STACK EMISSIONS MONITORING REPORT

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

Your contact at SOCOTEC LTD
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Operator & Address:
Babcock & Wilcox Vølund Limited Land Off Longlands Lane (Heol Cae'r Bont) Margam Neath Port Talbot

Permit Reference:
EPR Permit: EPR/DP3137EG

Release Point:
A1 - Main Stack

Sampling Date(s):
23rd - 26th August 2022

SOCOTEC Job Number:	LSO 220613
Report Date:	29th September 2022
Version:	1
Report By:	Jose Navarro
MCERTS Number:	MM 19 1542
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2 & 3
Report Approved By:	David May
MCERTS Number:	MM 07 862
Business Title:	MCERTS Level 2 - Operations Manager
Technical Endorsements:	1, 2, 3 & 4
Signature:	

1015

CONTENTS

EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Babcock & Wilcox Vølund Limited operates a wood fired incineration process at Margam Green Energy Plant which is subject to EPR Permit EPR/DP3137EG, under the Environmental Permitting Regulations 2010.

SOCOTEC LTD were commissioned by David Appleby 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/DP3137EG.

Plant

A1 - Main Stack

Operator

Babcock & Wilcox Vølund Limited
Land Off Longlands Lane (Heol Cae'r Bont)
Margam
Neath
Port Talbot
SA13 2NU

EPR Permit: EPR/DP3137EG

Stack Emissions Monitoring Test House

SOCOTEC - 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
Dioxins & Furans - UPPER Limits					
Dioxins & Furans (NATO I-TEQ)	ng/m³	0.1261	0.0381	0.1	MCERTS
Dioxins & Furans (NATO I-TEQ) Emission Rate	µg/hr	26.1651	7.9019	-	
Dioxins & Furans (WHO TEQ Humans / Mammals)	ng/m³	0.1353	0.0408	-	MCERTS
Dioxins & Furans (WHO TEQ H / M) Emission Rate	µg/hr	28.0710	8.4774	-	
Dioxins & Furans (WHO TEQ Fish)	ng/m³	0.1530	0.0462	-	MCERTS
Dioxins & Furans (WHO TEQ Fish) Emission Rate	µg/hr	31.7554	9.5901	-	
Dioxins & Furans (WHO TEQ Birds)	ng/m³	0.2016	0.0609	-	MCERTS
Dioxins & Furans (WHO TEQ Birds) Emission Rate	µg/hr	41.8418	12.6362	-	
Dioxins & Furans - LOWER Limits					
Dioxins & Furans (NATO I-TEQ)	ng/m³	0.1261	0.0381	-	MCERTS
Dioxins & Furans (NATO I-TEQ) Emission Rate	µg/hr	26.1651	7.9019	-	
Dioxins & Furans (WHO TEQ Humans / Mammals)	ng/m³	0.1353	0.0408	-	MCERTS
Dioxins & Furans (WHO TEQ H / M) Emission Rate	µg/hr	28.0710	8.4774	-	
Dioxins & Furans (WHO TEQ Fish)	ng/m³	0.1530	0.0462	-	MCERTS
Dioxins & Furans (WHO TEQ Fish) Emission Rate	µg/hr	31.7554	9.5901	-	
Dioxins & Furans (WHO TEQ Birds)	ng/m³	0.2016	0.0609	-	MCERTS
Dioxins & Furans (WHO TEQ Birds) Emission Rate	µg/hr	41.8418	12.6362	-	
Dioxin-like PCBs - UPPER Limits					
Dioxin-like PCBs (WHO TEQ Humans / Mammals)	ng/m³	0.0113	0.0017	-	MCERTS
Dioxin-like PCBs (WHO TEQ H / M) Emission Rate	µg/hr	2.3457	0.3542	-	
Dioxin-like PCBs (WHO TEQ Fish)	ng/m³	0.0005	0.0001	-	MCERTS
Dioxin-like PCBs (WHO TEQ Fish) Emission Rate	µg/hr	0.1137	0.0172	-	
Dioxin-like PCBs (WHO TEQ Birds)	ng/m³	0.0180	0.0027	-	MCERTS
Dioxin-like PCBs (WHO TEQ Birds) Emission Rate	µg/hr	3.7381	0.5644	-	
Dioxin-like PCBs - LOWER Limits					
Dioxin-like PCBs (WHO TEQ Humans / Mammals)	ng/m³	0.0113	0.0017	-	MCERTS
Dioxin-like PCBs (WHO TEQ H / M) Emission Rate	µg/hr	2.3457	0.3542	-	
Dioxin-like PCBs (WHO TEQ Fish)	ng/m³	0.0005	0.0001	-	MCERTS
Dioxin-like PCBs (WHO TEQ Fish) Emission Rate	µg/hr	0.1137	0.0172	-	
Dioxin-like PCBs (WHO TEQ Birds)	ng/m³	0.0180	0.0027	-	MCERTS
Dioxin-like PCBs (WHO TEQ Birds) Emission Rate	µg/hr	3.7381	0.5644	-	
PAHs	ug/m^3	0.45	0.34	-	MCERTS
PAHs Emission Rate	g/hr	0.08	0.06	-	
Cadmium & Thallium	mg/m³	0.0008	0.0008	0.05	MCERTS
Cadmium & Thallium Emission Rate	g/hr	0.1761	0.1704	-	
Heavy Metals	mg/m³	0.0291	0.0040	0.5	MCERTS
Heavy Metals Emission Rate	g/hr	6.1577	0.8375	-	
Oxygen	% v/v	7.1	0.729	-	MCERTS
Moisture	%	18.18	0.60	-	MCERTS
Stack Gas Temperature	°C	126	-	-	MCERTS
Stack Gas Velocity	m/s	23.6	0.58	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	384200.6	19753.5	-	
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	262552.5	13499.0	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	214829.7	11045.4	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	189383.4	9737.1	-	

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 6% Oxygen.

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	**Sampling Date(s)**	**Sampling Times**	**Sampling Duration**
Dioxins, Furans & Dioxin-like PCBs Run 1	24 August 2022	09:40 - 15:45	360 minutes
PAHs Run 1	25 August 2022	08:41 - 14:48	360 minutes
Cadmium & Thallium Run 1	24 August 2022	10:10 - 12:14	120 minutes
Heavy Metals Run 1	24 August 2022	10:10 - 12:14	120 minutes
Preliminary Stack Traverse	24 August 2022	09:15	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Wood Fired Incineration
Continuous or batch	Continuous
Product Details	Power
Part of batch to be monitored (if applicable)	N/A
Normal load, throughput or continuous rating	Normal-100% on 24th August / 95% on 25th August
Fuel used during monitoring	Wood grade 2-4 and Fuel oil
Abatement	PAC, Lime SNCR injection, NH3
Plume Appearance	Steam plume 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**
Dioxins & Furans	SRM - BS EN 1948-1	AE 109	1015	MCERTS	0.0019 ng/m³	30.2%	38.1%
PCBs	SRM - BS EN 1948-1	AE 109	1015	MCERTS	0.00004 ng/m³	15.1%	N/A - No ELV
PAHs	SRM - BS ISO 11338 - 1	AE 110	1015	MCERTS	0.023 ug/m³	76%	N/A - No ELV
Cadmium & Thallium	SRM - BS EN 14385	AE 108	1015	MCERTS	0.00039 mg/m³	96.8%	1.6%
Heavy Metals	SRM - BS EN 14385	AE 108	1015	MCERTS	0.001 mg/m³	13.6%	0.8%
Oxygen	SRM - BS EN 14789:2017	AE 102	1015	MCERTS	0.01%	10.3%	N/A - No ELV
Moisture	SRM - BS EN 14790	AE 105	1015	MCERTS	0.05%	3.3%	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%	N/A - No ELV

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
Dioxins and Furans	Gas Chromatography - High Resolution Mass Spectometry	2002a	1668	MCERTS	Marchwood	232815 07 Sep 2022	8 Weeks
PCBs	Gas Chromatography - High Resolution Mass Spectometry	2002a	1668	MCERTS	Marchwood	232815 07 Sep 2022	8 Weeks
PAHs	Gas Chromatography - High Resolution Mass Spectometry	2002a	1668	MCERTS	Marchwood	232815 07 Sep 2022	8 Weeks
Cadmium & Thallium	Inductively coupled Plasma - Mass Spectrometry	ASC/SOP/117	1252	MCERTS	SOCOTEC (Bretby)	ASC/55039 14 Sep 2022	8 Weeks
Heavy Metals	Inductively coupled Plasma - Mass Spectrometry	ASC/SOP/117	1252	MCERTS	SOCOTEC (Bretby)	ASC/55039 14 Sep 2022	8 Weeks

ON-SITE TESTING							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	Accreditation	Laboratory	Data Archive Location	Archive Period
Oxygen	Paramagnetic	AE 102	1015	MCERTS	SOCOTEC Cirencester	SOCOTEC Cirencester	5 years
Moisture	Gravimetric	AE 105	1015	MCERTS	SOCOTEC Cirencester	-	-

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	**Value**	**Units**	**Requirement**	**Compliant**	**Method**
Lowest Differential Pressure	284	Pa	>= 5 Pa	Yes	BS EN 15259
Lowest Gas Velocity	22.4	m/s	-	-	-
Highest Gas Velocity	24.6	m/s	-	-	-
Ratio of Gas Velocities	1.1	: 1	< 3 : 1	Yes	BS EN 15259
Mean Velocity	23.6	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	2.40	m
Width	-	m
Area	4.52	m^2
Port Depth	90	mm

SAMPLING LINES & POINTS		
	Isokinetic	**Non-Iso & Gases**
Sample port size	4 " BSP	2 " Port
Number of lines used	2	1
Number of points / line	10	1
Duct orientation	Vertical	Vertical
Filtration	Out-stack	Out-stack

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

M1 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)

The sampling location meets all the requirements as specified in EA Guidance Note M1.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

In this instance there were no deviations from the sampling and analytical methods employed.

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**
Dioxins & Furans	SRM - BS EN 1948-1	AE 109	1015	MCERTS	1
PCBs	SRM - BS EN 1948-1	AE 109	1015	MCERTS	1
PAHs	SRM - BS ISO 11338 - 1	AE 110	1015	MCERTS	1
Cadmium & Thallium	SRM - BS EN 14385	AE 108	1015	MCERTS	1
Heavy Metals	SRM - BS EN 14385	AE 108	1015	MCERTS	1
Moisture	SRM - 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	P2947/P3145	Horiba PG - 350 Analyser	P2659	Laboratory Balance	P3225
Box Thermocouples	P2947/P3145	FT-IR	-	Tape Measure	P3136
Meter In Thermocouple	P2947/P3145	FT-IR Oven Box	-	Stopwatch	P1343
Meter Out Thermocouple	P2947/P3145	Bernath 3006 FID	-	Protractor	-
Control Box Timer	P2947/P3145	Signal 3030 FID	-	Barometer	P341
Oven Box	P1375/P1397	Servomex	-	Digital Micromanometer	P1940
Probe		JCT Heated Head Filter	-	Digital Temperature Meter	P2675
Probe Thermocouple	P2971/P2114	Thermo FID	-	Stack Thermocouple	P2322
Probe		Stackmaster	P9808	Mass Flow Controller	P2816
Probe Thermocouple		FTIR Heater Box for Heated Line	P2418	MFC Display module	-
S-Pitot	P1587/P2261	Anemometer	-	1m Heated Line (1)	-
L-Pitot		Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	P2769	Chiller (JCT/MAK 10)	P3263	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	P1897	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	-	Site temperature Logger	P2215	10m Heated Line (2)	-
Small DGM	-			15m Heated Line (1)	-
Heater Controller	-			20m Heated Line (1)	P2546
Inclinometer (Swirl Device)	P2594			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	CG 58	BOC	-	9.9	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**
Jose Navarro	MM 19 1542	MCERTS Level 2	Jul-24	Oct-25	Dec-25	Dec-25	Nov-25	Jul-24
Alistair Holmes	MM 02 086	MCERTS Level 1	Sep-27	-	-	-	-	Sep-27

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	09:40 - 15:45 24 August 2022	0.1261	0.0019	0.1	26.17
Field Blanks Run 1	-	0.000058	0.00006	-	-

WHO TEQ (Humans / Mammals)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.1353	0.0021	-	28.07
Field Blanks Run 1	-	0.00007	0.00007	-	-

WHO TEQ (Fish)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.1530	0.0022	-	31.76
Field Blanks Run 1	-	0.00008	0.00008	-	-

WHO TEQ (Birds)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.2016	0.0032	-	41.84
Field Blanks Run 1	-	0.00010	0.00010	-	-

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

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	09:40 - 15:45 24 August 2022	0.1261	-	0.1	26.17
Field Blanks Run 1	-	0.0000010	-	-	-

WHO TEQ (Humans / Mammals)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.1353	-	-	28.07
Field Blanks Run 1	-	0.00000029	-	-	-

WHO TEQ (Fish)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.1530	-	-	31.76
Field Blanks Run 1	-	0.000000000	-	-	-

WHO TEQ (Birds)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	ELV ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.2016	-	-	41.84
Field Blanks Run 1	-	0.00000000	-	-	-

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

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	0.0957	0.0957	0.0957	98	50% - 130%		
1,2,3,7,8 Penta CDD	0.446	0.2230	0.4460	110	50% - 130%		
1,2,3,4,7,8 Hexa CDD	0.405	0.0405	0.0405	87	50% - 130%		
1,2,3,6,7,8 Hexa CDD	0.818	0.0818	0.0818	88	50% - 130%		
1,2,3,7,8,9 Hexa CDD	0.465	0.0465	0.0465		-		
1,2,3,4,6,7,8 Hepta CDD	2.55	0.0255	0.0255	74	40% - 130%		
OCDD Octa CDD	1.88	0.0019	0.0006	84	40% - 130%		
Total -Dioxins	**6.6597**	**0.5149**	**0.7366**				
Furans							
2,3,7,8 Tetra CDF	0.297	0.0297	0.0297	78	50% - 130%		
1,2,3,7,8 Penta CDF	0.484	0.0242	0.0145		-	0	>=50
2,3,4,7,8 Penta CDF	0.668	0.3340	0.2004	93	50% - 130%		
1,2,3,4,7,8 Hexa CDF	0.442	0.0442	0.0442	84	50% - 130%		
1,2,3,6,7,8 Hexa CDF	0.568	0.0568	0.0568	86	50% - 130%		
2,3,4,6,7,8 Hexa CDF	0.58	0.0580	0.0580	81	50% - 130%		
1,2,3,7,8,9 Hexa CDF	0.0109	0.0011	0.0011		-	0	>=50
1,2,3,4,6,7,8 Hepta CDF	1.19	0.0119	0.0119	71	40% - 130%		
1,2,3,4,7,8,9 Hepta CDF	0.0478	0.0005	0.0005		-	0	>=50
OCDF Octa CDF	0.108	0.0001	0.0000	75	40% - 130%		
Total -Furans	**4.3957**	**0.5605**	**0.4171**				
Mean Recoveries (%)				**85**		**0**	
Total Isomers	**11.0554**	**1.0754**	**1.1537**				
Total ITEQ (<LOD = 0)		**1.0754**	**1.1537**				

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	0.0957	0.0957	0.0957	98	50% - 130%		
1,2,3,7,8 Penta CDD	0.446	0.4460	0.4460	110	50% - 130%		
1,2,3,4,7,8 Hexa CDD	0.405	0.2025	0.0203	87	50% - 130%		
1,2,3,6,7,8 Hexa CDD	0.818	0.0082	0.0082	88	50% - 130%		
1,2,3,7,8,9 Hexa CDD	0.465	0.0047	0.0047		-		
1,2,3,4,6,7,8 Hepta CDD	2.55	0.0026	0.0026	74	40% - 130%		
OCDD Octa CDD	1.88	-	-	84	40% - 130%		
Total -Dioxins	**6.6597**	**0.7596**	**0.5773**				
Furans							
2,3,7,8 Tetra CDF	0.297	0.0149	0.2970	78	50% - 130%		
1,2,3,7,8 Penta CDF	0.484	0.0242	0.0048		-	0	>=50
2,3,4,7,8 Penta CDF	0.668	0.3340	0.6680	93	50% - 130%		
1,2,3,4,7,8 Hexa CDF	0.442	0.0442	0.0442	84	50% - 130%		
1,2,3,6,7,8 Hexa CDF	0.568	0.0568	0.0568	86	50% - 130%		
2,3,4,6,7,8 Hexa CDF	0.58	0.0580	0.0580	81	50% - 130%		
1,2,3,7,8,9 Hexa CDF	0.0109	0.0011	0.0011		-	0	>=50
1,2,3,4,6,7,8 Hepta CDF	1.19	0.0119	0.0119	71	40% - 130%		
1,2,3,4,7,8,9 Hepta CDF	0.0478	0.0005	0.0005		-	0	>=50
OCDF Octa CDF	0.108	0.0000	0.0000	75	40% - 130%		
Total -Furans	**4.3957**	**0.5455**	**1.1423**				
Mean Recoveries (%)				**85**		**0**	
Total Isomers	**11.0554**	**1.3051**	**1.7196**				
Total ITEQ (<LOD = 0)		**1.3051**	**1.7196**				

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	< 0.0001	0.000100	0.000100	87	50% - 130%		
1,2,3,7,8 Penta CDD	< 0.0003	0.000150	0.000300	98	50% - 130%		
1,2,3,4,7,8 Hexa CDD	< 0.0002	0.000020	0.000020	78	50% - 130%		
1,2,3,6,7,8 Hexa CDD	< 0.0002	0.000020	0.000020	73	50% - 130%		
1,2,3,7,8,9 Hexa CDD	< 0.0002	0.000020	0.000020		-		
1,2,3,4,6,7,8 Hepta CDD	< 0.0002	0.000002	0.000002	61	40% - 130%		
OCDD Octa CDD	0.0083	0.000008	0.000002	72	40% - 130%		
TOTAL 2,3,7,8-Dioxins	**0.0095**	**0.0003**	**0.0005**				
Furans							
2,3,7,8 Tetra CDF	< 0.0002	0.000020	0.000020	61	50% - 130%		
1,2,3,7,8 Penta CDF	< 0.0002	0.000010	0.000006		-	0	>=50
2,3,4,7,8 Penta CDF	< 0.0002	0.000100	0.000060	77	50% - 130%		
1,2,3,4,7,8 Hexa CDF	< 0.0001	0.000010	0.000010	67	50% - 130%		
1,2,3,6,7,8 Hexa CDF	< 0.0001	0.000010	0.000010	65	50% - 130%		
2,3,4,6,7,8 Hexa CDF	< 0.0001	0.000010	0.000010	65	50% - 130%		
1,2,3,7,8,9 Hexa CDF	< 0.0001	0.000010	0.000010		-	0	>=50
1,2,3,4,6,7,8 Hepta CDF	< 0.0001	0.000001	0.000001	59	40% - 130%		
1,2,3,4,7,8,9 Hepta CDF	< 0.0002	0.000002	0.000002		-	0	>=50
OCDF Octa CDF	< 0.0005	0.000001	0.000000	59	40% - 130%		
TOTAL 2,3,7,8-Furans	**0.0018**	**0.0002**	**0.0001**				
Mean Recoveries (%)				**71**		**0**	
Total Isomers	**0.0113**	**0.0005**	**0.0006**				
Total ITEQ (<LOD = 0)		**0.0000083**	**0.0000025**				

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	< 0.0001	0.000100	0.000100	87	50% - 130%		
1,2,3,7,8 Penta CDD	< 0.0003	0.000300	0.000300	98	50% - 130%		
1,2,3,4,7,8 Hexa CDD	< 0.0002	0.000100	0.000010	78	50% - 130%		
1,2,3,6,7,8 Hexa CDD	< 0.0002	0.000002	0.000002	73	50% - 130%		
1,2,3,7,8,9 Hexa CDD	< 0.0002	0.000002	0.000002		-		
1,2,3,4,6,7,8 Hepta CDD	< 0.0002	0.000000	0.000000	61	40% - 130%		
OCDD Octa CDD	0.0083	-	-	72	40% - 130%		
TOTAL 2,3,7,8-Dioxins	**0.0095**	**0.0005**	**0.0004**				
Furans							
2,3,7,8 Tetra CDF	< 0.0002	0.000010	0.000200	61	50% - 130%		
1,2,3,7,8 Penta CDF	< 0.0002	0.000010	0.000002		-	0	>=50
2,3,4,7,8 Penta CDF	< 0.0002	0.000100	0.000200	77	50% - 130%		
1,2,3,4,7,8 Hexa CDF	< 0.0001	0.000010	0.000010	67	50% - 130%		
1,2,3,6,7,8 Hexa CDF	< 0.0001	0.000010	0.000010	65	50% - 130%		
2,3,4,6,7,8 Hexa CDF	< 0.0001	0.000010	0.000010	65	50% - 130%		
1,2,3,7,8,9 Hexa CDF	< 0.0001	0.000010	0.000010		-	0	>=50
1,2,3,4,6,7,8 Hepta CDF	< 0.0001	0.000001	0.000001	59	40% - 130%		
1,2,3,4,7,8,9 Hepta CDF	< 0.0002	0.000002	0.000002		-	0	>=50
OCDF Octa CDF	< 0.0005	0.000000	0.000000	59	40% - 130%		
TOTAL 2,3,7,8-Furans	**0.0018**	**0.0002**	**0.0004**				
Mean Recoveries (%)				**71**		**0**	
Total Isomers	**0.0113**	**0.0007**	**0.0009**				
Total ITEQ (<LOD = 0)		**0.0000000**	**0.0000000**				

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

DIOXIN-LIKE PCBs -UPPER LIMIT

WHO TEQ (Humans / Mammals)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	Limit ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.01130	0.000039	-	2.346
Field Blanks Run 1	-	0.000013	0.000013	-	-

WHO TEQ (Fish)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	Limit ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.00055	0.0000014	-	0.114
Field Blanks Run 1	-	0.0000008	0.0000007	-	-

WHO TEQ (Birds)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	Limit ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.01801	0.0000545	-	3.738
Field Blanks Run 1	-	0.000029	0.0000147	-	-

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXIN-LIKE PCBs - LOWER LIMIT

WHO TEQ (Humans / Mammals)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	Limit ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.01130	-	-	2.346
Field Blanks Run 1	-	0.0000001	-	-	-

WHO TEQ (Fish)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	Limit ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.00055	-	-	0.114
Field Blanks Run 1	-	0.0000002	-	-	-

WHO TEQ (Birds)					
Test	Sampling Times	Concentration ng/m³	LOD ng/m³	Limit ng/m³	Emission Rate µg/hr
Run 1	09:40 - 15:45 24 August 2022	0.01801	-	-	3.738
Field Blanks Run 1	-	0.000015	-	-	-

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXIN-LIKE PCBs ANALYSIS SUMMARY - RUN 1

Congener	LOD ng	Result ng	WHO TEQ Humans / Mammals ng	WHO TEQ Fish ng	WHO TEQ Birds ng	Recovery %
Non-ortho PCBs						
33'44' TCB (77)	0.0016	0.843	0.0002529	0.0004215	0.0421500	93
344'5 TCB (81)	0.0016	0.271	0.0000271	0.0000271	0.0271000	88
33'44'5 PeCB (126)	0.0022	0.838	0.0838000	0.0041900	0.0838000	86
33'44'55' HxCB (169)	0.0037	0.408	0.0122400	0.0000204	0.0004080	85
Mono-ortho PCBs						
233'44' PeCB (105)	0.0035	0.442	0.000013260	0.000002210	0.000044200	102
2344'5 PeCB (114)	0.0029	0.087	0.000002601	0.000000434	0.000008670	111
23'44'5 PeCB (118)	0.0029	0.420	0.000012600	0.000002100	0.000004200	106
2'344'5 PeCB (123)	0.0029	0.080	0.000002412	0.000000402	0.000000804	105
233'44'5 HxCB (156)	0.004	0.628	0.000018840	0.000003140	0.000062800	101
233'44'5' HxCB (157)	0.004	0.437	0.000013110	0.000002185	0.000043700	100
23'44'55' HxCB (167)	0.004	0.197	0.000005910	0.000000985	0.000001970	116
233'44'55' HpCB (189)	0.0022	0.597	0.000017910	0.000002985	0.000005970	95
Total PCBs	0.0355	5.2481	0.0964	0.0047	0.1536	-
Reported PCBs (>= or equal to Blank)	-	5.2481	0.0964	0.0047	0.1536	-
Internal Std Recovery						
PCB -60	-	-	-	-	-	108
PCB 127	-	-	-	-	-	-
PCB 159	-	-	-	-	-	96
Mean Analytical Recovery						102

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXIN-LIKE PCBs ANALYSIS SUMMARY - BLANK RUN 1

Congener	LOD ng	Result ng	WHO TEQ Humans / Mammals ng	WHO TEQ Fish ng	WHO TEQ Birds ng	Recovery %
Non-ortho PCBs						
344'5 TCB (81)	0.00010	0.0026	0.0000008	0.0000013	0.0001300	73
33'44' TCB (77)	0.00010	< 0.0001	0.0000000	0.00000001	0.0000100	79
33'44'5 PeCB (126)	0.00110	< 0.0011	0.0001100	0.0000055	0.0001100	66
33'44'55' HxCB (169)	0.00010	< 0.0001	0.0000030	0.0000000	0.0000001	61
Mono-ortho PCBs						
233'44' PeCB (105)	0.00070	0.0049	0.000000147	0.000000025	0.000000490	117
2344'5 PeCB (114)	0.00070	< 0.0007	0.000000021	0.000000004	0.000000070	102
23'44'5 PeCB (118)	0.00070	< 0.0007	0.000000021	0.000000004	0.000000007	97
2'344'5 PeCB (123)	0.00070	< 0.0007	0.000000021	0.000000004	0.000000007	99
233'44'5 HxCB (156)	0.00020	< 0.0002	0.000000006	0.000000001	0.000000020	110
233'44'5' HxCB (157)	0.00020	< 0.0002	0.000000006	0.000000001	0.000000020	103
23'44'55' HxCB (167)	0.00020	< 0.0002	0.000000006	0.000000001	0.000000002	117
233'44'55' HpCB (189)	0.00010	< 0.0001	0.000000003	0.000000001	0.000000001	88
Total PCBs	0.0049	0.0116	0.00011	0.0000069	0.0003	-
Internal Std Recovery						
PCB -60	-	-	-	-	-	111
PCB 127	-	-	-	-	-	-
PCB 159	-	-	-	-	-	99
Mean Analytical Recovery						105

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	101.00
Stack static pressure, P_{static}	Pa	100.00
$P_s = P_b + (P_{static})$	kPa	101.10
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	H_2O by Non Iso
$V_{wstd} = (0.001246)(V_{lc})$	m^3	-
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m	m	9.59
Gas meter correction factor, Y_d		1.01
Mean dry gas meter temperature, T_m		302.38
Mean pressure drop across orifice, DH	mmH_2O	76.09
$V_{mstd} = (0.3592)(V_m)(P_b+(DH/13.6))(Y_d) / (T_m + 273)$	m^3	8.79
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	10.7416
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		6.44
% oxygen reference condition		6
O_2 Reference Factor: $O2\ Ref = (21.0 - act\%O2) / (21.0 - ref\%O2)$		0.97
$V_{mstd@X\%oxygen} = (V_{mstd})(O_{2\ Ref})$	m^3	8.53
Moisture content, B_{wo}		
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$		0.1818
	%	18.18
Moisture by FTIR	%	-

Molecular weight of dry gas, M_d		
CO_2	%	9.85
O_2	%	6.44
Total	%	16.29
N_2 (100 -Total)	%	83.71
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.83
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	27.68
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.84
Mean of velocity heads, DP_{avg}	Pa	330.34
Mean stack gas temperature, T_s	K	399.00
Gas density (wet, ambient), p		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	0.844
Stack Velocity, Vs $V_s = Cp\sqrt{\frac{\Delta DPavg}{p}}$	m/s	23.51
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	4.52
$Q_a = (60)(A_s)(V_s)$	m^3/min	6381.3
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		
$Q_{std} = (Q_a)P_s(0.3592)(1-B_{wo}) / (Ts)$	Dry	3564.2
$Q_{stdO2} = (Q_a)P_s(0.3592)(1-B_{wo})(O_2REF) / (Ts)$	@O2ref	3459
$Q_{stw} = (Q_a)P_s(0.3592) / (Ts)$	Wet	4356
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	6.4
Nozzle area, A_n	mm^2	32.3
Total sampling time, q	min	360.0
$\%I = (4.6398E6)(T_s)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1-B_{wo})$	%	96.0
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
Run 1	26.93	0.32	0.35	-381	Yes	1.35

Isokinetic Criterion Compliance	Isokinetic Variation %	Acceptable Isokineticity %
Run 1	96.0	Yes

Acceptable isokinetic range 95% to 115%

Filtration	Filter Material	Filter Size mm	Maximum Filtration Temperature °C
Run 1	Quartz Fibre	110	123

Critical Sampling Requirement	Maximum Temperature at Condenser / Adsorber °C	Acceptable Temperature?	Temperature during storage / transit <25°C
Run 1	13	Yes	Yes
Acceptance Criteria	< 20°C	-	< 25°C

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PAHs SUMMARY					
Test	Sampling Times	Concentration ug/m^3	LOD ug/m^3	ELV ug/m^3	Emission Rate g/hr
Run 1	08:41 - 14:48 25 August 2022	0.45	0.02	-	0.077
Field Blank	-	0.45	0.02	-	-

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

PAHs ANALYSIS SUMMARY RUN 1

Compound Name	LOD Blank ug	Blank Result ug	Blank Result ug/m^3	LOD Run ug	Run 1 Result ug	Run 1 Result ug/m^3	Run 1 Uncertainites %
Anthanthrene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Benzo(a)anthracene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Benzo[b]fluoranthene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Benzo(k)fluoranthene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Benzo(b)naphtho(1,2-d)thiopene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Benzo(c)phenanthrene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Benzo(g,h,i)perylene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Benzo(a)pyrene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Cholanthrene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Chrysene	0.01	0.01	< 0.0014	0.01	0.02	0.00	147.6
Cyclopenta(cd)pyrene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Dibenzo[ah]anthracene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Dibezo(a,i)pyrene	0.01	0.01	< 0.0014	0.01	0.01	< 0.0014	212.9
Fluoranthene	0.01	0.01	0.00	0.01	0.21	0.03	73.7
Indeno(1,2,3-cd)pyrene	0.01	0.01	< 0.0014	0.01	0.01	0.00	197.5
Naphthalene	0.01	3.00	0.43	0.01	1.08	0.15	73.1
TOTAL PAHs	0.16	3.15	0.45	0.16	1.44	0.21	76.0
REPORTED PAHs (>= or equal to blank)	-	-	-	-	-	0.45	

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS RUN 1 — PAHs

Absolute pressure of stack gas, P_s		
Barometric pressure, P_b	kPa	101.00
Stack static pressure, P_{static}	Pa	100.00
$P_s = P_b + (P_{static})$	kPa	101.10
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase,Vlc	g	H_2O by Non Iso
$V_{wstd} = (0.001246)(V_{lc})$	m^3	-
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m	m^3	9.163
Gas meter correction factor, Y_d		1.01
Mean dry gas meter temperature, T_m	K	303.15
Mean pressure drop across orifice, DH mmH_2O		69.29
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m + 273}$	m^3	8.37
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	10.2294
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		8.43
% oxygen reference condition		6
O_2 Reference Factor $\frac{O2\ Ref = 21.0 - act\%O2}{21.0 - ref\%O2}$		0.84
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	7.01
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.1818
	%	18.18
Moisture by FTIR	%	-

Molecular weight of dry gas, M_d		
CO_2	%	9.85
O_2	%	8.43
Total	%	18.28
N_2 (100 -Total)	%	81.72
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.91
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	27.75
Velocity of stack gas, V_s		
Velocity pressure coefficient, C_p		0.84
Mean of velocity heads, DP_{avg}	Pa	294.00
Mean stack gas temperature, T_s	K	391.00
Gas density (wet, ambient), p		
p=(Ms*Ps)/(8.314*Ts)	kg/m^3	0.863
Stack Velocity, Vs $V_s = Cp\sqrt{\frac{\Delta DPavg}{p}}$	m/s	21.93
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	4.52
$Q_a = (60)(A_s)(V_s)$	m^3/min	5952.4
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	3392.7
$Q_{std02} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(Ts)}$	@O2ref	2843
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(Ts)}$	Wet	4146
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	6.4
Nozzle area, A_n	mm^2	32.3
Total sampling time, q	min	360.0
$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	96.1
Acceptable isokinetic range 95% to 115%		Yes

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PAHs 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	Acceptable Leak Rate litre/min	Leak Tests Acceptable litre/min
Run 1	25.7	0.41	0.43	-381	1.29	Yes

Isokinetic Criterion Compliance	Isokinetic Variation %	Acceptable Isokineticity
Run 1	96.1	Yes

Acceptable isokinetic range 95% to 115%

Filtration	Filter Material	Filter Size mm	Maximum Filtration Temperature °C
Run 1	Quartz Fibre	110	123

Critical Sampling Requirement	Maximum Temperature at Condenser / Adsorber °C	Acceptable Temperature?	Temperature during storage / transit <25°C
Run 1	15	Yes	Yes
Acceptance Criteria	< 20°C	-	< 25°C

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

HEAVY METALS SOLID & VAPOUR PHASES COMBINED

CADMIUM & THALLIUM COMBINED					
Test	Sampling Times	Concentration mg/m³	LOD mg/m³	ELV mg/m³	Emission Rate g/hr
Run 1	10:10 - 12:14 24 August 2022	0.0008	0.0004	0.05	0.18
Field Blank	-	0.2208	-	-	-

TOTAL HEAVY METALS COMBINED					
Test	Sampling Times	Concentration mg/m³	LOD mg/m³	ELV mg/m³	Emission Rate g/hr
Run 1	10:10 - 12:14 24 August 2022	0.029	0.0013	0.5	6.2
Field Blank	-	1.1845	-	-	-

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

INDIVIDUAL METALS SUMMARY - SOLID & VAPOUR PHASES COMBINED

Metals	LOD mg/m³	Concentration mg/m³	Emission Rate g/hr	Uncertainty %	UKAS Accredited
Cadmium	0.00018	0.00060	0.127	56%	✓
Thallium	0.00022	0.00023	0.049	173%	✓
Cadmium & Thallium	0.00039	0.00083	0.176	96.8%	-

Metals	LOD mg/m³	Concentration mg/m³	Emission Rate g/hr	Uncertainty %	UKAS Accredited
Arsenic	0.00015	0.00070	0.149	40%	✓
Antimony	0.00015	0.00061	0.129	45%	✓
Chromium	0.00013	0.01059	2.239	22%	✓
Cobalt	0.00008	0.00010	0.020	141%	✓
Copper	0.00018	0.00243	0.514	22%	✓
Lead	0.00018	0.00890	1.882	16%	✓
Manganese	0.00015	0.00091	0.192	32%	✓
Nickel	0.00015	0.00472	0.999	34%	✓
Vanadium	0.00012	0.00015	0.033	131%	✓
Sum of Heavy Metals (Excluding Cd / Tl)	0.00129	0.02911	6.158	13.6%	-

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

HEAVY METALS - RUN 1 SUMMARY

Metals	PARTICULATE PHASE			VAPOUR PHASE		
	Stack LOD mg/m³	Laboratory Result ug	Concentration mg/m³	Stack LOD mg/m³	Laboratory Result ug	Concentration mg/m³
Cadmium	0.00017	0.90	0.00030	0.00001	0.88	0.00030
Thallium	0.00020	0.60	0.00020	0.00001	0.09	0.00003
Cadmium & Thallium	0.00037	1.50	0.00051	0.00001	0.96	0.00033
Volume Sampled m^3		2.9588			2.9588	

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

Metals	PARTICULATE PHASE			VAPOUR PHASE		
	Stack LOD mg/m³	Laboratory Result ug	Concentration mg/m³	Stack LOD mg/m³	Laboratory Result ug	Concentration mg/m³
Arsenic	0.00014	2.00	0.00068	0.00001	0.08550	0.00003
Antimony	0.00014	0.50	0.00017	0.00001	1.30950	0.00044
Chromium	0.00010	3.50	0.00118	0.00003	27.82800	0.00941
Cobalt	0.00007	0.20	0.00007	0.00001	0.08550	0.00003
Copper	0.00017	4.00	0.00135	0.00001	3.19500	0.00108
Lead	0.00017	25.00	0.00845	0.00001	1.32300	0.00045
Manganese	0.00014	1.00	0.00034	0.00001	1.68300	0.00057
Nickel	0.00014	1.00	0.00034	0.00001	12.97350	0.00438
Vanadium	0.00010	0.30	0.00010	0.00001	0.15750	0.00005
Sum of Heavy Metals	0.00115	37.50	0.01267	0.00014	48.64050	0.01644
Volume Sampled m^3		2.9588			2.9588	

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

HEAVY METALS - BLANK SUMMARY

Metals	PARTICULATE PHASE			VAPOUR PHASE		
	Stack LOD mg/m³	Laboratory Result ug	Concentration mg/m³	Stack LOD mg/m³	Laboratory Result ug	Concentration mg/m³
Cadmium	0.00017	0.0001	0.00000	0.00001	297.00	0.10038
Thallium	0.00017	0.0001	0.00000	0.00001	356.40	0.12045
Cadmium & Thallium	0.00034	0.0002	0.00000	0.00001	653.40	0.22083
Volume Sampled m^3		2.9588			2.9588	

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

Metals	PARTICULATE PHASE			VAPOUR PHASE		
	Stack LOD mg/m³	Laboratory Result ug	Concentration mg/m³	Stack LOD mg/m³	Laboratory Result ug	Concentration mg/m³
Arsenic	0.00014	0.0001	0.00000	0.00001	237.60	0.08030
Antimony	0.00014	0.0001	0.00000	0.00001	237.60	0.08030
Chromium	0.00010	0.0036	0.00000	0.00003	594.00	0.20076
Cobalt	0.00007	0.0001	0.00000	0.00001	118.80	0.04015
Copper	0.00017	0.0001	0.00000	0.00001	297.00	0.10038
Lead	0.00017	0.0001	0.00000	0.00001	297.00	0.10038
Manganese	0.00014	0.0001	0.00000	0.00001	356.40	0.12045
Nickel	0.00014	0.0001	0.00000	0.00001	1188.00	0.40152
Vanadium	0.00010	0.0001	0.00000	0.00001	178.20	0.06023
Sum of Heavy Metals	0.00115	0.0044	0.00000	0.00014	3504.60	1.18447
Volume Sampled m^3		2.9588			2.9588	

Reference conditions are 273K, 101.3kPa, dry gas 6% Oxygen.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS RUN 1 — Heavy Metals

Absolute pressure of stack gas, P_s			**Molecular weight of dry gas, M_d**		
Barometric pressure, P_b	kPa	101.60	CO_2	%	9.85
Stack static pressure, P_{static}	Pa	100.00	O_2	%	6.44
$P_s = P_b + (P_{static})$	kPa	101.70	Total	%	16.29
			N_2 (100 -Total)	%	83.71
			$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		29.83
Vol. of water vapour collected, V_{wstd}			**Molecular weight of wet gas, M_s**		
Moisture trap weight increase,Vlc	g	H_20 by Non Iso	$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	27.68
$V_{wstd} = (0.001246)(V_{lc})$	m^3	-	**Velocity of stack gas, V_s**		
Volume of gas metered dry, V_{mstd}			Velocity pressure coefficient, C_p		0.84
			Mean of velocity heads, DP_{avg}	Pa	341.10
Volume of gas sample through gas meter, V_m	m^3	2.96	Mean stack gas temperature, T_s	K	399.00
Gas meter correction factor, Y_d		1.12	Gas density (wet, ambient), p		
Mean dry gas meter temperature, T_m		299.90	p=(Ms*Ps)/(8.314*Ts)	kg/m^3	0.849
Mean pressure drop across orifice, DH	mmH_2O	54.74	Stack Velocity, Vs $V_s = Cp\sqrt{\frac{\Delta DPavg}{p}}$	m/s	23.82
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(DH/13.6))(Y_d)}{T_m + 273}$	m^3	3.05	**Actual flow of stack gas, Q_a**		
Volume of gas metered wet, V_{mstw}			Area of stack, A_s	m^2	4.52
			$Q_a = (60)(A_s)(V_s)$	m^3/min	6465.2
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	3.7262	**Total flow of stack gas, Q**		
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$			Conversion factor (K/mm.Hg)		
			$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(Ts)}$	Dry	3632.5
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No	$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(Ts)}$	@O2ref	3525
% oxygen measured in gas stream, act%O_2		6.44	$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(Ts)}$	Wet	4439
% oxygen reference condition		6			
O_2 Reference Factor $O2\ Ref = \frac{21.0 - act\%O2}{21.0 - ref\%O2}$		0.97	**Percent isokinetic, %I**		
			Nozzle diameter, D_n	mm	6.2
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	2.96	Nozzle area, A_n	mm^2	29.7
Moisture content, B_{wo}			Total sampling time, q	min	124.0
			$\%I = \frac{(4.6398E6)(T_s)(V_{mstd})}{(P_s)(V_s)(A_n)(q)(1-B_{wo})}$	%	103.1
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$	%	0.1818 18.18			
Moisture by FTIR	%	-	Acceptable isokinetic range 95% to 115%		Yes

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

HEAVY METALS QA 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	Acceptable Leak Rate litre/min	Leak Tests Acceptable litre/min
Run 1	26.8	0.31	0.33	-381	0.54	Yes

Isokinetic Criterion Compliance	Isokinetic Variation %	Acceptable Isokineticity
Run 1	103.1	Yes

Filtration / Temp	Filter Material	Filter Size mm	Maximum Filtration Temperature °C	Temperature during storage / transit <25°C
Run 1	Quartz Fibre	90	162	Yes

Metals	Type of Absorbers - Metals	Absorption Solutions - Metals
Run 1	Glass	3.3% Nitric Acid, 1.5% Hydrogen Peroxide

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

HEAVY METALS ABSORBTION EFFICIENCY

Parameter		Total ug	3rd Absorber ug	Absorption Efficiency (%)	Required %	Pass / Fail
Cadmium	Run 1	1.77750	ND	100	90	N/A <30% ELV
Thallium	Run 1	0.68550	ND	100	90	N/A <30% ELV
Arsenic	Run 1	2.08550	ND	100	90	N/A <30% ELV
Antimony	Run 1	1.80950	ND	100	90	N/A <30% ELV
Chromium	Run 1	31.32800	1.19	96	90	N/A <30% ELV
Cobalt	Run 1	0.28550	ND	100	90	N/A <30% ELV
Copper	Run 1	7.19500	0.03	100	90	N/A <30% ELV
Lead	Run 1	26.32300	0.03	100	90	N/A <30% ELV
Manganese	Run 1	2.68300	0.03	99	90	N/A <30% ELV
Nickel	Run 1	13.97350	ND	100	90	N/A <30% ELV
Vanadium	Run 1	0.45750	ND	100	90	N/A <30% ELV

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DAILY OXYGEN SUMMARY

Sampling Times	Concentration %	LOD %
09:40 - 16:00 24 August 2022	6.44	0.01
08:40 - 15:00 25 August 2022	8.43	0.01

PRE SAMPLING CALIBRATION DATA								
Date	Time of Analyser Checks	Range (%)	Zero Reading at analyser	Span Reading at analyser	Zero Check at analyser	Zero Check down line	Span Check down line	Leak Rate %
24 August 2022	08:35 - 08:45	25	0.00	9.92	0.00	0.01	9.89	-0.30
25 August 2022	08:35 - 08:45	25	0.00	10.02	0.03	0.01	10.00	-0.20

POST SAMPLING CALIBRATION DATA					
Date	Time of Analyser Checks	Zero Check down line	Span Check down line	Zero Drift (%)	Span Drift (%)
24 August 2022	15:05 - 15:10	0.01	10.02	0.10	0.91
25 August 2022	15:00 - 15:15	0.01	10.02	-0.20	0.20

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

MOISTURE CALCULATIONS

Moisture Determination - Non Isokinetic							
Test Number	Sampling Time and Date	Start Weight kg	End Weight kg	Total gain kg	Concentration %	LOD %	Uncertainty %
Run 1	09:40 - 15:45 24th August 2022	3.0134	3.0587	0.0453	18.2	0.05	3.3

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	360	254	0.7	0.01	0.01	0.01	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	2.40	m
Stack Width, W	-	m
Stack Area, A	4.52	m^2
Average stack gas temperature	126	°C
Stack static pressure	0.1	kPa
Barometric Pressure	101	kPa

Stack Gas Composition & Molecular Weights								
Component	Molar Mass M	Density kg/m^3 p	Conc Dry % Vol	Dry Volume Fraction r	Dry Conc kg/m^3 pi	Conc Wet % Vol	Wet Volume Fraction r	Wet Conc kg/m^3 pi
CO_2	44	1.963059	9.850000	0.098500	0.193361	8.059615	0.080596	0.158215
O_2	32	1.427679	7.105460	0.071055	0.101443	5.813937	0.058139	0.083004
N_2	28	1.249219	83.044540	0.830445	1.037408	67.949952	0.679500	0.848844
H_2O	18	0.803070	-	-	-	18.176496	0.181765	0.145970

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

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.3322	kg/m^3
Wet Density (STP), P_{STW}	1.2360	kg/m^3
Dry Density (Actual), P_{Actual}	0.9104	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	0.845	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	24 August 2022
Time of Survey	09:15
Velocity Measurement Device:	S-Type Pitot

Sampling Line A								
Traverse Point	Distance into duct (m)	DP pt Pa (average of 3 readings)	DP pt mmH_2O (average of 3 readings)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m^3/s	O_2 % Vol	Angle of Swirl °
1	0.06	303.8	31.0	124	22.5	101.9	-	<15
2	0.20	323.4	33.0	124	23.2	105.2	-	<15
3	0.35	320.1	32.7	126	23.1	104.6	-	<15
4	0.54	343.0	35.0	126	23.9	108.3	-	<15
5	0.82	343.0	35.0	126	23.9	108.3	-	<15
6	1.58	343.0	35.0	126	23.9	108.3	-	<15
7	1.86	349.5	35.7	127	24.2	109.3	-	<15
8	2.05	352.8	36.0	126	24.3	109.8	-	<15
9	2.20	323.4	33.0	126	23.2	105.2	-	<15
10	2.34	300.5	30.7	126	22.4	101.4	-	<15
Mean	-	330.3	33.7	126	23.5	106.2	-	-

Sampling Line B								
Traverse Point	Distance into duct (m)	DP pt Pa (average of 3 readings)	DP pt mmH_2O (average of 3 readings)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m^3/s	O_2 % Vol	Angle of Swirl °
1	0.06	316.9	32.3	123	23.0	104.1	-	<15
2	0.20	343.0	35.0	124	23.9	108.3	-	<15
3	0.35	339.7	34.7	126	23.8	107.8	-	<15
4	0.54	343.0	35.0	126	23.9	108.3	-	<15
5	0.82	349.5	35.7	126	24.2	109.3	-	<15
6	1.58	329.9	33.7	126	23.5	106.2	-	<15
7	1.86	349.5	35.7	127	24.2	109.3	-	<15
8	2.05	362.6	37.0	128	24.6	111.3	-	<15
9	2.20	320.1	32.7	126	23.1	104.6	-	<15
10	2.34	310.3	31.7	125	22.8	103.0	-	<15
Mean	-	336.5	34.3	126	23.7	107.2	-	-

PRELIMINARY STACK SURVEY QUALITY ASSURANCE CHECKLIST

PITOT LEAK CHECK								
Run	Pre Traverse Leak Rate				Post Traverse Leak Rate			
	Start Value mmH2O	End Value mmH2O	Difference %	Outcome	Start Value mmH2O	End Value mmH2O	Difference %	Outcome
Run 1	112	114	-1.8	Pass	113	113	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	100	100	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	301	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	22.4	m/s	-	-
Highest Gas Velocity	24.6	m/s	-	-
Ratio of Gas Velocities	1.1	-	< 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	**23.6**	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	126	0	°C
Total Pressure	101.1	101.3	kPa
Oxygen	7.8	6	%
Moisture	18.18	0.00	%
Pitot tube calibration coefficient, K_{pt}	0.84		

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	23.59	m/s
Stack Area (A)	4.52	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	384200.64	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	262552.53	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	214829.68	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	189383.38	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))

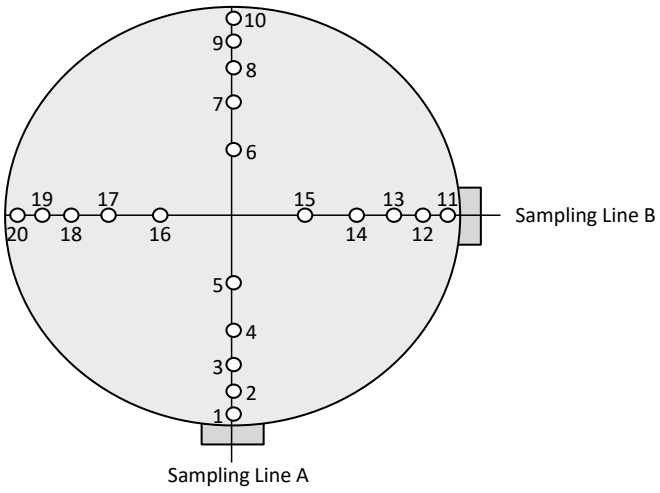
Nomenclature:
Ts = Absolute Temperature, Standard Conditions, 273 K
Ps = Absolute Pressure, Standard Conditions, 101.3 kPa
Ta = Absolute Temperature, Actual Conditions, K
Pa = Absolute Pressure, Actual Conditions, kPa
Ma = Water vapour, Actual Conditions, % Vol
Ms = Water vapour, Reference Conditions, % 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	2.40	m
Stack Width	-	m
Area	4.52	m^2

Non-Isokinetic/Gases Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack	Units
A	50	1.20	m



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	2.6	0.06	< 15
2	8.2	0.20	< 15
3	14.6	0.35	< 15
4	22.6	0.54	< 15
5	34.2	0.82	< 15
6	65.8	1.58	< 15
7	77.4	1.86	< 15
8	85.4	2.05	< 15
9	91.8	2.20	< 15
10	97.4	2.34	< 15
11	2.6	0.06	< 15
12	8.2	0.20	< 15
13	14.6	0.35	< 15
14	22.6	0.54	< 15
15	34.2	0.82	< 15
16	65.8	1.58	< 15
17	77.4	1.86	< 15
18	85.4	2.05	< 15
19	91.8	2.20	< 15
20	97.4	2.34	< 15

SAMPLING LOCATION

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - DIOXINS & FURANS

Run	Sampled Volume m^3	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	0.017	2.0	0.50	1.0	0.1	-	0.00006
as a %	0.20	0.7	0.50	1.0	1.55	1.30	0.06
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**

Run	Volume (STP) m^3	O2 Correction -	Mass of Dioxin & Furan ng	Leak ng/m^3	Uncollected Mass ng/m^3	Laboratory analysis -	Combined uncertainty
Run 1	7.6778	1.0	11.0554	0.00095	0.00003	-	-
MU as ng/m^3	0.0017	0.0009	0.0001	0.00095	0.0000000	0.0189	**0.0190**
MU as %	1.3160	-	0.0398	0.7503	0.0000	15.00	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.0381**	**ng/m^3**	**30.2**	**% Result**	**38.06**	**% 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 - PCBs

Run	Sampled Volume m^3	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	0.017	2.0	1.0	1.0	0.1	-	-
as a %	0.20	0.7	1.0	1.0	1.55	1.30	N/A
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**

Run	Volume (STP) m^3	O2 Correction -	Mass of PCBs mg	Leak ng/m^3	Uncollected Mass ng/m^3	Laboratory analysis -	Combined uncertainty
Run 1	7.6778	1.0	5.2481	0.000085	0.000008	-	-
MU as ng/m^3	0.0002	0.00008	0.0001	0.000085	0.00000001	0.0017	**0.0017**
MU as %	1.5707	0.6870	0.6764	0.7503	0.0000	15.00	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.0034**	**ng/m^3**	**30.3**	**% 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 - PAHs

Run	Sampled Volume m³	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Leak %	Uncollected Mass ug
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 5%**	**≤ 10% ELV**
Run 1	0.014	2.0	0.50	1.0	0.1	-	-
as a %	0.20	0.7	0.50	1.0	1.19	1.67	N/A
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**

Run	Volume (STP) m³	O2 Correction -	Mass of PAHs ug	Uncollected Mass ug	Leak ug/m³	Laboratory analysis -	Combined uncertainty
Run 1	6.2982	1.2	1.4355	0.2595	0.0043	-	-
MU as ug/m³	0.0059	0.0036	0.0502	0.1496	0.0043	0.0675	**0.1719**
MU as %	1.3153	0.7955	11.1459	33.2547	0.9649	15.00	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.344**	**ug/m³**	**76.4**	**% 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 - CADMIUM & THALLIUM

Run	Sampled Volume	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Concentration in impinger	Leak
	m³	K	kPa	% by volume	% by volume	mg	%
MU required	**<=2%**	**<2.5 k**	**<=1%**	**<=1%**	**<=5%**	**<5%**	**<=2%**
Run 1	0.006	2.0	0.50	1.0	0.1	0.000034	-
as a %	0.20	0.7	0.49	1.0	1.55	3.00	1.23
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Run	Volume (STP)	O2 Correction	Mass of Cadmium & Thallium	Leak	Lab Uncertainty	Combined uncertainty
	m³	-	mg	mg/m³	mg	
Run 1	2.7013	1.0305	2.4630	0.000006	-	-
MU as mg	0.00001	0.00001	0.0004	0.000006	0.00004	**0.0004**
MU as %	1.3172	0.6870	48.1324	0.7109	4.88409	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.001**	**mg/m³**	**96.82**	**% Result**	**1.61**	**% 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 - HEAVY METALS

Run	Sampled Volume m^3	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Concentration in impinger mg	Leak %
MU required	**<=2%**	**<2.5 k**	**<=1%**	**<=1%**	**<=5%**	**<5%**	**<=2%**
Run 1	0.006	2.0	0.50	1.0	0.10	0.00	-
as a %	0.20	0.73	0.49	1.0	1.55	3.00	1.23
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Run	Volume (STP) m^3	O2 Correction -	Mass of Heavy Metals mg	Leak mg/m^3	Lab Uncertainty mg	Combined uncertainty
Run 1	2.9676	1.0305	86.1405	0.0002	-	-
MU as mg/m^3	0.0004	0.0002	0.0013	0.0002	0.00142	**0.0020**
MU as %	1.3486	0.6870	4.4433	0.7109	4.88409	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.004**	**mg/m^3**	**13.62**	**% Result**	**0.79**	**% 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 m³	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	0.000	2.0	0.50	1.0	0.1	-
as a %	0.01	0.50	0.49	1.0	1.41	1.42
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

Run	Volume (STP) m³	Mass Gained mg	O2 Correction -	Leak mg/m³	Uncollected Mass mg	Combined uncertainty
Run 1	0.2	45300	1.1	1458.4	58	-
MU as % v/v	0.27	0.05	0.02	0.18	0.03	**0.34**
MU as %	1.2	0.2	0.72	0.8	0.1	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.67**	**% v/v**	**3.32**	**%**

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXYGEN

Day 1 - 24 August 2022

Reference	6	%vol
Measured concentration	6.44	%vol
Calibration gas	9.9	%vol
Analyser Full Scale	25	%vol

	Value	Units	specification	MU Met?
Response time	32	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	380	minutes	-	-
Number of readings in measurement	380	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.1	% of value	<2 % range	Yes
Zero drift	0.10	% full scale	<2% range / 24hr	Yes
Span drift	0.91	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	-0.0425	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.0475	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	0.0025	% full scale/10K	<3% range / 10 K	Yes
Combined interference	0.00	% range	<4% of Range	Yes
dependence on voltage	0.01	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	-0.30	% of value	< 2% of value	Yes
Uncertainty of calibration gas	1.00	% of value	< 2% of value	Yes

losses in the line (leak)	Uncertainty	< 2% of value
repeatability	$U_r = S_r$	0.0083
lack of fit	U_{lof}	0.0577
short term zero drift	$U_{d,z}$	0.0577
short term span drift	$U_{d,s}$	0.5249
influence of Ambient Temp at Zero	$U_{t,z}$	0.0000
influence of Ambient Temp at Span	$U_{t,s}$	0.0001
influence of sample gas pressure	U_p	0.0000
influence of sample gas flow	U_{fit}	-0.0294
influence of supply voltage	U_v	0.0003
Combined Interfence	U_i	0.0000
Uncertainty of Cal gas	U_{adj}	0.0495

Measurement uncertainty (Concentration Measured)	6.44	%
Combined Interfence	0.53	%
Uncertainty of Cal gas	1.05	%

Expanded uncertainty expressed with a level of confidence of 95%	**1.05**	**%**

Expanded uncertainty as percentage of the result	**16.25**	**% vol**

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXYGEN

Day 2 - 25 August 2022

Reference	6	%vol
Measured concentration	8.43	%vol
Calibration gas	9.9	%vol
Analyser Full Scale	25	%vol

	Value	Units	specification	MU Met?
Response time	34	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	380	minutes	-	-
Number of readings in measurement	380	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.1	% of value	<2 % range	Yes
Zero drift	-0.20	% full scale	<2% range / 24hr	Yes
Span drift	0.20	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	-0.0425	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.0475	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	0.0025	% full scale/10K	<3% range / 10 K	Yes
Combined interference	0.00	% range	<4% of Range	Yes
dependence on voltage	0.01	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	-0.20	% of value	< 2% of value	Yes
Uncertainty of calibration gas	1.00	% of value	< 2% of value	Yes

losses in the line (leak)	Uncertainty	< 2% of value
repeatability	$U_r = S_r$	0.00833
lack of fit	U_{lof}	0.05774
short term zero drift	$U_{d,z}$	-0.11570
short term span drift	$U_{d,s}$	0.11664
influence of Ambient Temp at Zero	$U_{t,z}$	0.00000
influence of Ambient Temp at Span	$U_{t,s}$	0.00013
influence of sample gas pressure	U_p	0.00000
influence of sample gas flow	U_{fit}	-0.02944
influence of supply voltage	U_v	0.00029
Combined Interfence	U_i	0.00000
Uncertainty of Cal gas	U_{adj}	0.04950

Measurement uncertainty (Concentration Measured)	8.43	%
Combined Interfence	0.18	%
Uncertainty of Cal gas	0.36	%

Expanded uncertainty expressed with a level of confidence of 95%	**0.36**	**%**

Expanded uncertainty as percentage of the result	**4.27**	**% vol**

Reference – SOCOTEC Technical Procedure AE150 Estimation of Uncertainty of Measurement

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	23.6	m/s
Measured Volumetric Flow rate at Actual Conditions	384201	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	-	2.57		
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	49.98	<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	2.03	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	516		
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	0.29
Expanded uncertainty at a 95% Confidence Interval	0.58

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	10078
Expanded uncertainty at a 95% Confidence Interval	19754

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