STACK EMISSIONS MONITORING REPORT

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Operator & Address:
Medite Smartply Redmonstown Clonmel Co. Tipperary Ireland

Permit Reference:
IE Licence: P0027-04

Release Point:
A2-5

Sampling Date(s):
18 October 2022

SOCOTEC Job Number:	LEK 13463 / Q4
Report Date:	23-Nov-22
Version:	1
Report By: MCERTS Number: MCERTS Level: Technical Endorsements:	Daniel Scully MM 19 1563 MCERTS Level 1 - Technician 1 & 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 Smartply operates a wood fibre board manufacturing process at Clonmel which is subject to IE Licence P0027-04, under the EPA Act 1992.

SOCOTEC LTD were commissioned by Medite Europe Ltd 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 Smartply
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

EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	**Units**	**Result**	**Calculated Uncertainty +/-**	**Emission Limit Value (ELV)**	**Accreditation**
Total Particulate Matter Particulate Emission Rate	mg/m³ g/hr	8.3 1470	0.74 130.8	20 -	MCERTS
Oxides of Nitrogen (as NO_2) Oxides of Nitrogen (as NO_2) Emission Rate	mg/m³ g/hr	40 5100	4.3 550	110 -	MCERTS
Carbon Monoxide Carbon Monoxide Emission Rate	mg/m³ g/hr	10.04 1280.77	1.83 233.57	600 -	MCERTS
Moisture	%	33.87	0.92	-	MCERTS
Stack Gas Temperature	°C	52	-	-	MCERTS
Stack Gas Velocity	m/s	15.4	0.38	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	230957.3	11865.5	-	
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	192857.9	9908.1	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	127541.9	6552.5	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	127541.9	6552.5	174160	

ND = None Detected,
Results at or below the limit of detection are highlighted by bold italic text.
The above volumetric flow rate is an average of the data collected during the isokinetic tests. Mass emissions for non isokinetic tests are also calculated using these 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	18 October 2022	12:34 - 13:06	32 minutes
Combustion Gases	18 October 2022	12:35 - 13:06	31 minutes
Preliminary Stack Traverse	18 October 2022	12:24 - 12:34	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Wood Fibre Board Manufacturing
Continuous or batch	Continuous
Product Details	Wood Fibre Board
Part of batch to be monitored (if applicable)	Normal Operation
Normal load, throughput or continuous rating	Normal Load
Fuel used during monitoring	N/A
Abatement	Cyclone
Plume Appearance	Heavy Moisture Plume

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard reference / alternative methods employed by SOCOTEC is determined, wherever possible by the hierarchy of method selection outlined in Environmental Protection Agency Technical Guidance Note (Monitoring) AG2.

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	0.35 mg/m³	8.9%	3.67%
Oxides of Nitrogen	SRM - EN 14792:2017	AE 102	1015	MCERTS	0.51 mg/m³	10.8%	3.92%
Carbon Monoxide	SRM - EN 15058:2017	AE 102	1015	MCERTS	0.28 mg/m³	18.2%	0.3%
Moisture	EN 14790	AE 105	1015	MCERTS	0.02%	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%	3.76%
-	-	-	-	-	-	-	-

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 number	Archive Period
Total Particulate Matter	Gravimetric	AE 106	1015	MCERTS	SOCOTEC (East Kilbride)	N/A	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	49	Pa	>= 5 Pa	Yes	EN 15259
Lowest Gas Velocity	9.1	m/s	-	-	-
Highest Gas Velocity	22.8	m/s	-	-	-
Ratio of Gas Velocities	2.5	: 1	< 3 : 1	Yes	EN 15259
Mean Velocity	15.4	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	Outside

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	Yes
Depth of Platform = >Stack depth / diameter + wall and port thickness + 1.5m	Yes

Sampling Platform Improvement Recommendations (if applicable)

Although the monitoring position doesn't comply with most of the sampling plane validation criteria described in AG1, it is the safest and only real means of access practically possible in order to undertake extractive sampling.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

Nozzle Size

Due to the high velocities at the sampling point selected in the stack a 4mm nozzle was required to achieve isokinetic monitoring, this does not completely adhere to EN 13284-1.

Sampling lines

It was only possible to sample from one representative sampling point for all isokinetic monitoring due to a number of factors i.e. flow being excessively high, swirl being greater than 15° & negative flow experienced throughout sample point locations. This sampling location does not therefore comply with all the requirements of AG1 & IS EN 16911-1.

Velocity traverse

As this sampling location shows high levels of turbulence throughout the results from the standard flow traverse are only 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.

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
Oxides of Nitrogen	SRM - EN 14792:2017	AE 102	1015	MCERTS	1
Carbon Monoxide	SRM - EN 15058:2017	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 9.49	Horiba PG-250 Analyser	LEK 12.18	Laboratory Balance	LEK 15.21
Box Thermocouples	LEK 17.77	FT-IR Gasmet	-	Tape Measure	LEK 20.2
Meter In Thermocouple	LEK 17.78	FT-IR Oven Box	-	Stopwatch	-
Meter Out Thermocouple	LEK 17.79	Bernath 3006 FID	-	Protractor	-
Control Box Timer	LEK 9.50	Signal 3030 FID	-	Barometer	LEK 16.8
Oven Box	LEK 13.25	Servomex	-	Digital Micromanometer	LEK 1.20
Probe	LEK 6.53	JCT Heated Head Filter	LEK 13.32a	Digital Temperature Meter	LEK 2.11
Probe Thermocouple	LEK 3.187	Thermo FID	-	Stack Thermocouple	-
Probe	LEK 6.17	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	LEK 6.17	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	LEK 6.77	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	LEK 23.16	Chiller (JCT/MAK 10)	LEK 12.12	1m Heated Line (3)	-
Last Impinger Arm	LEK 3.109	Heated Line Controller (1)	LEK 8.49	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	LEK 10.93	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	LEK 15.1X	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-			15m Heated Line (1)	-
Heater Controller	-			20m Heated Line (1)	LEK 8.49
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 +/- %
Nitric Oxide	LEK 293	BOC	207	-	2.0
Carbon Monoxide	LEK 293	BOC	157	-	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
Brian Walsh	MM 17 1414	MCERTS Level 2	Jan-23	Jan-23	Nov-23	Nov-23	May-23	May-25
Aidan Whitney	MM20 1603	MCERTS Level 1	Sep-25	Nov-26	-	-	-	Sep-25

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	12:34 - 13:06 18 October 2022	8.29	0.73	20	1470
Blank	-	0.35	-	-	-

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	AQ 4906	0.14632	0.15119	0.00487	161.72330	161.72270	-0.00060	0.00427

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	AQ 4883	0.14519	0.14525	0.00006	215.16770	215.16690	-0.00080	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	101.9
Stack static pressure, P_{static}	pa	-180.0
$P_s = P_b + P_{static}$	Kpa	101.7
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	211.7
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.2637782
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.572
Gas meter correction factor, Y_d		0.959
Mean dry gas meter temperature, T_m		294
Mean pressure drop across orifice, DH	mmH_2O	44.528
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.515
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.7789
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		20.3
% 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}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.3387
	%	33.87
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.84
Mean of velocity heads, DP_{avg}	Pa	300.13
Mean stack gas temperature, T_s	K	324
Gas density (wet, ambient), ρ p=(Ms*Ps)/(8.314*Ts)	kg/m^3	0.952
Stack Velocity, Vs $V_s = Cp\sqrt{\frac{\Delta DPavg}{p}}$	m/s	21.19

Molecular weight of dry gas, M_d		
CO_2	%	0.65
O_2	%	20.30
Total	%	20.96
N_2 (100 -Total)	%	79.04
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.92
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	25.22
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	5282.9
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	2954.9
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	4468.20
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	5.02
Nozzle area, A_n	mm^2	19.77
Total sampling time, q	min	32
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	114.5
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.00487
Mass collected in probe, M_p	g	-0.00060
Total mass collected, M_n	g	0.00427
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m³	5.482
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m³	8.290
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m³	No O2 Ref
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		1469.79

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	17.14	0.12	0.12	-482.6	0.34	Yes

ISOKINETICITY		
Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	114.50	Yes

Acceptable isokinetic range 95% to 115%

WEIGHING BALANCE UNCERTAINTY			
Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.35	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	0.35	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	Quartz Fibre	47	51	180	160

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	12:35 - 13:06 18 October 2022	40.0	0.51	110	5100
Carbon Monoxide	12:35 - 13:06 18 October 2022	10.0	0.28	600	1280.77

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

PRE-SAMPLING CALIBRATION DATA

Date	18 October 2022
Start Time	11:15
End Time	11:40

Chiller Temperature (°C)	3.0
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	206.9	0.00	0.20	206.5	23	0.19
Carbon Monoxide	200	0.10	157.0	0.00	0.10	156.7	29	0.19

POST-SAMPLING CALIBRATION DATA

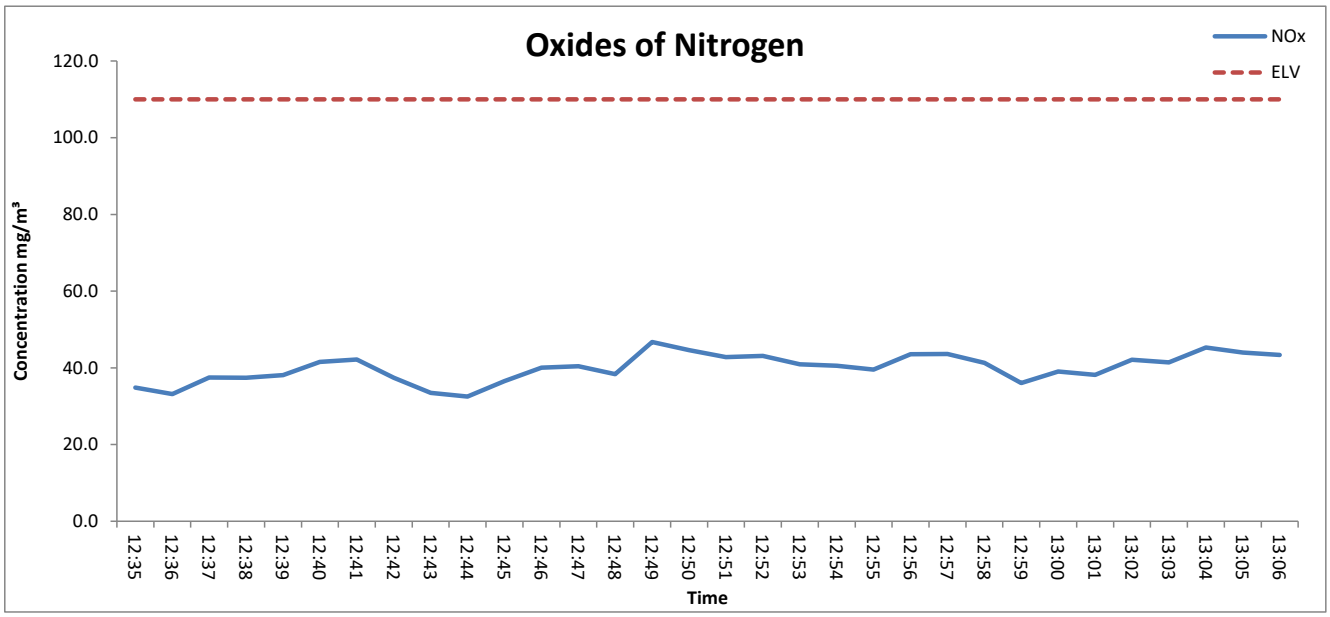
Date	18 October 2022
Start Time	14:00
End Time	14:12

Chiller Temperature (°C)	2.4
Requirement	< 4°C
Compliant	Yes

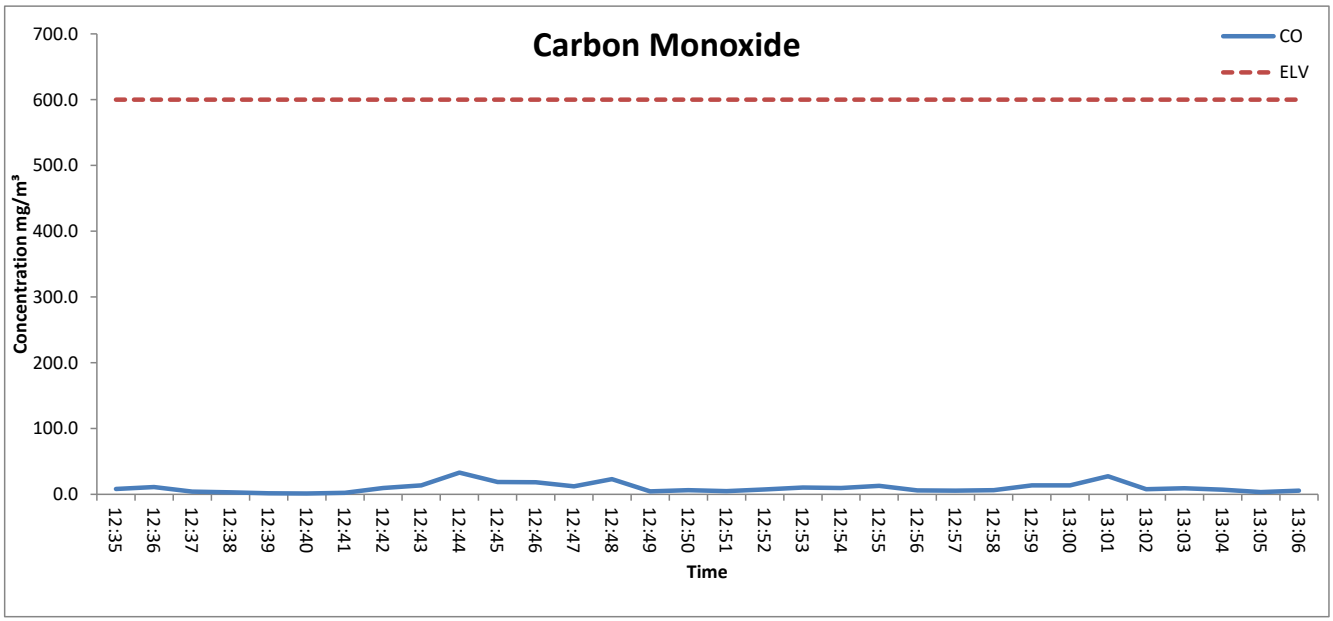
Gas	Zero Check at Analyser	Span Check at Analyser	Zero Drift (%)	Span Drift (%)	Corrected for Zero Drift	Corrected for Span Drift	Corrected Values ppm / %
Nitric Oxide	0.07	207.0	0.03	0.01	×	×	N/A - not corrected
Carbon Monoxide	0.02	157.0	0.01	-0.01	×	×	N/A - not corrected

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

OXIDES OF NITROGEN (as NO_2) EMISSIONS CHART



CARBON MONOXIDE EMISSIONS CHART



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	12:34 - 13:06 18 October 2022	2.1232	2.3349	0.2117	33.9	0.02	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	32	779	17.1	0.12	0.12	0.34	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	52	°C
Stack static pressure	-0.1985	kPa
Barometric Pressure	100.9	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	0.652161	0.006522	0.012802	0.431291	0.004313	0.008466
O_2	32	1.427679	20.304803	0.203048	0.289887	13.428095	0.134281	0.191710
N_2	28	1.249219	79.043036	0.790430	0.987421	52.273217	0.522732	0.653007
H_2O	18	0.803070	-	-	-	33.867397	0.338674	0.271979

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

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2901	kg/m^3
Wet Density (STP), P_{STW}	1.1252	kg/m^3
Dry Density (Actual), P_{Actual}	1.0773	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	0.940	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	18 October 2022
Time of Survey	12:24 - 12:34
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	307.1	31.3	52	21.6	89.6	-	<15
2	0.21	267.9	27.3	52	20.2	83.7	-	<15
3	0.38	290.7	29.7	52	21.0	87.2	-	<15
4	0.61	245.0	25.0	52	19.3	80.1	-	<15
5	1.15	149.3	15.2	52	15.0	62.5	-	<15
6	1.69	115.0	11.7	52	13.2	54.9	-	<15
7	1.92	90.2	9.2	52	11.7	48.6	-	<15
8	2.09	79.7	8.1	52	11.0	45.7	-	<15
9	2.23	54.6	5.6	52	9.1	37.8	-	<15
-	-	-	-	-	-	-	-	-
Mean	-	177.7	18.1	52	15.8	65.6	-	-

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	343.0	35.0	52	22.8	94.7	-	<15
2	0.21	248.3	25.3	52	19.4	80.6	-	<15
3	0.38	218.9	22.3	52	18.2	75.7	-	<15
4	0.61	177.4	18.1	52	16.4	68.1	-	<15
5	1.15	132.6	13.5	52	14.2	58.9	-	<15
6	1.69	118.6	12.1	52	13.4	55.7	-	<15
7	1.92	97.0	9.9	52	12.1	50.4	-	<15
8	2.09	68.3	7.0	52	10.2	42.3	-	<15
9	2.23	55.9	5.7	52	9.2	38.2	-	<15
-	-	-	-	-	-	-	-	-
Mean	-	162.2	16.6	52	15.1	62.7	-	-

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	149	143	4.0	Pass	133	131	1.5	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	-201	-196	-5.0	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	55	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	9.1	m/s	-	-
Highest Gas Velocity	22.8	m/s	-	-
Ratio of Gas Velocities	2.5	-	< 3 : 1	Yes
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	**15.4**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	52	0	°C
Total Pressure	100.7015	101.3	kPa
Oxygen	20.3	21	%
Moisture	33.87	0.00	%
Pitot tube calibration coefficient, K_{pt}	0.84		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	15.44	m/s
Stack Area (A)	4.16	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	230957.3	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	192857.9	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	127541.9	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	127541.9	m^3/hr

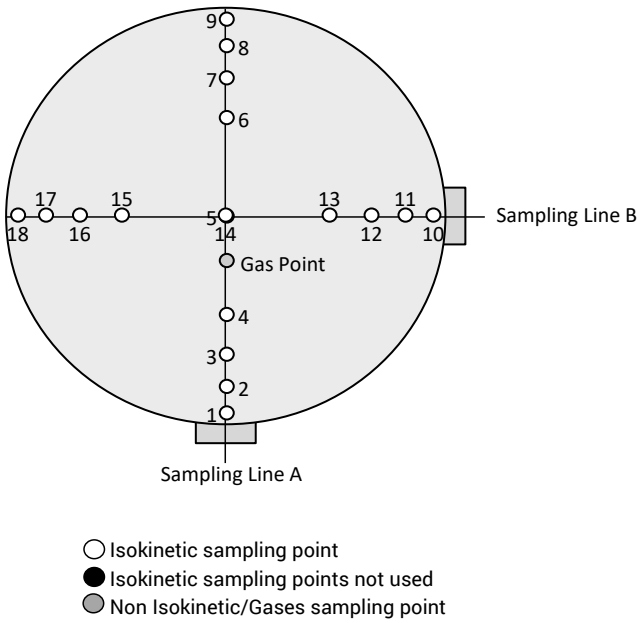
Where:
Q_{Actual} = Va x A x 3600
Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps) x 3600
$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma)) x 3600
Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((21 - O_2a) / (21 - O_2s))

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	30	0.69	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 m^3	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Limit of Detection % by mass	Leak %	Uncollected Mass mg
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 5% of ELV**	**≤ 2%**	**≤ 10% of ELV**
Run 1	0.001	2.0	0.50	1.0	N/A	0.1800	-	-
as a %	0.20	0.62	0.49	1.0	N/A	1.74731	0.70	0.001
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**	**Yes**

Run	Volume (STP) m^3	Mass of particulate mg	O_2 Correction -	Leak mg/m^3	Uncollected Mass mg	Combined uncertainty
Run 1	0.44	4.2700	1.0	0.0335	0.0001	-
MU as mg/m^3	0.11	0.3495	-	0.0335	0.0002	**0.37**
MU as %	1.30	4.2155	-	0.404	0.0024	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.73**	**mg/m^3**	**8.86**	**% Result**	**3.67**	**% 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 - OXIDES OF NITROGEN

Limit value	110	mg/m^3
Concentration @ Ref conditions	40.0	mg/m^3
Cal gas conc	424	mg/m^3
Analyser Full Scale	513	mg/m^3

	Value	Units	specification	MU Met?
Response time	23	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	31	minutes	-	-
Number of readings in measurement	31	-	-	-
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	0.03	% full scale	<2% range / 24hr	Yes
Span drift	0.01	% full scale	<2% 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	-1.30	% range	<4% of Range	Yes
dependence on voltage	0.01	% 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)	0.01	% 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	$U_{d,z}$	0.0195
short term span drift	$U_{d,s}$	0.0084
influence of Ambient Temp at Zero	$U_{t,z}$	0.0000
influence of Ambient Temp at Span	$U_{t,s}$	0.6874
influence of sample gas pressure	U_p	-0.0192
influence of sample gas flow	U_{fit}	0.1732
influence of supply voltage	U_v	0.0430
Combined Interfence	U_i	-0.0018
Uncertainty of Cal gas	U_{adj}	2.0700

Measurement uncertainty (Concentration Measured)	39.98	mg/m^3
Combined uncertainty	2.20	mg/m^3
Expanded at a 95% confidence interval	4.31	mg/m^3

Expanded uncertainty expressed with a level of confidence of 95%	**3.92**	**% 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%	**10.8**	**% value**

Developed for the STA by R Robinson, NPL

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - CARBON MONOXIDE

Limit value	600	mg/m^3
Concentration @ Ref conditions	10.0	mg/m^3
Cal gas conc	196.3	mg/m^3
Analyser Full Scale	250	mg/m^3

Performance characteristics	Value	Units	specification	MU Met?
Response time	29	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	31	minutes	-	-
Number of readings in measurement	31	-	-	-
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	0.01	% full scale	<2% range / 24hr	Yes
Span drift	-0.01	% full scale	<2% 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	$U_{d,s}$	0.01
influence of Ambient Temp zero	$U_{t,z}$	0.00
influence of Ambient Temp span	$U_{t,s}$	0.05
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	-0.29
Uncertainty of Cal gas	U_{adj}	0.79

Measurement uncertainty (Concentration Measured)	10.0	mg/m^3
Combined uncertainty	0.9	mg/m^3
Expanded uncertainty	1.8	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%	**1.8**	**mg/m^3**
Expanded uncertainty expressed with a level of confidence of 95%	**18.2**	**% value**

Developed for the STA by R Robinson, NPL

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	15.4	m/s
Measured Volumetric Flow rate at Actual Conditions	230957	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	-	1.39		
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	26.44	<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	1.66	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	514		
Uncertainty associated with the estimate of density	-	0.009		
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	0.19
Expanded uncertainty at a 95% Confidence Interval	0.38

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	6054
Expanded uncertainty at a 95% Confidence Interval	11865

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