STACK EMISSIONS MONITORING REPORT

Units C & D
Bankside Trade Park
Cirencester
GL7 1YT
Tel: 01285 700 593

Your contact at SOCOTEC UK LTD
[redacted]
Business Manager - South
[redacted]

Operator & Address:
Celtic Recycling
29-31 Clearwater Road
Queensway Meadows
Newport
NP19 4ST

Permit Reference:
EPR Permit: EPR/YP3135TE

Release Point:
A1 Shredder

Sampling Date(s):
27th November 2024

SOCOTEC Job Number:	LSW 241123
Report Date:	20th December 2024
Version:	1
Report By:	[redacted]
MCERTS Number:	
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2 & 4
Report Approved By:	[redacted]
MCERTS Number:	
Business Title:	MCERTS Level 2 - Project Manager
Technical Endorsements:	1, 2, 3 & 4
Signature:	[redacted]

UKAS TESTING 1015

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

CONTENTS

EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Celtic Recycling operates a shredding paper covered copper process at Newport which is subject to EPR Permit EPR/YP3135TE, under the Environmental Permitting Regulations 2016.

SOCOTEC UK LTD were commissioned by Celtic Recycling 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, EPR/YP3135TE.

Plant

A1 Shredder

Operator

Celtic Recycling
29-31 Clearwater Road
Queensway Meadows
Newport
NP19 4ST

EPR Permit: EPR/YP3135TE

Stack Emissions Monitoring Test House

SOCOTEC UK LTD - Cirencester Laboratory
Units C & D
Bankside Trade Park
Cirencester
GL7 1YT
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	1.10 7.6	0.76 5.3	10 -	MCERTS
Oil Mist Oil Mist Emission Rate	mg/m³ g/hr	0.09 0.76	2.22 21	- -	None
Moisture	%	1.11	0.04	-	MCERTS
Stack Gas Temperature	°C	10	-	-	MCERTS
Stack Gas Velocity	m/s	12.5	0.26	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	7178	358	-	
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	6927	346	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	6850	342	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	6927	346	-	

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	27 November 2024	09:44 - 10:44	60 minutes
Oil Mist Run 1	27 November 2024	10:55 - 11:55	60 minutes
Preliminary Stack Traverse	27 November 2024	09:36 - 09:45	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Shredding paper covered copper
Continuous or batch	Batch
Product Details	Shredded Copper
Part of batch to be monitored (if applicable)	60 Minute period
Normal load, throughput or continuous rating	Normal
Fuel used during monitoring	None
Abatement	Bag Filter
Plume Appearance	None Visible

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	0.38 mg/m³	69%	7.6%
Moisture	BS EN 14790	AE 063	1015	MCERTS	0.01%	3.7%	N/A - No ELV
Velocity	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	5 Pa	2.1%	N/A - No ELV
Volumetric Flow Rate	SRM - EN ISO 16911-1	AE 154	1015	MCERTS	-	5.0%	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 (Cirencester)	N/A	8 Weeks
Oil Mist	Gravimetric	AE 106	1052	None	SOCOTEC (Bretby)	ASC/65321	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 (Cirencester)	-	-

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	**Value**	**Units**	**Requirement**	**Compliant**	**Method**
Lowest Differential Pressure	88	Pa	>= 5 Pa	Yes	BS EN 15259
Lowest Gas Velocity	12.4	m/s	-	-	-
Highest Gas Velocity	12.6	m/s	-	-	-
Ratio of Gas Velocities	1.0	: 1	< 3 : 1	Yes	BS EN 15259
Mean Velocity	12.5	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	0.45	m
Width	-	m
Area	0.16	m^2
Port Depth	90	mm

SAMPLING LINES & POINTS		
	Isokinetic	**Non-Iso & Gases**
Sample port size	3" Flange	-
Number of lines used	1	-
Number of points / line	4	-
Duct orientation	Vertical	-
Filtration	In Stack	-
Filtration for TPM	In Stack	-

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

Sampling Platform Improvement Recommendations (if applicable)

The sampling location meets all the requirements specified in EA Guidance, Monitoring stack emissions: measurement locations.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

Sampling Line

There is only one available sampling port, therefore sampling was only conducted along the one sampling line. The number of sampling points along the one available line were doubled.

APPENDICES

CONTENTS

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	2
Oil Mist	SRM - BS EN 13284-1	AE 104	1015	None	1
Moisture	BS EN 14790	AE 063	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	P2947	Horiba PG-350 Analyser	-	Laboratory Balance	P3225
Box Thermocouples	P2947	FT-IR	-	Tape Measure	-
Meter In Thermocouple	P2947	FT-IR Oven Box	-	Stopwatch	P2733
Meter Out Thermocouple	P2947	Bernath 3006 FID	-	Protractor	-
Control Box Timer	P2947	Signal 3030 FID	-	Barometer	-
Oven Box	-	Servomex	-	Digital Micromanometer	P1909
Probe	-	JCT Heated Head Filter	-	Digital Temperature Meter	P1639
Probe Thermocouple	-	Thermo FID	-	Stack Thermocouple	-
Probe	-	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	-	Anemometer	-	1m Heated Line (1)	-
L-Pitot	P2511	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	P3321	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	-	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-			15m Heated Line (1)	-
Heater Controller	-			20m Heated Line (1)	-
Inclinometer (Swirl Device)	P3079			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.

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
[redacted]	[redacted]	MCERTS Level 2	Sep-26	May-28	Apr-29	-	Jul-28	Sep-26
[redacted]	[redacted]	MCERTS Level 1	Sep-27	-	-	-	-	Sep-27

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	09:44 - 10:44 27 November 2024	1.10	0.76	10	7.6
Blank	-	0.38	-	-	-

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	321588	0.10605	0.10610	0.00005	104.61880	104.62020	0.00140	0.00145

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	321587	0.10629	0.10630	0.00001	85.59390	85.59400	0.00010	0.00050

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	134.0
$P_s = P_b + P_{static}$	Kpa	101.4
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	10.4
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0129584
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		1.342
Gas meter correction factor, Y_d		1.008
Mean dry gas meter temperature, T_m		285
Mean pressure drop across orifice, DH	mmH_2O	47.358
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m}$	m^3	1.300
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	1.3127
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		20.8
% 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}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0099
	%	0.99
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		1.00
Mean of velocity heads, DP_{avg}	Pa	97.18
Mean stack gas temperature, T_s	K	285
Gas density $_{(wet,\ ambient)}$, ρ p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.231
Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	12.54

Molecular weight of dry gas, M_d		
CO_2	%	0.04
O_2	%	20.80
Total	%	20.84
N_2 (100 -Total)	%	79.16
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.84
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.73
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	0.16
$Q_a = (60)(A_s)(V_s)$	m^3/min	119.7
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	113.8
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	114.92
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	6.17
Nozzle area, A_n	mm^2	29.90
Total sampling time, q	min	60
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	101.3
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.00005
Mass collected in probe, M_p	g	0.00140
Total mass collected, M_n	g	0.00145
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m³	1.105
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m³	1.116
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m³	No O2 Ref
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		7.62

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 2			OIL MIST
Absolute pressure of stack gas, P_s			**Molecular weight of dry gas, M_d**		
Barometric pressure, P_b	Kpa	101.3	CO_2	%	0.04
Stack static pressure, P_{static}	pa	134.0	O_2	%	20.80
$P_s = P_b + P_{static}$	Kpa	101.4	Total	%	20.84
			N_2 (100 -Total)	%	79.16
Vol. of water vapour collected, V_{wstd}			$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		28.84
Moisture trap weight increase,Vlc	g	12.4	**Molecular weight of wet gas, M_s**		
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0154504	$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	28.70
Volume of gas metered dry, V_{mstd}			**Actual flow of stack gas, Q_a**		
Volume of gas sample through gas meter, V_m		1.293	Area of stack, A_s	m^2	0.16
Gas meter correction factor, Y_d		1.008	$Q_a = (60)(A_s)(V_s)$	m^3/min	120.5
Mean dry gas meter temperature, T_m		289	**Total flow of stack gas, Q**		
Mean pressure drop across orifice, DH	mmH_2O	48.212	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	1.237	$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s)}$	Dry	113.9
Volume of gas metered wet, V_{mstw}			$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s)}$	@O_2ref	No O2 Ref
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	1.2520	$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s)}$	Wet	115.35
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$			**Percent isokinetic, %I**		
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No	Nozzle diameter, D_n	mm	6.17
% oxygen measured in gas stream, act%O_2		20.8	Nozzle area, A_n	mm^2	29.90
% oxygen reference condition		21	Total sampling time, q	min	60
O_2 Reference Factor O_2 Ref = $\frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$		No O2 Ref	$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	96.2
$V_{mstd@X\%oxygen} = (V_{mstd})(O_{2\,Ref})$	m^3	No O2 Ref	Acceptable isokinetic range 95% to 115%		Yes
Moisture content, B_{wo}			**Particulate Concentration, C**		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0123	Mass collected on filter, M_f	g	N/A
	%	1.23	Mass collected in probe, M_p	g	N/A
Moisture by FTIR	%	-	Total mass collected, M_n	g	N/A
Velocity of stack gas, V_s			$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	N/A
Velocity pressure coefficient, C_p		1.00	$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	N/A
Mean of velocity heads, DP_{avg}	Pa	98.00	$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
Mean stack gas temperature, T_s	K	286	**Particulate Emission Rates, E**		
Gas density (wet, ambient), p p=(Ms*Ps)/(8.314*Ts)	kg/m^3	1.227	$E = [(C_{wet})(Q_{stw})(60)] / 1000$		N/A
Stack Velocity, Vs $V_s = \frac{\sum_{i=1}^{n} V_i}{n}$	m/s	12.63			

TAR FUME DATA - RUN 1		
Parameters	**Units**	**Results**
Mass Collected	mg	0.110
Concentration wet	mg/m^3	0.088
Concentration Dry	mg/m^3	0.089
Mass Emission	g/hr	0.761

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	22.55	0.24	-	-381	0.45	Yes
Run 2	21.72	0.22	-	-381	0.43	Yes

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

ISOKINETICITY		
Run	Isokinetic Variation %	Acceptable Isokineticity
Run 1	101.27	Yes
Run 2	96.22	Yes

Acceptable isokinetic range 95% to 115%

WEIGHING BALANCE UNCERTAINTY			
Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.38	0.5	Yes
Run 2	0.00	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	0.38	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	14	180	160
Run 2	Quartz Fibre	47	14	180	160

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	09:44 - 10:44 27 November 2024	3.0182	3.0286	0.0104	1.0	0.01	3.7

Moisture Quality Assurance							
Test Number	Sampling Duration mins	Total Volume Sampled l	Sampling Rate l/min	Start Leak Rate l/min	End Leak Rate l/min	Acceptable Leak Rate l/min	Leak Tests Acceptable?
Run 1	60	1313	22.5	0.24	-	0.45	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	0.45	m
Stack Width, W	-	m
Stack Area, A	0.16	m^2
Average stack gas temperature	10	°C
Stack static pressure	0.13	kPa
Barometric Pressure	101.3	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	0.041628	0.000416	0.000817
O_2	32	1.427679	20.800000	0.208000	0.296957	20.568989	0.205690	0.293659
N_2	28	1.249219	79.157905	0.791579	0.988856	78.278753	0.782788	0.977873
H_2O	18	0.803070	-	-	-	1.110630	0.011106	0.008919

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

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2866	kg/m^3
Wet Density (STP), P_{STW}	1.2813	kg/m^3
Dry Density (Actual), P_{Actual}	1.2417	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.236	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	27 November 2024
Time of Survey	09:36 - 09:45
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	0.05	94.7	9.7	10	12.4	2.0	-	<15
2	0.11	98.0	10.0	11	12.6	2.0	-	<15
3	0.34	98.0	10.0	10	12.6	2.0	-	<15
4	0.40	98.0	10.0	10	12.6	2.0	-	<15
Mean	-	97.2	9.9	10	12.5	2.0	-	-

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	103	102	1.0	Pass	98	98	0.0	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	129	126	3.0	Pass

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY (CONTINUED)

Sampling Plane Validation Criteria				
EA Technical Guidance Note (Monitoring) M1	Result	Units	Requirement	Compliant
Lowest Average Differential Pressure	95	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	12.4	m/s	-	-
Highest Gas Velocity	12.6	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} x (1-e) * Ô(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	**12.5**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	10	0	°C
Total Pressure	101.43	101.3	kPa
Oxygen	20.8	21	%
Moisture	1.11	1.11	%
Pitot tube calibration coefficient, K_{pt}	1.00		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	12.54	m/s
Stack Area (A)	0.16	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	7177.94	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	6927.07	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	6850.14	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	6927.07	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))

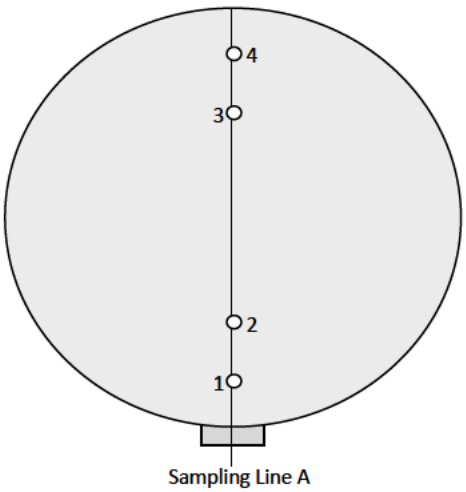
Nomenclature:
Ts = Absolute Temperature, Standard Conditions, 273 K
Ps = Absolute Pressure, Standard Conditions, 101.3 kPa
Ta = Absolute Temperature, Actual Conditions, K
Pa = Absolute Pressure, Actual Conditions, kPa
Ma = Water vapour, Actual Conditions, % Vol
Ms = Water vapour, Reference Conditions, % 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	0.45	m
Stack Width	-	m
Area	0.16	m^2

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



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

Isokinetic Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	11.1	0.05	< 15
2	25.0	0.11	< 15
3	75.0	0.34	< 15
4	88.9	0.40	< 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	0.003	2.0	0.50	1.0	N/A	0.5000	-	-
as a %	0.20	0.70	0.49	1.0	N/A	3.80894	1.06	0.000
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**	**Yes**
Run 2	0.003	2.0	0.50	1.0	N/A	0.000	-	-
as a %	0.20	0.69	0.49	1.0	N/A	3.809	1.01	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	1.25	1.4500	1.0	0.0068	0.0003	-
MU as mg/m^3	0.01	0.3809	-	0.0068	0.0002	**0.38**
MU as %	1.33	34.4828	-	0.615	0.0199	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.76**	**mg/m^3**	**69.03**	**% Result**	**7.62**	**% 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	0.002599488	2.0	0.50	1.0	N/A	-
as a %	0.20	0.70	0.49	1.0	N/A	1.06
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	1.25	10400	1.0	49.18	58	-
MU as % v/v	0.01	0.01	-	0.01	0.006	**0.02**
MU as %	1.33	0.96	-	0.61	0.56	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.04**	**% v/v**	**3.68**	**%**

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	12.5	m/s
Measured Volumetric Flow rate at Actual Conditions	7178	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	-	0.87		
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	15.96	<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	1.45	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	518		
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	-	0.0001		

Measurement Uncertainty - Velocity	m/s
Combined uncertainty	0.13
Expanded uncertainty at a 95% Confidence Interval	0.26

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	1.1
Expanded uncertainty at a 95% Confidence Interval	2.1

Measurement Uncertainty Volumetric Flow Rate	m³/hr
Combined uncertainty	183
Expanded uncertainty at a 95% Confidence Interval	358

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	2.5
Expanded uncertainty at a 95% Confidence Interval	5.0

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