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Stack Emissions Testing Report Commissioned by
Viridor Waste Management Ltd

Installation Name & Address
Viridor Waste Management Ltd
Cardiff Energy Recovery Facility
Trident Park
Glass Avenue
Ocean Way
Cardiff
CF24 5EN

EPR Permit: EPR/LP3030XA

Stack Reference
A1 - Stream 1

Dates of the Monitoring Campaign
3rd - 5th March 2015

Job Reference Number
CSW-1752

Report Written by
Wayne Rossouw Technician MCERTS Level 1 MM 10 1083 TE1 TE2 TE3 TE4

Report Approved by
Matthew Hopes Team Leader MCERTS Level 2 MM 06 688 TE1 TE2 TE3 TE4

Report Date
1st April 2015

Version
Version 1

Signature of Report Approver


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Executive Summary

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MONITORING OBJECTIVES

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A1 - Stream 1

3rd - 5th March 2015

Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by Viridor Waste Management Ltd to carry out stack emissions testing on the A1 - Stream 1 at Cardiff Energy Recovery Facility.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Permit.

Special Requirements

There were no special requirements.

Target Parameters

PM₁₀, PM_{2.5}, Cadmium & Thallium, Heavy Metals, Mercury, Dioxins & Furans, PCBs, PAHs (DEFRA 16), Hydrogen Fluoride, Nitrous Oxide

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MONITORING RESULTS

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A1 - Stream 1

3rd - 5th March 2015

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
PM ₁₀	¹ mg/m ³	0.10	0.20	-	g/hr	16.8	33.2	-
PM _{2.5}	¹ mg/m ³	0.076	0.15	-	g/hr	12.6	24.8	-
Cadmium & Thallium	¹ mg/m ³	< 0.00082	0.00013	0.05	g/hr	< 0.14	0.023	-
Heavy Metals	¹ mg/m ³	0.015	0.0023	0.5	g/hr	2.5	0.40	-
Mercury	¹ mg/m ³	0.0030	0.00041	0.05	g/hr	0.50	0.071	-
Dioxins & Furans Upper Limit (worst case where <LOD = LOD)								
Dioxins & Furans (NATO I-TEQ)	¹ ng/m ³	0.096	0.020	0.1	µg/hr	16.0	3.4	-
Dioxins & Furans (WHO TEQ Humans / Mammals)	¹ ng/m ³	0.093	0.019	-	µg/hr	15.5	3.3	-
Dioxins & Furans (WHO TEQ Fish)	¹ ng/m ³	0.10	0.022	-	µg/hr	17.3	3.7	-
Dioxins & Furans (WHO TEQ Birds)	¹ ng/m ³	0.16	0.034	-	µg/hr	27.2	5.7	-
Dioxins & Furans Lower Limit (best case where <LOD = 0)								
Dioxins & Furans (NATO I-TEQ)	¹ ng/m ³	0.096	0.020	-	µg/hr	16.0	3.4	-
Dioxins & Furans (WHO TEQ Humans / Mammals)	¹ ng/m ³	0.093	0.019	-	µg/hr	15.5	3.3	-
Dioxins & Furans (WHO TEQ Fish)	¹ ng/m ³	0.10	0.022	-	µg/hr	17.3	3.7	-
Dioxins & Furans (WHO TEQ Birds)	¹ ng/m ³	0.16	0.034	-	µg/hr	27.2	5.7	-
PCBs Upper Limit (worst case where <LOD = LOD)								
PCBs (WHO TEQ Humans / Mammals)	¹ ng/m ³	0.0078	0.0016	-	µg/hr	1.3	0.27	-
PCBs (WHO TEQ Fish)	¹ ng/m ³	0.00038	0.000079	-	µg/hr	0.06	0.013	-
PCBs (WHO TEQ Birds)	¹ ng/m ³	0.015	0.0031	-	µg/hr	2.5	0.52	-
PCBs Lower Limit (best case where <LOD = 0)								
PCBs (WHO TEQ Humans / Mammals)	¹ ng/m ³	0.0078	0.0016	-	µg/hr	1.3	0.27	-
PCBs (WHO TEQ Fish)	¹ ng/m ³	0.00038	0.000079	-	µg/hr	0.064	0.013	-
PCBs (WHO TEQ Birds)	¹ ng/m ³	0.015	0.0031	-	µg/hr	2.5	0.52	-
PAHs (DEFRA 16) see p5 for individual breakdown	¹ µg/m ³	1.5	0.32	-	g/hr	0.25	0.054	-
Hydrogen Fluoride	¹ mg/m ³	< 0.027	0.0041	2	g/hr	< 4.5	0.70	-
Nitrous Oxide	¹ mg/m ³	0.63	0.67	-	g/hr	104	111	-
Oxygen	% v/v	Dry 7.6	0.24					
Water Vapour	% v/v	16.8	0.85					
Stack Gas Temperature	°C	145						
Stack Gas Velocity	m/s	23.0	0.25					
Volumetric Flow Rate (ACTUAL)	m ³ /hr	232661	10821					
Volumetric Flow Rate (REF)	¹ m ³ /hr	165409	7693					

NOTE: VOLUMETRIC FLOW RATE DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

¹ Reference Conditions (REF) are: 273K, 101.3kPa, dry gas, 11% oxygen.

Executive Summary

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MONITORING RESULTS

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A1 - Stream 1

3rd - 5th March 2015

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Breakdown of PAHs								
Anthanthrene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Benzo(a)anthracene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Benzo(a)pyrene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Benzo(b)fluoranthene	µg/m ³	0.070	0.014	-	g/hr	0.012	0.0024	
Benzo(b)naptho(2,1-d)thiophene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Benzo(c)phenanthrene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Benzo(ghi)perylene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Benzo(k)fluoranthene	µg/m ³	0.040	0.0082	-	g/hr	0.0066	0.0014	
Cholanthrene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Chrysene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Cyclopenta(cd)pyrene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Dibenzo (ai) pyrene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Dibenzo(ah)anthracene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Fluoranthene	µg/m ³	0.020	0.0041	-	g/hr	0.0033	0.00068	
Indeno(123-cd)pyrene	µg/m ³	< 0.010	0.0021	-	g/hr	< 0.0017	0.00034	
Naphthalene	µg/m ³	1.3	0.27	-	g/hr	0.21	0.044	
TOTAL (DEFRA 16)	µg/m ³	< 1.5	0.32	-	g/hr	< 0.26	0.053	

PAHs Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

DEFRA 16 PAHs

Anthanthrene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(b)naptho(2,1-d)thiophene, Benzo(c)phenanthrene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Cholanthrene, Chrysene, Cyclopenta(c,d)pyrene, Dibenzo(ai)pyrene, Dibenzo(ah)anthracene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Naphthalene.

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MONITORING DATE(S) & TIMES

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A1 - Stream 1

3rd - 5th March 2015

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
PM ₁₀	R1	mg/m³	0.10	g/hr	16.8	05/03/2015	10:30 - 12:30	120
PM _{2.5}	R1	mg/m³	0.076	g/hr	12.6	05/03/2015	10:30 - 12:30	120
Cadmium & Thallium	R1	mg/m³	< 0.00082	g/hr	< 0.14	05/03/2015	08:40 - 09:10, 09:12 - 09:42	60
Heavy Metals	R1	mg/m³	0.015	g/hr	2.5	05/03/2015	08:40 - 09:10, 09:12 - 09:42	60
Mercury	R1	mg/m³	0.0030	g/hr	0.50	05/03/2015	08:40 - 09:10, 09:12 - 09:42	60
Dioxins & Furans (NATO)	R1	ng/m³	0.096	µg/hr	16.0	04/03/2015	08:45 - 11:45; 11:50 - 14:50	360
PCBs	R1	ng/m³	0.0078	µg/hr	1.3	04/03/2015	08:45 - 11:45; 11:50 - 14:50	360
PAHs (DEFRA 16)	R1	µg/m³	1.5	g/hr	0.25	03/03/2015	10:10 - 17:16	360
Hydrogen Fluoride	R1	mg/m³	< 0.027	g/hr	< 4.5	05/03/2015	09:30 - 10:30	60
Oxygen	R1	% v/v	7.2			03/03/2015	10:10 - 17:16	360
Oxygen	R2	% v/v	7.7			04/03/2015	08:45 - 14:50	360
Oxygen	R3	% v/v	7.7			05/03/2015	08:40 - 12:30	230
Nitrous Oxide	R1	mg/m³	0.63	g/hr	104	03/03/2015	15:00 - 16:00	60
Water Vapour	R1	% v/v	18.5			03/03/2015	15:00 - 16:00	60
Velocity & Volumetric Flow Rate	R1					03/03/2015	09:12 - 09:30	

All results are expressed at the respective reference conditions.

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PROCESS DETAILS

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A1 - Stream 1

3rd - 5th March 2015

Standard Operating Conditions

Parameter	Value
Process Status	Operational
Capacity (of 100%) and Tonnes / Hour	Normal Operation
Continuous or Batch Process	Continuous
Feedstock (if applicable)	Municipal Waste
Abatement System	Bag Filter and Lime/Carbon Dosing
Abatement System Running Status	Operational
Fuel	Diesel Oil
Plume Appearance	Not Visible from Sampling Locatiom

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MONITORING & ANALYTICAL METHODS

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A1 - Stream 1

3rd - 5th March 2015

Parameter	Monitoring				Analysis				MCERTS Testing	LOD (Average)
	Standard	Technical Procedure	ISO 17025 Testing	Testing Lab	Analytical Procedure	Analytical Technique	ISO 17025 Analysis	Analysis Lab		
PM ₁₀	BS EN ISO 23210	CAT-TP-18	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.1 mg/m ³
PM _{2.5}	BS EN ISO 23210	CAT-TP-18	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.08 mg/m ³
Cadmium & Thallium	EN 14385	CAT-TP-06	Yes	CAT	M31	ICP-MS	Yes	RPS	Yes	0.001 mg/m ³
Heavy Metals	BS EN 14385	CAT-TP-06	Yes	CAT	M31	ICP-MS	Yes	RPS	Yes	0.004 mg/m ³
Mercury	MID 13211	CAT-TP-06	Yes	CAT	M112	CV-AFS	Yes	RPS	Yes	0.0004 mg/m ³
Dioxins & Furans	EN 1948	CAT-TP-07	Yes	CAT	SOP 1C	GC-HRMS	Yes	SAL	Yes	0.0007 ng/m ³
PCBs	EN 1948	CAT-TP-07	Yes	CAT	SOP 11	GC-HRMS	Yes	SAL	Yes	0.0014 ng/m ³
PAHs	ISO 11338	CAT-TP-08	Yes	CAT	SOP 12K	GC-MS (Soxhlet)	Yes	SAL	Yes	0.1597 µg/m ³
Hydrogen Fluoride	ISO 15713	CAT-TP-10	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.027 mg/m ³
Water Vapour	EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.1 % v/v
Oxygen	EN 14789	CAT-TP-21	Yes	CAT	Dry Paramagnetic Cell by Horiba PG-250 SRM				Yes	0.1 %
Nitrous Oxide	TGN M22	CAT-TP-22(b)	Yes	CAT	FTIR by Gasmet Technologies Oy DX4000				Yes	0 mg/m ³
Water Vapour	TGN M22	CAT-TP-22(b)	Yes	CAT	FTIR by Gasmet Technologies Oy DX4000				Yes	0.01 %
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	Yes	CAT	Pitot Tube and Thermocouple				Yes	3 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Exova Catalyst (CAT)	ISO 17025 Accreditation Number: 4279
Scientific Analysis Laboratories Ltd (SAL)	ISO 17025 Accreditation Number: 1549
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All	All	There are no deviations associated with the sampling employed.

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SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	1.89
Width	m	-
Area	m ²	2.81
Port Depth	cm	20
Orientation of Duct	-	Vertical
Sample Port Size	-	5" Flange

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Inside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	N/A
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and EN 15259, and therefore there are no improvement recommendations.

EN 15259 Homogeneity Test Requirements

A valid EN 15259 Homogeneity test was performed by Exova-Catalyst on this Stack on 12th Month Year, Report ID: CSW-15259-1633, and the stack gas profile was found to be homogenous.

Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	245.0	> 5 Pa	Yes
Mean Velocity	m/s	23.03	-	-
Lowest Gas Velocity	m/s	20.75	-	-
Highest Gas Velocity	m/s	25.36	-	-
Ratio of Above	: 1	1.22	< 3 : 1	Yes
Maximum Angle of Swirl	°	9	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

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PLANT PHOTOS

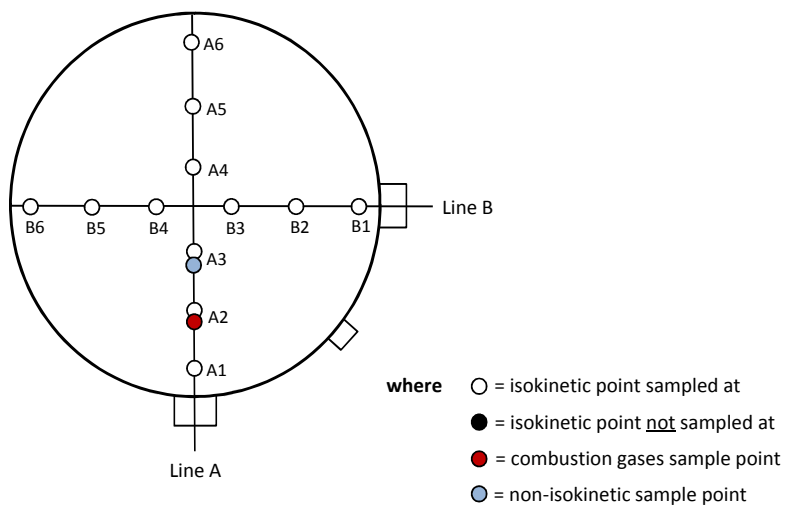
Photo 1



Photo 2



SAMPLE POINTS



APPENDIX CONTENTS

APPENDIX 1 - Stack Emissions Monitoring Personnel, List of Equipment & Methods and Technical Procedures Used

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Martin Futter	MCERTS Level 2	MM 03 216	TE1 TE2 TE3 TE4
Technician	Wayne Rossouw	MCERTS Level 1	MM 10 1083	TE1 TE2 TE3 TE4
Technician	William Trueman	MCERTS Level 1	MM 06 753	None

LIST OF EQUIPMENT

Extractive Sampling		Instrumental Analysers		Miscellaneous Items	
Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.
Control Box DGM (1)	CAT 7.22	Horiba PG-250 SRM	CAT 9.14	Digital Manometer (1)	CAT 3.89
Control Box DGM (2)	-	Horiba PG-250	-	Digital Manometer (2)	-
Box Thermocouples (1)	CAT 3.61	Servomex 4900	-	Digital Temperature Meter	CAT 3.56
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 14.61
Umbilical (1)	CAT 3.61	ABB AO2020-URAS26	-	Barometer	CAT 13.17
Umbilical (2)	-	Servomex 5200MP	-	Stack Thermocouple (1)	CAT 4.309
Oven Box (1)	CAT 12.42	JCT JCC P1 Cooler	-	Stack Thermocouple (2)	CAT 4.261
Oven Box (2)	-	Gasmet DX4000	CAT 19.4	Stack Thermocouple (3)	-
Heated Probe (1)	CAT 5.47	Gasmet Sampling System	CAT 19.4	1m Heated Line (1)	CAT 20.39
Heated Probe (2)	CAT 5.61	Bernath 3006 FID	-	1m Heated Line (2)	CAT 20.40
Heated Probe (3)	-	M&C PSS	CAT 12.46	1m Heated Line (3)	-
S-Pitot (1)	CAT 21P.32	Mass Flow Controller (1)	CAT 6.34	5m Heated Line (1)	-
S-Pitot (2)	-	Mass Flow Controller (2)	CAT 6.35	15m Heated Line (1)	CAT 20.84
L-Pitot	-	Mass View (1)	CAT 25.27	20m Heated Line (1)	-
500g Check Weight	CAT 17.14	Mass View (2)	CAT 25.28	20m Heated Line (2)	-
1Kg Check Weight	CAT 17.14	Easylogger EN-EL-12 Bit	-	Dual Channel Heater Controller	CAT 3.39
Last Impinger Arm	CAT 4.209	Easylogger EN-EL-12 Bit	-	Single Channel Heater Controller	-
Callipers	CAT 23.20	Bioaerosols Temperature Logger	-	Laboratory Balance	CAT 1.18 / 1.18a
Tubes Kit Thermocouple	-	Electronic Refrigerator	-	Tape Measure	CAT 16.22

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
PM ₁₀	BS EN ISO 23210	CAT-TP-18
PM _{2.5}	BS EN ISO 23210	CAT-TP-18
Cadmium & Thallium	EN 14385	CAT-TP-06
Heavy Metals	BS EN 14385	CAT-TP-06
Mercury	MID 13211	CAT-TP-06
Dioxins & Furans	EN 1948	CAT-TP-07
PCBs	EN 1948	CAT-TP-07
PAHs	ISO 11338	CAT-TP-08
Hydrogen Fluoride	ISO 15713	CAT-TP-10
Water Vapour	EN 14790	CAT-TP-05
Oxygen	EN 14789	CAT-TP-21
Nitrous Oxide	TGN M22	CAT-TP-22(b)
Water Vapour	TGN M22	CAT-TP-22(b)
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	1.89
Stack Width, W	m	-
Stack Area, A	m ²	2.81
Average Stack Gas Temperature, T _a	°C	144.9
Average Stack Gas Pressure	Pa	302.7
Average Stack Static Pressure, P _{static}	kPa	-2.486
Average Barometric Pressure, P _b	kPa	101.6
Average Pitot Tube Calibration Coefficient, C _p	-	0.84

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m ³ p	Conc kg/m ³ p _i
CO ₂ (Estimated)	-	11.00	9.15	0.1100	44.01	1.9635	0.21599
O ₂	-	7.62	6.34	0.0762	32.00	1.4277	0.10886
N ₂	-	81.38	67.68	0.8138	28.01	1.2498	1.01706
Moisture (H ₂ O)	-	-	16.84	0.1684	18.02	0.8037	0.13531

Where: $p = M / 22.41$

$p_i = r \times p$

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P _{STD}	kg/m ³	1.342
Wet Density (STP), P _{STW}	kg/m ³	1.251
Dry Density (Actual), P _{Actual}	kg/m ³	0.858
Average Wet Density (Actual), P _{ActualW}	kg/m ³	0.800

Where: P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m³ (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) = P_{STW} x (T_s / P_s) x (P_a / T_a)

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF ¹
Temperature	°C	144.9	0.0
Total Pressure	kPa	99.1	101.3
Moisture	%	16.84	0.00
Oxygen (Dry)	%	7.6	11.0

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m ³ /hr	232661
Gas Volumetric Flowrate (STP, Wet)	m ³ /hr	148704
Gas Volumetric Flowrate (STP, Dry)	m ³ /hr	123669
Gas Volumetric Flowrate REF ¹	m ³ /hr	165409

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	03/03/2015
Time of Survey	-	09:12 - 09:30
Atmospheric Pressure	kPa	101.6
Average Stack Static Pressure	Pa	-2486
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 200 (10000Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C _p	-	0.84
Number of Lines Available	-	2
Number of Lines Used	-	2

Sampling Line A							Sampling Line B				
Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m ³	Velocity m/s	Swirl °	ΔP Pa	Temp °C	Wet Density kg/m ³	Velocity m/s	Swirl °
STATIC (Units: Pa)		-2504.0					-2468.0				
Mean		302.5	144.8	0.800	23.05		302.8	145.0	0.800	23.02	
1	0.08	285.0	144.0	0.802	22.36	9.0	245.0	145.0	0.800	20.75	8.0
2	0.28	323.0	145.0	0.800	23.83	9.0	266.0	145.0	0.800	21.62	8.0
3	0.56	312.0	145.0	0.800	23.42	8.0	290.0	145.0	0.800	22.58	9.0
4	1.33	289.0	145.0	0.800	22.54	8.0	305.0	145.0	0.800	23.15	7.0
5	1.61	298.0	145.0	0.800	22.89	9.0	366.0	145.0	0.800	25.36	8.0
6	1.81	308.0	145.0	0.800	23.27	9.0	345.0	145.0	0.800	24.63	9.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	$u(k)$	0.0051	-
Standard Uncertainty associated with the mean local dynamic pressures	$u(\Delta p_i)$	8.126	Pa
- Resolution	$u(res)$	0.08677	
- Calibration	$u(cal)$	9.538	
- Drift	$u(drift)$	33.333	
- Lack of Fit	$u(fit)$	22.073	
- Overall corrections to dynamic measurements	$u(C_f)$	65.032	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00010	-
- $\varphi O_{2,w}$	-	6.341	
- $\varphi CO_{2,w}$	-	9.148	
- Oxygen, dry	$u(\phi O_{2,d})$	0.233	
- Carbon Dioxide, dry	$u(\phi CO_{2,d})$	0.337	
- Water Vapour	$u(\phi H_2O)$	0.859	
- Oxygen, wet	$u(\phi O_{2,w})$	0.205	
- Carbon Dioxide, wet	$u(\phi CO_{2,w})$	0.296	
Standard uncertainty associated with the stack temperature	$u(T_c)$	2.132	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.786	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	5.746	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00432	-
Standard uncertainty associated with the local velocities	$u(v_i)$	0.323	Pa
Standard uncertainty associated with the mean velocity	$u(\bar{v})$	0.126	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	0.246	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	1.07	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV,w)$	10821.5	m ³ /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00056	
- $u^2(qV,w)$	-	30483125	
- $u(qV,w)$	-	5521.2	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV,w)$	4.65	%

PM₁₀: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m ³	0.10		0.10
Uncertainty	±mg/m ³	0.20		0.20
Mass Emission	g/hr	16.8		16.8
Uncertainty	±g/hr	33.2		33.2

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the maximum Blank concentration has been reported.

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	16.8		16.8
Uncertainty	±% v/v	0.92		0.92

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	0.10		0.10

NOTE: Where the Balance Uncertainty / Limit of Detection is higher than the Blank concentration, the Balance Uncertainty / Limit of Detection concentration has been reported.

General Sampling Information

Parameter	Value	
Standard	BS EN ISO 23210	
Technical Procedure	CAT-TP-18	
Sizing Device	TCR Tecora MSS1 3-Stage Cascade Impactor	
Sizing Device Material	Stainless Steel	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B4	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

PM₁₀: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P _b	mmHg	780.0	
Stack static pressure, P _{static}	mmH ₂ O	-254.9	
P _s = (P _b + (P _{static} / 13.6))	mmHg	761.3	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	470.8	
Total mass collected in impingers (silica trap)	g	8.1	
Total mass of liquid collected, V _{lc}	g	478.9	
V _{wstd} = (0.001246)(V _{lc})	m ³	0.5967	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V _m	m ³	3.2010	
Gas meter correction factor, Y _d	-	0.9550	
Average dry gas meter temperature, T _m	°C	19.7	
Average pressure drop across orifice, ΔH	mmH ₂ O	92.7	
V _{mstd} = ((0.3592)(V _m)(P _b + (ΔH/13.6))(Y _d)) / (T _m + 273)	m ³	2.9522	
Moisture content, B_{w0} & R_{wv}			
B _{w0} = V _{wstd} / (V _{mstd} + V _{wstd})	m ³	0.1681	
B _{w0} as a percentage	% v/v	16.81	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	16.81	
Volume of gas metered wet, V_{mstw}			
V _{mstw} = (V _{mstd})(100/(100 - R _{wv}))	m ³	3.5489	
Volume of gas metered at Oxygen Reference Conditions, V_{mstd@X%O₂} & V_{mstw@X%O₂}			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	6.39	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	7.66	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet (O _{2REFw}) = (21 - REF%O ₂) / (21 - ACT%O _{2w})	-	0.68	
O ₂ Reference Factor dry (O _{2REFd}) = (21 - REF%O ₂) / (21 - ACT%O _{2d})	-	0.75	
V _{mstw@X%oxygen} = (V _{mstw}) / (O _{2REFw})	m ³	5.1863	
V _{mstd@X%oxygen} = (V _{mstd}) / (O _{2REFd})	m ³	3.9376	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	11.00	
O ₂	% v/v	7.66	
Total	% v/v	18.66	
N ₂	% v/v	81.34	
M _d = 0.44(%CO ₂) + 0.32(%O ₂) + 0.28(%N ₂)	g/gmol	30.07	
Molecular weight of stack gas (wet), M_s			
M _s = M _d (1 - (R _{wv} /100)) + 18(R _{wv} /100)	g/gmol	28.04	
Velocity of stack gas, V_{spt}			
Velocity pressure coefficient, C _p	-	0.84	
Average stack gas temperature, T _s	°C	135.2	
Velocity of stack gas (pre-test from traverse), V _{spt}	m/s	21.99	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO₂}), Dry@O_{2REF} (Q_{stdO₂})			
Area of stack, A _s	m ²	2.81	
Q _a = (60)(A _s)(V _s)	m ³ /min	3702.7	
Conversion factor (K/mm.Hg), C _f	-	0.3592	
Q _{stw} = ((Q _a)(P _s)(C _f)) / ((T _s) + 273)	m ³ /min	2480.6	
Q _{std} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s) + 273)	m ³ /min	2063.5	
Q _{stwO₂} = ((Q _a)(P _s)(C _f)) / ((T _s) + 273) / (O _{2REFw})	m ³ /min	3625.1	
Q _{stdO₂} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s) + 273) / (O _{2REFd})	m ³ /min	2752.3	
Percent isokinetic, %I			
Nozzle diameter, D _n	mm	6.88	
Nozzle area, A _n	mm ²	37.15	
Total sampling time, q	min	120	
Velocity at nozzle, V _n	m/s	19.80	
%I = V _n / V _{spt} x 100	%	90.0	

PM₁₀: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	10:30 - 12:30	
Sampling Dates	-	05/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	3.9376	
2nd Stage of Cascade Impactor (PM₁₀ to PM_{2.5})			
Filter I.D. Number (2nd Stage)	-	PM2-00673	
Start Filter Mass (2nd Stage)	g	0.11939	
End Filter Mass (2nd Stage)	g	0.11928	
Total Mass	g	-0.00011	
3rd Stage of Cascade Impactor (≤ PM_{2.5})			
Filter I.D. Number (3rd Stage)	-	PM3-00673	
Start Filter Mass (3rd Stage)	g	0.13906	
End Filter Mass (3rd Stage)	g	0.13894	
Total Mass	g	-0.00012	
Total Mass Collected	mg	-0.23	
Calculated Concentration	mg/m ³	-0.06	
Balance Uncertainty / LOD	mg/m ³	0.10	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	05/03/2015	
Average Volume Sampled (REF)	m ³	3.9376	
2nd Stage of Cascade Impactor (PM₁₀ to PM_{2.5})			
Filter I.D. Number (2nd Stage)	-	PM2-00709	
Start Filter Mass (2nd Stage)	g	0.12006	
End Filter Mass (2nd Stage)	g	0.12000	
Total Mass	g	-0.00006	
3rd Stage of Cascade Impactor (≤ PM_{2.5})			
Filter I.D. Number (3rd Stage)	-	PM3-00709	
Start Filter Mass (3rd Stage)	g	0.14114	
End Filter Mass (3rd Stage)	g	0.14113	
Total Mass	g	-0.00001	
Total Mass Collected	mg	-0.07	
Calculated Concentration	mg/m ³	-0.02	
Balance Uncertainty / LOD	mg/m ³	0.10	

PM₁₀: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Expected Sampling Rate	l/min	30.00	
Pre-Sampling Leak Rate	l/min	0.56	
Allowable Leak Rate	l/min	0.60	
Leak Test Acceptable	-	Yes	
Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	
MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.5	
Allowable MU	%	20	
MU Acceptable	%	Yes	
Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	90.0	
Allowable Isokinetic Range	%	90 - 130	
Isokineticity Acceptable	-	Yes	
Filter Temperatures	Units	Run 1	
Pre-Conditioning Temperature	°C	180	
Post-Conditioning Temperature	°C	160	
Maximum Filter Temperature	°C	135	
Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	
Cut Size	Units	Run 1	
D ₅₀ Cut Size	µm	10.03	
Allowable D ₅₀ Cut Size	µm	9 - 11	
D ₅₀ Cut Size Acceptable	-	Yes	

PM₁₀: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	30.00	
Pre-Sampling Leak Rate	l/min	0.54	
Allowable Leak Rate	l/min	0.60	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	N/A	
Blank Acceptable	-	N/A	

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	
There are no deviations associated with the sampling employed.	wx	

PM₁₀: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	3.2010		uV _m	m ³	0.0640	
Sampled Gas Temperature	T _m	292.7		uT _m	K	2.0	
Sampled Gas Pressure	p _m	101.5		up _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	1.87		uL	%	-	
Mass of Particulate	m	0.40		um	mg	0.40	
Uncollected Mass	UCM	-0.07		uUCM	mg	-	
Particulate Sizing	PS	10.00		uPS	%	-	

Uncertainty as a Percentage				Requirement of Standard
Measured Quantities	Units	Run 1		
Sampled Volume (Actual)	%	2.0000		≤2%
Sampled Gas Temperature	%	0.7		≤1%
Sampled Gas Pressure	%	0.5		≤1%
Sampled Gas Humidity	%	1.0		≤1%
Leak	%	1.87		≤2%
Mass of Particulate	%	-		<5% of ELV
Uncollected Mass	%	-		-
Particulate Sizing	%	10.00		-

Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	Symbol	Units	Run 1	Run 1	
Sampled Volume (STP)	V _m	m ³	2.9522	0.034	
Leak	L	mg/m ³	0.0011	1.00	
Mass of Particulate	L _r	mg	0.400	0.25	
Uncollected Mass	UCM	mg	-0.04	0.25	
Particulate Sizing	PS	mg	0.01	1.00	

Uncertainty in Result			
Measured Quantities	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.003	
Leak	mg/m ³	0.0011	
Mass of Particulate	mg/m ³	0.1016	
Uncollected Mass	mg/m ³	-0.0098	
Particulate Sizing	mg/m ³	0.0059	

Oxygen Correction Part of MU Budget			
Measured Quantities	Units	Run 1	
O ₂ Correction Factor	-	0.75	
Stack Gas O ₂ Content	% v/v	7.66	
MU for O ₂ Correction	-	0.03	
Overall MU For O ₂ Measurement	%	3.75	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	0.10	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.20	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	0.20	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.20	
Reported Uncertainty	mg/m ³	0.20	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	197.3	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	197.3	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	197.3	
Reported Uncertainty	%	197.3	

PM_{2.5}: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m ³	0.076		0.076
Uncertainty	±mg/m ³	0.15		0.15
Mass Emission	g/hr	12.6		12.6
Uncertainty	±g/hr	24.8		24.8

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the maximum Blank concentration has been reported.

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	16.8		16.8
Uncertainty	±% v/v	0.92		0.92

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	0.076		0.076

NOTE: Where the Balance Uncertainty / Limit of Detection is higher than the Blank concentration, the Balance Uncertainty / Limit of Detection concentration has been reported.

General Sampling Information

Parameter	Value	
Standard	BS EN ISO 23210	
Technical Procedure	CAT-TP-18	
Sizing Device	TCR Tecora MSSI 3-Stage Cascade Impactor	
Sizing Device Material	Stainless Steel	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B4	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

PM_{2.5}: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P _b	mmHg	780.0	
Stack static pressure, P _{static}	mmH ₂ O	-254.9	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	761.3	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	470.8	
Total mass collected in impingers (silica trap)	g	8.1	
Total mass of liquid collected, V _{lc}	g	478.9	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.5967	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V _m	m ³	3.2010	
Gas meter correction factor, Y _d	-	0.9550	
Average dry gas meter temperature, T _m	°C	19.7	
Average pressure drop across orifice, ΔH	mmH ₂ O	92.7	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	2.9522	
Moisture content, B_{w0} & R_{wv}			
$B_{w0} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.1681	
B _{w0} as a percentage	% v/v	16.81	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	16.81	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd}) / (100 / (100 - R_{wv}))$	m ³	3.5489	
Volume of gas metered at Oxygen Reference Conditions, V_{mstd@X%O₂} & V_{mstw@X%O₂}			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	6.39	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	7.66	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet (O _{2REFw}) = (21 - REF%O ₂) / (21 - ACT%O _{2w})	-	0.68	
O ₂ Reference Factor dry (O _{2REFd}) = (21 - REF%O ₂) / (21 - ACT%O _{2d})	-	0.75	
$V_{mstw@X\%O_2} = (V_{mstw}) / (O_{2REFw})$	m ³	5.1863	
$V_{mstd@X\%O_2} = (V_{mstd}) / (O_{2REFd})$	m ³	3.9376	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	11.00	
O ₂	% v/v	7.66	
Total	% v/v	18.66	
N ₂	% v/v	81.34	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	30.07	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.04	
Velocity of stack gas, V_{spt}			
Velocity pressure coefficient, C _p	-	0.84	
Average stack gas temperature, T _s	°C	135.2	
Velocity of stack gas (pre-test from traverse), V _{spt}	m/s	21.99	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO₂}), Dry@O_{2REF} (Q_{stdO₂})			
Area of stack, A _s	m ²	2.81	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	3702.7	
Conversion factor (K/mm.Hg), C _f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	2480.6	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	2063.5	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	3625.1	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	2752.3	
Percent isokinetic, %I			
Nozzle diameter, D _n	mm	6.88	
Nozzle area, A _n	mm ²	37.15	
Total sampling time, q	min	120	
Velocity at nozzle, V _n	m/s	19.80	
$\%I = V_n / V_{spt} \times 100$	%	90.0	

PM_{2.5}: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	10:30 - 12:30	
Sampling Dates	-	05/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	3.9376	
3rd Stage of Cascade Impactor (\leq PM_{2.5})			
Filter I.D. Number (3rd Stage)	-	PM3-00673	
Start Filter Mass (3rd Stage)	g	0.13906	
End Filter Mass (3rd Stage)	g	0.13894	
Total Mass	g	-0.00012	
Total Mass Collected	mg	-0.12	
Calculated Concentration	mg/m ³	-0.03	
Balance Uncertainty / LOD	mg/m ³	0.08	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	05/03/2015	
Average Volume Sampled (REF)	m ³	3.9376	
3rd Stage of Cascade Impactor (\leq PM_{2.5})			
Filter I.D. Number (3rd Stage)	-	PM3-00709	
Start Filter Mass (3rd Stage)	g	0.14114	
End Filter Mass (3rd Stage)	g	0.14113	
Total Mass	g	-0.00001	
Total Mass Collected	mg	-0.01	
Calculated Concentration	mg/m ³	0.00	
Balance Uncertainty / LOD	mg/m ³	0.08	

PM_{2.5}: QUALITY ASSURANCE

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Sample Runs

Leak Test Results	Units	Run 1	
Expected Sampling Rate	l/min	30.00	
Pre-Sampling Leak Rate	l/min	0.56	
Allowable Leak Rate	l/min	0.60	
Leak Test Acceptable	-	Yes	
Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	
MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.5	
Allowable MU	%	20	
MU Acceptable	%	Yes	
Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	90.0	
Allowable Isokinetic Range	%	90 - 130	
Isokineticity Acceptable	-	Yes	
Filter Temperatures	Units	Run 1	
Pre-Conditioning Temperature	°C	180	
Post-Conditioning Temperature	°C	160	
Maximum Filter Temperature	°C	135	
Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	
Cut Size	Units	Run 1	
D ₅₀ Cut Size	µm	2.51	
Allowable D ₅₀ Cut Size	µm	2.25 - 2.75	
D ₅₀ Cut Size Acceptable	-	Yes	

PM_{2.5}: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	30.00	
Pre-Sampling Leak Rate	l/min	0.54	
Allowable Leak Rate	l/min	0.60	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	N/A	
Blank Acceptable	-	N/A	

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	
There are no deviations associated with the sampling employed.	wx	

PM_{2.5}: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	3.2010		uV _m	m ³	0.0640	
Sampled Gas Temperature	T _m	292.7		uT _m	K	2.0	
Sampled Gas Pressure	ρ _m	101.5		uρ _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	1.87		uL	%	-	
Mass of Particulate	m	0.30		um	mg	0.30	
Uncollected Mass	UCM	-0.01		uUCM	mg	-	
Particulate Sizing	PS	10.00		uPS	%	-	

Uncertainty as a Percentage				Requirement of Standard
Measured Quantities	Units	Run 1		
Sampled Volume (Actual)	%	2.0000		≤2%
Sampled Gas Temperature	%	0.7		≤1%
Sampled Gas Pressure	%	0.5		≤1%
Sampled Gas Humidity	%	1.0		≤1%
Leak	%	1.87		≤2%
Mass of Particulate	%	-		<5% of ELV
Uncollected Mass	%	-		-
Particulate Sizing	%	10.00		-

Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	Symbol	Units	Run 1	Run 1	
Sampled Volume (STP)	V _m	m ³	2.9522	0.03	
Leak	L	mg/m ³	0.001	1.00	
Mass of Particulate	L _r	mg	0.300	0.25	
Uncollected Mass	UCM	mg	-0.01	0.25	
Particulate Sizing	PS	mg	0.004	1.00	

Uncertainty in Result			
Measured Quantities	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.002	
Leak	mg/m ³	0.0008	
Mass of Particulate	mg/m ³	0.0762	
Uncollected Mass	mg/m ³	-0.0015	
Particulate Sizing	mg/m ³	0.0044	

Oxygen Correction Part of MU Budget			
Measured Quantities	Units	Run 1	
O ₂ Correction Factor	-	0.75	
Stack Gas O ₂ Content	% v/v	7.66	
MU for O ₂ Correction	-	0.03	
Overall MU For O ₂ Measurement	%	3.75	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	0.08	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.15	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	0.15	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.15	
Reported Uncertainty	mg/m ³	0.15	
Expanded uncertainty (95% confidence)	%	196.4	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	196.5	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	196.5	
Reported Uncertainty	%	196.5	

CADMIUM & THALLIUM: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m ³	< 0.00082		< 0.00082
Uncertainty	±mg/m ³	0.00013		0.00013
Mass Emission	g/hr	< 0.14		< 0.14
Uncertainty	±g/hr	0.023		0.023

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	16.9		16.9
Uncertainty	±% v/v	0.85		0.85

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	< 0.00076		< 0.00076

General Sampling Information

Parameter	Value
Standard	EN 14385
Technical Procedure	CAT-TP-06
Name of Analytical Laboratory	RPS
Analytical Laboratory's Procedure	M31
ISO 17025 Accredited Analysis?	Yes
Date of Sample Analysis	17/03/2015
Probe Material	Titanium
Filter Housing Material	Titanium
Impinger Material	Borosilicate Glass
Absorption Solution	Nitric Peroxide
Positioning of Filter	Out Stack
Filter Size and Material	47mm Quartz Fibre
Number of Sampling Lines Used	2 / 2
Number of Sampling Points Used	12 / 12
Sample Point I.D.'s	A1 - A6, B1 - B6

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

CADMIUM & THALLIUM: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	780.8	
Stack static pressure, P_{static}	mmH ₂ O	-244.7	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	762.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	177.8	
Total mass collected in impingers (silica trap)	g	9.7	
Total mass of liquid collected, V_{lc}	g	187.5	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.2336	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m ³	1.2190	
Gas meter correction factor, Y_d	-	0.9550	
Average dry gas meter temperature, T_m	°C	13.4	
Average pressure drop across orifice, ΔH	mmH ₂ O	51.6	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	1.1454	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.1694	
B_{wo} as a percentage	% v/v	16.94	
Reported Water Vapour, checked with Tables in EN 14790, R_{wv}	% v/v	16.94	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd}) / (100 / (100 - R_{wv}))$	m ³	1.3790	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	7.31	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	8.77	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet ($O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$)	-	0.73	
O ₂ Reference Factor dry ($O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$)	-	0.82	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	1.8880	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	1.4009	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	11.50	
O ₂	% v/v	8.77	
Total	% v/v	20.27	
N ₂	% v/v	79.73	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	30.19	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.13	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.84	
Average of velocity heads, ΔP_{avg}	mmH ₂ O	29.33	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	5.42	
Average stack gas temperature, T_s	°C	145.8	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s	22.23	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})			
Area of stack, A_s	m ²	2.81	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	3742.0	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	2448.4	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	2033.6	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	3352.0	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	2487.2	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.89	
Nozzle area, A_n	mm ²	27.28	
Total sampling time, q	min	60	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	96.5	

CADMIUM & THALLIUM: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	08:40 - 09:10, 09:12 - 09:42	
Sampling Dates	-	05/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	1.4009	
Cadmium			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.10	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.63	
Calculated Concentration	mg/m ³	< 0.0004	
Reported Concentration	mg/m ³	< 0.0004	
Mass Emission	g/hr	< 0.07	
Thallium			
Mass on Filter / in Rinse	µg	< 0.40	
Mass in Front Impingers	µg	< 0.10	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.53	
Calculated Concentration	mg/m ³	< 0.0004	
Reported Concentration	mg/m ³	< 0.0004	
Mass Emission	g/hr	< 0.06	
Cadmium & Thallium Combined			
Total Mass Collected	µg	< 1.15	
Calculated Concentration	mg/m ³	< 0.0008	
Reported Concentration	mg/m ³	< 0.0008	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	04/03/2015	
Average Volume Sampled (REF)	m ³	1.4009	
Cadmium			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.05	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.58	
Calculated Concentration	mg/m ³	< 0.0004	
Reported Concentration	mg/m ³	< 0.0004	
Thallium			
Mass on Filter / in Rinse	µg	< 0.40	
Mass in Front Impingers	µg	< 0.05	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.48	
Calculated Concentration	mg/m ³	< 0.0003	
Reported Concentration	mg/m ³	< 0.0003	
Cadmium & Thallium Combined			
Total Mass Collected	µg	< 1.06	
Calculated Concentration	mg/m ³	< 0.0008	
Reported Concentration	mg/m ³	< 0.0008	

CADMIUM & THALLIUM: QUALITY ASSURANCE

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Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	19.40	
Pre-Sampling Leak Rate	l/min	0.04	
Post-Sampling Leak Rate	l/min	0.11	
Allowable Leak Rate	l/min	0.39	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Cadmium	%	100.0	
Thallium	%	100.0	
Allowable Absorption Efficiency	%	N/A	
Absorption Efficiency Acceptable	-	N/A	

Where the emissions are < 30% of the ELV, MID 14385 does not require the 90% absorption efficiency requirement to be applied

Detection Limit	Units	Run 1	
Cadmium	µg/m ³	0.4	
Thallium	µg/m ³	0.4	
Allowable Detection Limit	µg/m ³	5	
Detection Limit Acceptable	-	Yes	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.0	
Allowable MU	%	20	
MU Acceptable	%	Yes	

Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	

Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	96.5	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	180	

Impingers Exit Temperature	Units	Run 1	
Maximum Temperature Recorded	°C	12	
Maximum Allowable Temperature	°C	30	
Exit Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

CADMIUM & THALLIUM: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	12.00	
Pre-Sampling Leak Rate	l/min	0.11	
Post-Sampling Leak Rate	l/min	0.11	
Allowable Leak Rate	l/min	0.24	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	0.0050	
Blank Acceptable	-	Yes	

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	
There are no deviations associated with the sampling employed.	wx	

CADMIUM & THALLIUM: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	1.2190		uV _m	m ³	0.0244	
Sampled Gas Temperature	T _m	286.4		uT _m	K	2.0	
Sampled Gas Pressure	p _m	101.7		uP _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	0.57		uL	%	-	
Laboratory Result	L _r	7.50		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.70		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.57		≤2%
Laboratory Result	%	7.50		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	1.1454		0.0007	
Leak	L	mg/m ³	2.7E-06		1.00	
Laboratory Result	L _r	mg/m ³	6.2E-05		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	2.1E-05	
Leak	mg/m ³	2.7E-06	
Laboratory Result	mg/m ³	6.2E-05	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	0.82	
Stack Gas O ₂ Content	% v/v	8.77	
MU for O ₂ Correction	-	0.03	
Overall MU For O ₂ Measurement	%	4.09	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	6.5E-05	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	1.3E-04	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	1.3E-04	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	1.3E-04	
Reported Uncertainty	mg/m ³	1.3E-04	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	15.5	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	16.0	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	16.0	
Reported Uncertainty	%	16.0	

HEAVY METALS: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m ³	0.015		0.015
Uncertainty	±mg/m ³	0.0023		0.0023
Mass Emission	g/hr	2.5		2.5
Uncertainty	±g/hr	0.40		0.40

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	16.9		16.9
Uncertainty	±% v/v	0.85		0.85

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	0.0043		0.0043

General Sampling Information

Parameter	Value	
Standard	BS EN 14385	
Technical Procedure	CAT-TP-06	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	M31	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	17/03/2015	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Borosilicate Glass	
Absorption Solution	Nitric Peroxide	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	12 / 12	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A6, B1 - B6	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

HEAVY METALS: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	780.8	
Stack static pressure, P_{static}	mmH ₂ O	-244.7	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	762.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	177.8	
Total mass collected in impingers (silica trap)	g	9.7	
Total mass of liquid collected, V_{lc}	g	187.5	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.2336	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m ³	1.2190	
Gas meter correction factor, Y_d	-	0.9550	
Average dry gas meter temperature, T_m	°C	13.4	
Average pressure drop across orifice, ΔH	mmH ₂ O	51.6	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	1.1454	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.1694	
B_{wo} as a percentage	% v/v	16.94	
Reported Water Vapour, checked with Tables in EN 14790, R_{wv}	% v/v	16.94	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd}) / (100 / (100 - R_{wv}))$	m ³	1.3790	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	7.31	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	8.77	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet ($O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$)	-	0.73	
O ₂ Reference Factor dry ($O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$)	-	0.82	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	1.8880	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	1.4009	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	11.50	
O ₂	% v/v	8.77	
Total	% v/v	20.27	
N ₂	% v/v	79.73	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	30.19	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.13	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.84	
Average of velocity heads, ΔP_{avg}	mmH ₂ O	29.33	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	5.42	
Average stack gas temperature, T_s	°C	145.8	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s	22.23	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})			
Area of stack, A_s	m ²	2.81	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	3742.0	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	2448.4	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	2033.6	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	3352.0	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	2487.2	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.89	
Nozzle area, A_n	mm ²	27.28	
Total sampling time, q	min	60	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	96.5	

HEAVY METALS: SAMPLING DETAILS

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Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	08:40 - 09:10, 09:12 - 09:42	
Sampling Dates	-	05/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	1.4009	
Arsenic			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.14	
Mass in Back Impinger	µg	< 0.05	
Total Mass Collected	µg	< 0.69	
Calculated Concentration	mg/m ³	< 0.0005	
Reported Concentration	mg/m ³	< 0.0005	
Mass Emission	g/hr	< 0.08	
Cobalt			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.10	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.63	
Calculated Concentration	mg/m ³	< 0.0004	
Reported Concentration	mg/m ³	< 0.0004	
Mass Emission	g/hr	< 0.07	
Chromium			
Mass on Filter / in Rinse	µg	2.00	
Mass in Front Impingers	µg	2.88	
Mass in Back Impinger	µg	0.08	
Total Mass Collected	µg	4.95	
Calculated Concentration	mg/m ³	0.0035	
Reported Concentration	mg/m ³	0.0035	
Mass Emission	g/hr	0.58	
Copper			
Mass on Filter / in Rinse	µg	5.00	
Mass in Front Impingers	µg	< 0.19	
Mass in Back Impinger	µg	< 0.06	
Total Mass Collected	µg	5.25	
Calculated Concentration	mg/m ³	0.0038	
Reported Concentration	mg/m ³	0.0038	
Mass Emission	g/hr	0.62	
Manganese			
Mass on Filter / in Rinse	µg	1.00	
Mass in Front Impingers	µg	< 0.10	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	1.13	
Calculated Concentration	mg/m ³	0.0008	
Reported Concentration	mg/m ³	0.0008	
Mass Emission	g/hr	0.13	

HEAVY METALS: SAMPLING DETAILS

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Sample Runs (continued)

Parameter	Units	Run 1	
Nickel			
Mass on Filter / in Rinse	µg	4.00	
Mass in Front Impingers	µg	< 0.10	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	4.13	
Calculated Concentration	mg/m ³	0.0029	
Reported Concentration	mg/m ³	0.0029	
Mass Emission	g/hr	0.49	
Lead			
Mass on Filter / in Rinse	µg	3.00	
Mass in Front Impingers	µg	0.14	
Mass in Back Impinger	µg	0.09	
Total Mass Collected	µg	3.24	
Calculated Concentration	mg/m ³	0.0023	
Reported Concentration	mg/m ³	0.0023	
Mass Emission	g/hr	0.38	
Antimony			
Mass on Filter / in Rinse	µg	< 0.60	
Mass in Front Impingers	µg	< 0.10	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.73	
Calculated Concentration	mg/m ³	< 0.0005	
Reported Concentration	mg/m ³	< 0.0005	
Mass Emission	g/hr	< 0.09	
Vanadium			
Mass on Filter / in Rinse	µg	< 0.40	
Mass in Front Impingers	µg	< 0.05	
Mass in Back Impinger	µg	< 0.02	
Total Mass Collected	µg	< 0.46	
Calculated Concentration	mg/m ³	< 0.0003	
Reported Concentration	mg/m ³	< 0.0003	
Mass Emission	g/hr	< 0.05	

HEAVY METALS: SAMPLING DETAILS

(PAGE 3 OF 5)

Sample Runs (continued)

Parameter	Units	Run 1	
Heavy Metals Combined			
Total Mass Collected	µg	21.20	
Calculated Concentration	mg/m ³	0.0151	
Reported Concentration	mg/m ³	0.0151	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	04/03/2015	
Average Volume Sampled (REF)	m ³	1.4009	
Arsenic			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.08	
Mass in Back Impinger	µg	< 0.04	
Total Mass Collected	µg	< 0.62	
Calculated Concentration	mg/m ³	< 0.0004	
Reported Concentration	mg/m ³	< 0.0004	
Cobalt			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.05	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.58	
Calculated Concentration	mg/m ³	< 0.0004	
Reported Concentration	mg/m ³	< 0.0004	

HEAVY METALS: SAMPLING DETAILS

(PAGE 4 OF 5)

Blank Runs (continued)

Parameter	Units	Blank 1	
Chromium			
Mass on Filter / in Rinse	µg	< 0.60	
Mass in Front Impingers	µg	0.26	
Mass in Back Impinger	µg	0.12	
Total Mass Collected	µg	0.99	
Calculated Concentration	mg/m ³	0.0007	
Reported Concentration	mg/m ³	0.0007	
Copper			
Mass on Filter / in Rinse	µg	< 0.60	
Mass in Front Impingers	µg	< 0.10	
Mass in Back Impinger	µg	0.10	
Total Mass Collected	µg	< 0.80	
Calculated Concentration	mg/m ³	< 0.0006	
Reported Concentration	mg/m ³	< 0.0006	
Manganese			
Mass on Filter / in Rinse	µg	< 0.40	
Mass in Front Impingers	µg	< 0.05	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.48	
Calculated Concentration	mg/m ³	< 0.0003	
Reported Concentration	mg/m ³	< 0.0003	
Nickel			
Mass on Filter / in Rinse	µg	< 0.60	
Mass in Front Impingers	µg	< 0.05	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.68	
Calculated Concentration	mg/m ³	< 0.0005	
Reported Concentration	mg/m ³	< 0.0005	
Lead			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	0.16	
Mass in Back Impinger	µg	0.12	
Total Mass Collected	µg	0.78	
Calculated Concentration	mg/m ³	0.0006	
Reported Concentration	mg/m ³	0.0006	
Antimony			
Mass on Filter / in Rinse	µg	< 0.60	
Mass in Front Impingers	µg	< 0.05	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.68	
Calculated Concentration	mg/m ³	< 0.0005	
Reported Concentration	mg/m ³	< 0.0005	
Vanadium			
Mass on Filter / in Rinse	µg	< 0.40	
Mass in Front Impingers	µg	< 0.03	
Mass in Back Impinger	µg	< 0.01	
Total Mass Collected	µg	< 0.44	
Calculated Concentration	mg/m ³	< 0.0003	
Reported Concentration	mg/m ³	< 0.0003	

HEAVY METALS: SAMPLING DETAILS

(PAGE 5 OF 5)

Blank Runs (continued)

Parameter	Units	Blank 1	
Heavy Metals Combined			
Total Mass Collected	µg	6.05	
Calculated Concentration	mg/m ³	0.0043	
Reported Concentration	mg/m ³	0.0043	

HEAVY METALS: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	19.40	
Pre-Sampling Leak Rate	l/min	0.04	
Post-Sampling Leak Rate	l/min	0.11	
Allowable Leak Rate	l/min	0.39	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Arsenic	%	100.0	
Cobalt	%	100.0	
Chromium	%	98.4	
Copper	%	100.0	
Manganese	%	100.0	
Nickel	%	100.0	
Lead	%	97.1	
Antimony	%	100.0	
Vanadium	%	100.0	
Allowable Absorption Efficiency	%	N/A	
Absorption Efficiency Acceptable	-	N/A	

Where the emissions are < 30% of the ELV, MID 14385 does not require the 90% absorption efficiency requirement to be applied

Detection Limit	Units	Run 1	
Arsenic	µg/m ³	0.5	
Cobalt	µg/m ³	0.4	
Chromium	µg/m ³	0.5	
Copper	µg/m ³	0.6	
Manganese	µg/m ³	0.4	
Nickel	µg/m ³	0.5	
Lead	µg/m ³	0.4	
Antimony	µg/m ³	0.5	
Vanadium	µg/m ³	0.3	
Allowable Detection Limit	µg/m ³	5	
Detection Limit Acceptable	-	Yes	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.0	
Allowable MU	%	20	
MU Acceptable	%	Yes	

HEAVY METALS: QUALITY ASSURANCE

(PAGE 2 OF 2)

Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	96.5	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	
Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	180	
Impingers Exit Temperature	Units	Run 1	
Maximum Temperature Recorded	°C	12	
Maximum Allowable Temperature	°C	30	
Exit Temperature Acceptable	-	Yes	
Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	12.00	
Pre-Sampling Leak Rate	l/min	0.11	
Post-Sampling Leak Rate	l/min	0.11	
Allowable Leak Rate	l/min	0.24	
Leak Test Acceptable	-	Yes	
Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	0.0500	
Blank Acceptable	-	Yes	

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	
There are no deviations associated with the sampling employed.	wx	

HEAVY METALS: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	1.2190		uV _m	m ³	0.0244	
Sampled Gas Temperature	T _m	286.4		uT _m	K	2.0	
Sampled Gas Pressure	p _m	101.7		uP _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	0.57		uL	%	-	
Laboratory Result	L _r	7.00		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.70		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.57		≤2%
Laboratory Result	%	7.00		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	1.1454		0.013	
Leak	L	mg/m ³	5.0E-05		1.00	
Laboratory Result	L _r	mg/m ³	0.0011		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	3.8E-04	
Leak	mg/m ³	5.0E-05	
Laboratory Result	mg/m ³	1.1E-03	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	0.82	
Stack Gas O ₂ Content	% v/v	8.77	
MU for O ₂ Correction	-	0.03	
Overall MU For O ₂ Measurement	%	4.09	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	1.1E-03	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	2.2E-03	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	2.3E-03	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	2.3E-03	
Reported Uncertainty	mg/m ³	2.3E-03	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	14.6	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	15.1	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	15.1	
Reported Uncertainty	%	15.1	

MERCURY: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m ³	0.0030		0.0030
Uncertainty	±mg/m ³	0.00041		0.00041
Mass Emission	g/hr	0.50		0.50
Uncertainty	±g/hr	0.071		0.071

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	16.9		16.9
Uncertainty	±% v/v	0.85		0.85

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	< 0.00027		< 0.00027

General Sampling Information

Parameter	Value
Standard	MID 13211
Technical Procedure	CAT-TP-06
Name of Analytical Laboratory	RPS
Analytical Laboratory's Procedure	M112
ISO 17025 Accredited Analysis?	Yes
Date of Sample Analysis	17/03/2015
Probe Material	Titanium
Filter Housing Material	Titanium
Impinger Material	Borosilicate Glass
Absorption Solution	Nitric Peroxide & Potassium Dichromate
Positioning of Filter	Out Stack
Filter Size and Material	47mm Quartz Fibre
Number of Sampling Lines Used	2 / 2
Number of Sampling Points Used	12 / 12
Sample Point I.D.'s	A1 - A6, B1 - B6

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

MERCURY: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	780.8	
Stack static pressure, P_{static}	mmH ₂ O	-244.7	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	762.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	177.8	
Total mass collected in impingers (silica trap)	g	9.7	
Total mass of liquid collected, V_{lc}	g	187.5	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.2336	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m ³	1.2190	
Gas meter correction factor, Y_d	-	0.9550	
Average dry gas meter temperature, T_m	°C	13.4	
Average pressure drop across orifice, ΔH	mmH ₂ O	51.6	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	1.1454	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.1694	
B_{wo} as a percentage	% v/v	16.94	
Reported Water Vapour, checked with Tables in EN 14790, R_{wv}	% v/v	16.94	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd}) / (100 / (100 - R_{wv}))$	m ³	1.3790	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	7.31	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	8.77	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet ($O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$)	-	0.73	
O ₂ Reference Factor dry ($O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$)	-	0.82	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	1.8880	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	1.4009	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	11.50	
O ₂	% v/v	8.77	
Total	% v/v	20.27	
N ₂	% v/v	79.73	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	30.19	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.13	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.84	
Average of velocity heads, ΔP_{avg}	mmH ₂ O	29.33	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	5.42	
Average stack gas temperature, T_s	°C	145.8	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s	22.23	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})			
Area of stack, A_s	m ²	2.81	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	3742.0	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	2448.4	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	2033.6	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	3352.0	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	2487.2	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.89	
Nozzle area, A_n	mm ²	27.28	
Total sampling time, q	min	60	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	96.5	

MERCURY: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	08:40 - 09:10, 09:12 - 09:42	
Sampling Dates	-	05/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	1.4009	
Mass on Filter / in Rinse	µg	< 0.03	
Mass in Front Impinger/s	µg	4.14	
Mass in Final Impinger	µg	< 0.08	
Total Mass Collected	µg	4.24	
Calculated Concentration	mg/m ³	0.0030	
Reported Concentration	mg/m ³	0.0030	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	04/03/2015	
Average Volume Sampled (REF)	m ³	1.4009	
Mass on Filter / in Rinse	µg	< 0.03	
Mass in Front Impinger/s	µg	< 0.28	
Mass in Final Impinger	µg	< 0.07	
Total Mass Collected	µg	< 0.38	
Calculated Concentration	mg/m ³	< 0.0003	
Reported Concentration	mg/m ³	< 0.0003	

MERCURY: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	19.40	
Pre-Sampling Leak Rate	l/min	0.04	
Post-Sampling Leak Rate	l/min	0.11	
Allowable Leak Rate	l/min	0.39	
Leak Test Acceptable	-	Yes	
Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	100.0	
Allowable Absorption Efficiency	%	N/A	
Absorption Efficiency Acceptable	-	N/A	
Where the emissions are < 30% of the ELV, MID 14385 does not require the 95% absorption efficiency requirement to be applied			
Concentration in Final Impinger	Units	Run 1	
Concentration in Final Impinger	µg/m ³	0.06	
Allowable Concentration	µg/m ³	2.0	
Concentration Acceptable	-	Yes	
Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	
MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.0	
Allowable MU	%	20	
MU Acceptable	%	Yes	
Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	96.5	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	
Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	180	
Impingers Exit Temperature	Units	Run 1	
Maximum Temperature Recorded	°C	12	
Maximum Allowable Temperature	°C	30	
Exit Temperature Acceptable	-	Yes	
Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

MERCURY: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	12.00	
Pre-Sampling Leak Rate	l/min	0.11	
Post-Sampling Leak Rate	l/min	0.11	
Allowable Leak Rate	l/min	0.24	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	0.0050	
Blank Acceptable	-	Yes	

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	
In order to maintain isokinetic sampling, a nozzle size smaller than that specified in the Standard was used.	wx	

MERCURY: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	1.2190		uV _m	m ³	0.0244	
Sampled Gas Temperature	T _m	286.4		uT _m	K	2.0	
Sampled Gas Pressure	p _m	101.7		uP _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	0.57		uL	%	-	
Laboratory Result	L _r	6.00		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.70		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.57		≤2%
Laboratory Result	%	6.00		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	1.1454		0.0026	
Leak	L	mg/m ³	9.9E-06		1.00	
Laboratory Result	L _r	mg/m ³	1.8E-04		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	7.6E-05	
Leak	mg/m ³	9.9E-06	
Laboratory Result	mg/m ³	1.8E-04	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	0.82	
Stack Gas O ₂ Content	% v/v	8.77	
MU for O ₂ Correction	-	0.03	
Overall MU For O ₂ Measurement	%	4.09	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	2.0E-04	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	3.9E-04	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	4.1E-04	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	4.1E-04	
Reported Uncertainty	mg/m ³	4.1E-04	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	12.8	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	13.4	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	13.4	
Reported Uncertainty	%	13.4	

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 1 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Sample Runs (UPPER NATO I-TEQ)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.096		0.096
Uncertainty	±ng/m ³	0.020		0.020
Mass Emission	µg/hr	16.0		16.0
Uncertainty	±µg/hr	3.4		3.4

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.093		0.093
Uncertainty	±ng/m ³	0.019		0.019
Mass Emission	µg/hr	15.5		15.5
Uncertainty	±µg/hr	3.3		3.3

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.10		0.10
Uncertainty	±ng/m ³	0.022		0.022
Mass Emission	µg/hr	17.3		17.3
Uncertainty	±µg/hr	3.7		3.7

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.16		0.16
Uncertainty	±ng/m ³	0.034		0.034
Mass Emission	µg/hr	27.2		27.2
Uncertainty	±µg/hr	5.7		5.7

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 2 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Sample Runs (LOWER NATO I-TEQ)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.096		0.096
Uncertainty	±ng/m ³	0.020		0.020
Mass Emission	µg/hr	16.0		16.0
Uncertainty	±µg/hr	3.4		3.4

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.093		0.093
Uncertainty	±ng/m ³	0.019		0.019
Mass Emission	µg/hr	15.5		15.5
Uncertainty	±µg/hr	3.3		3.3

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.10		0.10
Uncertainty	±ng/m ³	0.022		0.022
Mass Emission	µg/hr	17.3		17.3
Uncertainty	±µg/hr	3.7		3.7

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.16		0.16
Uncertainty	±ng/m ³	0.034		0.034
Mass Emission	µg/hr	27.2		27.2
Uncertainty	±µg/hr	5.7		5.7

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 3 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Blank Runs (UPPER NATO I-TEQ)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.00085		0.00085

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.00088		0.00088

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.00086		0.00086

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.0012		0.0012

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Blank Runs (LOWER NATO I-TEQ)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.00085		0.00085

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.00088		0.00088

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.00086		0.00086

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.0012		0.0012

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 4 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	15.5		15.5
Uncertainty	±% v/v	0.81		0.81

General Sampling Information

Parameter	Value	
Standard	EN 1948	
Technical Procedure	CAT-TP-07	
Name of Analytical Laboratory	SAL	
Analytical Laboratory's Procedure	SOP 1C	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	24/03/2015	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Glassware Material	Borosilicate Glass	
Absorption Material	XAD-2	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	12 / 12	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A6, B1 - B6	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

DIOXINS & FURANS: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	772.5	
Stack static pressure, P_{static}	mmH ₂ O	-254.9	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	753.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	1025.3	
Total mass collected in impingers (silica trap)	g	53.8	
Total mass of liquid collected, V_{lc}	g	1079.1	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	1.3446	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m ³	7.9820	
Gas meter correction factor, Y_d	-	0.9550	
Average dry gas meter temperature, T_m	°C	17.7	
Average pressure drop across orifice, ΔH	mmH ₂ O	51.3	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	7.3109	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.1553	
B_{wo} as a percentage	% v/v	15.53	
Reported Water Vapour, checked with Tables in EN 14790, R_{wv}	% v/v	15.53	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd}) / (100 / (100 - R_{wv}))$	m ³	8.6554	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	6.54	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	7.85	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet ($O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$)	-	0.69	
O ₂ Reference Factor dry ($O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$)	-	0.76	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	12.5149	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	9.6155	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	11.50	
O ₂	% v/v	7.85	
Total	% v/v	19.35	
N ₂	% v/v	80.65	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	30.15	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.27	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.84	
Average of velocity heads, ΔP_{avg}	mmH ₂ O	28.53	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	5.34	
Average stack gas temperature, T_s	°C	177.8	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s	22.82	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})			
Area of stack, A_s	m ²	2.81	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	3842.0	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	2307.7	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	1949.2	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	3336.6	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	2563.6	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.89	
Nozzle area, A_n	mm ²	27.28	
Total sampling time, q	min	360	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	107.2	

DIOXINS & FURANS: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	08:45 - 11:45; 11:50 - 14:50
Sampling Dates	-	04/03/2015
Sampling Device	-	ISO
Volume Sampled (REF)	m ³	9.6155

Where: ISO stands for Manual Isokinetic Sampling Train

Parameter	Units	Result	DL	NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		% Rec
				TEQ1	TEQ2	TEQ1	TEQ2	TEQ1	TEQ2	TEQ1	TEQ2	
2378-TCDD	ng	0.0490	0.0027	0.0490	0.0490	0.0490	0.0490	0.0490	0.0490	0.0490	0.0490	73
12378-PeCDD	ng	0.2200	0.0017	0.1100	0.1100	0.2200	0.2200	0.2200	0.2200	0.2200	0.2200	117
123478-HxCDD	ng	0.2600	0.0023	0.0260	0.0260	0.0260	0.0260	0.1300	0.1300	0.0130	0.0130	87
123678-HxCDD	ng	0.6000	0.0026	0.0600	0.0600	0.0600	0.0600	0.0060	0.0060	0.0060	0.0060	78
123789-HxCDD	ng	0.3800	0.0026	0.0380	0.0380	0.0380	0.0380	0.0038	0.0038	0.0380	0.0380	-
1234678-HPeCDD	ng	2.8000	0.0040	0.0280	0.0280	0.0280	0.0280	0.0028	0.0028	0.0028	0.0028	80
OCDD	ng	3.5000	0.0061	0.0035	0.0035	0.0011	0.0011	0.0004	0.0004	0.0004	0.0004	66
Total Dioxins	ng	7.8090	-	0.3145	0.3145	0.4221	0.4221	0.4120	0.4120	0.3292	0.3292	-
2378-TCDF	ng	0.3300	0.0024	0.0330	0.0330	0.0330	0.0330	0.0165	0.0165	0.3300	0.3300	82
12378-PeCDF	ng	0.4300	0.0022	0.0215	0.0215	0.0129	0.0129	0.0215	0.0215	0.0430	0.0430	-
23478-PeCDF	ng	0.6400	0.0022	0.3200	0.3200	0.1920	0.1920	0.3200	0.3200	0.6400	0.6400	92
123478-HxCDF	ng	0.6100	0.0020	0.0610	0.0610	0.0610	0.0610	0.0610	0.0610	0.0610	0.0610	98
123678-HxCDF	ng	0.5700	0.0024	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570	84
234678-HxCDF	ng	0.8100	0.0022	0.0810	0.0810	0.0810	0.0810	0.0810	0.0810	0.0810	0.0810	91
123789-HxCDF	ng	0.2300	0.0022	0.0230	0.0230	0.0230	0.0230	0.0230	0.0230	0.0230	0.0230	-
1234678-HPeCDF	ng	1.4000	0.0049	0.0140	0.0140	0.0140	0.0140	0.0140	0.0140	0.0140	0.0140	82
1234789-HPeCDF	ng	0.2200	0.0049	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	-
OCDF	ng	0.6000	0.0047	0.0006	0.0006	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	85
Total Furans	ng	5.8400	-	0.6133	0.6133	0.4763	0.4763	0.5963	0.5963	1.2513	1.2513	-
Totals	ng	5.8400	-	0.9278	0.9278	0.8983	0.8983	1.0082	1.0082	1.5804	1.5804	-
Total Concentration	ng/m ³	-	-	0.0965	0.0965	0.0934	0.0934	0.1049	0.1049	0.1644	0.1644	-
Limit of Detection	ng/m ³	-	-	0.0007	-	0.0007	-	0.0008	-	0.0011	-	-

Where: ND stands for Non Detected

DL stands for Analytical Detection Limit

TEQ1 refers to Non Detected Congeners at the Detection Limit

TEQ2 refers to Non Detected Congeners at Zero

% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: SAMPLING DETAILS

(Continued)

BLANK 1

Parameter	Units	Value
Sampling Dates	-	04/03/2015
Sampling Device	-	ISO
Average Volume Sampled (REF)	m ³	9.6155

Where: ISO stands for Manual Isokinetic Sampling Train

Parameter	Units	Result	DL	NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		% Rec
				TEQ1	TEQ2	TEQ1	TEQ2	TEQ1	TEQ2	TEQ1	TEQ2	
2378-TCDD	ng	0.0021	0.0021	0.00210	0.00210	0.00210	0.00210	0.00210	0.00210	0.00210	0.00210	93
12378-PeCDD	ng	0.0020	0.0020	0.00100	0.00100	0.00200	0.00200	0.00200	0.00200	0.00200	0.00200	100
123478-HxCDD	ng	0.0022	0.0022	0.00022	0.00022	0.00022	0.00022	0.00110	0.00110	0.00011	0.00011	90
123678-HxCDD	ng	0.0054	0.0025	0.00054	0.00054	0.00054	0.00054	0.00005	0.00005	0.00005	0.00005	80
123789-HxCDD	ng	0.0043	0.0025	0.00043	0.00043	0.00043	0.00043	0.00004	0.00004	0.00043	0.00043	-
1234678-HPeCDD	ng	0.0590	0.0046	0.00059	0.00059	0.00059	0.00059	0.00006	0.00006	0.00006	0.00006	70
OCDD	ng	0.2300	0.0068	0.00023	0.00023	0.00007	0.00007	0.00002	0.00002	0.00002	0.00002	59
Total Dioxins	ng	0.3050	-	0.00511	0.00511	0.00595	0.00595	0.00538	0.00538	0.00478	0.00478	-
2378-TCDF	ng	0.0030	0.0025	0.00030	0.00030	0.00030	0.00030	0.00015	0.00015	0.00300	0.00300	79
12378-PeCDF	ng	0.0024	0.0024	0.00012	0.00012	0.00007	0.00007	0.00012	0.00012	0.00024	0.00024	-
23478-PeCDF	ng	0.0024	0.0024	0.00120	0.00120	0.00072	0.00072	0.00120	0.00120	0.00240	0.00240	82
123478-HxCDF	ng	0.0030	0.0020	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	0.00030	99
123678-HxCDF	ng	0.0023	0.0023	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023	87
234678-HxCDF	ng	0.0047	0.0021	0.00047	0.00047	0.00047	0.00047	0.00047	0.00047	0.00047	0.00047	94
123789-HxCDF	ng	0.0021	0.0021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	0.00021	-
1234678-HPeCDF	ng	0.0160	0.0053	0.00016	0.00016	0.00016	0.00016	0.00016	0.00016	0.00016	0.00016	75
1234789-HPeCDF	ng	0.0053	0.0053	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	-
OCDF	ng	0.0200	0.0056	0.00002	0.00002	6.0E-06	6.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	72
Total Furans	ng	0.0612	-	0.00306	0.00306	0.00252	0.00252	0.00290	0.00290	0.00707	0.00707	-
Totals	ng	0.0612	-	0.0082	0.0082	0.0085	0.0085	0.0083	0.0083	0.0118	0.0118	-
Total Concentration	ng/m ³	-	-	0.0008	0.0008	0.0009	0.0009	0.0009	0.0009	0.0012	0.0012	-

Where: ND stands for Non Detected
DL stands for Analytical Detection Limit
TEQ1 refers to Non Detected Congeners at the Detection Limit
TEQ2 refers to Non Detected Congeners at Zero
% Rec stands for the Recovery Percentage of the Sample

DIOXINS & FURANS: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	21.17	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.20	
Allowable Leak Rate	l/min	1.06	
Leak Test Acceptable	-	Yes	
Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	
MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.2	
Allowable MU	%	20	
MU Acceptable	%	Yes	
Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	107.2	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	
Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	120	
Condenser Exit Temperature	Units	Run 1	
Maximum Temperature Recorded	°C	19	
Maximum Allowable Temperature	°C	20	
Exit Temperature Acceptable	-	Yes	
Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

DIOXINS & FURANS: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	16.00	
Sampling Leak Rate	l/min	0.18	
Allowable Leak Rate	l/min	0.80	
Leak Test Acceptable	-	Yes	

Validity of NATO I-TEQ Blank vs ELV	Units	Blank 1	
Allowable Blank	ng/m ³	0.0100	
Blank Acceptable	-	Yes	

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	
There are no deviations associated with the sampling employed.	wx	

DIOXINS & FURANS (NATO I-TEQ): MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	7.9820		uV _m	m ³	0.1596	
Sampled Gas Temperature	T _m	290.7		uT _m	K	2.0	
Sampled Gas Pressure	p _m	100.5		uρ _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	0.94		uL	%	-	
Laboratory Result	L _r	10.00		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.69		≤1%
Sampled Gas Pressure	%	0.50		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.94		≤5%
Laboratory Result	%	10.00		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	7.3109		0.013	
Leak	L	ng/m ³	0.0005		1.00	
Laboratory Result	L _r	ng/m ³	0.0096		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	ng/m ³	0.0025	
Leak	ng/m ³	0.00053	
Laboratory Result	ng/m ³	0.0096	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	0.76	
Stack Gas O ₂ Content	% v/v	7.85	
MU for O ₂ Correction	-	0.03	
Overall MU For O ₂ Measurement	%	3.80	

Parameter	Units	Run 1	
Combined uncertainty	ng/m ³	0.010	
Expanded uncertainty (95% confidence), without Oxygen Correction	ng/m ³	0.020	
Expanded uncertainty (95% confidence), with Oxygen Correction	ng/m ³	0.020	
Expanded uncertainty (95% confidence), estimated with Method Deviations	ng/m ³	0.020	
Reported Uncertainty	ng/m ³	0.020	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.3	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.6	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.6	
Reported Uncertainty	%	20.6	

PCBs: RESULTS SUMMARY

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Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.0078		0.0078
Uncertainty	±ng/m ³	0.0016		0.0016
Mass Emission	µg/hr	1.3		1.3
Uncertainty	±µg/hr	0.27		0.27

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.00038		0.00038
Uncertainty	±ng/m ³	0.000079		0.000079
Mass Emission	µg/hr	0.064		0.064
Uncertainty	±µg/hr	0.013		0.013

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.015		0.015
Uncertainty	±ng/m ³	0.0031		0.0031
Mass Emission	µg/hr	2.5		2.5
Uncertainty	±µg/hr	0.52		0.52

PCBs: RESULTS SUMMARY

(PAGE 2 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.0078		0.0078
Uncertainty	±ng/m ³	0.0016		0.0016
Mass Emission	µg/hr	1.3		1.3
Uncertainty	±µg/hr	0.27		0.27

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.00038		0.00038
Uncertainty	±ng/m ³	0.000079		0.000079
Mass Emission	µg/hr	0.064		0.064
Uncertainty	±µg/hr	0.013		0.013

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1		Mean
Concentration	ng/m ³	0.015		0.015
Uncertainty	±ng/m ³	0.0031		0.0031
Mass Emission	µg/hr	2.5		2.5
Uncertainty	±µg/hr	0.52		0.52

PCBs: RESULTS SUMMARY

(PAGE 3 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

TEQ1 - UPPER LIMITS (worst case where <LOD = LOD)

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.0014		0.0014

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.000060		0.000060

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.0026		0.0026

TEQ2 - LOWER LIMITS (best case where <LOD = 0)

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.000000		0.000000

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.000000		0.000000

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m ³	0.000000		0.000000

PCBs: RESULTS SUMMARY

(PAGE 4 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	15.5		15.5
Uncertainty	±% v/v	0.81		0.81

General Sampling Information

Parameter	Value	
Standard	EN 1948	
Technical Procedure	CAT-TP-07	
Name of Analytical Laboratory	SAL	
Analytical Laboratory's Procedure	SOP 11	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	24/03/2015	
Probe Material	Titanium	
Filter Housing Material	Borosilicate Glass	
Glassware Material	Borosilicate Glass	
Absorption Material	XAD-2	
Positioning of Filter	Out Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	2 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	12 / 12	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A6, B1 - B6	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

PCBs: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	772.5	
Stack static pressure, P_{static}	mmH ₂ O	-254.9	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	753.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	1025.3	
Total mass collected in impingers (silica trap)	g	53.8	
Total mass of liquid collected, V_{lc}	g	1079.1	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	1.3446	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m ³	7.9820	
Gas meter correction factor, Y_d	-	0.9550	
Average dry gas meter temperature, T_m	°C	17.7	
Average pressure drop across orifice, ΔH	mmH ₂ O	51.3	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	7.3109	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.1553	
B_{wo} as a percentage	% v/v	15.53	
Reported Water Vapour, checked with Tables in EN 14790, R_{wv}	% v/v	15.53	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd}) / (100 / (100 - R_{wv}))$	m ³	8.6554	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	6.54	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	7.85	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet ($O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$)	-	0.69	
O ₂ Reference Factor dry ($O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$)	-	0.76	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	12.5149	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	9.6155	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	11.50	
O ₂	% v/v	7.85	
Total	% v/v	19.35	
N ₂	% v/v	80.65	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	30.15	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.27	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.84	
Average of velocity heads, ΔP_{avg}	mmH ₂ O	28.53	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	5.34	
Average stack gas temperature, T_s	°C	177.8	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s	22.82	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})			
Area of stack, A_s	m ²	2.81	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	3842.0	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	2307.7	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	1949.2	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	3336.6	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	2563.6	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.89	
Nozzle area, A_n	mm ²	27.28	
Total sampling time, q	min	360	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	107.2	

PCBs: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	08:45 - 11:45; 11:50 - 14:50
Sampling Dates	-	04/03/2015
Sampling Device	-	ISO
Volume Sampled (REF)	m ³	9.6155

Where: ISO stands for Manual Isokinetic Sampling Train

Parameter	Units	Result	DL	WHO Humans / Mammals		WHO Fish		WHO Birds		% Rec
				TEQ1	TEQ2	TEQ1	TEQ2	TEQ1	TEQ2	
PCB-81	ng	0.4000	0.1000	0.0001200	0.0001200	0.0002000	0.0002000	0.0400000	0.0400000	141
PCB-77	ng	0.6900	0.1000	0.0000690	0.0000690	0.0000690	0.0000690	0.0345000	0.0345000	132
PCB-105	ng	0.5900	0.1300	0.0000177	0.0000177	0.0000030	0.0000030	0.0000590	0.0000590	109
PCB-114	ng	0.2200	0.1000	0.0000066	0.0000066	0.0000011	0.0000011	0.0000220	0.0000220	113
PCB-118	ng	0.8100	0.1900	0.0000243	0.0000243	0.0000041	0.0000041	0.0000081	0.0000081	103
PCB-123	ng	ND	0.2500	0.0000075	0.0000000	0.0000013	0.0000000	0.0000025	0.0000000	119
PCB-126	ng	0.6800	0.1000	0.0680000	0.0680000	0.0034000	0.0034000	0.0680000	0.0680000	116
PCB-156	ng	0.3400	0.1100	0.0000102	0.0000102	0.0000017	0.0000017	0.0000340	0.0000340	92
PCB-157	ng	0.5600	0.1100	0.0000168	0.0000168	0.0000028	0.0000028	0.0000560	0.0000560	93
PCB-167	ng	0.2100	0.1200	0.0000063	0.0000063	0.0000011	0.0000011	0.0000021	0.0000021	86
PCB-169	ng	0.2200	0.1000	0.0066000	0.0066000	0.0000110	0.0000110	0.0002200	0.0002200	77
PCB-189	ng	0.4800	0.3300	0.0000144	0.0000144	0.0000024	0.0000024	0.0000048	0.0000048	34
Totals	ng	5.2000	-	0.074893	0.074885	0.003697	0.003696	0.142909	0.142906	-
Total Concentration	ng/m ³	-	-	0.007789	0.007788	0.000385	0.000384	0.014862	0.014862	-
Limit of Detection	ng/m ³	-	-	0.001360	-	0.000059	-	0.002616	-	-

Where: ND stands for Non Detected
DL stands for Analytical Detection Limit
TEQ1 refers to Non Detected Congeners at the Detection Limit
TEQ2 refers to Non Detected Congeners at Zero
% Rec stands for the Recovery Percentage of the Sample

PCBs: SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	04/03/2015
Sampling Device	-	ISO
Volume Sampled (REF)	m ³	9.6155

Where: ISO stands for Manual Isokinetic Sampling Train

Parameter	Units	Result	DL	WHO Humans / Mammals		WHO Fish		WHO Birds		% Rec
				TEQ1	TEQ2	TEQ1	TEQ2	TEQ1	TEQ2	
PCB-81	ng	ND	0.1000	0.0000300	0.0000000	0.0000500	0.0000000	0.0100000	0.0000000	117
PCB-77	ng	ND	0.1000	0.0000100	0.0000000	0.0000100	0.0000000	0.0050000	0.0000000	106
PCB-105	ng	ND	0.2500	0.0000075	0.0000000	0.0000013	0.0000000	0.0000250	0.0000000	99
PCB-114	ng	ND	0.1000	0.0000030	0.0000000	0.0000005	0.0000000	0.0000100	0.0000000	94
PCB-118	ng	ND	0.5500	0.0000165	0.0000000	0.0000028	0.0000000	0.0000055	0.0000000	91
PCB-123	ng	ND	0.1000	0.0000030	0.0000000	0.0000005	0.0000000	0.0000010	0.0000000	103
PCB-126	ng	ND	0.1000	0.0100000	0.0000000	0.0005000	0.0000000	0.0100000	0.0000000	87
PCB-156	ng	ND	0.1100	0.0000033	0.0000000	0.0000006	0.0000000	0.0000110	0.0000000	88
PCB-157	ng	ND	0.1100	0.0000033	0.0000000	0.0000006	0.0000000	0.0000110	0.0000000	89
PCB-167	ng	ND	0.1200	0.0000036	0.0000000	0.0000006	0.0000000	0.0000012	0.0000000	81
PCB-169	ng	ND	0.1000	0.0030000	0.0000000	0.0000050	0.0000000	0.0001000	0.0000000	59
PCB-189	ng	ND	0.1100	0.0000033	0.0000000	0.0000006	0.0000000	0.0000011	0.0000000	43
Totals	ng	0.0000	-	0.013084	0.0000000	0.000572	0.0000000	0.025166	0.0000000	-
Total Concentration	ng/m ³	-	-	0.001361	0.0000000	0.000060	0.0000000	0.002617	0.0000000	-

Where: ND stands for Non Detected
DL stands for Analytical Detection Limit
TEQ1 refers to Non Detected Congeners at the Detection Limit
TEQ2 refers to Non Detected Congeners at Zero
% Rec stands for the Recovery Percentage of the Sample

PCBs: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	21.17	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.20	
Allowable Leak Rate	l/min	1.06	
Leak Test Acceptable	-	Yes	
Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	
MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.2	
Allowable MU	%	20	
MU Acceptable	%	Yes	
Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	107.2	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	
Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	120	
Condenser Exit Temperature	Units	Run 1	
Maximum Temperature Recorded	°C	19	
Maximum Allowable Temperature	°C	20	
Exit Temperature Acceptable	-	Yes	
Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

PCBs: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	16.00	
Sampling Leak Rate	l/min	0.18	
Allowable Leak Rate	l/min	0.80	
Leak Test Acceptable	-	Yes	

Validity of WHO TEQ H/M Blank vs ELV	Units	Blank 1	
Allowable Blank	ng/m ³	N/A	
Blank Acceptable	-	N/A	

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	
There are no deviations associated with the sampling employed.	wx	

PCBs (WHO TEQ HUMANS / MAMMALS): MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	7.9820		uV _m	m ³	0.1596	
Sampled Gas Temperature	T _m	290.7		uT _m	K	2.0	
Sampled Gas Pressure	p _m	100.5		uρ _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	0.94		uL	%	-	
Laboratory Result	L _r	10.00		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.69		≤1%
Sampled Gas Pressure	%	0.50		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.94		≤5%
Laboratory Result	%	10.00		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	7.3109		1.1E-03	
Leak	L	ng/m ³	4E-05		1.00	
Laboratory Result	L _r	ng/m ³	8E-04		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	ng/m ³	2E-04	
Leak	ng/m ³	4E-05	
Laboratory Result	ng/m ³	8E-04	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	0.76	
Stack Gas O ₂ Content	% v/v	7.85	
MU for O ₂ Correction	-	0.03	
Overall MU For O ₂ Measurement	%	3.80	

Parameter	Units	Run 1	
Combined uncertainty	ng/m ³	0.0008	
Expanded uncertainty (95% confidence), without Oxygen Correction	ng/m ³	0.0016	
Expanded uncertainty (95% confidence), with Oxygen Correction	ng/m ³	0.0016	
Expanded uncertainty (95% confidence), estimated with Method Deviations	ng/m ³	0.0016	
Reported Uncertainty	ng/m ³	0.0016	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.3	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.6	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.6	
Reported Uncertainty	%	20.6	

PAHs: RESULTS SUMMARY (Page 1 of 2)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Sample Runs

DEFRA 16

Parameter	Units	Run 1		Mean
Concentration	µg/m ³	1.5		1.5
Uncertainty	±µg/m ³	0.32		0.32
Mass Emission	g/hr	0.25		0.25
Uncertainty	±g/hr	0.054		0.054

NOTE: Where the maximum Blank concentration is higher than the Sample concentration, the Blank concentration has been reported.

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	18.2		18.2
Uncertainty	±% v/v	0.95		0.95

PAHs: RESULTS SUMMARY (Page 2 of 2)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Blank Runs

DEFRA 16

Parameter	Units	Blank 1	Maximum
Concentration	µg/m ³	1.5	1.5

General Sampling Information

Parameter	Value
Standard	ISO 11338
Technical Procedure	CAT-TP-08
Name of Analytical Laboratory	SAL
Analytical Laboratory's Procedure	SOP 12K
ISO 17025 Accredited Analysis?	Yes
Date of Sample Analysis	20/03/2015
Probe Material	Titanium
Filter Housing Material	Borosilicate Glass
Glassware Material	Borosilicate Glass
Absorption Material	XAD-2
Positioning of Filter	Out Stack
Filter Size and Material	47mm Quartz Fibre
Number of Sampling Lines Used	2
Number of Sampling Points Used	12 / 12
Sample Point I.D.'s	A1 - A6, B1 - B6

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

PAHs: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	762.0	
Stack static pressure, P_{static}	mmH ₂ O	-254.9	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	743.3	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	1253.4	
Total mass collected in impingers (silica trap)	g	54.6	
Total mass of liquid collected, V_{lc}	g	1308.0	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	1.6298	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m ³	8.1860	
Gas meter correction factor, Y_d	-	0.9550	
Average dry gas meter temperature, T_m	°C	20.7	
Average pressure drop across orifice, ΔH	mmH ₂ O	51.2	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	7.3217	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.1821	
B_{wo} as a percentage	% v/v	18.21	
Reported Water Vapour, checked with Tables in EN 14790, R_{wv}	% v/v	18.21	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m ³	8.9515	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	6.10	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	7.32	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet ($O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$)	-	0.67	
O ₂ Reference Factor dry ($O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$)	-	0.73	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	13.3375	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	10.0179	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	11.50	
O ₂	% v/v	7.32	
Total	% v/v	18.82	
N ₂	% v/v	81.18	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	30.13	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	27.92	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.84	
Average of velocity heads, ΔP_{avg}	mmH ₂ O	26.99	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	5.19	
Average stack gas temperature, T_s	°C	140.1	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s	21.53	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})			
Area of stack, A_s	m ²	2.81	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	3624.4	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	2342.4	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	1915.9	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	3490.1	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	2621.4	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.89	
Nozzle area, A_n	mm ²	27.28	
Total sampling time, q	min	360	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	109.2	

PAHs: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	10:10 - 17:16	
Sampling Dates	-	03/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	10.0179	
Anthanthrene	µg	< 0.10	
Benzo(a)anthracene	µg	< 0.10	
Benzo(a)pyrene	µg	< 0.10	
Benzo(b)fluoranthene	µg	< 0.10	
Benzo(b)naphtho(2,1-d)thiophene	µg	< 0.10	
Benzo(c)phenanthrene	µg	< 0.10	
Benzo(ghi)perylene	µg	< 0.10	
Benzo(k)fluoranthene	µg	< 0.10	
Cholanthrene	µg	< 0.10	
Chrysene	µg	< 0.10	
Cyclopenta(cd)pyrene	µg	< 0.10	
Dibenzo (ai) pyrene	µg	< 0.10	
Dibenzo(ah)anthracene	µg	< 0.10	
Fluoranthene	µg	0.20	
Indeno(123-cd)pyrene	µg	< 0.10	
Naphthalene	µg	2.6	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	03/03/2015	
Average Volume Sampled (REF)	m ³	10.018	
Anthanthrene	µg	< 0.10	
Benzo(a)anthracene	µg	< 0.10	
Benzo(a)pyrene	µg	< 0.10	
Benzo(b)fluoranthene	µg	0.70	
Benzo(b)naphtho(2,1-d)thiophene	µg	< 0.10	
Benzo(c)phenanthrene	µg	< 0.10	
Benzo(ghi)perylene	µg	< 0.10	
Benzo(k)fluoranthene	µg	0.40	
Cholanthrene	µg	< 0.10	
Chrysene	µg	< 0.10	
Cyclopenta(cd)pyrene	µg	< 0.10	
Dibenzo (ai) pyrene	µg	< 0.10	
Dibenzo(ah)anthracene	µg	< 0.10	
Fluoranthene	µg	< 0.10	
Indeno(123-cd)pyrene	µg	< 0.10	
Naphthalene	µg	13.0	

PAHs: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	21.7	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.14	
Allowable Leak Rate	l/min	1.1	
Leak Test Acceptable	-	Yes	

Detection Limit	Units	Run 1	
Anthanthrene	µg/m ³	0.010	
Benzo(a)anthracene	µg/m ³	0.010	
Benzo(a)pyrene	µg/m ³	0.010	
Benzo(b)fluoranthene	µg/m ³	0.010	
Benzo(b)naphtho(2,1-d)thiophene	µg/m ³	0.010	
Benzo(c)phenanthrene	µg/m ³	0.010	
Benzo(ghi)perylene	µg/m ³	0.010	
Benzo(k)fluoranthene	µg/m ³	0.010	
Cholanthrene	µg/m ³	0.010	
Chrysene	µg/m ³	0.010	
Cyclopenta(cd)pyrene	µg/m ³	0.010	
Dibenzo (ai) pyrene	µg/m ³	0.010	
Dibenzo(ah)anthracene	µg/m ³	0.010	
Fluoranthene	µg/m ³	0.010	
Indeno(123-cd)pyrene	µg/m ³	0.010	
Naphthalene	µg/m ³	0.010	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.2	
Allowable MU	%	20	
MU Acceptable	%	Yes	

Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	

Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	109.2	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	120	

Condenser Exit Temperature	Units	Run 1	
Maximum Temperature Recorded	°C	20	
Maximum Allowable Temperature	°C	20	
Exit Temperature Acceptable	-	Yes	

PAHs: QUALITY ASSURANCE

(PAGE 2 OF 2)

Sample Runs (continued)

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	15.00	
Sampling Leak Rate	l/min	0.11	
Allowable Leak Rate	l/min	0.75	
Leak Test Acceptable	-	Yes	

DEFRA 16

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	µg/m ³	N/A	
Blank Acceptable	-	N/A	

Method Deviations

Nature of Deviation	Run Number	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	
There are no deviations associated with the sampling employed.	wx	

PAHs (DEFRA 16): MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	8.1860		uV _m	m ³	0.1637	
Sampled Gas Temperature	T _m	293.7		uT _m	K	2.0	
Sampled Gas Pressure	p _m	99.1		uρ _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	0.64		uL	%	-	
Laboratory Result	L _r	10.00		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.68		≤1%
Sampled Gas Pressure	%	0.50		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.64		≤5%
Laboratory Result	%	10.00		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	7.3217		0.21	
Leak	L	μg/m ³	0.006		1.00	
Laboratory Result	L _r	μg/m ³	0.154		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	μg/m ³	0.040	
Leak	μg/m ³	0.0057	
Laboratory Result	μg/m ³	0.1537	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	0.73	
Stack Gas O ₂ Content	% v/v	7.32	
MU for O ₂ Correction	-	0.03	
Overall MU For O ₂ Measurement	%	3.65	

Parameter	Units	Run 1	
Combined uncertainty	μg/m ³	0.16	
Expanded uncertainty (95% confidence), without Oxygen Correction	μg/m ³	0.31	
Expanded uncertainty (95% confidence), with Oxygen Correction	μg/m ³	0.32	
Expanded uncertainty (95% confidence), estimated with Method Deviations	μg/m ³	0.32	
Reported Uncertainty	μg/m ³	0.32	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.3	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.6	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.6	
Reported Uncertainty	%	20.6	

HYDROGEN FLUORIDE: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A1 - Stream 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m ³	< 0.027		< 0.027
Uncertainty	±mg/m ³	0.0041		0.0041
Mass Emission	g/hr	< 4.5		< 4.5
Uncertainty	±g/hr	0.70		0.70

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	16.1		16.1
Uncertainty	±% v/v	0.68		0.68

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	< 0.020		< 0.020

General Sampling Information

Parameter	Value
Standard	ISO 15713
Technical Procedure	CAT-TP-10
Name of Analytical Laboratory	CAT
Analytical Laboratory's Procedure	CAT-AP-01
ISO 17025 Accredited Analysis?	Yes
Date of Sample Analysis	12/03/2015
Probe Material	Monel
Filter Housing Material	Monel
Impinger Material	Polyethylene
Absorption Solution	0.1 mol/l Sodium Hydroxide
Positioning of Filter	In Stack
Filter Size and Material	47mm Quartz Fibre
Number of Sampling Lines Used	1 / 1
Number of Sampling Points Used	1 / 1
Sample Point I.D.'s	A3

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

HYDROGEN FLUORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	09:30 - 10:30	
Sampling Dates	-	05/03/2015	
Sampling Device	-	MFC / MV	
Duration	mins	60	
Volume Sampled (STP, Dry)	m ³	0.7245	
Volume Sampled (STP, Wet)	m ³	0.8638	
Volume Sampled (REF)	m ³	0.9940	
Sample Flow Rate	l/min	11.64	
Laboratory Result for Front Impingers	µg/ml	< 0.05	
Laboratory Result for Back Impinger	µg/ml	< 0.05	
Volume in Front Impingers	ml	372.8	
Volume in Back Impinger	ml	169.6	
Mass in Front Impingers	µg	< 18.6	
Mass in Back Impinger	µg	< 8.5	
Total Mass Collected	µg	< 27.1	
Calculated Concentration	mg/m ³	< 0.03	
Liquid Trap Start Mass	g	1526.3	
Liquid Trap End Mass	g	1634.4	
Silica Trap Start Mass	g	1331.1	
Silica Trap End Mass	g	1334.8	
Total Mass Of Water Vapour	g	111.8	
Calculated Water Vapour	% v/v	16.13	

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	05/03/2015	
Average Volume Sampled (REF)	m ³	0.9940	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	393.4	
Total Mass Collected	µg	< 19.7	
Calculated Concentration	mg/m ³	< 0.02	

HYDROGEN FLUORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	11.64	
Pre-Sampling Leak Rate	l/min	0.11	
Post-Sampling Leak Rate	l/min	0.13	
Allowable Leak Rate	l/min	0.23	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	100.0	
Allowable Absorption Efficiency	%	N/A ²	
Absorption Efficiency Acceptable	-	N/A ²	

² The concentration is less than 30% of the ELV, therefore no assessment against an allowable efficiency is required.

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	4.2	
Allowable MU	%	20	
MU Acceptable	%	Yes	

Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	12.00	
Pre-Sampling Leak Rate	l/min	0.12	
Post-Sampling Leak Rate	l/min	0.10	
Allowable Leak Rate	l/min	0.24	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	0.2	
Blank Acceptable	-	Yes	

Method Deviations

Nature of Deviation	Run Number
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1
There are no deviations associated with the sampling employed.	wx

HYDROGEN FLUORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (STP)	V _m	0.7245		uV _m	m ³	0.0145	
Leak	L	1.12		uL	%	-	
Laboratory Result	L _r	7.05		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	1.12		≤2%
Laboratory Result	%	7.05		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	0.7245		0.038	
Leak	L	mg/m ³	0.0002		1.00	
Laboratory Result	L _r	mg/m ³	0.0019		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.0005	
Leak	mg/m ³	0.0002	
Laboratory Result	mg/m ³	0.0019	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	0.73	
Stack Gas O ₂ Content	% v/v	7.28	
MU for O ₂ Correction	-	0.03	
Overall MU For O ₂ Measurement	%	3.64	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	0.0020	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.0039	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	0.0041	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.0041	
Reported Uncertainty	mg/m ³	0.0041	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	14.4	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	14.9	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	14.9	
Reported Uncertainty	%	14.9	

OXYGEN: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	% v/v	7.2	7.7	7.7	7.5
Uncertainty	±% v/v	0.23	0.24	0.25	0.24

General Sampling Information

Parameter	Value
Standard	EN 14789
Technical Procedure	CAT-TP-21
Probe Material	Stainless Steel
Filtration Type / Size	0.1µm Glass Fibre
Heated Head Filter Used	N/A
Heated Line Temperature	Orsat Used
Span Gas Type	Synthetic Air (5 Grade)
Span Gas Reference Number	CYL 11.0154
Span Gas Expiry Date	06/02/2019
Span Gas Start Pressure (bar)	40
Gas Cylinder Concentration (% v/v)	21.07
Span Gas Uncertainty (%)	2
Zero Gas Type	Nitrogen (5 Grade)
Number of Sampling Lines Used	2 / 2
Number of Sampling Points Used	12 / 12
Sample Point I.D.'s	A1 - A6, B1 - B6

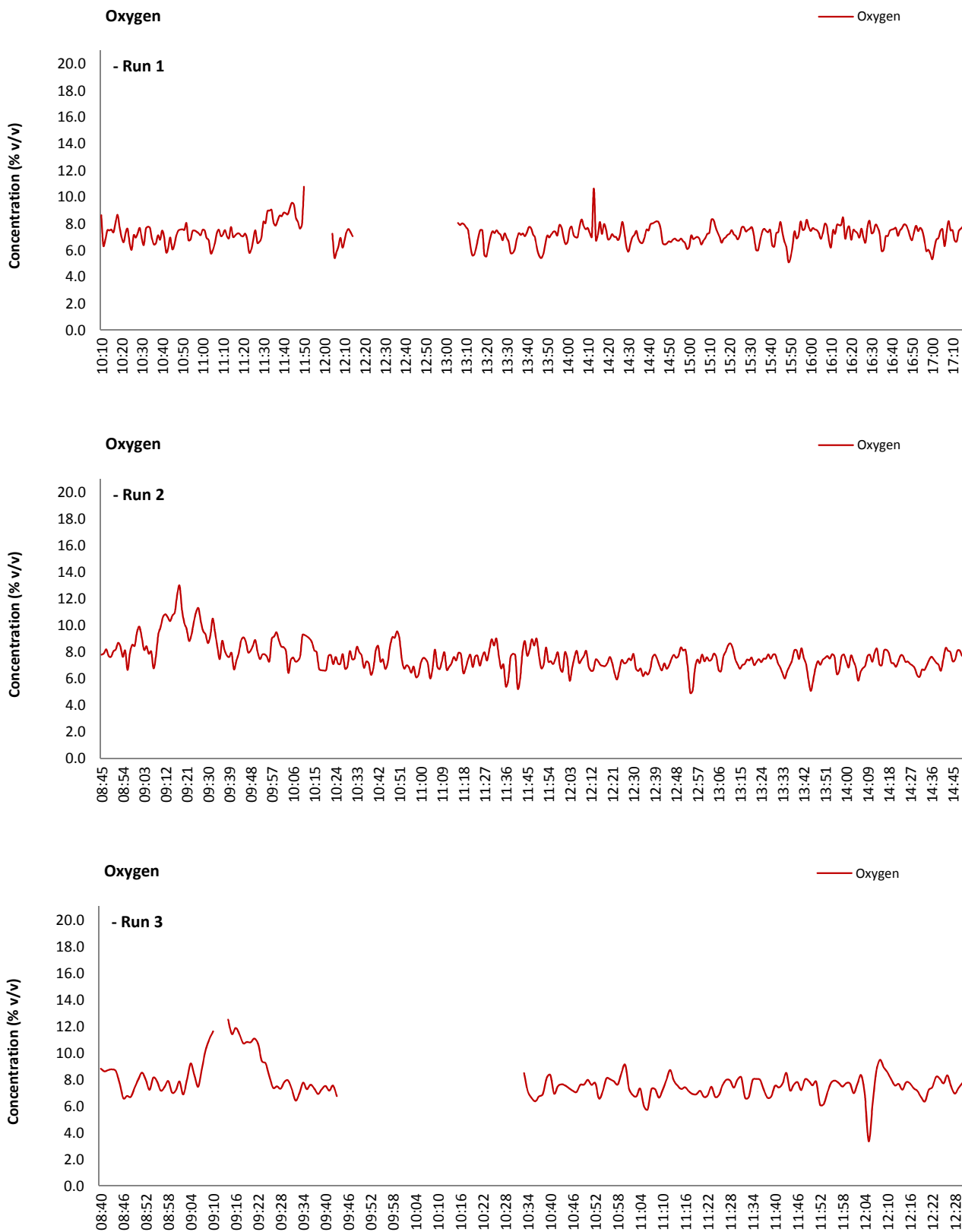
NOTE: Dilution performed to achieve correct span value

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

OXYGEN: DATA TREND

Graphical Trend of Data



OXYGEN: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	10:10 - 17:16	08:45 - 14:50	08:40 - 12:30
Sampling Dates	-	03/03/2015	04/03/2015	05/03/2015
Instrument Range	% v/v	25	25	25
Span Gas Value	% v/v	11.00	11.00	11.00

Quality Assurance

Conditioning Unit Temperature	Units	Run 1	Run 2	Run 3
Average Temperature	°C	N/A	N/A	N/A
Allowable Temperature	< °C	N/A	N/A	N/A
Temperature Acceptable	-	N/A	N/A	N/A

Zero Drift	Units	Run 1	Run 2	Run 3
Zero Down Sampling Line (Pre)	% v/v	0.08	0.10	0.10
Zero Down Sampling Line (Post)	% v/v	0.10	0.13	0.06
Zero Drift	% v/v	0.02	0.03	-0.04
Allowable Zero Drift	± % v/v	0.55	0.55	0.55
Zero Drift Acceptable	-	Yes	Yes	Yes

Span Drift	Units	Run 1	Run 2	Run 3
Span Down Sampling Line (Pre)	% v/v	11.12	11.10	11.25
Span Down Sampling Line (Post)	% v/v	10.86	10.94	10.77
Span Drift	% v/v	-0.26	-0.16	-0.48
Allowable Span Drift	± % v/v	0.55	0.55	0.55
Span Drift Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Run Ambient Temperature Range	°C	18 - 22	15 - 25	15 - 21

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number		
	1	2	3
There are no deviations associated with the sampling employed.	x	x	x

OXYGEN: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Limit value	N/A	N/A	N/A	%vol
TGN M2 Allowable MU	6.0	6.0	6.0	%
Measured concentration	7.22	7.67	7.75	%vol
Range Used	25.0	25.0	25.0	%vol
Cal gas conc.	21.1	21.1	21.1	%vol

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Response time	110	110	110	seconds
Number of readings in measurement	360	360	230	-
Repeatability at zero	0.030	0.030	0.030	% full scale
Repeatability at span level	0.030	0.030	0.030	% full scale
Deviation from linearity	0.10	0.10	0.10	% of value
Zero drift	0.18	0.27	-0.36	% full scale
Span drift	0.00	-1.44	0.00	% full scale
Volume or pressure flow dependence	0.080	0.080	0.080	% of full scale
Atmospheric pressure dependence	0.91	0.91	0.91	% of value/kPa
Ambient temperature dependence	0.15	0.15	0.15	% full scale/10K
Combined interference	0.19	0.19	0.19	% range
Dependence on voltage	0.050	0.050	0.050	% full scale/10V
Losses in the line (leak)	0.00	0.00	0.18	% of value
Uncertainty of calibration gas	2.00	2.00	2.00	% of value

Performance characteristic	RUN 1	RUN 2	RUN 3	Units
Standard deviation of repeatability at zero	use rep at span	use rep at span	use rep at span	%vol
Standard deviation of repeatability at span level	0.0016	0.0016	0.0020	%vol
Lack of fit	0.014	0.014	0.014	%vol
Drift	0.022	-0.031	-0.043	%vol
Volume or pressure flow dependence	0.00012	0.00012	0.00012	%vol
Atmospheric pressure dependence	0.066	0.066	0.066	%vol
Ambient temperature dependence	0.022	0.022	0.022	%vol
Combined interference (from MCERTS Certificate)	0.027	0.027	0.027	%vol
Dependence on voltage	0.0058	0.0058	0.0058	%vol
Losses in the line (leak)	0.0000	0.0000	0.0081	%vol
Uncertainty of calibration gas	0.083	0.089	0.089	%vol

		RUN 1	RUN 2	RUN 3	Units
Measurement uncertainty	Result	7.22	7.67	7.75	%vol
Combined uncertainty		0.12	0.12	0.13	%vol
Expanded uncertainty	k = 1.96	0.23	0.24	0.25	%vol

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O ₂) - at 95% Confidence	3.21	3.16	3.25	% of Value
Result of Compliance with Uncertainty Requirement in M2	COMPLIANT	COMPLIANT	COMPLIANT	-

Requirement for SRM is that Uncertainty should be 0.5%vol absolute or 6% relative whichever is the lower, on a dry gas basis. Ref EA TGN M2.

NITROUS OXIDE: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m ³	0.63		0.63
Uncertainty	±mg/m ³	0.67		0.67
Mass Emission	g/hr	104		104
Uncertainty	±g/hr	111		111

General Sampling Information

Parameter	Value	
Standard	TGN M22	
Technical Procedure	CAT-TP-22(b)	
Analysis Areas (Wave Number Limits)	2000 - 2222 & 2540 - 2590	
Sampling System Path Length (m)	5	
Sample Cell Temperature (°C)	180	
Sample Cell Pressure (mbar)	1013	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Check Gas Type	NO	
Check Gas Reference Number	CYL 12.0031	
Check Gas Expiry Date	20/06/2016	
Check Gas Start Pressure (bar)	80	
Gas Cylinder Concentration (ppm)	400.2	
Check Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

References Used in Analytical Algorithm Application

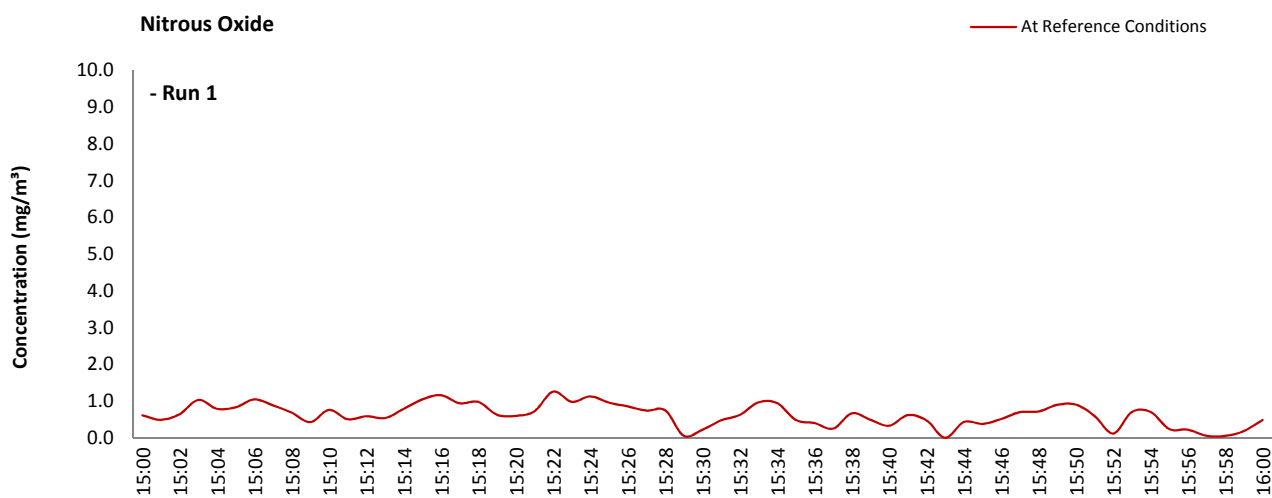
Type of Reference	Concentration of References
Instrument Specific	50.00

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

NITROUS OXIDE: DATA TREND

Graphical Trend of Data



NITROUS OXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

RUN 1				Measured (ppm)		0.37
Nitrous Oxide				Range (ppm)		10
Source of Uncertainty	Value (±%)	Probability Distribution	Divisor	Conversion Factor	ui ppm	
Lack of Fit	0.60	rectangular	√3	0.0037	0.0013	
Zero Drift	0.50	rectangular	√3	0.1	0.029	
Span Drift	2.00	rectangular	√3	0.1	0.12	
Sensitivity to Atmospheric Pressure	N/A	rectangular	√3	N/A	0.00	
Sensitivity to Sample Gas Pressure	N/A	rectangular	√3	N/A	0.00	
Sensitivity to Ambient Temperature	0.60	rectangular	√3	0	0.00	
Sensitivity to Electrical Voltage	-0.10	rectangular	√3	0.0	-0.0012	
Interferents	2.70	rectangular	√3	0.1	0.16	
Standard Deviation of Repeatability at Zero	0.05	normal	1	0.1	0.0050	
Standard Deviation of Repeatability at Span	N/A	normal	1	N/A	0.00	
Uncertainty of Certified Reference Material	2.00	normal	2	0.0037	0.0037	
Combined Uncertainty	-	normal	-	-	0.20	
Expanded Uncertainty (ppm)	-	t-distribution (k=2)	-	-	0.39	
Expanded Uncertainty (%age of Reading)	-	t-distribution (k=2)	-	-	106.43	

WATER VAPOUR: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A1 - Stream 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	% v/v	18.5		18.5
Uncertainty	% v/v	0.85		0.85

General Sampling Information

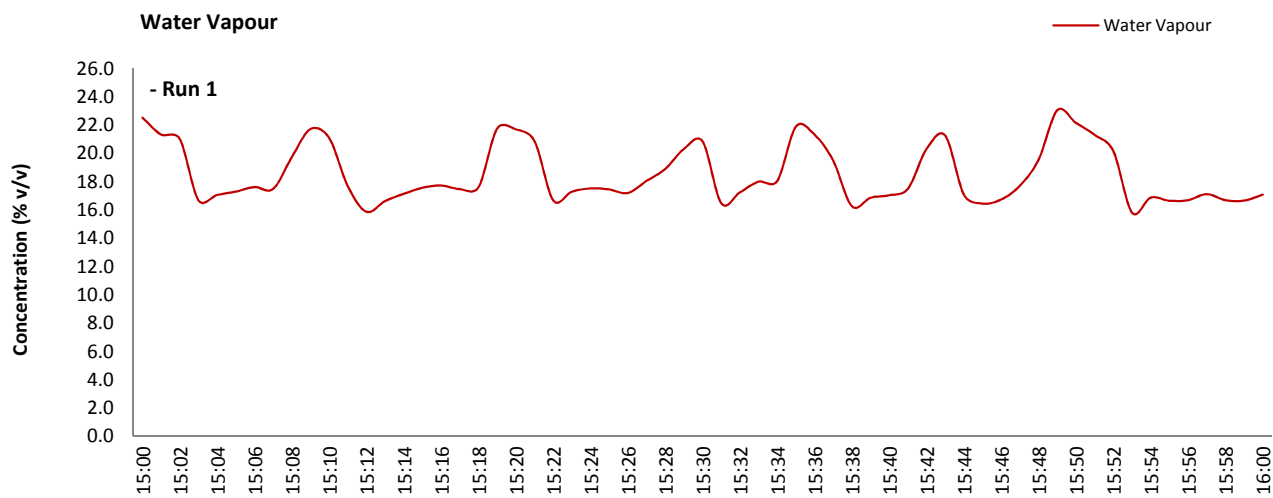
Parameter	Value	
Standard	TGN M22	
Technical Procedure	CAT-TP-22(b)	
Analysis Areas (Wave Number Limits)	3200 - 3401	
Sampling System Path Length (m)	5	
Sample Cell Temperature (°C)	180	
Sample Cell Pressure (mbar)	1013	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Check Gas Type	C ₃ H ₈	
Check Gas Reference Number	CYL 12.0031	
Check Gas Expiry Date	20/06/2016	
Check Gas Start Pressure (bar)	80	
Gas Cylinder Concentration (ppm)	81.23	
Check Gas Uncertainty (%)	2	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

References Used in Analytical Algorithm Application

Type of Reference	Concentration of References
Instrument Specific	30.00

WATER VAPOUR: DATA TREND

Graphical Trend of Data



WATER VAPOUR: MEASUREMENT UNCERTAINTY CALCULATIONS

RUN 1				Measured (% v/v)		18.50
Water Vapour				Range (%v/v)		20
Source of Uncertainty	Value (±%)	Probability Distribution	Divisor	Conversion Factor	ui % v/v	
Lack of Fit	0.32	rectangular	√3	0.185	0.034	
Zero Drift	0.50	rectangular	√3	0.2	0.058	
Span Drift	2.00	rectangular	√3	0.2	0.23	
Sensitivity to Atmospheric Pressure	N/A	rectangular	√3	N/A	0.00	
Sensitivity to Sample Gas Pressure	N/A	rectangular	√3	N/A	0.00	
Sensitivity to Ambient Temperature	-1.00	rectangular	√3	0	0.00	
Sensitivity to Electrical Voltage	0.12	rectangular	√3	0.0	0.0027	
Interferents	3.90	rectangular	√3	0.2	0.45	
Standard Deviation of Repeatability at Zero	0.05	normal	1	0.2	0.010	
Standard Deviation of Repeatability at Span	N/A	normal	1	N/A	0.00	
Uncertainty of Certified Reference Material	2.00	normal	2	0.185	0.19	
Combined Uncertainty	-	normal	-	-	0.54	
Expanded Uncertainty (% v/v)	-	t-distribution (k=2)	-	-	1.09	
Expanded Uncertainty (%age of Reading)	-	t-distribution (k=2)	-	-	5.87	

M22 FTIR SAMPLING DETAILS & QUALITY ASSURANCE

(PAGE 1 OF 2)

Sampling Details

Parameter	Units	Run 1	
Sampling Times	-	15:00 - 16:00	
Sampling Date	-	03/03/2015	

Quality Assurance

	Background / Zero Calibration Check	Units	Value
CAL 1	Minimum Energy in Cell	AU	-0.0005
	Maximum Energy in Cell	AU	0.0011
	Allowable Energy in Cell	± AU	0.0050

Test Conditions	Units	Run 1	
Run Ambient Temperature Range	°C	12 - 14°C	

Method Deviations

Nature of Deviation	Run Number
(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x

Interference Check

Target Parameter	DAY 1	
Nitrous Oxide	P	
Water Vapour	P	

where "P" = Pass and "F" = Fail

M22 FTIR SAMPLING DETAILS & QUALITY ASSURANCE

(PAGE 2 OF 2)

					REACTIVE GAS CHECK
Check Gas Check - Pre Test					SO ₂
Units	NO		C ₃ H ₈		
Response Time, T ₉₀	s	35	35		30
Reverse Response Time, RT ₉₀	s	20	(performed against decreasing H ₂ O)		
Allowable Response Time	s	200	200		200
Response Time Acceptable	-	Yes	Yes		Yes
Response Time from ASC, ASC T ₉₀	s	20	20		20
System Lag Time [ASC T ₉₀ - T ₉₀]	s	15	15		10
Check Gas Reference Number	-	CYL 12.0031	CYL 12.0031		CYL 12.0031
CAL 1 03/03/2015	Check Gas Value	ppm	400.2	81.2	103.4
	Check Gas Reading on Analyser	ppm	400.7	80.3	98.4
	Difference	ppm	0.5	-0.9	-5.0
	Allowable Difference	± ppm	20.0	4.1	10.3
	Check Gas Acceptable	-	Yes	Yes	Yes
Check Gas Check - Post Test					SO ₂
Units	NO		C ₃ H ₈		
CAL 1 03/03/2015	Check Gas Reading - Pre Test	ppm	400.7	80.3	98.4
	Check Gas Reading - Post Test	ppm	399.8	80.1	96.8
	Difference	ppm	-0.9	-0.2	-1.7
	Drift	%	-0.2	-0.3	
	Allowable Drift	± %	5.0	5.0	
	Drift Acceptable	-	Yes	Yes	

NOTE: Drift correction will be automatically applied to the data if the maximum check gas drift is between 2 - 5%.