

**Report for the Periodic Monitoring of Emissions to Air from a Biogas
Engine Stack Located at Waen Anaerobic Digestion Site**

Part 1: Executive Summary

Permit Number: EPR/DP3735NP

Operator: Biogen Ltd.

Installation: Waen AD Site (Engine)



4251

Monitoring dates: 3rd December 2015

Job Number: **R15264**

Version: 1

Address: Biogen Ltd
Milton Park
Milton Ernest
Bedfordshire
MK44 1YU

Monitoring Organisation: **EnviroDat Ltd.**

Address: Science & Technology Centre
Earley Gate
Whiteknights Road
Reading, RG6 6BZ

Date of Report: 17th December 2015

Report Approved By: David Littlewood

MCERTS Registration Number: MM 06 772 (Level II, TE1, 2, 3 & 4)

Function: Operations Manager (Team Leader)

Signed:

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PART 1: EXECUTIVE SUMMARY

1.1 Monitoring Objectives

Biogen Ltd operates a spark ignition engine at Waen Anaerobic Digestion Site. This combustion plant has the potential to pollute the atmosphere. Consequently, these processes are subject to regulation and periodic environmental monitoring is necessary under this regulation.

Methane is produced from the decomposition of organic waste that is anaerobically digested within the plant system. This methane is extracted and pumped through inert piping to a gas holder which in-turn supplies the fuel for the engine or flare.

EnviroDat Ltd. was commissioned to monitor the pollutants within the engine emissions - as prescribed in the operational permit - in order to establish the sites environmental compliance.

The pollutants monitored, as required under EPR/DP3735NP, are summarised below:

Substances to be monitored	Emission Point Identification
	Engine
Oxides of Nitrogen (NO _x as NO ₂)	✓
Carbon Monoxide (CO)	✓
Total Volatile Organic Compounds (VOCs)	✓
Sulphur Dioxide (SO ₂)	✓
Oxygen (O ₂ - for correction)	✓
Moisture (H ₂ O - for correction)	✓
Special requirements	None requested

1.2 Monitoring Results

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Estimate of Uncertainty (2σ at 95% confidence)	Units	Reference Conditions	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method (see note below)	Operating Status
Engine	Oxides of Nitrogen (as NO ₂)	500	514	±23	mg(N)m ⁻³	101.3kPa, 273K, dry gas, 5% Oxygen	03/12/2015	11:02-12:02	BS EN 14792	A	At 100% MCR
	Carbon Monoxide	1400	551	±26	mg(N)m ⁻³				BS EN 15058	A	
	Volatile Organic Compounds (VOCs as carbon)	1000	936	±36	mg(N)m ⁻³				BS EN 12619	A	
	Sulphur Dioxide (SO ₂)	350	548	±52	mg(N)m ⁻³				BS EN 14791	B	
	Moisture	-	12.1	n/a	%	101.3kPa, 273K, dry gas			BS EN 14790	A	
	Oxygen	-	7.58	±0.41	%				BS EN 14789	A	

NOTE:

- EnviroDat Ltd MCerts/UKAS Accredited for sampling and analysis.
- EnviroDat Ltd MCerts/UKAS Accredited for sampling only, UKAS Accredited analysis conducted by sub-contract laboratory.
- EnviroDat Ltd UKAS Accredited for sampling only (further clarification is given in section 1.4). Analysis of this component is not UKAS Accredited.
- The method for sampling and analysis is not UKAS or MCerts Accredited, method follows documented in-house procedure (further clarification is given in section 1.4).

1.3 Operating Information

Emission Point Reference	Date	Process Type	Process Duration	Fuel	Feedstock	Abatement	Load	Comparison of Operator CEMS and Periodic Monitoring Results			
								Substance	CEMS Results	Periodic Monitoring Results	Units
Engine	03/12/15	Combustion	Continuous	Biogas	N/A	None	Producing 1065kW (100% MCR)	N/A	N/A	N/A	N/A

1.4 Monitoring Deviations

Emission Point Reference	Substance Deviations	Monitoring Deviations	Other Relevant Issues
Engine	None	None	None

PART 2: SUPPORTING INFORMATION

2.1 Appendix I: General Information

2.1.1 Monitoring organisation staff details

Monitoring at Waen AD Site was conducted by the following EnviroDat Engineers:

Team Leader, David Littlewood - MCerts Level II (TE1, 2, 3 & 4) MM06 772

Assistant, Dean Kyle – Mcerts Level I MM12 1188

2.1.2 Monitoring organisation method details

2.1.2.1 Standard Reference Conditions

All pollutant concentrations measured have been expressed at standard reference conditions of 273K, 101.3kPa, dry gas and 5% oxygen.

2.1.2.2 NO_x (as NO₂)

A sample of the duct gas was passed via a short high temperature probe and down a heated PTFE line to a gas conditioner used to remove moisture. The conditioned (dry) gas then passed to a Horiba PG250 analyser, which, following specific pre-treatment of the NO_x within the sample, measured the concentration of NO_x (as NO₂) by chemiluminescent detector, in accordance with EnviroDat Ltd. documented procedure SP14792. The detector and sampling system was checked prior to, and immediately following, testing to ensure operational conformity. This involved ensuring the absence of sample egress or air ingress, span and zero gas checks and system response times as necessary. All raw data was logged at 60-second intervals via a Grant Instruments Squirrel Datalogger and these are presented in Appendix II. An estimate of the uncertainty associated with the monitoring is also presented, as Appendix III.

2.1.2.3 CO

A sample of the duct gas was passed via a short high temperature probe and down a heated PTFE line to a gas conditioner used to remove moisture. The conditioned (dry) gas then passed to a Horiba PG250 analyser, which measured the concentration of CO by non-dispersive infrared (NDIR) detector, in accordance with EnviroDat Ltd. documented procedure SP15058. The detector and sampling system was checked prior to, and immediately following, testing to ensure operational

conformity. This involved ensuring the absence of sample egress or air ingress, span and zero gas checks and system response times as necessary. All raw data was logged at 60-second intervals via a Grant Instruments Squirrel Datalogger and these raw data are presented in Appendix II. An estimate of the uncertainty associated with the monitoring is also presented, as Appendix III.

2.1.2.4 Total VOCs

VOC sampling was performed using a Signal 3010HM analyser that measures by use of a heated flame ionisation detector (FID) in accordance with SP12619, which implements the requirements of the SRM BSEN12619. The VOC analyser was positioned prior to the gas conditioner and measured the sample gas 'hot and wet.' The result was subsequently corrected to dry values. The detector and sampling system was checked prior to, and immediately following, testing to ensure operational conformity. This involved ensuring the absence of sample egress or air ingress, span and zero gas checks and system response times as necessary. All raw data was logged at 60-second intervals via a Grant Instruments Squirrel Datalogger and these raw data are presented in Appendix II. An estimate of the uncertainty associated with the monitoring is also presented, as Appendix III.

2.1.2.5 O₂

A sample of the duct gas was passed via a short high temperature probe and down a heated PTFE line to a gas conditioner used to remove moisture. The conditioned (dry) gas then passed to a Horiba PG250 analyser, which measured the concentration of O₂ by was measured by a zirconia cell, as detailed in documented procedure SP14789, which implements the requirements of the SRM BSEN14789. The detector and sampling system was checked prior to, and immediately following, testing to ensure operational conformity. This involved ensuring the absence of sample egress or air ingress, span and zero gas checks and system response times as necessary. All raw data was logged at 60-second intervals via a Grant Instruments Squirrel Datalogger and the raw data are presented in Appendix II. An estimate of the uncertainty associated with the monitoring is also presented, as Appendix III.

Determination of oxygen is essential for adjusting the prescribed pollutants to reference oxygen levels as detailed in the sites permit. This was performed in the following manner:

$$\text{Conc}_{\text{ref}} = \text{Conc}_{\text{meas}} \times \frac{(20.95 - \text{O}_{2\text{ref}})}{(20.95 - \text{O}_{2\text{meas}})}$$

Whereby, Conc_{ref} was the concentration at reference conditions and $\text{Conc}_{\text{meas}}$ was the measured concentration, $\text{O}_{2\text{ref}}$ is the oxygen reference conditions and $\text{O}_{2\text{meas}}$ is the measured oxygen value.

2.1.2.6 Moisture

Moisture levels in the stack were determined gravimetrically to the requirements of BSEN14790, which implements the requirements of the SRM BSEN14790. The equipment consisted of an Apex Instruments USEPA Method Five apparatus. This consisted of a heated probe, heated filter and impinger bucket, connected to the sampling console. The console contained a calibrated dry gas meter. The data obtained from this system combined with the gravimetric increases allowed water content to be calculated. The moisture correction factor was calculated in the following manner:

$$\frac{(100 - [\text{H}_2\text{O}]_{\text{reference}})}{(100 - [\text{H}_2\text{O}]_{\text{measured}})}$$

This correction factor is only applied to the VOC result and was not applied to the combustion gases as the sample train for combustion gases uses a gas conditioner to remove moisture and introduces dried gas to the analyser. The raw data relating to the moisture test is presented as Appendix IV.

2.1.2.7 Sulphur Dioxide

Sulphur Dioxide was performed with accordance with EnviroDat Ltd. documented procedure SP14792 based on BSEN14792 (2005). The procedure incorporates the equipment used in moisture sampling, as described above, with the addition of a 0.3% Hydrogen Peroxide solution in the impinger train. Solutions were sent to SAL Ltd for analysis by Ion Chromatography. The SO₂ results table and analytical results can be seen in Appendix V. The absorption efficiency of the primary impinger was 100%. This value meets the requirement of greater than 95% of the standard. The blank value was 0.08mg/m³, also meeting the standard requirements.

2.1.3 Monitoring organisation equipment and gas check list references

EQUIPMENT			
Item	Reference	Calibration Due	PAT Due
Portable Gas Analyser	PGA#01	27-Apr-16	Oct-16
Flame Ionisation Detector Analyser	FID#02	08-Oct-16	Oct-16
Gas Conditioner	COND#02	05-Feb-16	Oct-16
Data Logger	DL#05	04-Nov-16	-
Digital Barometer	DB#15	27-Feb-17	-
Digital Barometer	DB#17	05-Feb-17	
Balance	BAL#03	01-Apr-16	-
Heated Line ¹	HL#03B	08-Jan-16	-
Heated Line ²	HL#05	08-Jan-16	-
Heated Line Controller ¹	HLC#06	08-Jan-16	Oct-16
Heated Line Controller ²	HLC#04	08-Jan-16	Oct-16
Heated Filter Holder	HFH#01	26-Mar-16	Oct-16
'Apex' Kit	APEX#03	See each item	Oct-16
Dry Gas Meter ('Apex')	DGM#06	03-Sep-16	-
Timepiece ¹ ('Apex')	TP#12	03-Sep-16	-
Timepiece ²	TP#07	28-Apr-16	-
Timepiece ³	TP#11	28-Apr-16	-
Thermocouple ¹	TC#28	08-Oct-16	-
Thermocouple ² ('Apex' Dogleg Exit)	TC#20	03-Sep-16	-
Thermocouple ³ ('Apex' Dry Gas Meter)	TC#30	03-Sep-16	-
Thermocouple ⁴	TC#43	08-Oct-16	-
Thermocouple Reader ('Apex') ¹	TCR#12	03-Sep-16	-
Thermocouple Reader ²	TCR#09	09-Oct-16	-

Flow meter ¹	FM02	03-Sep-16	-
Flow meter ²	FM09	03-Sep-16	-
Transformer ¹	-	-	Oct-16
Transformer ²	-	-	Oct-16
Cable Reel/Splitter ¹	-	-	Oct-16
Cable Reel/Splitter ²	-	-	Oct-16

GAS CYLINDERS			
	Certificate No.	Level (ppm)	Validity
'Zero' Gas (%) ¹	VC7905216	99.999%	-
'Zero' Gas (%) ²	N10000018	8.11% O ₂ in N ₂	-
Carbon Monoxide Span Gas ¹	VCD115810	1205	16-Apr-16
Nitrogen Dioxide Span Gas ¹	VCD115810	261.8	16-Apr-16
Oxygen Span Gas (%) ¹	11787910	7.94	01-Jul-16
VOC Span Gas ¹	11787910	565	01-Jul-16

2.2 Appendix II: Emission Point Reference Data & Results

2.2.1 Photograph of Sampling Location on Engine



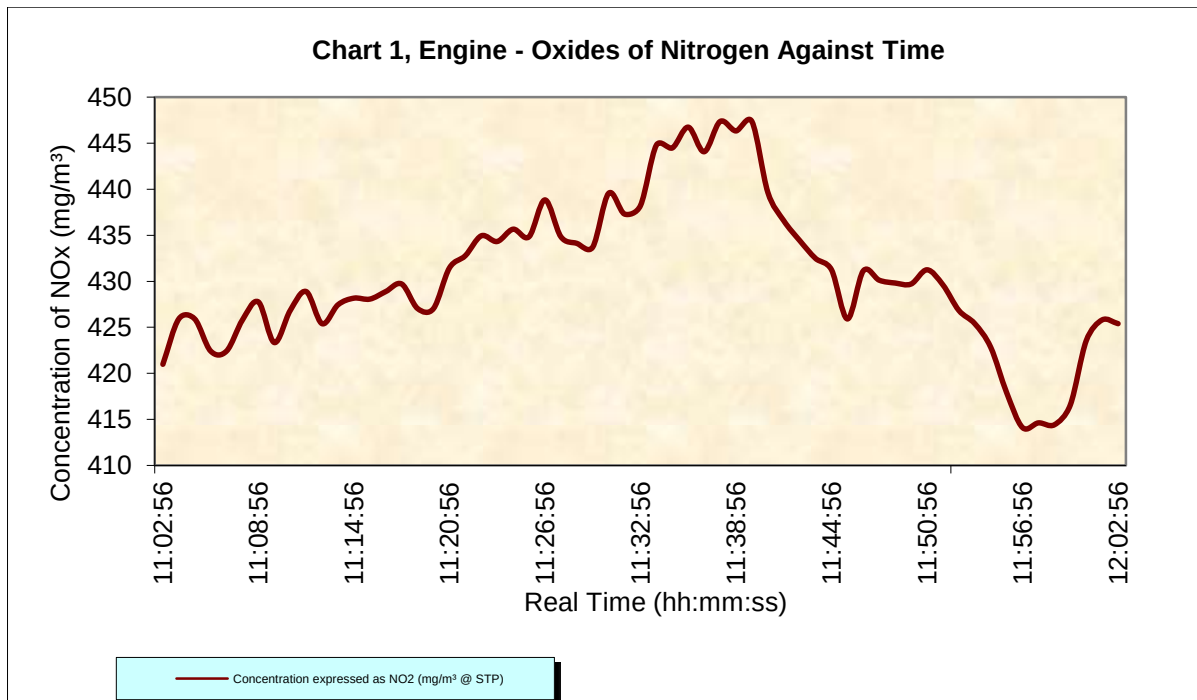
2.2.2 Homogeneity testing

BSEN15259 stipulates that the exhaust gases emitted from combustion processes are tested to ensure homogeneity and that a representative sample is obtained during the monitoring, subject to a number of caveats as elucidated in Environment Agency guidance MID15259. The details of the testing at each emission point are summarised below:

Stack	Result of Homogeneity Testing
Engine	N/A –homogeneity testing only required on stacks exceeding 1.13 m diameter, as specified in MID 15259. Homogeneity assumed and single point sampling acceptable.

2.2.3 Gas analyser site measurements and calibrations

The data in the following Charts 1 - 3 and in Table 2 are expressed in mgm^{-3} @ STP and is uncorrected for O_2 . In addition, VOC results are expressed as methane equivalent. This data was subsequently converted to reference oxygen concentrations (Section 1.2) with the addition of moisture correction for VOCs. Calibration data is shown in Table 1.



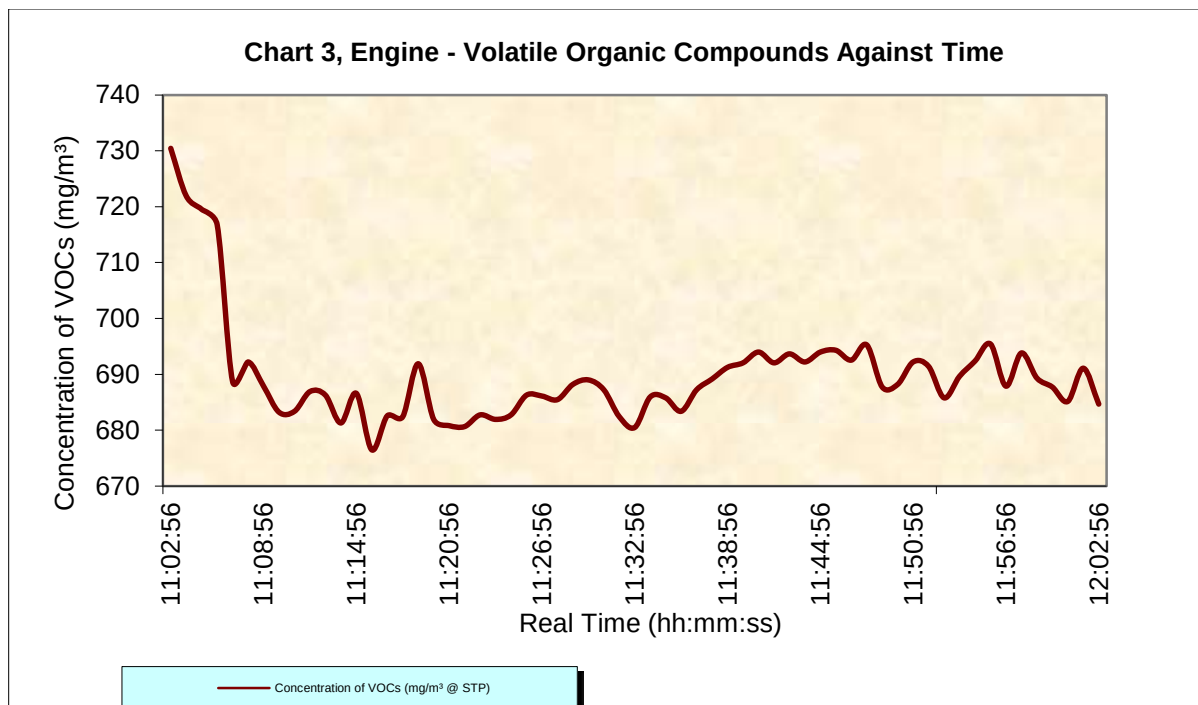
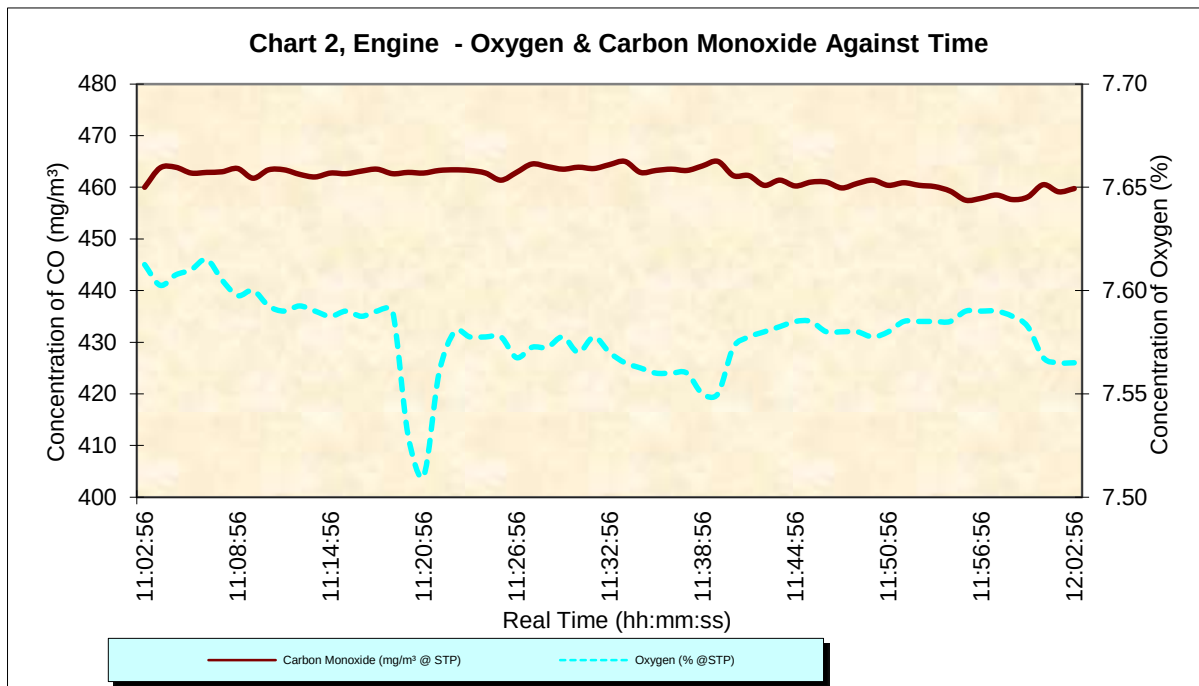


Table 1 – Calibration Data

ANALYSER CALIBRATION DATA					
Pre Sampling Check					
		NO (ppm)	CO (ppm)	O2 (%)	VOC's (ppm)
Range		500	1000	25	1000
Zero Gas	Cylinder No.	VC7905216			Scrubbed Air/ N10000018
Span Gas	Cylinder No.	VCD115810	VCD115810	11787910	11787910
	Certified Value	261.8	1205	7.94	565
Zero Check	Value	0.1	2	0	1
<2 x repeatability (Yes/No)		YES	YES	YES	YES
Down Line Zero & Span Check					
Zero Gas	Value	0.7	2	0.05	-1
	<2% of span	YES	YES	YES	YES
Span Gas	Value	260.8	1210	7.93	565
	Within 2% of span	YES	YES	YES	YES
Post Sampling Drift Check					
Zero Gas	Value	5.1	5	0.01	1
	Drift (%)	1.7	0.2	0.5	0.4
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required
Span Gas	Value	259.5	1210	7.94	559
	Drift (%)	0.5	0.0	0.1	1.1
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required

Table 2 – Engine, Raw data

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	Nox (mg/m ³)	Comment
11:02:56	7.6	730.4	460.0	421.0	
11:03:56	7.6	721.9	463.8	425.9	
11:04:56	7.6	719.5	463.9	425.9	
11:05:56	7.6	716.8	462.8	422.4	
11:06:56	7.6	688.7	462.9	422.4	
11:07:56	7.6	692.2	463.0	425.8	
11:08:56	7.6	687.9	463.6	427.8	
11:09:56	7.6	683.2	461.8	423.3	
11:10:56	7.6	683.4	463.4	426.8	
11:11:56	7.6	686.9	463.4	428.9	
11:12:56	7.6	686.3	462.5	425.4	
11:13:56	7.6	681.3	462.0	427.5	
11:14:56	7.6	686.6	462.8	428.2	
11:15:56	7.6	676.4	462.6	428.1	
11:16:56	7.6	682.6	463.1	428.9	
11:17:56	7.6	682.4	463.5	429.7	
11:18:56	7.6	691.9	462.6	427.0	
11:19:56	7.5	681.9	462.9	427.0	
11:20:56	7.5	680.8	462.8	431.5	
11:21:56	7.6	680.6	463.3	432.8	
11:22:56	7.6	682.7	463.4	434.9	
11:23:56	7.6	681.9	463.3	434.3	
11:24:56	7.6	682.7	462.8	435.7	
11:25:56	7.6	686.3	461.4	434.8	
11:26:56	7.6	686.1	462.9	438.8	
11:27:56	7.6	685.4	464.5	434.8	
11:28:56	7.6	688.2	464.0	434.1	
11:29:56	7.6	689.0	463.5	433.7	
11:30:56	7.6	687.2	463.9	439.6	
11:31:56	7.6	682.4	463.6	437.3	
11:32:56	7.6	680.5	464.4	438.2	
11:33:56	7.6	685.9	465.0	444.8	
11:34:56	7.6	685.8	462.9	444.5	
11:35:56	7.6	683.4	463.3	446.8	
11:36:56	7.6	687.2	463.5	444.1	
11:37:56	7.6	689.1	463.3	447.4	
11:38:56	7.6	691.2	464.1	446.3	
11:39:56	7.6	692.0	465.0	447.4	
11:40:56	7.6	694.0	462.3	439.7	
11:41:56	7.6	692.0	462.3	436.6	
11:42:56	7.6	693.6	460.4	434.4	
11:43:56	7.6	692.2	461.4	432.5	
11:44:56	7.6	694.0	460.3	431.3	
11:45:56	7.6	694.3	461.0	425.9	
11:46:56	7.6	692.5	461.0	431.1	

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	Nox (mg/m ³)	Comment
11:47:56	7.6	695.3	459.9	430.1	
11:48:56	7.6	687.7	460.8	429.8	
11:49:56	7.6	688.2	461.4	429.7	
11:50:56	7.6	692.2	460.4	431.3	
11:51:56	7.6	691.4	460.9	429.6	
11:52:56	7.6	685.8	460.4	426.8	
11:53:56	7.6	689.6	460.1	425.4	
11:54:56	7.6	692.4	459.3	422.8	
11:55:56	7.6	695.4	457.5	417.9	
11:56:56	7.6	687.9	457.9	414.1	
11:57:56	7.6	693.8	458.5	414.6	
11:58:56	7.6	689.3	457.6	414.4	
11:59:56	7.6	687.7	458.1	416.6	
12:00:56	7.6	685.1	460.5	423.5	
12:01:56	7.6	691.1	459.1	425.8	
12:02:56	7.6	684.6	459.8	425.4	

2.3 Appendix III: Uncertainty Calculation

NOx - Measurement performance related to stationary conditions				
Performance characteristic		Uncertainty	Value of uncertainty quantity	
Standard deviation of repeatability at zero		U _{r0}	0.80	
Standard deviation of repeatability at span level		U _{rs}	0.10	
Lack of fit		U _{fit}	2.37	
Drift		U _{odr}	8.40	
volume or pressure flow dependence		U _{spres}	0.06	
atmospheric pressure dependence		U _{apres}	1.18	
ambient temperature dependence		U _{temp}	0.23	
NH3 (20 mg/m3)		U _{interf}	0.14	
CO2 (15%)		-	0.02	
H2O (30%)		-	0.01	
Error in logger voltage		-	0.50	
Dependence on voltage		U _{vdt}	0.03	
Converter efficiency		U _{ceff}	1.99	
losses in the line (leak)		U _{leak}	4.97	
Uncertainty of calibration gas		U _{calib}	4.97	
NOx Measurement uncertainty		Result	430.63	mg/m ³
Combined uncertainty			11.46	mg/m ³
Expanded uncertainty	k = 2		22.92	mg/m ³
Uncertainty corrected to std conds			22.92	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%	4.58 % ELV	
Expanded uncertainty		expressed with a level of confidence of 95%	22.92 mg.m ⁻³ of result	

CO - Measurement performance related to stationary conditions				
Performance characteristic			Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero			U _{r0}	0.80
Standard deviation of repeatability at span level			U _{rs}	0.10
Lack of fit			U _{fit}	2.89
Drift			U _{odr}	9.88
volume or pressure flow dependence			U _{spres}	0.00
atmospheric pressure dependence			U _{apres}	1.15
ambient temperature dependence			U _{temp}	0.00
CO2 (15%)			U _{interf}	0.00
N2O (40mgm3)			-	0.00
CH4 (57mgm3)			-	0.00
H2O (1%)			-	0.00
Dependence on voltage			U _{vdt}	0.03
Error in Logger reading			-	1.00
losses in the line (leak)			U _{leak}	5.34
Uncertainty of calibration gas			U _{calib}	5.34
CO Measurement uncertainty		Result	462.03	mg/m ³
Combined uncertainty			12.86	mg/m ³
Expanded uncertainty	k = 2		25.71	mg/m ³
Uncertainty corrected to std conds			25.71	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%	1.84 % ELV	
Expanded uncertainty		expressed with a level of confidence of 95%	25.71 mg.m ⁻³ of result	

VOC - Measurement performance related to stationary conditions				
Performance characteristic			Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero			U _{r0}	0.80
Standard deviation of repeatability at span level			U _{rs}	0.10
Lack of fit			U _{fit}	3.74
Drift			U _{odr}	13.34
volume or pressure flow dependence			U _{spres}	0.00
atmospheric pressure dependence			U _{apres}	1.50
ambient temperature dependence			U _{temp}	0.00
NH3 (20 mg/m3)			U _{interf}	0.00
CO2 (15%)			-	0.00
H2O (30%)			-	0.00
Error on Logger voltage			-	1.00
Dependence on voltage			U _{volt}	0.03
losses in the line (leak)			U _{leak}	7.97
Uncertainty of calibration gas			U _{calib}	7.97
VOC Measurement uncertainty		Result	689.91	mg/m ³
Combined uncertainty			17.95	mg/m ³
Expanded uncertainty	k =	2	35.89	mg/m ³
Uncertainty corrected to std conds			35.89	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%	3.59 % ELV	
Expanded uncertainty		expressed with a level of confidence of 95%	35.89 mg.m ⁻³ of result	

Oxygen - Measurement performance related to stationary conditions				
Performance characteristic			Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero			U _{r0}	0.20
Standard deviation of repeatability at span level			U _{rs}	0.03
Lack of fit			U _{rit}	0.09
Drift			U _{odr}	0.11
volume or pressure flow dependence			U _{spres}	0.00
atmospheric pressure dependence			U _{apres}	0.01
ambient temperature dependence			U _{temp}	0.03
CO2 (15%)			-	0.00
NO(300)			-	0.06
NO2(30)			-	0.00
dependence on voltage			U _{volt}	0.02
losses in the line (leak)			U _{leak}	0.09
Error in Logger voltage			-	0.03
Uncertainty of calibration gas			U _{calib}	0.09
O2 Measurement uncertainty		Result	7.58	%vol
Combined uncertainty			0.21	%vol
% of value			2.72	%
Expanded uncertainty		expressed with a level of confidence of 95%	5.45 % of value	
Expanded uncertainty		expressed with a level of confidence of 95%	0.41 % vol	

Sulphur Dioxide						
Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution	Uncertainty as %
Corrected Volume (standard conditi	V	0.34	m ³	1354.04	3.10 mg.m ⁻³	0.68 %
Mass	m	189.53	mg	2.42	23.65 mg.m ⁻³	5.15 %
Factor for O2 Correction	fc	1.19		385.23	8.25 mg.m ⁻³	1.80 %
Leak	L	5.31	mg.m ⁻³	1.00	5.31 mg.m ⁻³	1.15 %
Combined uncertainty					25.79 mg.m ⁻³	
Expanded uncertainty as percentage of measured value			11.22	% measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)	
Expanded uncertainty in units of measurement			51.57	mg.m ⁻³		
Expanded uncertainty as percentqge of limit value			14.74	% ELV		

2.4 Appendix V: Moisture Calculations

Test No	1			Site	Biogen		
Date	3-12-15				Waen		
pbar (mbar)	1011			Stack	Engine		
pbar (mmHg)	758			Job Number:	R15264		
Nozzle Diameter (mm)	n/a			Site Team:	DI + DK		
Temp of Meter (in)/(out) deg. C	18			Data Entered By:	DL		
ΔH_{ave} (mmH ₂ O)	10.0						
DGM Cal Factor (Y)	0.9706						
Enter Data into coloured cells only							
Start Volume Reading	0.0000	m ³		Start time	11:02	hr:min	
End Volume Reading	0.4531	m ³		End time	12:02	hr:min	
Volume Sampled	0.4398	m ³		Total time	01:00	hr:min	
IMPINGER	1	2	3	4	Initials of Analyst		
Absorber Solution (Type):	H2O2	H2O2	KO IMP	SILICA			
Sample No:	T1A	T1B		n/a	SAL		
Analysis Required:	Sulphate			n/a	SAL		
Initial Weight of Impingers plus absorber (g)	1014.1	758.3	554.8	676.9	DL + DK		
Final Weight of Impingers plus absorber (g)	1054.0	758.9	554.9	681.7	DL + DK		
Weight Gain (g)	39.9	0.6	0.1	4.8			
Total Weight Gain (1+2+3+4) (g)	45.4						
Gas Volume of water at 0°C (l)	56.52						
Gas Meter volume at 0°C (l)	412.16						
Moisture content of Gases (%)	12.1						

2.5 Appendix V: Sulphur Dioxide Calculations & Lab Results

SUMMARY OF ACID GAS IMPINGMENT SAMPLING		
Stack ID		Engine
Stack Dimensions (m)		0.23
Date of Test		03-Dec-15
TEST NUMBER		T1
	Applied Standard	14791
Start Time	(hh:mm)	11:02
Stop Time	(hh:mm)	12:02
Duration	(minutes)	60
Sampled Gas Volume	(m3)	0.4531
Mean Temperature DGM	(oC)	18.00
Mean Sample Pressure	(mm H2O)	10.00
Mean Stack Temperature	(oC)	490.00
Corrected Sampled Gas Vol.	(Sm3@20oC)	0.4426
Corrected Sampled Gas Vol.	(Nm3@STP)	0.4124
Average Flowrate	(l/m @STP)	6.87
Required Pollutant (eg:HCl, HF or SO ₂)		SO2
Molecular Weight Pollutant		64
Determinant Species		sulphate
Molecular Weight Determinand		96
	Analysing Laboratory UKAS No.	1549
Measured concentration(Front)	(ug/ml)	690.0
Solution Sample Volume	(ml)	412.0
Measured concentration(Back)	(ug/ml)	0.1
Solution Sample Volume	(ml)	174.0
	Efficiency of Capture (%)	100.00%
Total Determinand Mass	(mg)	284.289
Moles of Determinand (mol)	(mol)	2.961
Mass of Pollutant	(mg)	189.53
Concentration (@ STP, Dry)	(mg/m3)	459.62
Stack Moisture	(%)v/v	12.05
Moisture Correction	dim'less	1.14
Stack Oxygen	(%)v/v	7.58
Oxygen Correction Factor	dim'less	1.19
Concentration @ Ref	(mg/(N)m3)	548.31
Sample as a percentage of ELV	(%)	156.66%
Blank Value	(mg/(N)m3)	0.08
Is Blank value < 10% of ELV		Yes



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Scientific Analysis Laboratories Ltd

Certificate of Analysis

Hadfield House
Hadfield Street
Combrook
Manchester
M16 9FE
Tel : 0161 874 2400
Fax : 0161 874 2404

Report Number: 531564-1

Date of Report: 14-Dec-2015

Customer: EnviroDat
Science & Technology Centre
Earley Gate
Whiteknights Road
Reading
RG6 6BZ

Customer Contact: Mr David Littlewood

Customer Job Reference: R15264
Date Job Received at SAL: 07-Dec-2015
Date Analysis Started: 08-Dec-2015
Date Analysis Completed: 11-Dec-2015

The results reported relate to samples received in the laboratory and may not be representative of a whole batch.

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation

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Tests covered by this certificate were conducted in accordance with SAL SOPs

All results have been reviewed in accordance with Section 25 of the SAL Quality Manual



Report checked
and authorised by :
Lauren Clarke
Trainee Project Manager

Issued by :
Mary Drury
Senior Project Manager

Validity unknown
Digitally signed by Mary Drury
Date: 2015.12.14 17:05:05 GMT
Reason: Issued
Location: SAL

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531564-1

SAL Reference: 531564				
Customer Reference: R15264				
Impinger(peroxide) Analysed as Impinger(peroxide)				
Miscellaneous				
SAL Reference		531564 001	531564 002	531564 003
Customer Sample Reference		B1A	B1B	T1A
Test Sample		AR	AR	AR
Date Sampled		03-DEC-2015	03-DEC-2015	03-DEC-2015
Determinand	Method	LOD	Units	Symbol
Sulphate	IC	0.05	mg/l	U
Volume	Vol	1	ml	U

Index to symbols used in 531564-1

Value	Description
AR	As Received
105	Due to levels found in the sample that are outside of the normal calibration range of the instrument, analysis was conducted on a diluted sample
13	Results have been blank corrected.
U	Analysis is UKAS accredited

