyser Full Scale	25	%vol

	Value	Units	specification	MU Met?
Response time	25	seconds	200	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.02	% Vol	≤0.2% Vol	Yes
Repeatability at span level	0.02	% Vol	≤0.2% Vol	Yes
Deviation from linearity	-0.10	% Vol	≤0.3% Vol	Yes
Zero drift	0.00	% Vol	≤0.2% Vol	Yes
Span drift	-0.07	% Vol	≤0.2% Vol	Yes
volume or pressure flow dependence	-0.01	% Vol for flow range	≤0.2% Vol	Yes
atmospheric pressure dependence	0.19	% Vol for 3kPa	≤0.2% Vol	Yes
ambient temperature dependence	-0.40	% Vol/20K	≤0.5% Vol	Yes
Combined interference	0.00	% Vol	≤0.4% Vol	Yes
dependence on voltage	0.02	% Vol	≤0.2% Vol	Yes
losses in the line (leak)	0.01	% of value	< 2% of value	Yes
Uncertainty of calibration gas	0.5	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.0042
lack of fit	U_{lof}	-0.0577
short term zero drift	$U_{d,z}$	-0.0017
short term span drift	$U_{d,s}$	-0.0387
influence of Ambient Temp at Zero	$U_{t,z}$	-0.0030
influence of Ambient Temp at Span	$U_{t,s}$	-0.0011
influence of sample gas pressure	U_p	0.0000
influence of sample gas flow	U_{fit}	-0.0029
influence of supply voltage	U_v	0.0115
Combined Interfence	U_i	0.0000
Uncertainty of Cal gas	U_{adj}	0.0987

Measurement uncertainty (Concentration Measured)	19.75	% vol
Combined uncertainty	0.12	% vol
Expanded uncertainty	0.24	% vol

Expanded uncertainty expressed with a level of confidence of 95%	**0.24**	**% vol**
Expanded uncertainty expressed with a level of confidence of 95%	**1.21**	**%**

Maximum permissible uncertainty is 6% of value or 0.3% by volume.
Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	26.8	m/s
Measured Volumetric Flow rate at Actual Conditions	401608	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	-	4.47		
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	87.45	<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	1.65	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	514		
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	0.33
Expanded uncertainty at a 95% Confidence Interval	0.65

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	10527
Expanded uncertainty at a 95% Confidence Interval	20633

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