STACK EMISSIONS MONITORING REPORT

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Operator & Address:
Kemira Chemicals Ltd New Potter Grange Road M62 Trading Estate Goole East Yorkshire DN14 6BZ

Permit Reference:
EPR Permit: TP3135PX

Release Point:
Buffer Tanks

Sampling Date(s):
10th December 2024

SOCOTEC Job Number:	LNO 19035
Report Date:	17th December 2024
Version:	1
Report By:	Johnathon Orley
MCERTS Number:	MM 08 983
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Report Approved By:	Gary Orley
MCERTS Number:	MM 13 1223
Business Title:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Signature:	

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EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Kemira Chemicals Ltd operates a pre-storage tank process at Goole which is subject to EPR Permit TP3135PX, under the Environmental Permitting Regulations 2016.

SOCOTEC UK LTD were commissioned by Kemira Chemicals 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 EPR Permit, TP3135PX.

Plant

Buffer Tanks

Operator

Kemira Chemicals Ltd
New Potter Grange Road
M62 Trading Estate
Goole
East Yorkshire
DN14 6BZ

EPR Permit: TP3135PX

Stack Emissions Monitoring Test House

SOCOTEC UK LTD- Altrincham Laboratory
Unit E Broadheath Network Centre
Atlantic Street, Altrincham
Cheshire
WA14 5EW
UKAS and MCERTS Accreditation Number: 1015

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

EXECUTIVE SUMMARY

EMISSIONS SUMMARY

Parameter	Units	Result	Calculated Uncertainty +/-	Emission Limit Value (ELV)	Accreditation
Total Particulate Matter Particulate Emission Rate	mg/m³ g/hr	1.0 0.16	0.56 0.092	10 -	MCERTS
Sulphur Dioxide Sulphur Dioxide Emission Rate	mg/m³ g/hr	0.11 0.018	0.054 0.0089	50 -	MCERTS
Moisture	%	1.5	0.064	-	MCERTS
Stack Gas Temperature	°C	30	-	-	MCERTS
Stack Gas Velocity	m/s	2.2	0.36	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	138	24	-	
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	127	22	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	125	22	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	127	22	-	

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 without correction for water vapour

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	**Sampling Date(s)**	**Sampling Times**	**Sampling Duration**
Total Particulate Matter Run 1	10 December 2024	09:55 - 10:55	60 minutes
Sulphur Dioxide Run 1	10 December 2024	09:55 - 10:55	60 minutes
Preliminary Stack Traverse	10 December 2024	09:40	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Pre-storage tank
Continuous or batch	Continuous
Product Details	Feric sulphate
Part of batch to be monitored (if applicable)	N/A
Normal load, throughput or continuous rating	Normal load
Fuel used during monitoring	None
Abatement	None
Plume Appearance	Slight steam 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 Environment Agency technical Guidance 'Monitoring stack emissions: techniques and standards for periodic monitoring'.

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 - BS EN 13284-1	AE 104	1015	MCERTS	0.28 mg/m³	58%	5.6%
Sulphur Dioxide	SRM - BS EN 14791	AE 112	1015	MCERTS	0.015 mg/m³	51%	0.11%
Moisture	BS EN 14790	AE 105	1015	MCERTS	0.02%	4.2%	N/A - No ELV
Velocity	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	5 Pa	17%	N/A - No ELV
Volumetric Flow Rate	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	-	17%	N/A - No ELV

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

EXECUTIVE SUMMARY

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 (Altrincham)	N/A	8 Weeks
Sulphur Dioxide	Ion Chromatography	ASC/SOP/110	1252	MCERTS	SOCOTEC (Bretby)	ASC 65409	8 Weeks

ON-SITE TESTING							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	Accreditation	Laboratory	Data Archive Location	Archive Period
Moisture	Gravimetric	AE 105	1015	MCERTS	SOCOTEC (Altrincham)	-	-

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	**Value**	**Units**	**Requirement**	**Compliant**	**Method**
Lowest Differential Pressure	3.9	Pa	>= 5 Pa	No	BS EN 15259
Lowest Gas Velocity	2.2	m/s	-	-	-
Highest Gas Velocity	2.2	m/s	-	-	-
Ratio of Gas Velocities	1.0	: 1	< 3 : 1	Yes	BS EN 15259
Mean Velocity	2.2	m/s	-	-	-
Maximum angle of flow with regard to duct axis	<15	°	< 15°	Yes	BS EN 15259
No local negative flow	Yes	-	-	Yes	BS EN 15259

DUCT CHARACTERISTICS		
	Value	**Units**
Shape	Circular	-
Depth	0.15	m
Width	-	m
Area	0.02	m^2
Port Depth	90	mm

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

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

EA Guidance, Monitoring stack emissions: measurement locations.	
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	No

Sampling Platform Improvement Recommendations (if applicable)

Scaffolding platform should have more depth to comply with EA Guidance Note M1. However on this occasion the sampling could be completed in a compliant manner.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

Lowest Differential Pressure

Lowest Differential Pressure <5Pa

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 - BS EN 13284-1	AE 104	1015	MCERTS	1
Sulphur Dioxide	SRM - BS EN 14791	AE 112	1015	MCERTS	1
Moisture	BS 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	LNO 13-27	Horiba PG - 350E Analyser	-	Laboratory Balance	LNO 00-13, 00-33
Box Thermocouples	LNO 03-27	FT-IR	-	Tape Measure	LNO 24-LM
Meter In Thermocouple	LNO 03-27	FT-IR Oven Box	-	Stopwatch	-
Meter Out Thermocouple	LNO 03-27	Bernath 3006 FID	-	Protractor	-
Control Box Timer	LNO 17-27	Signal 3030 FID	-	Barometer	LNO 08-LM
Oven Box	LNO 09-13	Servomex	-	Digital Micromanometer	-
Probe	LNO 11-08	JCT Heated Head Filter	-	Digital Temperature Meter	-
Probe Thermocouple	LNO 10-08	Thermo FID	-	Stack Thermocouple	-
Probe	-	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	LNO 06-LM	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	LNO 14-LM	Chiller (JCT/MAK 10)	-	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	-	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	LNO 31-LM	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-			15m Heated Line (1)	-
Heater Controller	LNO 03-46			20m Heated Line (1)	-
Inclinometer (Swirl Device)	LNO 23-LM			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 +/- %
-	-	-	-	-	-

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**
Johnathon Orley	MM 08 983	MCERTS Level 2	Mar-25	Mar-25	Dec-25	Dec-26	Mar-26	Sep-28
Josh Davenport	MM 16 1380	MCERTS Level 1	May-26	-	-	-	-	May-26

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	09:55 - 10:55 10 December 2024	0.96	0.56	10	0.16
Blank	-	0.96	-	-	-

Reference conditions are 273K, 101.3kPa without correction for water vapour

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	Q3801	0.15141	0.15160	0.00019	65.42870	65.42920	0.00050	0.00069

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	Q3800	0.15141	0.15160	0.00019	65.42870	65.42920	0.00050	0.00069

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	103.9
Stack static pressure, P_{static}	pa	15.0
$P_s = P_b + P_{static}$	Kpa	103.9
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	8.8
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0109648
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.741
Gas meter correction factor, Y_d		0.994
Mean dry gas meter temperature, T_m		293
Mean pressure drop across orifice, DH	mmH_2O	17.554
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.705
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.7161
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		21.0
% 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}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0153
	%	1.53
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.84
Mean of velocity heads, DP_{avg}	Pa	7.51
Mean stack gas temperature, T_s	K	308
Gas density $_{(wet,\ ambient)}$, ρ p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.164
Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	2.84

Molecular weight of dry gas, M_d		
CO_2	%	0.04
O_2	%	21.00
Total	%	21.04
N_2 (100 -Total)	%	78.96
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.85
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.68
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.02
$Q_a = (60)(A_s)(V_s)$	m^3/min	3.0
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	Dry	2.7
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	2.74
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	10.03
Nozzle area, A_n	mm^2	79.07
Total sampling time, q	min	60
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	97.5
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.00019
Mass collected in probe, M_p	g	0.00050
Total mass collected, M_n	g	0.00069
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	0.963
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	0.978
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		0.16

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	12.28	0.20	-	-381	0.25	Yes

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

ISOKINETICITY		
Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	97.45	Yes

Acceptable isokinetic range 95% to 115%

WEIGHING BALANCE UNCERTAINTY			
Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.28	0.5	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	0.96	10	1.0	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	160	180	160

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

SULPHUR DIOXIDE SUMMARY					
Test	**Sampling Times**	**Concentration mg/m³**	**LOD mg/m³**	**ELV mg/m³**	**Emission Rate g/hr**
Run 1	09:55 - 10:55 10 December 2024	0.11	0.015	50	0.018
Field Blank	-	0.025	-	-	-

Reference conditions are 273K, 101.3kPa without correction for water vapour

SULPHUR DIOXIDE 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	103.9	-	0.716	12.3	0.20	-	0.25	Yes

	Filter Material	Filter Size mm	Max. Filtration Temp. °C	Temperature during storage / transit <25°C	Type of Absorbers	Absorption Solutions
Run 1	Quartz Fibre	47	160	N/A	Glass	0.3% Hydrogen Peroxide

SULPHUR DIOXIDE ABSORPTION EFFICIENCY

Parameter	**Total ug**	**IMP C ug**	**Absorption Efficiency %**	**Acceptable Absorption Efficiency %**	**Absorption Efficiency Acceptable ?**
Run 1	76.4	10.4	86	95	N/A - <30% ELV

ND - None Detected

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS 1 — Sulphur Dioxide

Absolute pressure of stack gas, P_s			**Velocity of stack gas, V_s**		
Barometric pressure, P_b	kPa	104	Velocity pressure coefficient, C_p		0.84
Stack static pressure, P_{static}	Pa	15	Mean of velocity heads, DP_{avg}	Pa	7.51
$P_s = P_b + (P_{static})$	kPa	103.92	Mean stack gas temperature, T_s	K	308.08
			Gas density $_{(wet, ambient)}$, p		
Vol. of water vapour collected, V_{wstd}			p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.164
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	2.84
Volume of gas metered dry, V_{mstd}			**Actual flow of stack gas, Q_a**		
Volume of gas sample through gas meter, V_m	m^3	0.7410	Area of stack, A_s	m^2	0.02
Gas meter correction factor, Y_d		0.994	$Q_a = (60)(A_s)(V_s)$	m^3/min	3
Mean dry gas meter temperature, T_m	K	292.85	**Dry total flow of stack gas, Q_{std}**		
Mean pressure drop across orifice, DH	mmH_2O	17.55	Conversion factor (K/mm.Hg)		0.3592
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	0.71	$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	m^3/min	3
Volume of gas metered wet, V_{mstw}			**Wet total flow of stack gas, Q_{stw}**		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.7161	$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	m^3/min	3
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		21.00			
% oxygen reference condition		21	**Percent isokinetic, %I**		
O_2 Reference Factor $\frac{O2\ Ref = 21.0 - act\%O2}{21.0 - ref\%O2}$		No O2 Ref	Nozzle diameter, D_n	mm	10.03
			Nozzle area, A_n	mm^2	79.07
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	No O2 Ref	Total sampling time, q	min	60
Moisture content, B_{wo}			$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	97
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0153			
	%	1.53	Acceptable isokinetic range 95% to 115%		Yes
Moisture by FTIR	%	-	**Sulphur Dioxide Concentration, C**		
Molecular weight of dry gas, M_d			Mass collected , M	ug	76
CO_2		0.04	$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	0.107
O_2		21.00			
Total		21.04	$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	0.108
N_2 (100 -Total)		78.96			
			$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.85			
Molecular weight of wet gas, M_s			**Sulphur Dioxide Emission Rates, E**		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.7	$E = [(C_{wet})(Q_{stw})(60)] / 1000$	g/hr	0.02

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	09:55 - 10:55 10 December 2024	3.0997	3.1085	0.0088	1.5	0.017	4.2

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	716	12.3	0.20	-	0.25	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	0.15	m
Stack Width, W	-	m
Stack Area, A	0.02	m^2
Average stack gas temperature	30	°C
Stack static pressure	0.015	kPa
Barometric Pressure	103.9	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	0.042095	0.000421	0.000826	0.041451	0.000415	0.000814
O_2	32	1.427679	21.000000	0.210000	0.299813	20.678473	0.206785	0.295222
N_2	28	1.249219	78.957905	0.789579	0.986357	77.748994	0.777490	0.971255
H_2O	18	0.803070	-	-	-	1.531082	0.015311	0.012296

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

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2870	kg/m^3
Wet Density (STP), P_{STW}	1.2796	kg/m^3
Dry Density (Actual), P_{Actual}	1.1895	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.183	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	10 December 2024
Time of Survey	09:40
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	0.08	3.9	0.4	30	2.2	0.038	-	<15
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	3.9	0.4	30	2.2	0.038	-	-

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 °
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	-	-	-	-	-	-	-

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	200	198	1.0	Pass	198	195	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 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	15	15	0.0	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	3.9	Pa	>= 5 Pa	No
Lowest Gas Velocity	2.2	m/s	-	-
Highest Gas Velocity	2.2	m/s	-	-
Ratio of Gas Velocities	1.0	-	< 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	**2.2**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	30	0	°C
Total Pressure	103.915	101.3	kPa
Oxygen	21.0	21	%
Moisture	1.53	1.53	%
Pitot tube calibration coefficient, K_{pt}	0.84		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	2.16	m/s
Stack Area (A)	0.02	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	137.58	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	127.16	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	125.21	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	127.16	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	0.15	m
Stack Width	-	m
Area	0.02	m^2

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

Isokinetic Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	50.0	0.08	< 15
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
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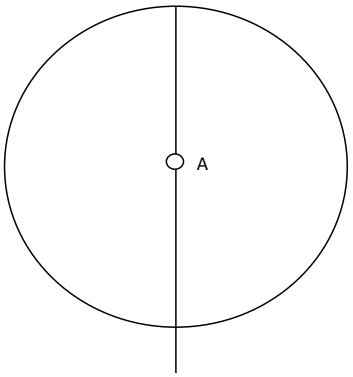

Sampling Line

○ Isokinetic sampling point
● Isokinetic sampling points not used
◍ Non Isokinetic/Gases sampling point

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	0.0014	2.0	0.50	1.0	N/A	0.20	-	-
as a %	0.20	0.65	0.48	1.0	N/A	2.79	1.63	0.0069
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	0.64	0.6900	1.0	0.0091	0.00040	-
MU as mg/m^3	0.013	0.2793	-	0.0091	0.00056	**0.28**
MU as %	1.30	28.9855	-	0.941	0.0577	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.56**	**mg/m^3**	**58.06**	**% Result**	**5.59**	**% 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 SULPHUR DIOXIDE

Run	Sampled Volume m³	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Limit of Detection % by mass	Leak %
MU required	**<=2%**	**<2.5 k**	**<=1%**	**<=1%**	**<=10%**	**≤ 5% of ELV**	**<=2%**
Run 1	0.716	293	104.05	1.0	-	0.1	-
as a %	0.14	0.68	0.48	1.0	-	0.05	1.63
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**

Run	Volume (STP) m³	Mass of Sulphur Dioxide mg	O2 Correction -	Leak mg/m³	Lab Uncertainty mg	Combined uncertainty
Run 1	0.6857	0.1296	-	0.0010	-	-
MU as mg/m^3	0.0014	0.0267	-	0.0010	0.0051	**0.0272**
MU as %	1.3110	25.0019	-	0.9406	4.8	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.05**	**mg/m³**	**51.02**	**% Result**	**0.11**	**% 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	0.0014	2.0	0.50	1.0	N/A	-
as a %	0.20	0.65	0.48	1.0	N/A	1.63
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	0.64	8800	1.0	117.38	58	-
MU as % v/v	0.021	0.018	-	0.015	0.010	**0.033**
MU as %	1.30	1.14	-	0.94	0.66	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.07**	**% v/v**	**4.15**	**%**

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	2.2	m/s
Measured Volumetric Flow rate at Actual Conditions	138	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	-	0.34		
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	2.52	<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	0.00003		
Uncertainty of temperature measurement	K	1.55	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	530		
Uncertainty associated with the calculation of density	kg/m3	0.007		
Uncertainty associated with the measurement of local velocity	-	0.0001		
Uncertainty associated with the measurement of mean velocity	-	0.0072		

Measurement Uncertainty - Velocity	m/s
Combined uncertainty	0.18
Expanded uncertainty at a 95% Confidence Interval	0.36

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	8.5
Expanded uncertainty at a 95% Confidence Interval	16.6

Measurement Uncertainty Volumetric Flow Rate	m³/hr
Combined uncertainty	12
Expanded uncertainty at a 95% Confidence Interval	24

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	8.8
Expanded uncertainty at a 95% Confidence Interval	17.2

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