

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

Part 1: Executive Summary

Permit Number: EPR/DP3735NP (V002)

Operator: Biogen UK Ltd.

Installation: Waen AD Site (Engine)



4251

Monitoring dates: 8th June 2018
Job Number: **R18085**
Version: 1
Address: **Biogen UK 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: 21st June 2018
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 UK 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 (V002), 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	472	±22	mg(N)m ⁻³	101.3kPa, 273K, dry gas, 5% Oxygen	08/06/2018	08:45-09:45	BS EN 14792	A	At 75% MCR
	Carbon Monoxide	1400	688	±42	mg(N)m ⁻³				BS EN 15058	A	
	Volatile Organic Compounds (VOCs as carbon)	1000	696	±31	mg(N)m ⁻³				BS EN 12619	A	
	Sulphur Dioxide (SO ₂)	350	758	±72	mg(N)m ⁻³				BS EN 14791	B	
	Moisture	-	9.3	n/a	%	BS EN 14790			A		
	Oxygen	-	7.44	±0.47	%	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	08/06/18	Combustion	Continuous	Biogas	N/A	None	Producing 800kW (75% 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, Dean Kyle – MCerts Level II (TE3 & 4)

MM12 1188

2.1.2 Monitoring method details

Parameter	Standard Reference Method/Alternative	EnviroDat Procedure	MCerts Accreditation
Oxides of Nitrogen (as NO ₂)	BS EN 14792	SP14792	MCerts
Carbon Monoxide (CO)	BS EN 15058	SP15058	MCerts
Volatile Organic Compounds (VOCs)	BS EN 12619	SP12619	MCerts
Sulphur Dioxide (SO ₂)	BS EN 14791	SP14791	MCerts
Moisture (H ₂ O)	BS EN 14790	SP14790	MCerts
Oxygen (O ₂)	BS EN 14789	SP14789	MCerts

2.1.3 Monitoring organisation equipment and gas check list references

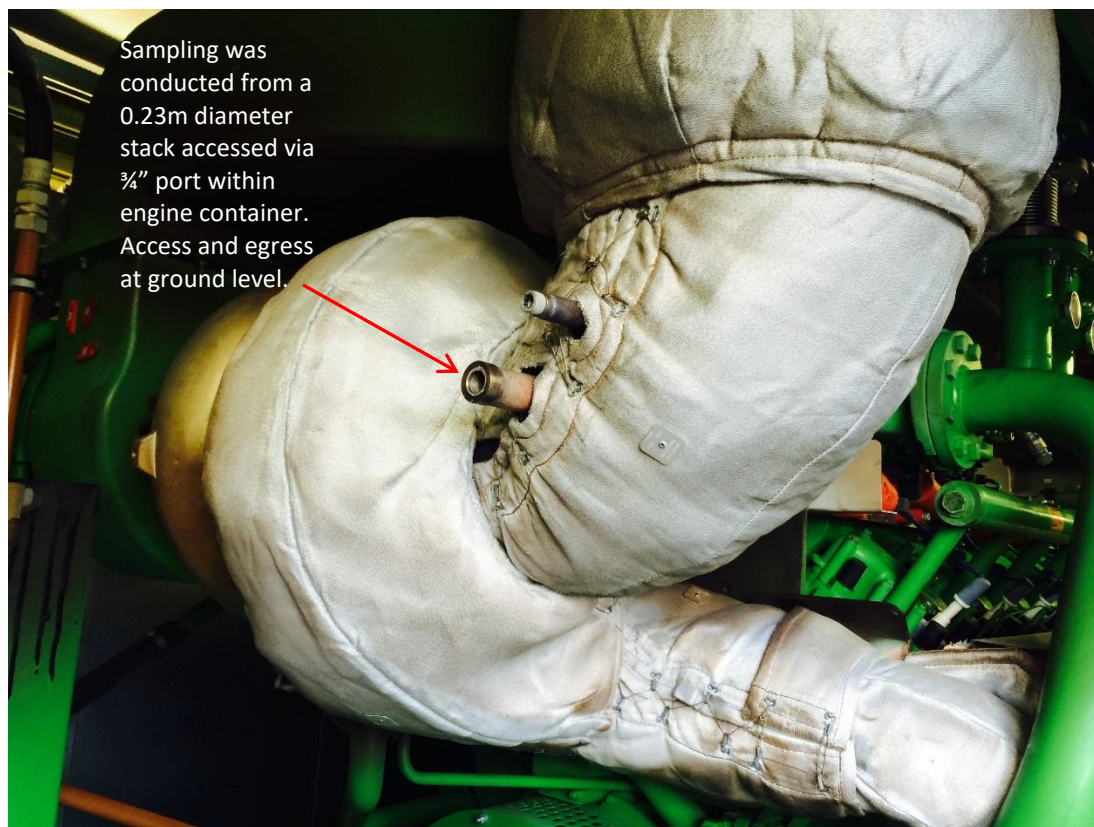
EQUIPMENT			
Item	Reference	Calibration Due	PAT Due
Portable Gas Analyser	PGA#06	08-Mar-19	Sep-18
Flame Ionisation Detector Analyser	FID#05	19-Sep-18	Sep-18
Gas Conditioner	COND#06	17-Nov-18	Sep-18
Data Logger	DL#04	03-Nov-18	-
Digital Barometer	DB#22	28-Oct-18	-
Balance	BAL#02	28-Mar-19	-
Balance Check Weight	CW#02	07-May-19	-
Heated Filter Head	HFH#03	01-Jan-19	-
HFH Thermocouple	TC#36	01-Jan-19	-
Heated Line	HL#11	02-Jan-19	-
Heated Line Controller	HLC#11	02-Jan-19	Sep-18
'Apex' Kit	Apex#04	See each item	Sep-18
Dry Gas Meter ('Apex')	DGM#11	31-Oct-18	-
Thermocouple Reader ¹ ('Apex')	TCR#16	31-Oct-18	-
Thermocouple Reader ² ('Apex')	TCR#17	31-Oct-18	-
Thermocouple Reader ³ ('Apex')	TCR#18	31-Oct-18	-
Thermocouple ('Apex')	TC#35	31-Oct-18	-
Manometer ('Apex' Orange)	MAN#08	31-Oct-18	-
Manometer ('Apex' Red)	MAN#09	31-Oct-18	-
Timepiece ¹ ('Apex')	TP#15	31-Oct-18	-
Timepiece ²	TP#18	01-Jan-19	-
Thermocouple (Apex Dogleg Exit)	TC#21	27-Sep-18	-
Thermocouple (Stack Temperature Check)	TC#43	09-Oct-18	-

Thermocouple Reader (Hand held)	TCR#05	18-Sep-18	-
Tape measure	TM08	24-Oct-18	-
Thermocouple	TC#17	18-Jun-18	-

GAS CYLINDERS			
	Certificate No.	Level (ppm)	Validity
'Zero' Gas (%) ¹	VCFN7082	99.999%	-
'Zero' Gas (%) ²	VCB7643	8.14% O ₂ in N ₂	-
Nitrogen Dioxide Span Gas	VC3583C	252.2	14-Jan-19
Carbon Monoxide Span Gas	VC3583C	1200	14-Jan-19
Oxygen Span Gas (%)	751952	8.00%	22-Jun-18
VOC Span Gas	751952	800	22-Jun-18

2.2 Appendix II: Emission Point Reference Data & Results

2.2.1 Photograph of Sampling Location on Engine



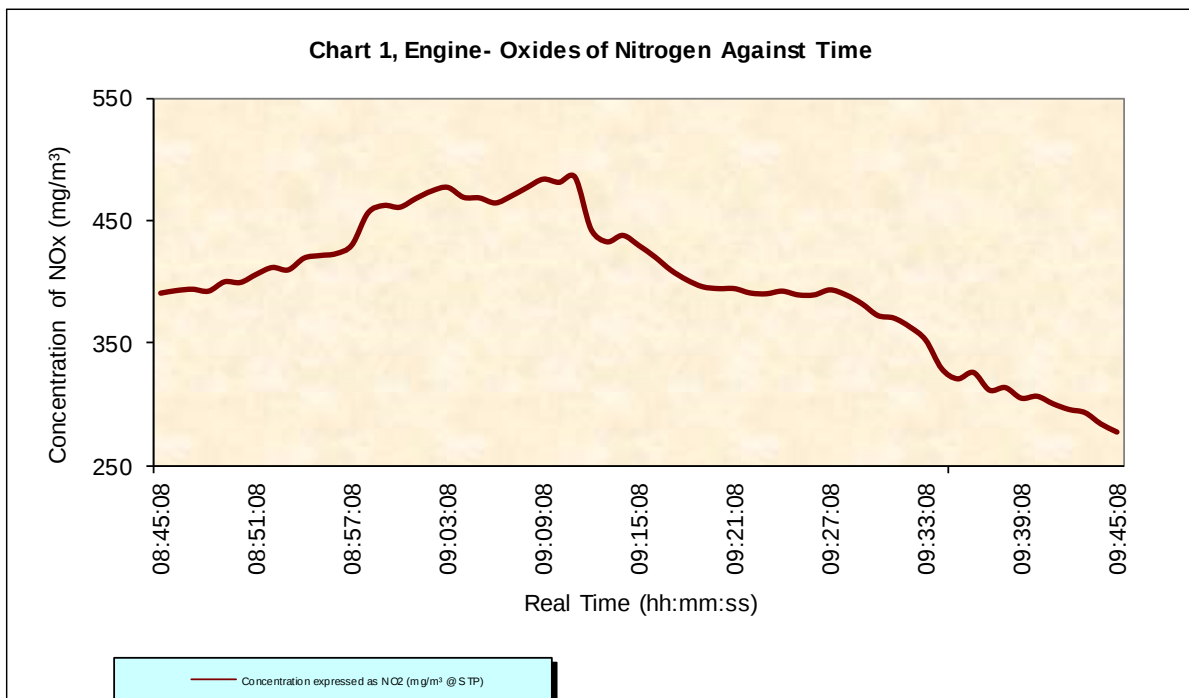
2.2.2 Homogeneity testing

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 carbon 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.



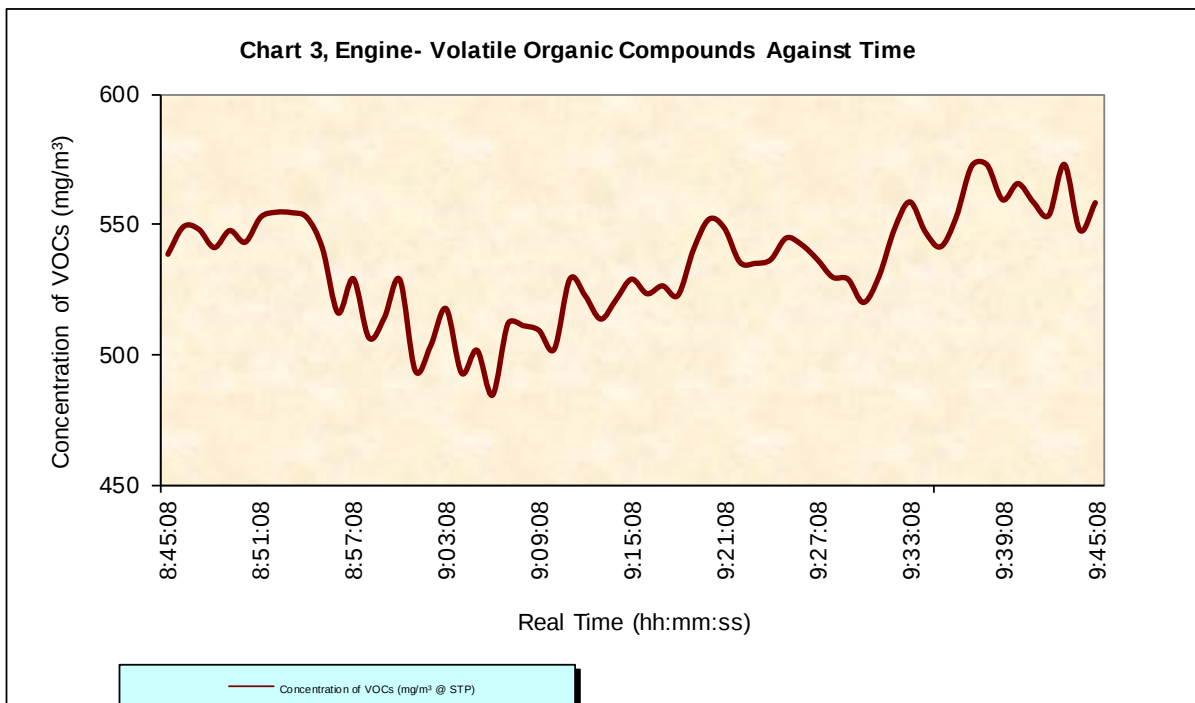
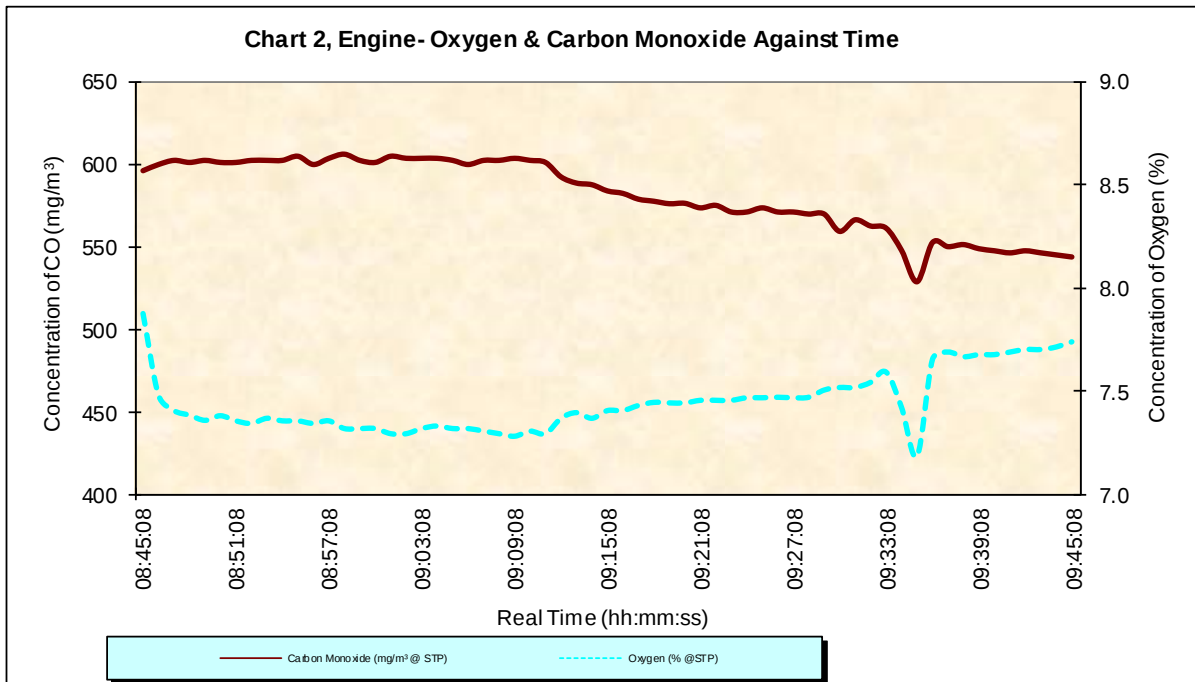


Table 1 – Calibration Data

ANALYSER CALIBRATION DATA					
Pre Sampling Check					
		NO (ppm)	CO (ppm)	O2 (%)	VOC's (ppm)
Range		500	2000	25	1000
Zero Gas	Cylinder No.	VCFN7082			VCB7643
Span Gas	Cylinder No.	VC3583C	VC3583C	751952	751952
	Certified Value	252.2	1200	8	800
Zero Check	Value	0.5	3	0.01	1
<2 x repeatability (Yes/No)		YES	YES	YES	YES
Down Line Zero & Span Check					
Zero Gas	Value	0.4	1	0.04	-1
	<2% of span	YES	YES	YES	YES
Span Gas	Value	252.9	1195	7.98	796
	Within 2% of span	YES	YES	YES	YES
Post Sampling Drift Check					
Zero Gas	Value	2.4	0	0.15	2
	Drift (%)	0.8	0.1	1.4	0.4
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required
Span Gas	Value	250.5	1179	8.06	799
	Drift (%)	1.0	1.3	1.0	0.4
	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
08:45:08	7.9	538.6	596.5	390.6	
08:46:08	7.5	549.2	600.3	392.7	
08:47:08	7.4	548.2	602.8	393.8	
08:48:08	7.4	541.1	601.5	392.2	
08:49:08	7.4	547.7	602.8	399.8	
08:50:08	7.4	543.2	601.5	399.3	
08:51:08	7.4	552.9	601.5	406.0	
08:52:08	7.3	554.8	602.8	411.5	
08:53:08	7.4	554.6	602.8	409.6	
08:54:08	7.4	552.7	602.8	419.2	
08:55:08	7.4	540.8	605.3	421.3	
08:56:08	7.3	515.9	600.3	422.8	
08:57:08	7.4	529.1	604.0	430.0	

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	Nox (mg/m ³)	Comment
08:58:08	7.3	506.3	606.5	456.0	
08:59:08	7.3	514.0	602.8	462.2	
09:00:08	7.3	528.8	601.5	460.7	
09:01:08	7.3	493.6	605.3	467.8	
09:02:08	7.3	503.2	604.0	474.0	
09:03:08	7.3	517.5	604.0	476.9	
09:04:08	7.3	492.6	604.0	468.8	
09:05:08	7.3	501.4	602.8	468.3	
09:06:08	7.3	484.1	600.3	464.2	
09:07:08	7.3	511.7	602.8	469.9	
09:08:08	7.3	510.9	602.8	476.9	
09:09:08	7.3	509.1	604.0	483.6	
09:10:08	7.3	501.9	602.8	481.0	
09:11:08	7.3	528.9	601.5	485.2	
09:12:08	7.4	522.5	592.8	442.8	
09:13:08	7.4	513.5	589.0	432.5	
09:14:08	7.4	521.0	588.0	437.7	
09:15:08	7.4	528.9	584.3	429.5	
09:16:08	7.4	523.3	582.8	420.3	
09:17:08	7.4	526.3	579.3	409.5	
09:18:08	7.4	522.6	578.0	401.5	
09:19:08	7.4	540.3	576.5	395.8	
09:20:08	7.4	552.1	576.8	394.3	
09:21:08	7.5	548.7	574.0	394.3	
09:22:08	7.5	535.5	575.5	390.7	
09:23:08	7.5	535.0	571.5	390.1	
09:24:08	7.5	536.5	571.5	392.2	
09:25:08	7.5	544.8	574.0	389.2	
09:26:08	7.5	542.3	571.5	389.2	
09:27:08	7.5	536.6	571.5	393.3	
09:28:08	7.5	529.7	570.3	389.2	
09:29:08	7.5	528.9	570.3	382.0	
09:30:08	7.5	519.9	559.8	372.3	
09:31:08	7.5	529.9	566.8	370.3	
09:32:08	7.5	548.2	563.0	363.1	
09:33:08	7.6	558.8	561.8	352.3	
09:34:08	7.4	547.2	548.3	329.0	
09:35:08	7.2	541.4	529.3	320.7	
09:36:08	7.7	552.9	553.0	325.8	
09:37:08	7.7	572.6	550.5	311.4	

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	Nox (mg/m ³)	Comment
09:38:08	7.7	573.1	551.8	313.5	
09:39:08	7.7	559.6	549.3	304.9	
09:40:08	7.7	565.9	548.0	306.4	
09:41:08	7.7	558.6	546.8	300.2	
09:42:08	7.7	553.7	548.0	295.6	
09:43:08	7.7	573.3	546.8	293.0	
09:44:08	7.7	547.9	545.5	283.8	
09:45:08	7.7	558.5	544.3	277.2	

2.3 Appendix III: Uncertainty Calculations

2.3.1 Engine, Uncertainty Calculations

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}	8.22	
volume or pressure flow dependence		U _{spres}	0.06	
atmosphseric pressure dependence		U _{apres}	0.00	
ambient temperature dependence		U _{temp}	0.81	
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}	1.85	
losses in the line (leak)		U _{leak}	4.61	
Uncertainty of calibration gas		U _{calib}	4.61	
NOx Measurement uncertainty		Result	399.59	mg/m ³
Combined uncertainty			10.96	mg/m ³
Expanded uncertainty	k = 2		21.93	mg/m ³
Uncertainty corrected to std conds			21.93	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%	4.39 % ELV	
Expanded uncertainty		expressed with a level of confidence of 95%	21.93 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 _{ro}	0.80
Standard deviation of repeatability at span level			U _{rs}	0.10
Lack of fit			U _{fit}	5.77
Drift			U _{odr}	17.79
volume or pressure flow dependence			U _{spres}	0.00
atmosphseric pressure dependence			U _{apres}	0.00
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 _{volt}	0.03
Error in Logger reading			-	2.00
losses in the line (leak)			U _{leak}	6.72
Uncertainty of calibration gas			U _{calib}	6.72
CO Measurement uncertainty		Result	582.16	mg/m ³
Combined uncertainty			21.08	mg/m ³
Expanded uncertainty	k = 2		42.16	mg/m ³
Uncertainty corrected to std conds			42.16	mg.m-3 (corrected)
Expanded uncertainty	expressed with a level of confidence of 95%		3.01 % ELV	
Expanded uncertainty	expressed with a level of confidence of 95%		42.16 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}	12.44
volume or pressure flow dependence			U _{spres}	0.00
atmosphseric pressure dependence			U _{apres}	0.00
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}	6.17
Uncertainty of calibration gas			U _{calib}	6.17
VOC Measurement uncertainty		Result	534.60	mg/m ³
Combined uncertainty			15.68	mg/m ³
Expanded uncertainty	k =	2	31.37	mg/m ³
Uncertainty corrected to std conds			31.37	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%	3.14 % ELV	
Expanded uncertainty		expressed with a level of confidence of 95%	31.37 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}	0.00
ambient temperature dependence			U _{temp}	0.12
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	7.44	%vol
Combined uncertainty			0.23	%vol
% of value			3.15	%
Expanded uncertainty		expressed with a level of confidence of 95%	6.29 % of value	
Expanded uncertainty		expressed with a level of confidence of 95%	0.47 % vol	

Sulphur Dioxide						
Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution	Uncertainty as %
Corrected Volume (standard conditi	V	0.42	m ³	1533.92	3.91 mg.m ⁻³	0.61 %
Mass	m	318.99	mg	2.01	33.27 mg.m ⁻³	5.18 %
Factor for O ₂ Correction	fc	1.18		543.87	11.41 mg.m ⁻³	1.78 %
Leak	L	7.41	mg.m ⁻³	1.00	7.41 mg.m ⁻³	1.15 %
Combined uncertainty					36.15 mg.m ⁻³	
Expanded uncertainty as percentage of measured value			11.26 % measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)		
Expanded uncertainty in units of measurement			72.31 mg.m ⁻³			
Expanded uncertainty as percentage of limit value			20.66 % ELV			

2.4 Appendix IV: Moisture Calculations

Test No	T2		Site	Biogen		
Date	8-6-18			Waen		
pbar (mbar)	1010		Stack	Engine		
pbar (mmHg)	758		Job Number:	R18085		
Nozzle Diameter (mm)	n/a		Site Team:	DK		
Temp of Meter (in)/(out) deg. C	20		Data Entered By:	DK		
ΔH_{ave} (mmH ₂ O)	10.0					
DGM Cal Factor (Y)	1.0210					
			Enter Data into coloured cells only			
Start Volume Reading	944.7790	m ³	Start time	08:45	hr:min	
End Volume Reading	945.3020	m ³	End time	09:45	hr:min	
Volume Sampled	0.5340	m ³	Total time	01:00	hr:min	
IMPINGER	1	2	3	4	Initials of Analyst	
Absorber Solution (Type):	H2O2			SILICA		
Sample No:	T2A		T2B	n/a		
Analysis Required:	Sulphate			n/a		
Initial Weight of Impingers plus absorber (g)	929.9	798.6	703.8	859.6	DK	
Final Weight of Impingers plus absorber (g)	962.8	800.4	704.7	864.8	DK	
Weight Gain (g)	32.9	1.8	0.9	5.2		
Total Weight Gain (1+2+3+4) (g)	40.8					
Gas Volume of water at 0 °C (l)	50.80					
Gas Meter volume at 0 °C (l)	496.54					
Moisture content of Gases (%)	9.3					

2.5 Appendix V: Sulphur Dioxide Calculations

SUMMARY OF ACID GAS IMPINGEMENT SAMPLING		
Stack ID		Engine
Stack Dimensions (m)		0.23
Date of Test		08-Jun-18
TEST NUMBER		T2
Applied Standard		14791
Start Time	(hh:mm)	08:45
Stop Time	(hh:mm)	09:45
Duration	(minutes)	60
Sampled Gas Volume	(m3)	0.5230
Mean Temperature DGM	(oC)	20.00
Mean Sample Pressure	(mm H2O)	10.00
Mean Stack Temperature	(oC)	497.00
Corrected Sampled Gas Vol.	(Sm3@20oC)	0.5332
Corrected Sampled Gas Vol.	(Nm3@STP)	0.4968
Average Flowrate	(l/m @STP)	8.28
Required Pollutant (eg:HCl, HF or SO ₂)		SO ₂
Molecular Weight Pollutant		64
Determinant Species		sulphate
Molecular Weight Determinand		96
Analysing Laboratory UKAS No.		1549
Measured concentration(Front)	(ug/ml)	1300.0
Solution Sample Volume	(ml)	368.0
Measured concentration(Back)	(ug/ml)	0.5
Solution Sample Volume	(ml)	188.0
Efficiency of Capture (%)		99.98%
Total Determinand Mass	(mg)	478.488
Moles of Determinand (mol)	(mol)	4.984
Mass of Pollutant	(mg)	318.99
Concentration (@ STP, Dry)	(mg/m3)	642.14
Stack Moisture	(%)v/v	9.27
Moisture Correction	dim'less	1.10
Stack Oxygen	(%)v/v	7.44
Oxygen Correction Factor	dim'less	1.18
Net Correction Factor	dim'less	1.18
Concentration @ Ref	(mg/(N)m3)	758.11
Sample as a percentage of ELV	(%)	216.60%
Blank Value	(mg/(N)m3)	0.26
Is Blank value < 10% of ELV		Yes