Industrial Compliance Solutions

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Project / Client Details

Rainbow Mountain Renewable Energy Limited

Site Address
Rainbow Mountain Renewable Energy Limited
216 State Highway 38
Waimangu
New Zealand

Stack/Release Point(s) Tested
Wet Electrostatic Precipitator (WESP)

Target Parameter(s)
Dioxins & Furans
PAH

Job Number
100747

Sampling Date(s)
21st August 2024

Report Date / Version:	08/10/24 v1.0
Report By: Business Title CASANZ Level Professional Qualification 1 Professional Qualification 2	Toby Campbell Principal Environmental Consultant Certificate Air Quality Professional (CAQP) BSc Environmental Management MSc Air Pollution Management and Control
Report Approved By: Business Title CASANZ Level Professional Qualification 1 Professional Qualification 2	Brent Kennedy Principal Scientist Certificate Air Quality Professional (CAQP) BSc Chemistry MSc Materials and Processing Engineering

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EXECUTIVE SUMMARY (Page 1 of 9)

Stack Emissions Monitoring Objectives

Rainbow Mountain Renewable Energy Limited operates a Anaerobic-Thermal-Reduction (ATR) Pyrolysis at Rainbow Mountain, 216 State Highway 38, Waimangu which is subject to a Resource Consent, under the Resource Management Act 1991 .

Industrial Compliance Solutions were commissioned by Rainbow Mountain Renewable Energy Limited to carry out stack emissions monitoring to determine the release of Dioxins & Furans, and PAHs from the following Plant under Normal operating conditions.

The results of this test shall be used to demonstrate compliance with emission limit values as specified in the Plant's Resource Consent, RM22-0076-AP.

Plant
Wet Electrostatic Precipitator (WESP)

Operator
Resource Consent: RM22-0076-AP
Rainbow Mountain Renewable Energy Limited
216 State Highway 38
Waimangu
New Zealand

Stack Emissions Monitoring Company
Industrial Compliance Solutions Ltd
Suite 4
21 Railside Place
Dinsdale
Hamilton

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EXECUTIVE SUMMARY (Page 2 of 9)

Emissions Summary

Rainbow Mountain Renewable Energy Limited, Rainbow Mountain, 216 State Highway 38, Waimangu
Wet Electrostatic Precipitator (WESP)
21st August 2024

Parameter	Units	Result	Uncertainty +/-	Emission Limit Value (ELV)	Outcome (above/below ELV)
Dioxins & Furans	ng/m^3	0.0516	0.0129	**0.1**	Below
PAHs	mg/m^3	0.0026	0.0006	**400**	Below
Moisture	%	5.3	1.06	-	-
Stack Gas Temperature	^oC	36.4	-	-	-
Stack Gas Velocity	m/s	4.4	-	-	-
Gas Volumetric Flow Rate (Actual)	m^3/hr	9049	-	-	-
Gas Volumetric Flow Rate (STP, Wet)	m^3/hr	8084	-	-	-
Gas Volumetric Flow Rate (STP, Dry)	m^3/hr	7656	-	-	-

25% uncertainty has been applied to the results due to the nature of the testing location.
All: Reference conditions are 273K, 101.3kPa, dry gas.

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Monitoring Times and Results - Dioxins & Furans, and PAHs

	Run 1	Run 2	Run 3
Sampling Date	21/08/2024		
Sampling Times	11:34 - 17:34		

Dioxins & Furans			PAHs		
Congener	**Run 1 ng/m^2**	**Run 1 g/hr**	**Congener**	**Run 1 mg/m^3**	**Run 1 g/hr**
2378-TCDF	0.008830	0.0003904	Naphthalene	0.00171411	0.075790
2378-TCDD	0.007272	0.0003215	2-Methylnaphthalene	0.00006406	0.002833
12378-PeCDF	0.002164	0.0000957	Acenaphthylene	0.00027703	0.012249
23478-PeCDF	0.025106	0.0011101	Acenaphthene	0.00001420	0.000628
12378-PeCDD	0.003290	0.0001455	Fluorene	0.00006579	0.002909
123478-HxCDF	0.001489	0.0000658	Phenanthrene	0.00027703	0.012249
123678-HxCDF	0.001593	0.0000704	Anthracene	0.00000294	0.000130
234678-HxCDF	0.000710	0.0000314	Fluoranthene	0.00005367	0.002373
123789-HxCDF	0.000260	0.0000115	Pyrene	0.00005714	0.002526
123478-HxCDD	0.000173	0.0000077	Benz(a)anthracene	0.00000260	0.000115
123678-HxCDD	0.000242	0.0000107	Chrysene	0.00000571	0.000253
123789-HxCDD	0.000208	0.0000092	Benzo(b)fluoranthene	0.00000467	0.000207
1234678-HpCDF	0.000173	0.0000077	Benzo(k)fluoranthene	0.00000450	0.000199
1234789-HpCDF	0.000035	0.0000015	Benzo(e)pyrene	0.00000502	0.000222
1234678-HpCDD	0.000080	0.0000035	Benzo(a)pyrene	0.00000260	0.000115
OCDF	0.000003	0.0000002	Perylene	0.00000038	0.000017
OCDD	0.000006	0.0000003	Indeno(1,2,3-cd)pyrene	0.00000467	0.000207
Total	**0.0516**		Dibenz(ah)anthracene	0.00000002	0.000001
			Benzo(ghi)perylene	0.00000796	0.000352
			Total	**0.0026**	

Process Details

Parameter	Process Details
Process Status	Normal
Capacity and / or Production Rate	10 tonnes per 16 hour cycle
Continuous or Batch Process	Batch
Feedstock (if applicable)	Flock
Abatement System	WESP
Abatement System Running Status	Operational
Fuel (if applicable)	Fuel Oil / Syngas
Plume Appearance	Visible Plume

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Monitoring Methods

Industrial Compliance Solutions Ltd employ USEPA methodologies for stack emissions testing. This section details all of the methods used on site during this monitoring campaign.

The table below summarises the monitoring methods, techniques and technical procedures employed, and details any deviations from the aforementioned hierarchy:

Sampling Methods with Subsequent Analysis

Species	Standard Method	ICS Technical Procedure	IANZ Lab Number	IANZ Accredited Method	Limit of Detection (LOD)	MU of Method (E) +/- %	MU +/- %
Dioxins & Furans	US EPA M23	TMM 2.12	N/A	N/A	~ 0.001 ng/m³	20%	25% (E)
PAHs	US EPA M23	TMM 2.12	N/A	N/A	~ 0.02 ug/m³	20%	25% (E)
H_2O	US EPA M4	TMM 2.4	N/A	N/A	0.1%	20%	-

where C = Calculated Measurement Uncertainty, E = Estimated Measurement Uncertainty

On-Site Testing and Analysis

The table below summarises the monitoring methods, techniques and technical procedures employed:

Species	Standard Method	ICS Technical Procedure	IANZ Lab Number	IANZ Accredited Method	Limit of Detection (LOD)	MU of Method (E) +/- %	MU +/- %
Sample and Velocity Traverse	US EPA M1	TMM2.1	N/A	N/A	N/A	10%	10%
Velocity and Volumeteric Flow	US EPA M2	TMM2.2	N/A	N/A	0.2 mm H_2O	10%	10%

where C = Calculated Measurement Uncertainty, E = Estimated Measurement Uncertainty

EXECUTIVE SUMMARY (Page 5 of 9)

Analytical Methods

The following tables list the analytical methods employed together with the custody and archiving details:

Sampling Methods with Subsequent Analysis

Species	Analytical Technique	Analytical Procedure	Lab Number	Accredited Analysis	Laboratory	Sample Archive Location	Archive Period
Dioxins & Furans	HRGC/HRMS	AUT_MET002	198	NATA	National Measurement Institute	New South Wales	3 months
PAHs	GC-MS/HPLC	NGCMS_1127	198	NATA	National Measurement Institute	New South Wales	3 months
H2O	Gravimetric	TMM 2.4	N/A	N/A	ICS	N/A	N/A

EXECUTIVE SUMMARY (Page 6 of 9)

Measurement Uncertainty (MU)

Manual Extractive Testing

There are 4 ways in which to report measurement uncertainty, these are listed in the hierarchical table below. The table also indicates which method has been used to calculate the MU for the parameters listed in this report.

MU Reported	Yes / No
a) Report a calculated MU	No
b) Report an estimated MU if there are any deviations from the sampling plane validation criteria	Yes
c) Report an estimated MU if there are any deviations from the specified method	Yes
d) Report the MU specified in the method	-

NOTE: The estimated uncertainty is based upon a calculated MU, coupled with the experience of the Stack Emissions Test house.

EXECUTIVE SUMMARY (Page 7 of 9)

Sampling Location

Sampling Plane Validation Criteria (Ideal Conditions)	Value	Units	Requirement	Compliance	Method
Lowest Differential Pressure	4	Pa	> 5 Pa	No	TMM2.2
Lowest Gas Velocity	5.48	m/s	-	-	-
Highest Gas Velocity	8.66	m/s	-	-	-
Ratio of Above	1.58	: 1	< 3 : 1	Yes	In-house
Mean Velocity	7.86	m/s	-	-	-
Angle of flow with regard to duct axis	0	^{o}	< 15^{o}	Yes	TMM2.2
No local negative flow	-	-	-	Yes	TMM2.2
Highly homogeneous flow stream / gas velocity	-	-	-	Yes	In-house
Sampling Plane Validation Criteria US EPA M2	**Value**	**Units**	**Requirement**	**Compliance**	**Method**
Duct diameters that measurements site is **upstream** from flow disturbance	4	Measured Diameters	> 2 Diameters	Yes	US EPA M1
Duct diameters that measurements site is **downstream** from flow disturbance	4	Measured Diameters	> 8 Diameters	No	US EPA M1

Duct Characteristics

Parameter	Value	Units
Type	Circular	-
Depth	0.86	m
Width	-	m
Area	0.57	m^2
Port Depth	483	mm

Sampling Lines & Sample Points

Parameter	TPM	Oxygen
Sample Port Size	4" Camlock	4" Camlock
Number Used	1	1
Sample Plane Orientation	Horizontal	-
Number Points / Line	12	1
In Stack / Out Stack Filtration	Out Stack	-

NOTE: 1 sampling line was used for sampling as only 1 sampling line was available, however the number of sample points was doubled to meet the requirements of the standard.

Sampling Platform

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

Ideal Platfrom Specifications	Present (Yes / No)
Minimum Platform Area 5 m2	Yes
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	Yes
Platform has vertical base boards (approximately 0.25 m high)	Yes
Platform has removable chains / self closing gates at the top of ladders	N/A
Handrail / obstructions do not hamper insertion of sampling equipment	Yes
Depth of Platform = Minimum of 2m or Probe Length + 1m	Yes

Sampling Location / Platform Improvement Recommendations

Two sample lines should be installed on the stack at 45 degrees relevant to the existing port.

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Sampling & Analytical Method Deviations

One Sampling Line

Only 1 sample line was present on the stack.

EXECUTIVE SUMMARY (Page 9 of 9)

Conclusion & Discussion

The results of these tests demonstrate that under normal operating conditions, this Plant is being operated in full compliance with the emission limits specified in its Resource Consent, RM22-0076-AP.

A regular programme of stack emissions testing in accordance with the Plant's Resource Consent, RM22-0076-AP, will be required to demonstrate continued compliance.

APPENDICES

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APPENDIX 1 - Stack Emissions Monitoring Team

STACK EMISSIONS MONITORING TEAM

Environmental Technician 1	Toby Campbell Principal Environmental Consultant Certificate Air Quality Professional (CAQP) BSc Environmental Management MSc Air Pollution Management and Control
Environmental Technician 2	Brent Kennedy Principal Scientist Certificate Air Quality Professional (CAQP) BSc Chemistry MSc Materials and Processing Engineering

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK PARAMETERS / SAMPLE LOCATION

	Value	Units
Stack Shape	Circular	-
Stack Depth	0.86	m
Stack Width	-	m
Area	0.57	m^2
Port Depth (including clamp)	483	mm

Gases and Non-Isokinetic Testing

Sampling Point	Distance (% of Depth)	Distance into Stack	Units
N/A	30	0.26	m

Sampling Location

Isokinetic Testing

Sampling Point	Distance into Stack	Probe Marking	Units
1	0.02	0.50	m
2	0.06	0.54	m
3	0.10	0.58	m
4	0.15	0.63	m
5	0.21	0.70	m
6	0.30	0.79	m
7	0.55	1.03	m
8	0.64	1.12	m
9	0.70	1.19	m
10	0.75	1.24	m
11	0.80	1.28	m
12	0.84	1.32	m

APPENDIX 2 - Calibrateable Equipment Checklist & Calibration Gases

EQUIPMENT CHECKLIST

Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	**Equipment I.D.**	**Equipment**	**Equipment I.D.**	**Equipment**	**Equipment I.D.**
Control Box DGM	ICS-011	-	-	Laboratory Balance	-
Box Thermocouples	ICS-014 to 018	-	-	Tapemeasure	ICS-032
Meter In Thermocouple	ICS-036	-	-	Stopwatch	TC iPhone
Meter Out Thermocouple	ICS-037	-	-	Protractor	-
Control Box Timer	ICS-019	-	-	Barometer	ICS-044
Umbilical	ICS-031	-	-	Digital Micromanometer	-
Oven Box	ICS-009	-	-	Digital Temperature Meter	-
Probe	ICS-004	-	-	Stack Thermocouple	ICS-005
S-Pitot	ICS-006	-	-	Dioxin Water Pump	ICS-030
L-Pitot	-	-	-	-	-
Site Balance	ICS-026	-	-	-	-
Last Impinger Arm	ICS-028	-	-	-	-
Calipers	ICS-040	-	-	-	-
Small DGM	-	-	-	-	-
Pump CAE	ICS-010	-	-	-	-
Dry Gas Meter Orifice	ICS-012	-	-	-	-
Vacuum Gauge	ICS-013	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-
-	-	-	-	-	-

NOTE: If the equipment I.D is represented by a dash (-), then this piece of equipment has not been used for this test.

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY

Rainbow Mountain Renewable Energy Limited, Rainbow Mountain, 216 State Highway 38, Waimangu
Wet Electrostatic Precipitator (WESP)
21st August 2024

Time of Survey	10:30 - 10:45
Velocity Measurement Device:	S-Type Pitot

Sampling Line A							
Traverse Point	Distance into duct (m)	ΔP pt mmH_2O	ΔP pt Pa	Temp ^oC	Velocity m/s	O_2 % Vol	Angle of Swirl ^{o}
1	0.02	0.4	4	20	5.48	-	0
2	0.06	0.6	6	20	6.71	-	
3	0.10	1.0	10	20	8.66	-	
4	0.15	1.0	10	20	8.66	-	
5	0.21	1.0	10	20	8.66	-	
6	0.30	1.0	10	20	8.66	-	
7	0.55	1.0	10	20	8.66	-	
8	0.64	1.0	10	20	8.66	-	
9	0.70	0.8	8	20	7.75	-	
10	0.75	0.6	6	20	6.71	-	0
Mean	-	0.8	8	20	7.86	-	

Sampling Line B							
Traverse Point	Distance into duct (m)	ΔP pt mmH_2O	ΔP pt Pa	Temp ^oC	Velocity m/s	O_2 % Vol	Angle of Swirl ^{o}
1	-	-	-	-	-	-	0
2	-	-	-	-	-	-	
3	-	-	-	-	-	-	
4	-	-	-	-	-	-	
5	-	-	-	-	-	-	
6	-	-	-	-	-	-	
7	-	-	-	-	-	-	
8	-	-	-	-	-	-	
9	-	-	-	-	-	-	
10	-	-	-	-	-	-	0
Mean	-	-	-	-	-	-	

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS SUMMARY - RUN 1

Rainbow Mountain Renewable Energy Limited, Rainbow Mountain, 216 State Highway 38, Waimangu
Wet Electrostatic Precipitator (WESP)
21-Aug-24

Test	Sampling Times	Duration min
Dioxins & Furans	11:34 - 17:34	360

Reference conditions are 273K, 101.3kPa, dry gas.

50% of LOD has been taken where the laboratory result is "<" a quoted value. This data is highlighted in "Green"

Congener	Laboratory Results (pg)	International Toxic Equivalence Factor (Humans)	iTEF Mass (pg) (Humans)	Concentration ng/m^3	Mass Emission g/hr
2378-TCDF	510.0	0.100	51.0	0.00883	0.0003904
2378-TCDD	42.0	1.000	42.0	0.00727	0.0003215
12378-PeCDF	250.0	0.050	12.5	0.00216	0.0000957
23478-PeCDF	290.0	0.500	145.0	0.02511	0.0011101
12378-PeCDD	38.0	0.500	19.0	0.00329	0.0001455
123478-HxCDF	86.0	0.100	8.6	0.00149	0.0000658
123678-HxCDF	92.0	0.100	9.2	0.00159	0.0000704
234678-HxCDF	41.0	0.100	4.1	0.00071	0.0000314
123789-HxCDF	15.0	0.100	1.5	0.00026	0.0000115
123478-HxCDD	10.0	0.100	1.0	0.00017	0.0000077
123678-HxCDD	14.0	0.100	1.4	0.00024	0.0000107
123789-HxCDD	12.0	0.100	1.2	0.00021	0.0000092
1234678-HpCDF	100.0	0.010	1.0	0.00017	0.0000077
1234789-HpCDF	20.0	0.010	0.2	0.00003	0.0000015
1234678-HpCDD	46.0	0.010	0.5	0.00008	0.0000035
OCDF	20.0	0.001	0.0	0.00000	0.0000002
OCDD	33.0	0.001	0.0	0.00001	0.0000003
Total	**1619.0**	**-**	**298.2**	**0.05163**	**0.0023**

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS SUMMARY - BLANK

Rainbow Mountain Renewable Energy Limited, Rainbow Mountain, 216 State Highway 38, Waimangu
Wet Electrostatic Precipitator (WESP)
21-Aug-24

Test	Sampling Times	Duration min
Dioxins & Furans	11:04 - 11:08	4

Reference conditions are 273K, 101.3kPa, dry gas.

50% of LOD has been taken where the laboratory result is "<" a quoted value. This data is highlighted in "Green"

Congener	Laboratory Results (pg)	International Toxic Equivalence Factor (Humans)	iTEF Mass (pg) (Humans)	Concentration ng/m^3	Mass Emission g/hr
2378-TCDF	<2	0.100	1.0	0.00017	0.0000077
2378-TCDD	<8	1.000	4.0	0.00069	0.0000306
12378-PeCDF	<1	0.050	0.5	0.00009	0.0000038
23478-PeCDF	<1	0.500	0.5	0.00009	0.0000038
12378-PeCDD	<7	0.500	3.5	0.00061	0.0000268
123478-HxCDF	<0.5	0.100	0.3	0.00004	0.0000019
123678-HxCDF	<0.5	0.100	0.3	0.00004	0.0000019
234678-HxCDF	<0.5	0.100	0.3	0.00004	0.0000019
123789-HxCDF	<0.5	0.100	0.3	0.00004	0.0000019
123478-HxCDD	<1	0.100	0.5	0.00009	0.0000038
123678-HxCDD	<1	0.100	0.5	0.00009	0.0000038
123789-HxCDD	<1	0.100	0.5	0.00009	0.0000038
1234678-HpCDF	<1	0.010	0.5	0.00009	0.0000038
1234789-HpCDF	<1	0.010	0.5	0.00009	0.0000038
1234678-HpCDD	<1	0.010	0.5	0.00009	0.0000038
OCDF	<1	0.001	0.5	0.00009	0.0000038
OCDD	<2	0.001	1.0	0.00017	0.0000077
Total	**0.0**	**-**	**15.0**	**0.00260**	**0.0001**

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PAHs SUMMARY - RUN 1

Rainbow Mountain Renewable Energy Limited, Rainbow Mountain, 216 State Highway 38, Waimangu
Wet Electrostatic Precipitator (WESP)
21-Aug-24

Test	Sampling Times	Duration min
PAHs	11:34 - 17:34	360

Reference conditions are 273K, 101.3kPa, dry gas.

50% of LOD has been taken where the laboratory result is "<" a quoted value. This data is highlighted in "Green"

Congener	Laboratory Results (ng)	Laboratory Results (µg)	Concentration mg/m^3	Mass Emission g/hr
Naphthalene	9900000.0	9.9000	0.00171411	0.0757899
2-Methylnaphthalene	370000.0	0.3700	0.00006406	0.0028326
Acenaphthylene	1600000.0	1.6000	0.00027703	0.0122489
Acenaphthene	82000.0	0.0820	0.00001420	0.0006278
Fluorene	380000.0	0.3800	0.00006579	0.0029091
Phenanthrene	1600000.0	1.6000	0.00027703	0.0122489
Anthracene	17000.0	0.0170	0.00000294	0.0001301
Fluoranthene	310000.0	0.3100	0.00005367	0.0023732
Pyrene	330000.0	0.3300	0.00005714	0.0025263
Benz(a)anthracene	15000.0	0.0150	0.00000260	0.0001148
Chrysene	33000.0	0.0330	0.00000571	0.0002526
Benzo(b)fluoranthene	27000.0	0.0270	0.00000467	0.0002067
Benzo(k)fluoranthene	26000.0	0.0260	0.00000450	0.0001990
Benzo(e)pyrene	29000.0	0.0290	0.00000502	0.0002220
Benzo(a)pyrene	15000.0	0.0150	0.00000260	0.0001148
Perylene	2200.0	0.0022	0.00000038	0.0000168
Indeno(1,2,3-cd)pyrene	27000.0	0.0270	0.00000467	0.0002067
Dibenz(ah)anthracene	<200	0.0001	0.00000002	0.0000008
Benzo(ghi)perylene	46000.0	0.0460	0.00000796	0.0003522
Total	**-**	**14.8**	**0.00256**	**0.1134**

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PAHs SUMMARY - BLANK

Rainbow Mountain Renewable Energy Limited, Rainbow Mountain, 216 State Highway 38, Waimangu
Wet Electrostatic Precipitator (WESP)
21-Aug-24

Test	Sampling Times	Duration min
PAHs	11:04 - 11:08	4

Reference conditions are 273K, 101.3kPa, dry gas.

50% of LOD has been taken where the laboratory result is "<" a quoted value. This data is highlighted in "Green"

Congener	Laboratory Results (ng)	Laboratory Results (µg)	Concentration mg/m^3	Mass Emission g/hr
Naphthalene	1200.0	1.200	0.000208	0.0091867
2-Methylnaphthalene	160.0	0.160	0.000028	0.0012249
Acenaphthylene	<20	0.010	0.000002	0.0000766
Acenaphthene	<20	0.010	0.000002	0.0000766
Fluorene	<20	0.010	0.000002	0.0000766
Phenanthrene	1500.0	1.500	0.000260	0.0114833
Anthracene	140.0	0.140	0.000024	0.0010718
Fluoranthene	260.0	0.260	0.000045	0.0019904
Pyrene	130.0	0.130	0.000023	0.0009952
Benz(a)anthracene	<20	0.010	0.000002	0.0000766
Chrysene	<20	0.010	0.000002	0.0000766
Benzo(b)fluoranthene	<20	0.010	0.000002	0.0000766
Benzo(k)fluoranthene	<20	0.010	0.000002	0.0000766
Benzo(e)pyrene	<20	0.010	0.000002	0.0000766
Benzo(a)pyrene	<20	0.010	0.000002	0.0000766
Perylene	<20	0.010	0.000002	0.0000766
Indeno(1,2,3-cd)pyrene	<20	0.010	0.000002	0.0000766
Dibenz(ah)anthracene	<20	0.010	0.000002	0.0000766
Benzo(ghi)perylene	<20	0.010	0.000002	0.0000766
Total	**-**	**3.5**	**0.00061**	**0.02695**

ISOKINETIC SAMPLING EQUATIONS 1 — Dioxins & Furans, and PAHs

Test	1	2	3	Units
Absolute pressure of stack gas, P_s				
Barometric pressure, P_b	769.5			mm Hg
Stack static pressure, P_{static}	0.2			mm H_2O
$P_s = P_b + \frac{(P_{static})}{13.6}$	769.5			mm Hg
Volume of water vapour collected, V_{wstd}				
Impinger volume collected	229.8			ml
Silica gel weight increase	30.9			g
Total volume of liquid collected, V_{lc}	260.7			ml
$V_{wstd} = (0.001246)(V_{lc})$	0.3233			m^3
Volume of gas metered dry, V_{mstd}				
Volume of gas sample through gas meter, V_m	5.9649			m^3
Gas meter correction factor, Y_d	1.015			-
Average dry gas meter temperature, T_m	17.5			^oC
Average pressure drop across orifice, ΔH	28.6			mm H_2O
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(\Delta H/13.6))(Y_d)}{T_m + 273}$	5.7756			m^3
Volume of gas metered wet, V_{mstw}				
$V_{mstw} = V_{mstd} + V_{wstd}$	6.0989			m^3
Volume of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$				
% oxygen measured in gas stream, act%O_2	18.0			%
% oxygen reference condition *(21.0 denotes no O2 correction)*	21.0			%
O_2 Reference Factor O2 Ref = $\frac{21.0 - act\%O2}{21.0 - ref\%O2}$	No O2 Ref			
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	No O2 Ref			m^3
Moisture content, B_{wo}				
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$	0.053			m^3
	5.30			%
Molecular weight of dry gas stream, M_d				
CO_2	2.5			%
O_2	18.0			%
Total	20.5			%
N_2 (100 -Total)	79.5			%
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	29.12			g/gmol
Molecular weight of stack gas (wet), M_s				
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	28.53			g/gmol

ISOKINETIC SAMPLING EQUATIONS 2 — Dioxins & Furans, and PAHs

Test	1	2	3	Units
Velocity of stack gas, V_s				
Pitot tube velocity constant, K_p	34.97			-
Velocity pressure coefficient, C_p	0.84			-
Average stack gas temperature, T_s	36			°C
$V_s = (K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273) / \sqrt{(M_s)(P_s)}$	4.38			m/s
V_s corrected for angle of swirl	4.38			m/s
Actual flow of stack gas, Q_a				
Area of stack, A_s	0.57			m²
$Q_a = (60)(A_s)(V_s)$	150.8			m³/min
	9049.3			m³/hr
Dry total flow of stack gas, Q_{std}				
Conversion factor (K/mm.Hg)	0.3592			-
$Q_{std} = (Q_a)P_s(0.3592)(1-B_{wo}) / (T_s) +273$	127.6			m³/min
	7656			m³/hr
Dry total flow of stack gas, at O2 Ref. Cond., $Q_{std@X\%O2}$				
% oxygen measured in gas stream, act%O_2	18.0			%
% oxygen reference condition *(21.0 denotes no O2 correction)*	21.0			%
O_2 Reference Factor O2 Ref = (21.0 - act%O2) / (21.0 - ref%O2)	No O2 Ref			
$Q_{std@X\%O2} = (Q_{std})(O_{2\ Ref})$	No O2 Ref			m³/min
Wet total flow of stack gas, Q_{stw}				
Conversion factor (K/mm.Hg)	0.3592			-
$Q_{stw} = (Q_a)P_s(0.3592) / (T_s) +273$	134.7			m³/min
	8084			m³/hr
Percent isokinetic, %I				
Nozzle diameter, D_n	9.28			mm
Nozzle area, A_n	67.64			mm²
Total sampling time, θ	360			min
$\%I = (4.6398E6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(\theta)(1-B_{wo})$	106.7			%
Acceptable isokinetic range 90% to 110%"	Yes			-

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

DIOXINS & FURANS AND PAHs QUALITY ASSURANCE CHECKLIST

Leak Test Results	Value Run 1	Value Run 2	Value Run 3	Units
Mean Sampling Rate	16.8			litre/min
Pre-sampling Leak Rate	0.16			litre/min
Post-sampling Leak Rate	0.19			litre/min
Acceptable Leak Rate (2% of sample rate)	0.34			litre/min
Leak Tests Acceptable?	Yes			-

Overall Blank Value	Dioxins & Furans Run 1	Units	PAHs Run 1	Units
Overall Blank Value	0.0026	ng/m³	0.0006	mg/m³
Emission Limit Value (ELV)	0.1	ng/m³	400.0	mg/m³
Acceptable Blank Value (10% of ELV)	0.01	mg/m³	40.0	mg/m³
Overall Blank Acceptable?	Yes	-	Yes	-

Isokinetic Criterion Compliance	Value Run 1	Value Run 2	Value Run 3	Units
Isokinetic Variation	106.7			%
Acceptable Isokineticity? (between 90% and 110%)	Yes			-

Acceptable isokinetic range 90% to 110%"

Total Particulate Matter Filters	Value Run 1	Value Run 2	Value Run 3	Units
Filter Material	GF			-
Filter Size	82			mm

GF = Glass Fibre

QF = Quartz Fibre

APPENDIX 4 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - DIOXINS & FURANS

	Value	Units
Limit value	0.1	ng/m³
Measured concentration	0.0516	ng/m³
Reference oxygen	N/A	% by volume

Measured Quantities	Symbol	Value	Units
Sampled Volume	V_m	5.8	m³
Sampled Gas Temperature	T_m	309.4	K
Sampled Gas Pressure	ρ_m	102.6	KPa
Sampled Gas Humidity	H_m	0.0	% by volume
Oxygen Content	$O_{2,m}$	18.0	% by volume
Mass of D&F	m	0.3	ng
Leak	L	1.1	%
Uncollected Mass	UCM	0.02	pg

NOTE: Sampled Gas Temperature, Pressure and Humidity are at the Dry Gas Meter.

Standard Uncertainty	Symbol	Value	Units	Uncertainty as a %	Uncertainty Required	Uncertainty Met?
Sampled Volume	uV_m	0.1155	m³	2.0	$\leq$ 2%	Yes
Sampled Gas Temperature	uT_m	3.0942	K	1.0	$\leq$ 1%	Yes
Sampled Gas Pressure	$u\rho_m$	1.0260	KPa	1.0	$\leq$ 1%	Yes
Sampled Gas Humidity	uH_m	0.0000	% by volume	0.0	$\leq$ 1%	Yes
Oxygen Content	$uO_{2,m}$	0.7497	% by volume	4.2	$\leq$ 10%	Yes
Total Mass of D&F	um	0.0010	ng	0.3	$\leq$ 5% of ELV	Yes
Leak	-	-	-	1.1	$\leq$ 2%	Yes
Uncollected Mass	-	-	-	6.7	$\leq$ 10% of ELV	Yes

Parameter	Symbol	Value	Units	Uncertainty in Result	Units	Uncertainty as a %	Units
Volume (STP)	V	5.1613	m³	0.0014	ng/m³	2.65	%
Total Mass of D&F	m	0.2982	ng	0.0002	ng/m³	0.34	%
Factor for O2 Correction	fc	1.0000	-	0.0022	ng/m³	4.16	%
Leak	L	0.0003	ng/m³	0.0003	ng/m³	0.65	%
Uncollected mass	UCM	0.0087	ng	0.0015	ng/m³	2.90	%
Combined uncertainty				0.0030	ng/m³	5.77	%

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.006**	**ng/m³**	**11.55**	**%**

(k is a coverage factor which gives a 95% confidence in the quoted figures)

NOTE: Because there are one or more method deviations from , a calculated MU can not be quoted for the concentration or mass emission of total particulate matter. Instead, this figure may be used to make a best estimate of what the MU might be.