ISO/IEC 17025 Accredited Legal Entity, UKAS Accredited Testing Laboratory No. 4279
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Stack Emissions Testing Report Commissioned by
Viridor Waste Management Ltd

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

EPR Permit: EPR/LP3030XA

Stack Reference
A2 - Stream 2

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


CONTENTS

Opinions and interpretations expressed herein are outside the scope of Exova Catalyst's ISO 17025 accreditation.

MONITORING OBJECTIVES

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2
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 A2 - Stream 2 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

PM_{10}, $PM_{2.5}$, Cadmium & Thallium, Heavy Metals, Mercury, Dioxins & Furans, PCBs, PAHs (DEFRA 16), Hydrogen Fluoride, Nitrous Oxide

Executive Summary

MONITORING RESULTS

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2
3rd - 5th March 2015

where MU = Measurement Uncertainty associated with the Result

		Concentration				Mass Emission			
Parameter		**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
PM_{10}	[1]	mg/m³	0.095	0.19	-	g/hr	13.5	26.7	-
$PM_{2.5}$	[1]	mg/m³	0.071	0.14	-	g/hr	10.1	20.2	-
Cadmium & Thallium	[1]	mg/m³	< 0.00079	0.00023	0.05	g/hr	< 0.11	0.033	-
Heavy Metals	[1]	mg/m³	0.015	0.0045	0.5	g/hr	2.1	0.65	-
Mercury	[1]	mg/m³	0.00065	0.000	0.05	g/hr	0.092	0.028	-
Dioxins & Furans Upper Limit (worst case where <LOD = LOD)									
Dioxins & Furans (NATO I-TEQ)	[1]	ng/m³	0.0077	0.0016	0.1	µg/hr	1.1	0.23	-
Dioxins & Furans (WHO TEQ Humans / Mammals)	[1]	ng/m³	0.0078	0.0016	-	µg/hr	1.1	0.23	-
Dioxins & Furans (WHO TEQ Fish)	[1]	ng/m³	0.0082	0.0017	-	µg/hr	1.2	0.25	-
Dioxins & Furans (WHO TEQ Birds)	[1]	ng/m³	0.012	0.0024	-	µg/hr	1.7	0.36	-
Dioxins & Furans Lower Limit (best case where <LOD = 0)									
Dioxins & Furans (NATO I-TEQ)	[1]	ng/m³	0.0077	0.0016	-	µg/hr	1.1	0.23	-
Dioxins & Furans (WHO TEQ Humans / Mammals)	[1]	ng/m³	0.0078	0.0016	-	µg/hr	1.1	0.23	-
Dioxins & Furans (WHO TEQ Fish)	[1]	ng/m³	0.0082	0.0017	-	µg/hr	1.2	0.25	-
Dioxins & Furans (WHO TEQ Birds)	[1]	ng/m³	0.012	0.0024	-	µg/hr	1.7	0.36	-
PCBs Upper Limit (worst case where <LOD = LOD)									
PCBs (WHO TEQ Humans / Mammals)	[1]	ng/m³	0.0020	0.00041	-	**µg/hr**	0.28	0.059	-
PCBs (WHO TEQ Fish)	[1]	ng/m³	0.000086	0.000018	-	µg/hr	0.012	0.0026	-
PCBs (WHO TEQ Birds)	[1]	ng/m³	0.0039	0.00080	-	µg/hr	0.55	0.116	-
PCBs Lower Limit (best case where <LOD = 0)									
PCBs (WHO TEQ Humans / Mammals)	[1]	ng/m³	0.00	0.00	-	µg/hr	0.00	0.00	-
PCBs (WHO TEQ Fish)	[1]	ng/m³	0.00	0.00	-	µg/hr	0.00	0.00	-
PCBs (WHO TEQ Birds)	[1]	ng/m³	0.00	0.00	-	µg/hr	0.00	0.00	-
PAHs (DEFRA 16) see p5 for individual breakdown	[1]	µg/m³	1.7	0.35	-	g/hr	0.24	0.051	-
Hydrogen Fluoride	[1]	mg/m³	< 0.031	0.0046	2	g/hr	< 4.4	0.69	-
Nitrous Oxide	[1]	mg/m³	6.4	0.74	-	g/hr	917	114	-
Oxygen		% v/v	**Dry** 8.9	0.38					
Water Vapour		% v/v	15.4	0.80					
Stack Gas Temperature		°C	142						
Stack Gas Velocity		m/s	21.3	0.24					
Volumetric Flow Rate (ACTUAL)		m³/hr	215641	10052					
Volumetric Flow Rate (REF)	[1]	m³/hr	142265	6632					

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

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

MONITORING RESULTS

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2
3rd - 5th March 2015

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
Breakdown of PAHs								
Anthanthrene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Benzo(a)anthracene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Benzo(a)pyrene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Benzo(b)fluoranthene	µg/m³	0.077	0.0158	-	g/hr	0.011	0.0022	
Benzo(b)naptho(2,1-d)thiophene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Benzo(c)phenanthrene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Benzo(ghi)perylene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Benzo(k)fluoranthene	µg/m³	0.044	0.0090	-	g/hr	0.0062	0.0013	
Cholanthrene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Chrysene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Cyclopenta(cd)pyrene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Dibenzo (ai) pyrene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Dibenzo(ah)anthracene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Fluoranthene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Indeno(123-cd)pyrene	µg/m³	< 0.011	0.0023	-	g/hr	< 0.0016	0.00032	
Naphthalene	µg/m³	1.4	0.29	-	g/hr	0.20	0.042	
TOTAL (DEFRA 16)	µg/m³	< 1.7	0.35	-	g/hr	< 0.24	0.049	

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.

MONITORING DATE(S) & TIMES

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A2 - Stream 2

3rd - 5th March 2015

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
PM_{10}	R1	mg/m³	0.095	g/hr	13.5	06/03/2015	09:30 - 11:30	120
$PM_{2.5}$	R1	mg/m³	0.071	g/hr	10.1	06/03/2015	09:30 - 11:30	120
Cadmium & Thallium	R1	mg/m³	< 0.00079	g/hr	< 0.11	06/03/2015	08:10 - 08:40; 08:42 - 09:12	60
Heavy Metals	R1	mg/m³	0.015	g/hr	2.1	06/03/2015	08:10 - 08:40; 08:42 - 09:12	60
Mercury	R1	mg/m³	0.00065	g/hr	0.092	06/03/2015	08:10 - 08:40; 08:42 - 09:12	60
Dioxins & Furans (NATO)	R1	ng/m³	0.0077	µg/hr	1.1	04/03/2015	08:36 - 10:28; 10:58 - 12:08; 12:13 - 15:13	360
PCBs	R1	ng/m³	0.0020	µg/hr	0.28	04/03/2015	08:36 - 10:28; 10:58 - 12:08; 12:13 - 15:13	360
PAHs (DEFRA 16)	R1	µg/m³	1.7	g/hr	0.24	03/03/2015	09:58 - 12:58, 13:00 - 16:00	360
Hydrogen Fluoride	R1	mg/m³	< 0.031	g/hr	< 4.4	06/03/2015	08:00 - 08:40; 08:42 - 09:02	60
Oxygen	R1	% v/v	8.5			03/03/2015	09:58 - 16:00	363
Oxygen	R2	% v/v	9.5			04/03/2015	08:36 - 15:13	398
Oxygen	R3	% v/v	9.3			06/03/2015	08:10 - 09:12	63
Nitrous Oxide	R1	mg/m³	6.4	g/hr	917	03/03/2015	13:17 - 14:17	60
Water Vapour	R1	% v/v	12.4			03/03/2015	13:17 - 14:17	60
Velocity & Volumetric Flow Rate	R1					03/03/2015	16:08 - 16:24	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2
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	Carbon & llme injection, Bag Filter
Abatement System Running Status	Operational
Fuel	Diesel Oil
Plume Appearance	Not Visible from Sample Locatiom

MONITORING & ANALYTICAL METHODS

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2
3rd - 5th March 2015

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**ISO 17025 Testing**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**ISO 17025 Analysis**	**Analysis Lab**	**MCERTS Testing**	**LOD (Average)**
PM_{10}	BS EN ISO 23210	CAT-TP-18	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.09 mg/m³
$PM_{2.5}$	BS EN ISO 23210	CAT-TP-18	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.07 mg/m³
Cadmium & Thallium	EN 14385	CAT-TP-06	Yes	CAT	Section 21	ICP-MS	Yes	SAL	Yes	0.001 mg/m³
Heavy Metals	BS EN 14385	CAT-TP-06	Yes	CAT	Section 21	ICP-MS	Yes	SAL	Yes	0.009 mg/m³
Mercury	MID 13211	CAT-TP-06	Yes	CAT	Section 22	CV-AFS	Yes	SAL	Yes	0.003 mg/m³
Dioxins & Furans	EN 1948	CAT-TP-07	Yes	CAT	SOP 1C	GC-HRMS	Yes	SAL	Yes	0.001 ng/m³
PCBs	EN 1948	CAT-TP-07	Yes	CAT	SOP 11	GC-HRMS	Yes	SAL	Yes	0.002 ng/m³
PAHs	ISO 11338	CAT-TP-08	Yes	CAT	SOP 12K	GC-MS (Soxhlet)	Yes	SAL	Yes	0.1749 µg/m³
Hydrogen Fluoride	ISO 15713	CAT-TP-10	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.031 mg/m³
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-33	Yes	CAT	Dry Paramagnetic Cell by Servomex 5200MP				Yes	0.1 %
Nitrous Oxide	TGN M22	CAT-TP-22(b)	Yes	CAT	FTIR by Gasmet Technologies Oy DX4000				Yes	0 mg/m³
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.

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	15
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	Yes
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 28th November 2014, 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	211.0		> 5 Pa	Yes
Mean Velocity	m/s	21.35		-	-
Lowest Gas Velocity	m/s	19.12		-	-
Highest Gas Velocity	m/s	23.15		-	-
Ratio of Above	: 1	1.21		< 3 : 1	Yes
Maximum Angle of Swirl	°	9		< 15°	Yes
No Local Negative Flow	-	Yes		-	Yes

Executive Summary

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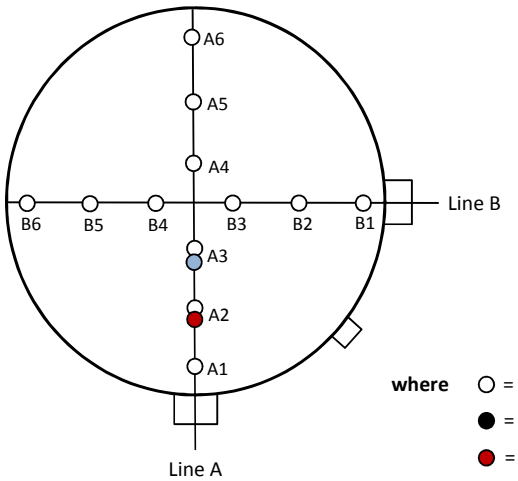
PLANT PHOTOS

Photo 1

Photo 2

SAMPLE POINTS



where ○ = isokinetic point sampled at

● = isokinetic point not sampled at

● = combustion gases sample point

● = non-isokinetic sample point

APPENDIX CONTENTS

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	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	CAT 7.18
Control Box DGM (2)	-
Box Thermocouples (1)	CAT 3.38
Box Thermocouples (2)	-
Umbilical (1)	CAT 3.38
Umbilical (2)	-
Oven Box (1)	CAT 12.41
Oven Box (2)	-
Heated Probe (1)	CAT 5.73
Heated Probe (2)	CAT 5.61
Heated Probe (3)	-
S-Pitot (1)	CAT 21P.65
S-Pitot (2)	-
L-Pitot	-
500g Check Weight	CAT 17.14
1Kg Check Weight	CAT 17.14
Last Impinger Arm	CAT 4.210 / 4.211
Callipers	CAT 23.18
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250 SRM	-
Horiba PG-250	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	CAT
Servomex 5200MP	CAT 24.8
JCT JCC P1 Cooler	-
Gasmet DX4000	CAT 19.4
Gasmet Sampling System	-
Bernath 3006 FID	-
M&C PSS	CAT 12.46
Mass Flow Controller (1)	CAT 6.34
Mass Flow Controller (2)	CAT 6.35
Mass View (1)	CAT 25.27
Mass View (2)	CAT 2528
Easylogger EN-EL-12 Bit	-
Easylogger EN-EL-12 Bit	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.56
Digital Manometer (2)	CAT 3.89
Digital Temperature Meter	CAT 3.56
Stopwatch	CAT 4.62 (MST)
Barometer	CAT 13.17
Stack Thermocouple (1)	CAT 4.551
Stack Thermocouple (2)	CAT 4.261
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	-
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	-
Laboratory Balance	CAT 1.18 / 1.18a
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-33
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	141.8
Average Stack Gas Pressure	Pa	264.7
Average Stack Static Pressure, P_{static}	kPa	-2.295
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/m³ p	Conc kg/m³ p_i
CO_2 (Estimated)	-	11.00	9.30	0.1100	44.01	1.9635	0.21599
O_2	-	8.91	7.54	0.0891	32.00	1.4277	0.12721
N_2	-	80.09	67.75	0.8009	28.01	1.2498	1.00099
Moisture (H_2O)	-	-	15.41	0.1541	18.02	0.8037	0.12387

Where: p = M / 22.41

p_i = r x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m³	1.344
Wet Density (STP), P_{STW}	kg/m³	1.261
Dry Density (Actual), P_{Actual}	kg/m³	0.867
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	0.813

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)

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

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

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	141.8	0.0
Total Pressure	kPa	99.3	101.3
Moisture	%	15.41	0.00
Oxygen (Dry)	%	8.9	11.0

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	215641
Gas Volumetric Flowrate (STP, Wet)	m³/hr	139118
Gas Volumetric Flowrate (STP, Dry)	m³/hr	117678
Gas Volumetric Flowrate REF [1]	m³/hr	142265

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	-	16:08 - 16:24
Atmospheric Pressure	kPa	101.6
Average Stack Static Pressure	Pa	-2295
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/m³**	**Velocity m/s**	**Swirl °**	**ΔP Pa**	**Temp °C**	**Wet Density kg/m³**	**Velocity m/s**	**Swirl °**
STATIC (Units: Pa)		*-2289.0*					*-2301.0*				
Mean		**253.0**	**141.5**	**0.814**	**20.89**		**276.3**	**142.2**	**0.813**	**21.81**	
1	0.08	222.0	143.0	0.811	19.61	8.0	211.0	143.0	0.811	19.12	9.0
2	0.28	257.0	142.0	0.813	21.08	9.0	245.0	143.0	0.811	20.60	8.0
3	0.56	244.0	141.0	0.815	20.51	6.0	310.0	142.0	0.813	23.15	9.0
4	1.33	274.0	141.0	0.815	21.74	7.0	285.0	141.0	0.815	22.17	7.0
5	1.61	256.0	141.0	0.815	21.01	9.0	298.0	142.0	0.813	22.70	7.0
6	1.81	265.0	141.0	0.815	21.38	8.0	309.0	142.0	0.813	23.11	7.0

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)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	7.655	Pa
- Resolution	u(res)	0.08677	
- Calibration	u(cal)	7.294	
- Drift	u(drift)	33.333	
- Lack of Fit	u(fit)	16.879	
- Overall corrections to dynamic measurements	u(Cf)	57.592	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00009	-
- $\varphi O_2,w$	-	7.537	
- $\varphi CO_2,w$	-	9.305	
- Oxygen, dry	u(ϕO_2,d)	0.273	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.337	
- Water Vapour	u(ϕH_2O)	0.786	
- Oxygen, wet	u(ϕO_2,w)	0.241	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.298	
Standard uncertainty associated with the stack temperature	u(Tc)	2.116	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.775	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	5.413	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00439	-
Standard uncertainty associated with the local velocities	u(vi)	0.321	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.121	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.238	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	1.11	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	10052.1	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00057	
- $u^2(qV,w)$	-	26302974	
- u(qV,w)	-	5128.6	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	4.66	%

PM_{10}: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	0.095		0.095
Uncertainty	±mg/m³	0.19		0.19
Mass Emission	g/hr	13.5		13.5
Uncertainty	±g/hr	26.7		26.7

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	14.4		14.4
Uncertainty	±% v/v	0.79		0.79

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.095		0.095

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_{10}: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	777.0	
Stack static pressure, P_{static}	mmH_2O	-234.5	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	427.3	
Total mass collected in impingers (silica trap)	g	7.4	
Total mass of liquid collected, V_{lc}	g	434.7	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.5416	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	3.5130	
Gas meter correction factor, Y_d	-	0.9580	
Average dry gas meter temperature, T_m	°C	20.6	
Average pressure drop across orifice, ΔH	mmH_2O	95.6	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	3.2280	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1437	
B_{wo} as a percentage	% v/v	14.37	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	14.37	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	3.7697	
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	6.68	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	7.92	
% oxygen reference condition, $REF\%O_2$	% v/v	11.00	
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.70	
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	5.3995	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	4.2208	
Molecular weight of dry gas stream, M_d			
CO_2 (Estimated)	% v/v	11.00	
O_2	% v/v	7.92	
Total	% v/v	18.92	
N_2	% v/v	81.08	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	30.08	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.34	
Velocity of stack gas, V_{spt}			
Velocity pressure coefficient, C_p	-	0.84	
Average stack gas temperature, T_s	°C	141.5	
Velocity of stack gas (pre-test from traverse), V_{spt}	m/s	22.21	
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	3738.9	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	2461.9	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	2108.2	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	3526.3	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	2756.5	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	6.91	
Nozzle area, A_n	mm^2	37.47	
Total sampling time, q	min	120	
Velocity at nozzle, V_n	m/s	21.22	
$\%I = V_n / V_{spt} \times 100$	%	95.5	

PM_{10}: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	09:30 - 11:30	
Sampling Dates	-	06/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m^3	4.2208	
2nd Stage of Cascade Impactor (PM_{10} to $PM_{2.5}$)			
Filter I.D. Number (2nd Stage)	-	PM2-00744	
Start Filter Mass (2nd Stage)	g	0.12828	
End Filter Mass (2nd Stage)	g	0.12842	
Total Mass	g	0.00014	
3rd Stage of Cascade Impactor (≤ $PM_{2.5}$)			
Filter I.D. Number (3rd Stage)	-	PM3-00744	
Start Filter Mass (3rd Stage)	g	0.15041	
End Filter Mass (3rd Stage)	g	0.15037	
Total Mass	g	-0.00004	
Total Mass Collected	mg	0.10	
Calculated Concentration	mg/m^3	0.02	
Balance Uncertainty / LOD	mg/m^3	0.09	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	06/03/2015	
Average Volume Sampled (REF)	m^3	4.2208	
2nd Stage of Cascade Impactor (PM_{10} to $PM_{2.5}$)			
Filter I.D. Number (2nd Stage)	-	PM2-00747	
Start Filter Mass (2nd Stage)	g	0.12968	
End Filter Mass (2nd Stage)	g	0.12968	
Total Mass	g	0.00000	
3rd Stage of Cascade Impactor (≤ $PM_{2.5}$)			
Filter I.D. Number (3rd Stage)	-	PM3-00747	
Start Filter Mass (3rd Stage)	g	0.15129	
End Filter Mass (3rd Stage)	g	0.15120	
Total Mass	g	-0.00009	
Total Mass Collected	mg	-0.09	
Calculated Concentration	mg/m^3	-0.02	
Balance Uncertainty / LOD	mg/m^3	0.09	

PM_{10}: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 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	

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	%	95.5	
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	141	

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	

PM_{10}: QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	30.00	
Pre-Sampling Leak Rate	l/min	0.55	
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 (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	
There are no deviations associated with the sampling employed.	wx	

PM_{10}: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	3.5130		uV_m	m^3	0.0703	
Sampled Gas Temperature	T_m	293.6		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	101.3		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	1.80		uL	%	-	
Mass of Particulate	m	0.40		um	mg	0.40	
Uncollected Mass	UCM	-0.09		uUCM	mg	-	
Particulate Sizing	PS	10.00		uPS	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
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	%	1.80		≤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	3.2280		0.03	
Leak	L	mg/m^3	0.001		1.00	
Mass of Particulate	L_r	mg	0.400		0.24	
Uncollected Mass	UCM	mg	-0.05		0.24	
Particulate Sizing	PS	mg	0.01		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	0.002	
Leak	mg/m^3	0.0010	
Mass of Particulate	mg/m^3	0.0948	
Uncollected Mass	mg/m^3	-0.0123	
Particulate Sizing	mg/m^3	0.0055	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	0.76	
Stack Gas O_2 Content	% v/v	7.92	
MU for O_2 Correction	-	0.03	
Overall MU For O_2 Measurement	%	3.82	

Parameter	**Units**	**Run 1**	
Combined uncertainty	mg/m^3	0.10	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.19	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.19	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.19	
Reported Uncertainty	mg/m^3	0.19	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	198.0	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	198.1	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	198.1	
Reported Uncertainty	%	198.1	

$PM_{2.5}$: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	0.071		0.071
Uncertainty	±mg/m³	0.14		0.14
Mass Emission	g/hr	10.1		10.1
Uncertainty	±g/hr	20.2		20.2

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	14.4		14.4
Uncertainty	±% v/v	0.79		0.79

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.071		0.071

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	777.0	
Stack static pressure, P_{static}	mmH_2O	-234.5	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	427.3	
Total mass collected in impingers (silica trap)	g	7.4	
Total mass of liquid collected, V_{lc}	g	434.7	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.5416	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	3.5130	
Gas meter correction factor, Y_d	-	0.9580	
Average dry gas meter temperature, T_m	°C	20.6	
Average pressure drop across orifice, ΔH	mmH_2O	95.6	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	3.2280	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1437	
B_{wo} as a percentage	% v/v	14.37	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	14.37	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	3.7697	
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	6.68	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	7.92	
% oxygen reference condition, $REF\%O_2$	% v/v	11.00	
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.70	
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	5.3995	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	4.2208	
Molecular weight of dry gas stream, M_d			
CO_2 (Estimated)	% v/v	11.00	
O_2	% v/v	7.92	
Total	% v/v	18.92	
N_2	% v/v	81.08	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	30.08	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.34	
Velocity of stack gas, V_{spt}			
Velocity pressure coefficient, C_p	-	0.84	
Average stack gas temperature, T_s	°C	141.5	
Velocity of stack gas (pre-test from traverse), V_{spt}	m/s	22.21	
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	3738.9	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	2461.9	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	2108.2	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	3526.3	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	2756.5	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	6.91	
Nozzle area, A_n	mm^2	37.47	
Total sampling time, q	min	120	
Velocity at nozzle, V_n	m/s	21.22	
$\%I = V_n / V_{spt} \times 100$	%	95.5	

$PM_{2.5}$: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	09:30 - 11:30	
Sampling Dates	-	06/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m^3	4.2208	
3rd Stage of Cascade Impactor (≤ $PM_{2.5}$)			
Filter I.D. Number (3rd Stage)	-	PM3-00744	
Start Filter Mass (3rd Stage)	g	0.15041	
End Filter Mass (3rd Stage)	g	0.15037	
Total Mass	g	-0.00004	
Total Mass Collected	mg	-0.04	
Calculated Concentration	mg/m^3	-0.01	
Balance Uncertainty / LOD	mg/m^3	0.07	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	06/03/2015	
Average Volume Sampled (REF)	m^3	4.2208	
3rd Stage of Cascade Impactor (≤ $PM_{2.5}$)			
Filter I.D. Number (3rd Stage)	-	PM3-00747	
Start Filter Mass (3rd Stage)	g	0.15129	
End Filter Mass (3rd Stage)	g	0.15120	
Total Mass	g	-0.00009	
Total Mass Collected	mg	-0.09	
Calculated Concentration	mg/m^3	-0.02	
Balance Uncertainty / LOD	mg/m^3	0.07	

$PM_{2.5}$: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 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	

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	%	95.5	
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	141	

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	0.55	
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 (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	
There are no deviations associated with the sampling employed.	wx	

$PM_{2.5}$: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	3.5130		uV_m	m^3	0.0703	
Sampled Gas Temperature	T_m	293.6		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	101.3		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	1.80		uL	%	-	
Mass of Particulate	m	0.30		um	mg	0.30	
Uncollected Mass	UCM	-0.09		uUCM	mg	-	
Particulate Sizing	PS	10.00		uPS	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
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	%	1.80		≤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	3.2280		0.022	
Leak	L	mg/m^3	0.001		1.00	
Mass of Particulate	L_r	mg	0.300		0.24	
Uncollected Mass	UCM	mg	-0.05		0.24	
Particulate Sizing	PS	mg	0.0041		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	0.0018	
Leak	mg/m^3	0.0007	
Mass of Particulate	mg/m^3	0.0711	
Uncollected Mass	mg/m^3	-0.0128	
Particulate Sizing	mg/m^3	0.0041	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	0.76	
Stack Gas O_2 Content	% v/v	7.92	
MU for O_2 Correction	-	0.03	
Overall MU For O_2 Measurement	%	3.82	

Parameter	**Units**	**Run 1**	
Combined uncertainty	mg/m^3	0.07	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.14	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.14	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.14	
Reported Uncertainty	mg/m^3	0.14	
Expanded uncertainty (95% confidence)	%	199.5	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	199.6	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	199.6	
Reported Uncertainty	%	199.6	

CADMIUM & THALLIUM: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	< 0.00079		< 0.00079
Uncertainty	±mg/m³	0.00023		0.00023
Mass Emission	g/hr	< 0.11		< 0.11
Uncertainty	±g/hr	0.033		0.033

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	17.1		17.1
Uncertainty	±% v/v	0.86		0.86

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.00074		< 0.00074

General Sampling Information

Parameter	Value	
Standard	EN 14385	
Technical Procedure	CAT-TP-06	
Name of Analytical Laboratory	SAL	
Analytical Laboratory's Procedure	Section 21	
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.

CADMIUM & THALLIUM: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	777.0	
Stack static pressure, P_{static}	mmH_2O	-234.5	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	189.9	
Total mass collected in impingers (silica trap)	g	13.5	
Total mass of liquid collected, V_{lc}	g	203.4	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.2534	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	1.3100	
Gas meter correction factor, Y_d	-	0.9580	
Average dry gas meter temperature, T_m	°C	13.0	
Average pressure drop across orifice, ΔH	mmH_2O	54.0	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.2310	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1707	
B_{wo} as a percentage	% v/v	17.07	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	17.07	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.4844	
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	7.79	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.25	
% oxygen reference condition, $REF\%O_2$	% v/v	11.00	
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.76	
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.85	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.9604	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.4463	
Molecular weight of dry gas stream, M_d			
CO_2 (Estimated)	% v/v	11.00	
O_2	% v/v	9.25	
Total	% v/v	20.25	
N_2	% v/v	79.75	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	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	28.06	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	25.44	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	5.04	
Average stack gas temperature, T_s	°C	140.6	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	20.76	
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	3494.8	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	2306.0	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	1912.3	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	3045.5	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	2246.9	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.99	
Nozzle area, A_n	mm^2	28.22	
Total sampling time, q	min	60	
$\%I = (4.6398E^{6})(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	106.7	

CADMIUM & THALLIUM: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	08:10 - 08:40; 08:42 - 09:12	
Sampling Dates	-	06/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m^3	1.4463	
Cadmium			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.09	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.62	
Calculated Concentration	mg/m^3	< 0.0004	
Reported Concentration	mg/m^3	< 0.0004	
Mass Emission	g/hr	< 0.06	
Thallium			
Mass on Filter / in Rinse	µg	< 0.40	
Mass in Front Impingers	µg	< 0.09	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.52	
Calculated Concentration	mg/m^3	< 0.0004	
Reported Concentration	mg/m^3	< 0.0004	
Mass Emission	g/hr	< 0.05	
Cadmium & Thallium Combined			
Total Mass Collected	µg	< 1.14	
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	1.4463	
Cadmium			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.06	
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	< 0.06	
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	< 1.07	
Calculated Concentration	mg/m^3	< 0.0007	
Reported Concentration	mg/m^3	< 0.0007	

CADMIUM & THALLIUM: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	20.92	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.08	
Allowable Leak Rate	l/min	0.42	
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/m³	0.6	
Thallium	µg/m³	0.5	
Allowable Detection Limit	µg/m³	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	%	106.7	
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	10	
Maximum Allowable Temperature	°C	30	
Exit Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

CADMIUM & THALLIUM: QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	16.00	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.08	
Allowable Leak Rate	l/min	0.32	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m³	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

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	1.3100		uV_m	m^3	0.0262	
Sampled Gas Temperature	T_m	286.0		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	101.3		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.38		uL	%	-	
Laboratory Result	L_r	14.40		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
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	%	0.38		≤2%
Laboratory Result	%	14.40		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	1.2310		0.0006	
Leak	L	mg/m^3	1.7E-06		1.00	
Laboratory Result	L_r	mg/m^3	1.1E-04		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	2.0E-05	
Leak	mg/m^3	1.7E-06	
Laboratory Result	mg/m^3	1.1E-04	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	0.85	
Stack Gas O_2 Content	% v/v	9.25	
MU for O_2 Correction	-	0.04	
Overall MU For O_2 Measurement	%	4.26	

Parameter	**Units**	**Run 1**	
Combined uncertainty	mg/m^3	0.0001	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0002	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.0002	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0002	
Reported Uncertainty	mg/m^3	0.0002	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	28.7	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	29.0	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	29.0	
Reported Uncertainty	%	29.0	

HEAVY METALS: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	0.015		0.015
Uncertainty	±mg/m³	0.0045		0.0045
Mass Emission	g/hr	2.1		2.1
Uncertainty	±g/hr	0.65		0.65

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	17.1		17.1
Uncertainty	±% v/v	0.86		0.86

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.0044		0.0044

General Sampling Information

Parameter	Value	
Standard	BS EN 14385	
Technical Procedure	CAT-TP-06	
Name of Analytical Laboratory	SAL	
Analytical Laboratory's Procedure	Section 21	
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	777.0	
Stack static pressure, P_{static}	mmH_2O	-234.5	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	189.9	
Total mass collected in impingers (silica trap)	g	13.5	
Total mass of liquid collected, V_{lc}	g	203.4	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.2534	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	1.3100	
Gas meter correction factor, Y_d	-	0.9580	
Average dry gas meter temperature, T_m	°C	13.0	
Average pressure drop across orifice, ΔH	mmH_2O	54.0	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.2310	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1707	
B_{wo} as a percentage	% v/v	17.07	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	17.07	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.4844	
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	7.79	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.25	
% oxygen reference condition, $REF\%O_2$	% v/v	11.00	
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.76	
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.85	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.9604	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.4463	
Molecular weight of dry gas stream, M_d			
CO_2 (Estimated)	% v/v	11.00	
O_2	% v/v	9.25	
Total	% v/v	20.25	
N_2	% v/v	79.75	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	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	28.06	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	25.44	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	5.04	
Average stack gas temperature, T_s	°C	140.6	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	20.76	
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	3494.8	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	2306.0	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	1912.3	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	3045.5	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	2246.9	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.99	
Nozzle area, A_n	mm^2	28.22	
Total sampling time, q	min	60	
$\%I = (4.6398E^{6})(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	106.7	

HEAVY METALS: SAMPLING DETAILS

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Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	08:10 - 08:40; 08:42 - 09:12	
Sampling Dates	-	06/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m^3	1.4463	
Arsenic			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.13	
Mass in Back Impinger	µg	< 0.04	
Total Mass Collected	µg	< 0.68	
Calculated Concentration	mg/m^3	< 0.0005	
Reported Concentration	mg/m^3	< 0.0005	
Mass Emission	g/hr	< 0.07	
Cobalt			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.09	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.62	
Calculated Concentration	mg/m^3	< 0.0004	
Reported Concentration	mg/m^3	< 0.0004	
Mass Emission	g/hr	< 0.06	
Chromium			
Mass on Filter / in Rinse	µg	3.00	
Mass in Front Impingers	µg	4.50	
Mass in Back Impinger	µg	3.01	
Total Mass Collected	µg	10.51	
Calculated Concentration	mg/m^3	0.0073	
Reported Concentration	mg/m^3	0.0073	
Mass Emission	g/hr	1.03	
Copper			
Mass on Filter / in Rinse	µg	0.90	
Mass in Front Impingers	µg	0.40	
Mass in Back Impinger	µg	0.43	
Total Mass Collected	µg	1.73	
Calculated Concentration	mg/m^3	0.0012	
Reported Concentration	mg/m^3	0.0012	
Mass Emission	g/hr	0.17	
Manganese			
Mass on Filter / in Rinse	µg	< 0.40	
Mass in Front Impingers	µg	< 0.09	
Mass in Back Impinger	µg	0.04	
Total Mass Collected	µg	0.53	
Calculated Concentration	mg/m^3	0.0004	
Reported Concentration	mg/m^3	0.0004	
Mass Emission	g/hr	0.05	

HEAVY METALS: SAMPLING DETAILS

(PAGE 2 OF 5)

Sample Runs (continued)

Parameter	Units	Run 1	
Nickel			
Mass on Filter / in Rinse	µg	2.00	
Mass in Front Impingers	µg	0.13	
Mass in Back Impinger	µg	0.09	
Total Mass Collected	µg	2.22	
Calculated Concentration	mg/m³	0.0015	
Reported Concentration	mg/m³	0.0015	
Mass Emission	g/hr	0.22	
Lead			
Mass on Filter / in Rinse	µg	3.00	
Mass in Front Impingers	µg	0.90	
Mass in Back Impinger	µg	0.43	
Total Mass Collected	µg	4.33	
Calculated Concentration	mg/m³	0.0030	
Reported Concentration	mg/m³	0.0030	
Mass Emission	g/hr	0.43	
Antimony			
Mass on Filter / in Rinse	µg	< 0.60	
Mass in Front Impingers	µg	< 0.09	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.72	
Calculated Concentration	mg/m³	< 0.0005	
Reported Concentration	mg/m³	< 0.0005	
Mass Emission	g/hr	< 0.07	
Vanadium			
Mass on Filter / in Rinse	µg	< 0.40	
Mass in Front Impingers	µg	< 0.04	
Mass in Back Impinger	µg	< 0.01	
Total Mass Collected	µg	< 0.46	
Calculated Concentration	mg/m³	< 0.0003	
Reported Concentration	mg/m³	< 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	21.80	
Calculated Concentration	mg/m³	0.0151	
Reported Concentration	mg/m³	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)	m³	1.4463	
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	< 0.63	
Calculated Concentration	mg/m³	< 0.0004	
Reported Concentration	mg/m³	< 0.0004	
Cobalt			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.06	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.58	
Calculated Concentration	mg/m³	< 0.0004	
Reported Concentration	mg/m³	< 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	0.28	
Mass in Back Impinger	µg	0.28	
Total Mass Collected	µg	1.16	
Calculated Concentration	mg/m³	0.0008	
Reported Concentration	mg/m³	0.0008	
Copper			
Mass on Filter / in Rinse	µg	< 0.60	
Mass in Front Impingers	µg	0.25	
Mass in Back Impinger	µg	0.07	
Total Mass Collected	µg	0.92	
Calculated Concentration	mg/m³	0.0006	
Reported Concentration	mg/m³	0.0006	
Manganese			
Mass on Filter / in Rinse	µg	< 0.40	
Mass in Front Impingers	µg	< 0.06	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.48	
Calculated Concentration	mg/m³	< 0.0003	
Reported Concentration	mg/m³	< 0.0003	
Nickel			
Mass on Filter / in Rinse	µg	< 0.60	
Mass in Front Impingers	µg	< 0.06	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.68	
Calculated Concentration	mg/m³	< 0.0005	
Reported Concentration	mg/m³	< 0.0005	
Lead			
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	0.22	
Mass in Back Impinger	µg	0.11	
Total Mass Collected	µg	0.84	
Calculated Concentration	mg/m³	0.0006	
Reported Concentration	mg/m³	0.0006	
Antimony			
Mass on Filter / in Rinse	µg	< 0.60	
Mass in Front Impingers	µg	< 0.06	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	< 0.68	
Calculated Concentration	mg/m³	< 0.0005	
Reported Concentration	mg/m³	< 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/m³	< 0.0003	
Reported Concentration	mg/m³	< 0.0003	

HEAVY METALS: SAMPLING DETAILS

(PAGE 5 OF 5)

Blank Runs (continued)

Parameter	Units	Blank 1	
Heavy Metals Combined			
Total Mass Collected	µg	6.43	
Calculated Concentration	mg/m³	0.0044	
Reported Concentration	mg/m³	0.0044	

HEAVY METALS: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	20.92	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.08	
Allowable Leak Rate	l/min	0.42	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Arsenic	%	100.0	
Cobalt	%	100.0	
Chromium	%	71.3	
Copper	%	75.2	
Manganese	%	91.9	
Nickel	%	96.1	
Lead	%	90.1	
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/m³	0.4	
Cobalt	µg/m³	0.4	
Chromium	µg/m³	1.6	
Copper	µg/m³	0.8	
Manganese	µg/m³	2.2	
Nickel	µg/m³	2.2	
Lead	µg/m³	0.5	
Antimony	µg/m³	0.9	
Vanadium	µg/m³	0.5	
Allowable Detection Limit	µg/m³	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	%	106.7	
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	10	
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	16.00	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.08	
Allowable Leak Rate	l/min	0.32	
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

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	1.3100		uV_m	m^3	0.0262	
Sampled Gas Temperature	T_m	286.0		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	101.3		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.38		uL	%	-	
Laboratory Result	L_r	15.00		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
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	%	0.38		≤2%
Laboratory Result	%	15.00		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	1.2310		0.012	
Leak	L	mg/m^3	0.00003		1.00	
Laboratory Result	L_r	mg/m^3	0.0023		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	0.0004	
Leak	mg/m^3	0.00003	
Laboratory Result	mg/m^3	0.0023	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	0.85	
Stack Gas O_2 Content	% v/v	9.25	
MU for O_2 Correction	-	0.04	
Overall MU For O_2 Measurement	%	4.26	

Parameter	**Units**	**Run 1**	
Combined uncertainty	mg/m^3	0.0023	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0045	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.0045	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0045	
Reported Uncertainty	mg/m^3	0.0045	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	29.8	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	30.1	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	30.1	
Reported Uncertainty	%	30.1	

MERCURY: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	0.00065		0.00065
Uncertainty	±mg/m³	0.00019		0.00019
Mass Emission	g/hr	0.092		0.092
Uncertainty	±g/hr	0.028		0.028

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	17.1		17.1
Uncertainty	±% v/v	0.86		0.86

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.00028		< 0.00028

General Sampling Information

Parameter	Value	
Standard	MID 13211	
Technical Procedure	CAT-TP-06	
Name of Analytical Laboratory	SAL	
Analytical Laboratory's Procedure	Section 22	
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	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.

MERCURY: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	777.0	
Stack static pressure, P_{static}	mmH_2O	-234.5	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	759.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	189.9	
Total mass collected in impingers (silica trap)	g	13.5	
Total mass of liquid collected, V_{lc}	g	203.4	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.2534	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	1.3100	
Gas meter correction factor, Y_d	-	0.9580	
Average dry gas meter temperature, T_m	°C	13.0	
Average pressure drop across orifice, ΔH	mmH_2O	54.0	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.2310	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1707	
B_{wo} as a percentage	% v/v	17.07	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	17.07	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.4844	
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	7.79	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.25	
% oxygen reference condition, $REF\%O_2$	% v/v	11.00	
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.76	
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.85	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	1.9604	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	1.4463	
Molecular weight of dry gas stream, M_d			
CO_2 (Estimated)	% v/v	11.00	
O_2	% v/v	9.25	
Total	% v/v	20.25	
N_2	% v/v	79.75	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	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	28.06	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	25.44	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	5.04	
Average stack gas temperature, T_s	°C	140.6	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	20.76	
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	3494.8	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	2306.0	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	1912.3	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	3045.5	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	2246.9	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.99	
Nozzle area, A_n	mm^2	28.22	
Total sampling time, q	min	60	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	106.7	

MERCURY: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	08:10 - 08:40; 08:42 - 09:12	
Sampling Dates	-	06/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m^3	1.4463	
Mass on Filter / in Rinse	µg	< 0.03	
Mass in Front Impinger/s	µg	0.83	
Mass in Final Impinger	µg	< 0.08	
Total Mass Collected	µg	0.94	
Calculated Concentration	mg/m^3	0.0006	
Reported Concentration	mg/m^3	0.0006	

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	1.4463	
Mass on Filter / in Rinse	µg	< 0.03	
Mass in Front Impinger/s	µg	< 0.29	
Mass in Final Impinger	µg	< 0.08	
Total Mass Collected	µg	< 0.40	
Calculated Concentration	mg/m^3	< 0.0003	
Reported Concentration	mg/m^3	< 0.0003	

MERCURY: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	20.92	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.08	
Allowable Leak Rate	l/min	0.42	
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/m³	0.05	
Allowable Concentration	µg/m³	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	%	106.7	
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	10	
Maximum Allowable Temperature	°C	30	
Exit Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

MERCURY: QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	16.00	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.08	
Allowable Leak Rate	l/min	0.32	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m³	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	

MERCURY: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	1.3100		uV_m	m^3	0.0262	
Sampled Gas Temperature	T_m	286.0		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	101.3		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.38		uL	%	-	
Laboratory Result	L_r	14.80		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
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	%	0.38		≤2%
Laboratory Result	%	14.80		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	1.2310		0.0005	
Leak	L	mg/m^3	1.4E-06		1.00	
Laboratory Result	L_r	mg/m^3	9.6E-05		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	1.6E-05	
Leak	mg/m^3	1.4E-06	
Laboratory Result	mg/m^3	9.6E-05	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	0.85	
Stack Gas O_2 Content	% v/v	9.25	
MU for O_2 Correction	-	0.04	
Overall MU For O_2 Measurement	%	4.26	

Parameter	**Units**	**Run 1**	
Combined uncertainty	mg/m^3	0.0001	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0002	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	0.0002	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0002	
Reported Uncertainty	mg/m^3	0.0002	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	29.4	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	29.7	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	29.7	
Reported Uncertainty	%	29.7	

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 1 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

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

Sample Runs (UPPER NATO I-TEQ)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0077		0.0077
Uncertainty	±ng/m³	0.0016		0.0016
Mass Emission	µg/hr	1.1		1.1
Uncertainty	±µg/hr	0.23		0.23

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0078		0.0078
Uncertainty	±ng/m³	0.0016		0.0016
Mass Emission	µg/hr	1.1		1.1
Uncertainty	±µg/hr	0.23		0.23

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0082		0.0082
Uncertainty	±ng/m³	0.0017		0.0017
Mass Emission	µg/hr	1.2		1.2
Uncertainty	±µg/hr	0.25		0.25

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.012		0.012
Uncertainty	±ng/m³	0.0024		0.0024
Mass Emission	µg/hr	1.7		1.7
Uncertainty	±µg/hr	0.36		0.36

DIOXINS & FURANS: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

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

Sample Runs (LOWER NATO I-TEQ)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0077		0.0077
Uncertainty	±ng/m³	0.0016		0.0016
Mass Emission	µg/hr	1.1		1.1
Uncertainty	±µg/hr	0.23		0.23

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0078		0.0078
Uncertainty	±ng/m³	0.0016		0.0016
Mass Emission	µg/hr	1.1		1.1
Uncertainty	±µg/hr	0.23		0.23

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0082		0.0082
Uncertainty	±ng/m³	0.0017		0.0017
Mass Emission	µg/hr	1.2		1.2
Uncertainty	±µg/hr	0.25		0.25

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.012		0.012
Uncertainty	±ng/m³	0.0024		0.0024
Mass Emission	µg/hr	1.7		1.7
Uncertainty	±µg/hr	0.36		0.36

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 3 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A2 - Stream 2

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

Blank Runs (UPPER NATO I-TEQ)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0015		0.0015

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0016		0.0016

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0027		0.0027

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0019		0.0019

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

Blank Runs (LOWER NATO I-TEQ)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.00067		0.00067

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.00057		0.00057

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.00040		0.00040

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0011		0.0011

DIOXINS & FURANS: RESULTS SUMMARY

(PAGE 4 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A2 - Stream 2

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	14.8		14.8
Uncertainty	±% v/v	0.76		0.76

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	774.8	
Stack static pressure, P_{static}	mmH_2O	-234.5	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	757.5	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	747.2	
Total mass collected in impingers (silica trap)	g	61.5	
Total mass of liquid collected, V_{lc}	g	808.7	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	1.0076	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	6.2690	
Gas meter correction factor, Y_d	-	0.9580	
Average dry gas meter temperature, T_m	°C	16.2	
Average pressure drop across orifice, ΔH	mmH_2O	36.2	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	5.7984	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1481	
B_{wo} as a percentage	% v/v	14.81	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	14.81	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	6.8060	
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	8.01	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.51	
% oxygen reference condition, $REF\%O_2$	% v/v	11.00	
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.77	
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.87	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	8.8414	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	6.6642	
Molecular weight of dry gas stream, M_d			
CO_2 (Estimated)	% v/v	11.00	
O_2	% v/v	9.51	
Total	% v/v	20.51	
N_2	% v/v	79.49	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	30.14	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.34	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	16.53	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	4.07	
Average stack gas temperature, T_s	°C	133.1	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	16.52	
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	2781.5	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	1863.7	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	1587.7	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	2421.0	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	1824.8	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.99	
Nozzle area, A_n	mm^2	28.22	
Total sampling time, q	min	360	
$\%I = (4.6398E^{6})(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	100.9	

DIOXINS & FURANS: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	08:36 - 10:28; 10:58 - 12:08; 12:13 - 15:13
Sampling Dates	-	04/03/2015
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	6.6642

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	0.0071	0.0026	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	76
12378-PeCDD	ng	0.0130	0.0014	0.0065	0.0065	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	138
123478-HxCDD	ng	0.0150	0.0024	0.0015	0.0015	0.0015	0.0015	0.0075	0.0075	0.0008	0.0008	84
123678-HxCDD	ng	0.0420	0.0026	0.0042	0.0042	0.0042	0.0042	0.0004	0.0004	0.0004	0.0004	78
123789-HxCDD	ng	0.0220	0.0026	0.0022	0.0022	0.0022	0.0022	0.0002	0.0002	0.0022	0.0022	-
1234678-HPeCDD	ng	0.2400	0.0040	0.0024	0.0024	0.0024	0.0024	0.0002	0.0002	0.0002	0.0002	81
OCDD	ng	0.8500	0.0052	0.0009	0.0009	0.0003	0.0003	0.0001	0.0001	0.0001	0.0001	76
Total Dioxins	ng	1.1891	-	0.0248	0.0248	0.0307	0.0307	0.0286	0.0286	0.0238	0.0238	-
2378-TCDF	ng	0.0150	0.0024	0.0015	0.0015	0.0015	0.0015	0.0008	0.0008	0.0150	0.0150	83
12378-PeCDF	ng	0.0180	0.0017	0.0009	0.0009	0.0005	0.0005	0.0009	0.0009	0.0018	0.0018	-
23478-PeCDF	ng	0.0270	0.0017	0.0135	0.0135	0.0081	0.0081	0.0135	0.0135	0.0270	0.0270	118
123478-HxCDF	ng	0.0260	0.0022	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	90
123678-HxCDF	ng	0.0280	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	72
234678-HxCDF	ng	0.0360	0.0024	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	0.0036	85
123789-HxCDF	ng	0.0110	0.0024	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	-
1234678-HPeCDF	ng	0.0640	0.0047	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	84
1234789-HPeCDF	ng	0.0099	0.0047	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	-
OCDF	ng	0.0550	0.0043	0.00006	0.00006	0.00002	0.00002	0.00001	0.00001	0.00001	0.00001	93
Total Furans	ng	0.2899	-	0.0268	0.0268	0.0210	0.0210	0.0260	0.0260	0.0546	0.0546	-
Totals	ng	0.2899	-	0.0515	0.0515	0.0517	0.0517	0.0546	0.0546	0.0784	0.0784	-
Total Concentration	ng/m^3	-	-	0.0077	0.0077	0.0078	0.0078	0.0082	0.0082	0.0118	0.0118	-
Limit of Detection	ng/m^3	-	-	0.0010	-	0.0010	-	0.0011	-	0.0015	-	-

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	6.6642

Where: ISO stands for Manual Isokinetic Sampling Train

				NATO I-TEQ		WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
2378-TCDD	ng	ND	0.0021	0.0021	0.0000	0.0021	0.0000	0.0021	0.0000	0.0021	0.0000	93
12378-PeCDD	ng	ND	0.0020	0.0010	0.0000	0.0020	0.0000	0.0020	0.0000	0.0020	0.0000	100
123478-HxCDD	ng	ND	0.0220	0.0022	0.0000	0.0022	0.0000	0.0110	0.0000	0.0011	0.0000	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	0.2987	-	0.0071	0.0018	0.0079	0.0016	0.0153	0.0002	0.0058	0.0006	-
2378-TCDF	ng	0.0030	0.0025	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0030	0.0030	79
12378-PeCDF	ng	ND	0.0024	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0002	0.0000	-
23478-PeCDF	ng	0.0024	0.0024	0.0012	0.0012	0.0007	0.0007	0.0012	0.0012	0.0024	0.0024	82
123478-HxCDF	ng	0.0030	0.0020	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	99
123678-HxCDF	ng	0.0023	0.0023	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	87
234678-HxCDF	ng	0.0047	0.0021	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	94
123789-HxCDF	ng	ND	0.0021	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	0.0002	0.0000	-
1234678-HPeCDF	ng	0.0160	0.0053	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	75
1234789-HPeCDF	ng	ND	0.0053	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	-
OCDF	ng	0.0200	0.0056	2.0E-05	2.0E-05	6.0E-06	6.0E-06	2.0E-06	2.0E-06	2.0E-06	2.0E-06	72
Total Furans	ng	0.0514	-	0.0031	0.0027	0.0025	0.0022	0.0029	0.0025	0.0071	0.0066	-
Totals	ng	0.0514	-	0.0102	0.0045	0.0105	0.0038	0.0182	0.0027	0.0128	0.0071	-
Total Concentration	ng/m^3	-	-	0.0015	0.0007	0.0016	0.0006	0.0027	0.0004	0.0019	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: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	16.68	
Pre-Sampling Leak Rate	l/min	0.05	
Post-Sampling Leak Rate	l/min	0.14	
Allowable Leak Rate	l/min	0.83	
Leak Test Acceptable	-	Yes	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.1	
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	%	100.9	
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	18	
Maximum Allowable Temperature	°C	20	
Exit Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

DIOXINS & FURANS: QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	18.00	
Sampling Leak Rate	l/min	0.06	
Allowable Leak Rate	l/min	0.90	
Leak Test Acceptable	-	Yes	

Validity of NATO I-TEQ Blank vs ELV	Units	Blank 1	
Allowable Blank	ng/m³	0.0100	
Blank Acceptable	-	Yes	

Method Deviations

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

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

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	6.2690		uV_m	m^3	0.1254	
Sampled Gas Temperature	T_m	289.2		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	101.0		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.84		uL	%	-	
Laboratory Result	L_r	10.00		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.69		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.84		≤5%
Laboratory Result	%	10.00		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	5.7984		0.0013	
Leak	L	ng/m^3	0.00004		1.00	
Laboratory Result	L_r	ng/m^3	0.0008		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	ng/m^3	0.0002	
Leak	ng/m^3	0.00004	
Laboratory Result	ng/m^3	0.0008	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	0.87	
Stack Gas O_2 Content	% v/v	9.51	
MU for O_2 Correction	-	0.04	
Overall MU For O_2 Measurement	%	4.35	

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	%	20.2	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.7	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.7	
Reported Uncertainty	%	20.7	

PCBs: RESULTS SUMMARY

(PAGE 1 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

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

Sample Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0020		0.0020
Uncertainty	±ng/m³	0.00041		0.00041
Mass Emission	µg/hr	0.28		0.28
Uncertainty	±µg/hr	0.059		0.059

Sample Runs (UPPER WHO TEQ Fish)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.000086		0.000086
Uncertainty	±ng/m³	0.000018		0.000018
Mass Emission	µg/hr	0.012		0.012
Uncertainty	±µg/hr	0.0026		0.0026

Sample Runs (UPPER WHO TEQ Birds)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0039		0.0039
Uncertainty	±ng/m³	0.00080		0.00080
Mass Emission	µg/hr	0.55		0.55
Uncertainty	±µg/hr	0.12		0.12

PCBs: RESULTS SUMMARY

(PAGE 2 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

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

Sample Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0000		0.0000
Uncertainty	±ng/m³	0.0000		0.0000
Mass Emission	µg/hr	0.0000		0.0000
Uncertainty	±µg/hr	0.0000		0.0000

Sample Runs (LOWER WHO TEQ Fish)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0000		0.0000
Uncertainty	±ng/m³	0.0000		0.0000
Mass Emission	µg/hr	0.0000		0.0000
Uncertainty	±µg/hr	0.0000		0.0000

Sample Runs (LOWER WHO TEQ Birds)

Parameter	Units	Run 1		Mean
Concentration	ng/m³	0.0000		0.0000
Uncertainty	±ng/m³	0.0000		0.0000
Mass Emission	µg/hr	0.0000		0.0000
Uncertainty	±µg/hr	0.0000		0.0000

PCBs: RESULTS SUMMARY

(PAGE 3 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A2 - Stream 2

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

Blank Runs (UPPER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0020		0.0020

Blank Runs (UPPER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.000086		0.000086

Blank Runs (UPPER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.0038		0.0038

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

Blank Runs (LOWER WHO TEQ Humans / Mammals)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.000000		0.000000

Blank Runs (LOWER WHO TEQ Fish)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.000000		0.000000

Blank Runs (LOWER WHO TEQ Birds)

Parameter	Units	Blank 1		Maximum
Concentration	ng/m³	0.000000		0.000000

PCBs: RESULTS SUMMARY

(PAGE 4 OF 4)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility

A2 - Stream 2

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	14.8		14.8
Uncertainty	±% v/v	0.76		0.76

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	774.8	
Stack static pressure, P_{static}	mmH_2O	-234.5	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	757.5	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	747.2	
Total mass collected in impingers (silica trap)	g	61.5	
Total mass of liquid collected, V_{lc}	g	808.7	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	1.0076	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	6.2690	
Gas meter correction factor, Y_d	-	0.9580	
Average dry gas meter temperature, T_m	°C	16.2	
Average pressure drop across orifice, ΔH	mmH_2O	36.2	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	5.7984	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1481	
B_{wo} as a percentage	% v/v	14.81	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	14.81	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	6.8060	
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	8.01	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	9.51	
% oxygen reference condition, $REF\%O_2$	% v/v	11.00	
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.77	
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.87	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	8.8414	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	6.6642	
Molecular weight of dry gas stream, M_d			
CO_2 (Estimated)	% v/v	11.00	
O_2	% v/v	9.51	
Total	% v/v	20.51	
N_2	% v/v	79.49	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	30.14	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.34	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	16.53	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	4.07	
Average stack gas temperature, T_s	°C	133.1	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	16.52	
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	2781.5	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	1863.7	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	1587.7	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	2421.0	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	1824.8	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.99	
Nozzle area, A_n	mm^2	28.22	
Total sampling time, q	min	360	
$\%I = (4.6398E^{-6})(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	100.9	

PCBs: SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	08:36 - 10:28; 10:58 - 12:08; 12:13 - 15:13
Sampling Dates	-	04/03/2015
Sampling Device	-	ISO
Volume Sampled (REF)	m^3	6.6642

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
PCB-81	ng	ND	0.1000	0.0000300	0.0000000	0.0000500	0.0000000	0.0100000	0.0000000	131
PCB-77	ng	ND	0.1100	0.0000110	0.0000000	0.0000110	0.0000000	0.0055000	0.0000000	108
PCB-105	ng	ND	0.2500	0.0000075	0.0000000	0.0000013	0.0000000	0.0000250	0.0000000	102
PCB-114	ng	ND	0.1000	0.0000030	0.0000000	0.0000005	0.0000000	0.0000100	0.0000000	98
PCB-118	ng	ND	0.5000	0.0000150	0.0000000	0.0000025	0.0000000	0.0000050	0.0000000	95
PCB-123	ng	ND	0.1000	0.0000030	0.0000000	0.0000005	0.0000000	0.0000010	0.0000000	109
PCB-126	ng	ND	0.1000	0.0100000	0.0000000	0.0005000	0.0000000	0.0100000	0.0000000	68
PCB-156	ng	ND	0.1100	0.0000033	0.0000000	0.0000006	0.0000000	0.0000110	0.0000000	90
PCB-157	ng	ND	0.1100	0.0000033	0.0000000	0.0000006	0.0000000	0.0000110	0.0000000	89
PCB-167	ng	ND	0.1100	0.0000033	0.0000000	0.0000006	0.0000000	0.0000011	0.0000000	91
PCB-169	ng	ND	0.1000	0.0030000	0.0000000	0.0000050	0.0000000	0.0001000	0.0000000	39
PCB-189	ng	ND	0.1000	0.0000030	0.0000000	0.0000005	0.0000000	0.0000010	0.0000000	28
Totals	ng	0.0000	-	0.013082	0.000000	0.000573	0.000000	0.025665	0.000000	-
Total Concentration	ng/m^3	-	-	0.001963	0.000000	0.000086	0.000000	0.003851	0.000000	-
Limit of Detection	ng/m^3	-	-	0.001963	-	0.000086	-	0.003851	-	-

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	6.6642

Where: ISO stands for Manual Isokinetic Sampling Train

				WHO Humans / Mammals		WHO Fish		WHO Birds		
Parameter	**Units**	**Result**	**DL**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**TEQ1**	**TEQ2**	**% Rec**
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	0.000000	0.000572	0.000000	0.025166	0.000000	-
Total Concentration	ng/m^3	-	-	0.001963	0.000000	0.000086	0.000000	0.003776	0.000000	-

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

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	16.68	
Pre-Sampling Leak Rate	l/min	0.05	
Post-Sampling Leak Rate	l/min	0.14	
Allowable Leak Rate	l/min	0.83	
Leak Test Acceptable	-	Yes	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.1	
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	%	100.9	
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	18	
Maximum Allowable Temperature	°C	20	
Exit Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

PCBs: QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	18.00	
Sampling Leak Rate	l/min	0.06	
Allowable Leak Rate	l/min	0.90	
Leak Test Acceptable	-	Yes	

Validity of WHO TEQ H/M Blank vs ELV	Units	Blank 1	
Allowable Blank	ng/m³	N/A	
Blank Acceptable	-	N/A	

Method Deviations

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

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

		Value			Standard uncertainty		
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	6.2690		uV_m	m^3	0.1254	
Sampled Gas Temperature	T_m	289.2		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	101.0		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.84		uL	%	-	
Laboratory Result	L_r	10.00		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.69		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.84		≤5%
Laboratory Result	%	10.00		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	5.7984		3E-04	
Leak	L	ng/m^3	9.5E-06		1.00	
Laboratory Result	L_r	ng/m^3	2.0E-04		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	ng/m^3	5E-05	
Leak	ng/m^3	1E-05	
Laboratory Result	ng/m^3	2E-04	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	0.87	
Stack Gas O_2 Content	% v/v	9.51	
MU for O_2 Correction	-	0.04	
Overall MU For O_2 Measurement	%	4.35	

Parameter	**Units**	**Run 1**	
Combined uncertainty	ng/m^3	0.0002	
Expanded uncertainty (95% confidence), without Oxygen Correction	ng/m^3	0.0004	
Expanded uncertainty (95% confidence), with Oxygen Correction	ng/m^3	0.0004	
Expanded uncertainty (95% confidence), estimated with Method Deviations	ng/m^3	0.0004	
Reported Uncertainty	ng/m^3	0.0004	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.2	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	20.7	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.7	
Reported Uncertainty	%	20.7	

PAHs: RESULTS SUMMARY (Page 1 of 2)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

Sample Runs

DEFRA 16

Parameter	Units	Run 1		Mean
Concentration	µg/m³	1.7		1.7
Uncertainty	±µg/m³	0.35		0.35
Mass Emission	g/hr	0.24		0.24
Uncertainty	±g/hr	0.051		0.051

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	17.2		17.2
Uncertainty	±% v/v	0.89		0.89

PAHs: RESULTS SUMMARY (Page 2 of 2)

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

Blank Runs

DEFRA 16

Parameter	Units	Blank 1		Maximum
Concentration	µg/m³	1.7		1.7

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 / 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.

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_2O	-234.5	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	744.8	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	1160.7	
Total mass collected in impingers (silica trap)	g	55.1	
Total mass of liquid collected, V_{lc}	g	1215.8	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	1.5149	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	8.0700	
Gas meter correction factor, Y_d	-	0.9580	
Average dry gas meter temperature, T_m	°C	18.0	
Average pressure drop across orifice, ΔH	mmH_2O	58.6	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	7.3126	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.1716	
B_{wo} as a percentage	% v/v	17.16	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	17.16	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	8.8275	
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	7.15	
% dry oxygen measured in gas stream, $ACT\%O_{2d}$	% v/v	8.49	
% oxygen reference condition, $REF\%O_2$	% v/v	11.00	
O_2 Reference Factor wet $(O_{2REFw}) = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$	-	0.72	
O_2 Reference Factor dry $(O_{2REFd}) = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$	-	0.80	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m^3	12.2236	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m^3	9.1481	
Molecular weight of dry gas stream, M_d			
CO_2 (Estimated)	% v/v	11.00	
O_2	% v/v	8.49	
Total	% v/v	19.49	
N_2	% v/v	80.51	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	30.10	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.02	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	25.30	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	5.03	
Average stack gas temperature, T_s	°C	146.1	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	21.06	
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	3545.6	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	2263.5	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	1875.0	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	3134.3	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	2345.7	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	5.99	
Nozzle area, A_n	mm^2	28.22	
Total sampling time, q	min	360	
$\%I = (4.6398E^{6})(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	107.7	

PAHs: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	09:58 - 12:58, 13:00 - 16:00	
Sampling Dates	-	03/03/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m^3	9.1481	
Anthanthrene	µg	< 0.10	
Benzo(a)anthracene	µg	< 0.10	
Benzo(a)pyrene	µg	< 0.10	
Benzo(b)fluoranthene	µg	< 0.10	
Benzo(b)naptho(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	< 0.10	
Indeno(123-cd)pyrene	µg	< 0.10	
Naphthalene	µg	0.90	

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	9.148	
Anthanthrene	µg	< 0.10	
Benzo(a)anthracene	µg	< 0.10	
Benzo(a)pyrene	µg	< 0.10	
Benzo(b)fluoranthene	µg	0.70	
Benzo(b)naptho(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

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	21.48	
Pre-Sampling Leak Rate	l/min	0.07	
Post-Sampling Leak Rate	l/min	0.12	
Allowable Leak Rate	l/min	1.07	
Leak Test Acceptable	-	Yes	

Detection Limit	Units	Run 1	
Anthanthrene	µg/m³	0.011	
Benzo(a)anthracene	µg/m³	0.011	
Benzo(a)pyrene	µg/m³	0.011	
Benzo(b)fluoranthene	µg/m³	0.011	
Benzo(b)naptho(2,1-d)thiophene	µg/m³	0.011	
Benzo(c)phenanthrene	µg/m³	0.011	
Benzo(ghi)perylene	µg/m³	0.011	
Benzo(k)fluoranthene	µg/m³	0.011	
Cholanthrene	µg/m³	0.011	
Chrysene	µg/m³	0.011	
Cyclopenta(cd)pyrene	µg/m³	0.011	
Dibenzo (ai) pyrene	µg/m³	0.011	
Dibenzo(ah)anthracene	µg/m³	0.011	
Fluoranthene	µg/m³	0.011	
Indeno(123-cd)pyrene	µg/m³	0.011	
Naphthalene	µg/m³	0.011	
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	%	107.7	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	121	

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

PAHs: QUALITY ASSURANCE

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/m³	N/A	
Blank Acceptable	-	N/A	

Method Deviations

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

PAHs (DEFRA 16): MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	8.0700		uV_m	m^3	0.1614	
Sampled Gas Temperature	T_m	291.0		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	99.3		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.56		uL	%	-	
Laboratory Result	L_r	10.00		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
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	%	0.56		≤5%
Laboratory Result	%	10.00		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	7.3126		0.23	
Leak	L	µg/m^3	0.005		1.00	
Laboratory Result	L_r	µg/m^3	0.168		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	µg/m^3	0.043	
Leak	µg/m^3	0.0054	
Laboratory Result	µg/m^3	0.1683	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	0.80	
Stack Gas O_2 Content	% v/v	8.49	
MU for O_2 Correction	-	0.03	
Overall MU For O_2 Measurement	%	4.00	

Parameter	**Units**	**Run 1**	
Combined uncertainty	µg/m^3	0.17	
Expanded uncertainty (95% confidence), without Oxygen Correction	µg/m^3	0.34	
Expanded uncertainty (95% confidence), with Oxygen Correction	µg/m^3	0.35	
Expanded uncertainty (95% confidence), estimated with Method Deviations	µg/m^3	0.35	
Reported Uncertainty	µg/m^3	0.35	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.2	
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

A2 - Stream 2

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	< 0.031		< 0.031
Uncertainty	±mg/m³	0.0046		0.0046
Mass Emission	g/hr	< 4.4		< 4.4
Uncertainty	±g/hr	0.69		0.69

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	15.0		15.0
Uncertainty	±% v/v	0.63		0.63

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.022		< 0.022

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	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A3, B3	

Reference Conditions

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

HYDROGEN FLUORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	08:00 - 08:40; 08:42 - 09:02	
Sampling Dates	-	06/03/2015	
Sampling Device	-	MFC / MV	
Duration	mins	60	
Volume Sampled (STP, Dry)	m^3	0.6942	
Volume Sampled (STP, Wet)	m^3	0.8169	
Volume Sampled (REF)	m^3	0.8157	
Sample Flow Rate	l/min	11.16	
Laboratory Result for Front Impingers	µg/ml	< 0.05	
Laboratory Result for Back Impinger	µg/ml	< 0.05	
Volume in Front Impingers	ml	362.8	
Volume in Back Impinger	ml	139.4	
Mass in Front Impingers	µg	< 18.1	
Mass in Back Impinger	µg	< 7.0	
Total Mass Collected	µg	< 25.1	
Calculated Concentration	mg/m^3	< 0.03	
Liquid Trap Start Mass	g	1451.6	
Liquid Trap End Mass	g	1548.1	
Silica Trap Start Mass	g	1334.8	
Silica Trap End Mass	g	1336.8	
Total Mass Of Water Vapour	g	98.5	
Calculated Water Vapour	% v/v	15.02	

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	0.8157	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	365.2	
Total Mass Collected	µg	< 18.3	
Calculated Concentration	mg/m^3	< 0.022	

HYDROGEN FLUORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	11.16	
Pre-Sampling Leak Rate	l/min	0.11	
Post-Sampling Leak Rate	l/min	0.12	
Allowable Leak Rate	l/min	0.22	
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	0.10	
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 (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number	
	1	
There are no deviations associated with the sampling employed.	wx	

HYDROGEN FLUORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (STP)	V_m	0.6942		uV_m	m³	0.0139	
Leak	L	1.08		uL	%	-	
Laboratory Result	L_r	7.05		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	1.08		≤2%
Laboratory Result	%	7.05		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m³	0.6942		0.044	
Leak	L	mg/m³	0.0002		1.00	
Laboratory Result	L_r	mg/m³	0.0022		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m³	0.0006	
Leak	mg/m³	0.0002	
Laboratory Result	mg/m³	0.0022	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**Units**	**Run 1**	
O_2 Correction Factor	-	0.85	
Stack Gas O_2 Content	% v/v	9.25	
MU for O_2 Correction	-	0.04	
Overall MU For O_2 Measurement	%	4.26	

Parameter	**Units**	**Run 1**	
Combined uncertainty	mg/m³	0.002	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m³	0.004	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m³	0.005	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m³	0.005	
Reported Uncertainty	mg/m³	0.005	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	14.4	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	15.0	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	15.0	
Reported Uncertainty	%	15.0	

OXYGEN: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

Sample Runs

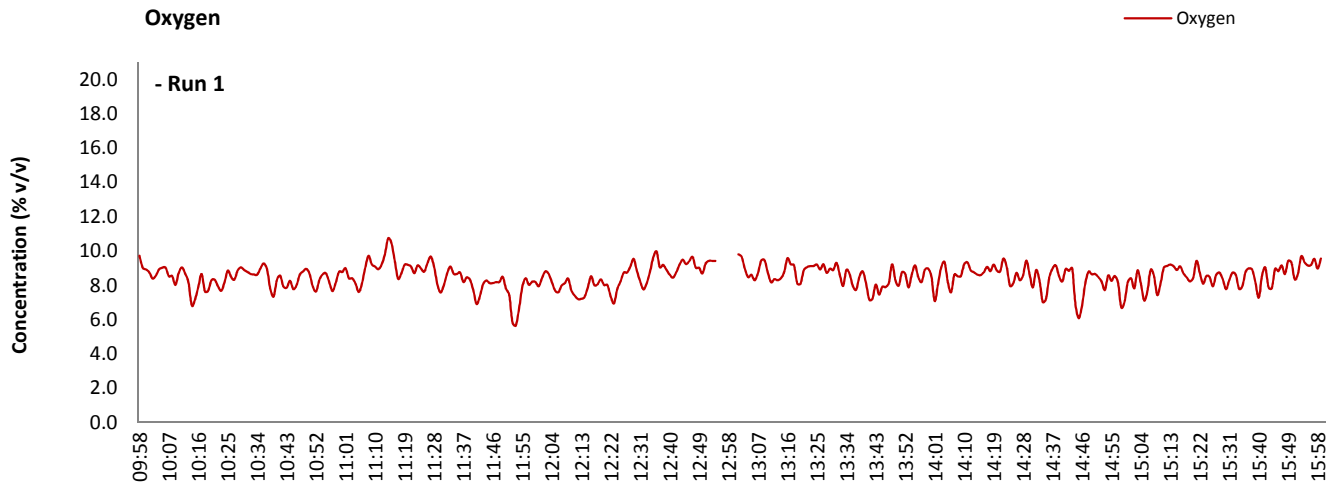
Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	% v/v	8.5	9.5	9.3	9.1
Uncertainty	±% v/v	0.38	0.39	0.39	0.39

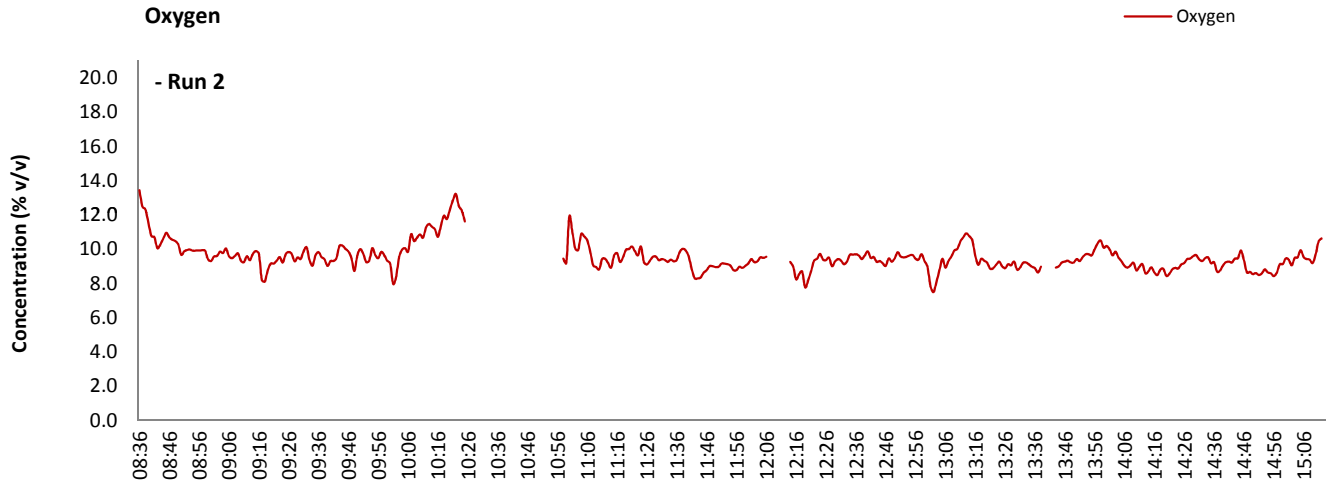
General Sampling Information

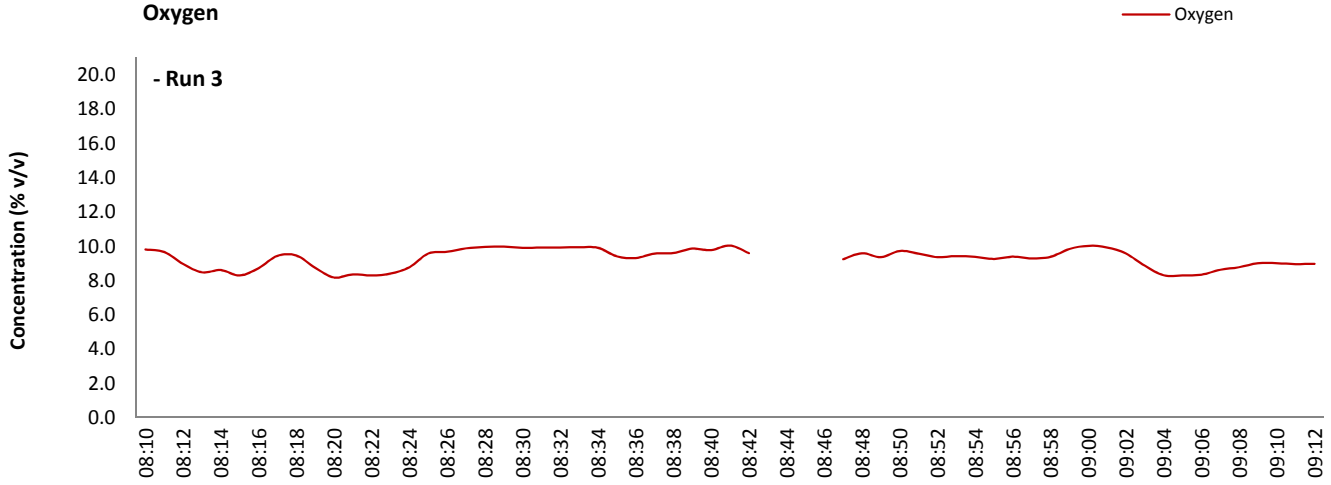
Parameter	Value	
Standard	EN 14789	
Technical Procedure	CAT-TP-33	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	N/A	
Heated Line Temperature	Orsat Used	
Span Gas Type	Synthetic Air (5 Grade)	
Span Gas Reference Number	CYL 11.0154	
Span Gas Expiry Date	06/02/2019	
Span Gas Start Pressure (bar)	40	
Gas Cylinder Concentration (% v/v)	21.07	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
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	

OXYGEN: DATA TREND

Graphical Trend of Data







OXYGEN: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	09:58 - 16:00	08:36 - 15:13	08:10 - 09:12
Sampling Dates	-	03/03/2015	04/03/2015	06/03/2015
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
CAL 1	Zero Down Sampling Line (Pre)	% v/v	0.00	0.00	0.00
	Zero Down Sampling Line (Post)	% v/v	0.10	0.10	0.10
	Zero Drift	% v/v	0.10	0.10	0.10
	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
CAL 1	Span Down Sampling Line (Pre)	% v/v	10.90	11.10	11.20
	Span Down Sampling Line (Post)	% v/v	11.00	11.20	11.30
	Span Drift	% v/v	0.10	0.10	0.10
	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	12 - 16	11 - 15	12 - 17

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	8.47	9.52	9.25	%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	70	70	70	seconds
Number of readings in measurement	363	398	63	-
Repeatability at zero	0.010	0.010	0.010	% full scale
Repeatability at span level	0.010	0.010	0.010	% full scale
Deviation from linearity	0.10	0.10	0.10	% of value
Zero drift	0.92	0.92	0.92	% full scale
Span drift	0.92	0.92	0.92	% full scale
Volume or pressure flow dependence	-0.040	-0.040	-0.040	% of full scale
Atmospheric pressure dependence	-0.40	-0.40	-0.40	% of value/kPa
Ambient temperature dependence	0.11	0.11	0.11	% full scale/10K
Combined interference	0.20	0.20	0.20	% range
Dependence on voltage	0.010	0.010	0.010	% full scale/10V
Losses in the line (leak)	0.00	0.00	0.00	% 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	0.0005	0.0005	0.0013	%vol
Lack of fit	0.014	0.014	0.014	%vol
Drift	0.16	0.16	0.16	%vol
Volume or pressure flow dependence	-0.000058	-0.000058	-0.000058	%vol
Atmospheric pressure dependence	-0.029	-0.029	-0.029	%vol
Ambient temperature dependence	0.016	0.016	0.016	%vol
Combined interference (from MCERTS Certificate)	0.029	0.029	0.029	%vol
Dependence on voltage	0.0012	0.0012	0.0012	%vol
Losses in the line (leak)	0.00	0.00	0.00	%vol
Uncertainty of calibration gas	0.10	0.11	0.11	%vol

			RUN 1	RUN 2	RUN 3	Units
Measurement uncertainty		**Result**	8.47	9.52	9.25	%vol
Combined uncertainty			0.19	0.19	0.19	%vol
Expanded uncertainty	k =	1.96	0.38	0.38	0.38	%vol

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O_2) - at 95% Confidence	4.45	4.45	4.45	% 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
A2 - Stream 2

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	6.4		6.4
Uncertainty	±mg/m³	0.74		0.74
Mass Emission	g/hr	917		917
Uncertainty	±g/hr	114		114

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

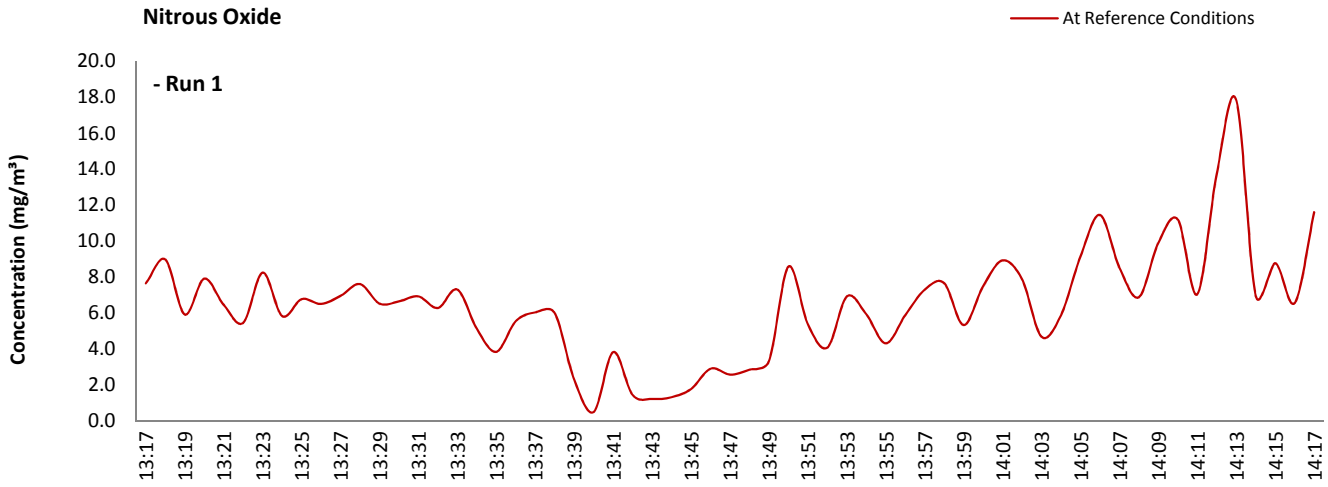
Type of Reference	Concentration of References
Instrument Specific	50.00

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)	3.46
Nitrous Oxide				Range (ppm)	10
Source of Uncertainty	**Value (±%)**	**Probability Distribution**	**Divisor**	**Conversion Factor**	**ui | ppm**
Lack of Fit	0.60	rectangular	√3	0.03	0.012
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	0.02	0.007
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	0.03	0.035
Combined Uncertainty	-	normal	-	-	0.20
Expanded Uncertainty (ppm)	-	t-distribution (k=2)	-	-	0.40
Expanded Uncertainty (%age of Reading)	-	t-distribution (k=2)	-	-	11.5

WATER VAPOUR: RESULTS SUMMARY

Viridor Waste Management Ltd, Cardiff Energy Recovery Facility
A2 - Stream 2

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	% v/v	12.4		12.4
Uncertainty	% v/v	0.81		0.81

General Sampling Information

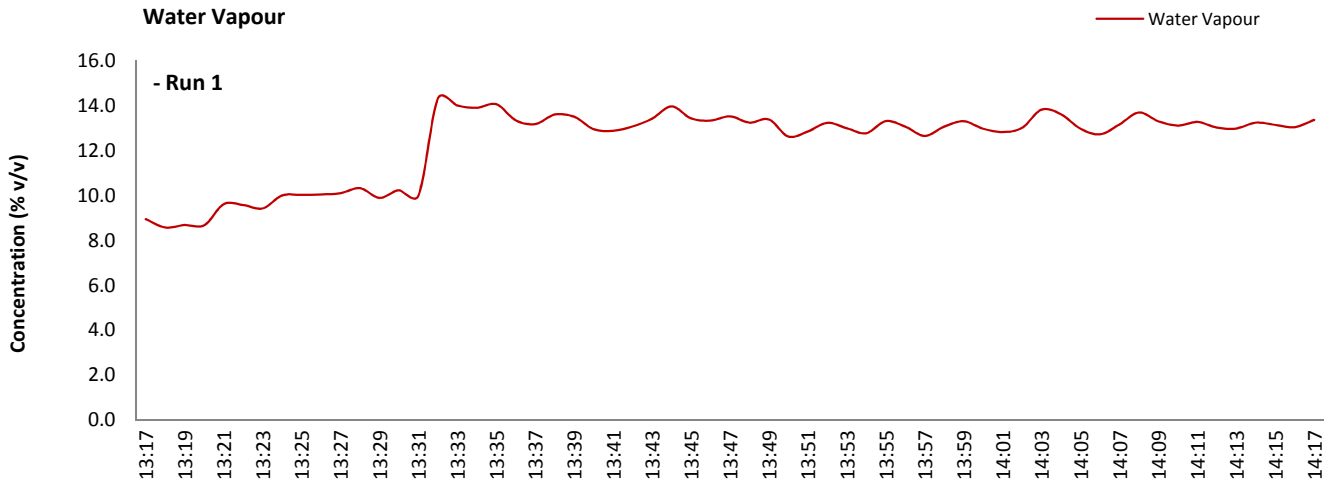
Parameter	Value	
Standard	TGN M22	
Technical Procedure	CAT-TP-22(b)	
Analysis Areas (Wave Number Limits)	3200 - 3401	
Sampling System Path Length (m)	5	
Sample Cell Temperature (°C)	180	
Sample Cell Pressure (mbar)	1013	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Check Gas Type	C_3H_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)	12.36
Water Vapour				Range (%v/v)	15
Source of Uncertainty	**Value (±%)**	**Probability Distribution**	**Divisor**	**Conversion Factor**	**ui | % v/v**
Lack of Fit	0.32	rectangular	√3	0.12	0.023
Zero Drift	0.50	rectangular	√3	0.15	0.043
Span Drift	2.00	rectangular	√3	0.15	0.17
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	0.03	-0.017
Sensitivity to Electrical Voltage	0.12	rectangular	√3	0.0	0.0020
Interferents	3.90	rectangular	√3	0.15	0.34
Standard Deviation of Repeatability at Zero	0.05	normal	1	0.15	0.0075
Standard Deviation of Repeatability at Span	N/A	normal	1	N/A	0.00
Uncertainty of Certified Reference Material	2.00	normal	2	0.12	0.12
Combined Uncertainty	-	normal	-	-	0.40
Expanded Uncertainty (% v/v)	-	t-distribution (k=2)	-	-	0.81
Expanded Uncertainty (%age of Reading)	-	t-distribution (k=2)	-	-	6.51

M22 FTIR SAMPLING DETAILS & QUALITY ASSURANCE

(PAGE 1 OF 2)

Sampling Details

Parameter	Units	Run 1	
Sampling Times	-	13:17 - 14:17	
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 (x = deviation applies to the associated run)	Run Number 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

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						REACTIVE GAS CHECK
		Check Gas Check - Pre Test	**Units**	**NO**		**C_3H_8**	**SO_2**
		Response Time, T_{90}	s	35		35	30
		Reverse Response Time, RT_{90}	s	20	**(performed against decreasing H_2O)**		
		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	**Units**	**NO**		**C_3H_8**	**SO_2**
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		80.3	96.8
		Difference	ppm	-0.9		0.0	-1.6
		Drift	%	-0.2		0.0	
		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%.