

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

Part 1: Executive Summary

Permit Number: EPR/SP3537VQ

Operator: Biogen (UK) Ltd.

Installation: Engine Exhaust Stack



4251

Monitoring dates: 9th May 2018

Job Number: **R18084**

Version: 1

Address: **Biogen (UK) Ltd.**

Milton Park

Milton Ernest

Bedfordshire, MK44 1YU

Monitoring Organisation: **EnviroDat Ltd.**

Address: Science & Technology Centre

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Date of Report: 31st May 2018

Report Approved By: Yu Shen

MCERTS Registration Number: MM 06 727 (Level II, TE1, 2, 3 & 4)

Function: Project 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 Bryn Pica 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.

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/SP3537VQ, 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 (for correction)	✓
Moisture (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 (2s at 95% confidence)	Units	Reference Conditions	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Operating Status
										(see note below)	
Engine	Oxides of Nitrogen (as NO ₂)	500	431	±20	mg(N)m ⁻³	101.3kPa, 273K, dry gas, 5% Oxygen	09/05/2018	12:30-13:30	BS EN 14792	A	At 100% MCR
	Carbon Monoxide	1400	535	±39	mg(N)m ⁻³				BS EN 15058	A	
	Volatile Organic Compounds (VOCs as carbon)	1000	600	±28	mg(N)m ⁻³				BS EN 12619	A	
	Sulphur Dioxide (SO ₂)	350	232	±13	mg(N)m ⁻³				BS EN 14791	B	
	Moisture	-	12.2	n/a	%	101.3kPa, 273K, dry gas			BS EN 14790	A	
	Oxygen	-	8.38	±0.46	%				BS EN 14789	A	

NOTE:

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

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	09/05/2018	Combustion	Continuous	Anaerobic Digestion Gas	N/A	None	Producing 1189kWe (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 Bryn Pica Anaerobic Digestion Site was conducted by the following EnviroDat Engineers:

Team Leader, Yu Shen - MCerts Level II (TE1, 2, 3 & 4) MM06 727

Technician, David Godfrey - MCerts Level I MM16 1393

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	BS EN 14791	SP14791	MCerts
Moisture (H ₂ O)	BS EN 14790	SP14790	MCerts
Oxygen (O ₂)	BS EN 14789	SP14789	MCerts

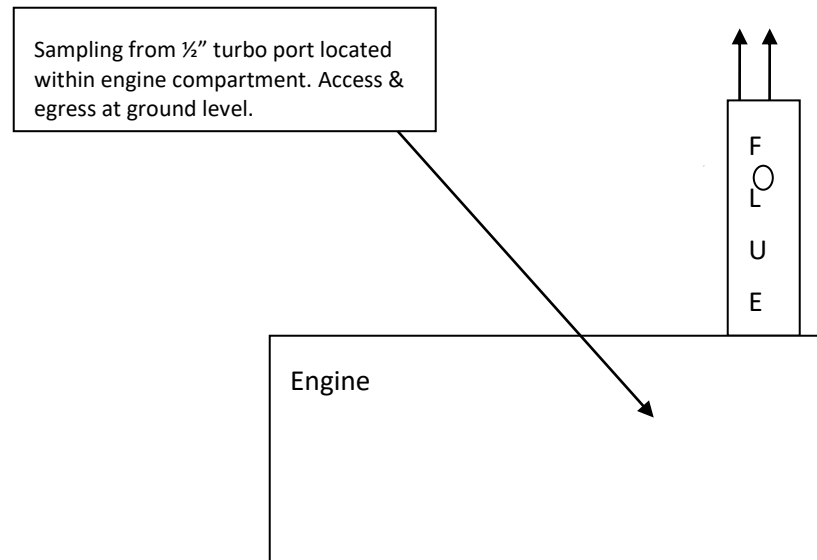
2.1.3 Monitoring organisation equipment and gas check list references

EQUIPMENT – BJ15 JKF			
Item	Reference	Calibration Due	PAT Due
Portable Gas Analyser	PGA#01	07-May-19	Sep-18
Flame Ionisation Detector Analyser	FID#02	04-Apr-19	Sep-18
Gas Conditioner	COND#01	28-Sep-18	Sep-18
NOx Converter	CONV#02	09-Nov-18	Sep-18
Data Logger	DL#03	10-Oct-18	-
Digital Barometer	DB#26	01-Sep-19	-
Balance	BAL#06	28-Mar-19	-
Heated Filter Head	HFH#01	02-Jan-19	Sep-18
Heated Line	HL#13	10-Oct-18	-
Heated Line Controller	HLC#13	10-Oct-18	Sep-18
'Apex' Kit	APEX#06	See each item	Sep-18
Dry Gas Meter ('Apex')	DGM#14	28-Sep-18	-
Timepiece ('Apex')	TP#20	28-Sep-18	-
Thermocouple ('Apex')	TC#46	28-Sep-18	-
Thermocouple Reader ('Apex')	TCR#24	28-Sep-18	-
Thermocouple Reader ('Apex')	TCR#25	28-Sep-18	-
Thermocouple Reader ('Apex')	TCR#26	28-Sep-18	-
Manometer ('Apex' Orange)	MAN#12	28-Sep-18	-
Manometer ('Apex' Red)	MAN#13	28-Sep-18	-
Thermocouple ('Apex' Dogleg Exit)	TC#40	29-Jan-19	-
Timepiece	TP#25	13-Sep-18	-
Tape Measure	TM#06	01-Oct-18	-

GAS CYLINDERS – BJ15 JKF			
	Certificate No.	Level (ppm)	Validity
'Zero' Gas (%)	VCEB21291	99.999%	n/a
Carbon Monoxide Span Gas	VC2106C	1200	14-Jan-19
Nitric Oxide Span Gas	VC2106C	251.6	14-Jan-19
Propane Span Gas	VCBT5258	564	14-Jan-19
Oxygen Span Gas (%)	VC2939189	7.97	14-Jan-19

2.2 Appendix II: Emission Point Reference Data & Results

2.2.1 Diagram of Sampling Location on Engine



2.2.2 Homogeneity testing

BS EN 15259 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 & single point sampling acceptable.

2.2.3 Gas analyser site measurements and calibrations

The data in the following Charts 1 - 3 and Table 1 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 2.

Chart 1, Engine - Oxides of Nitrogen Against Time

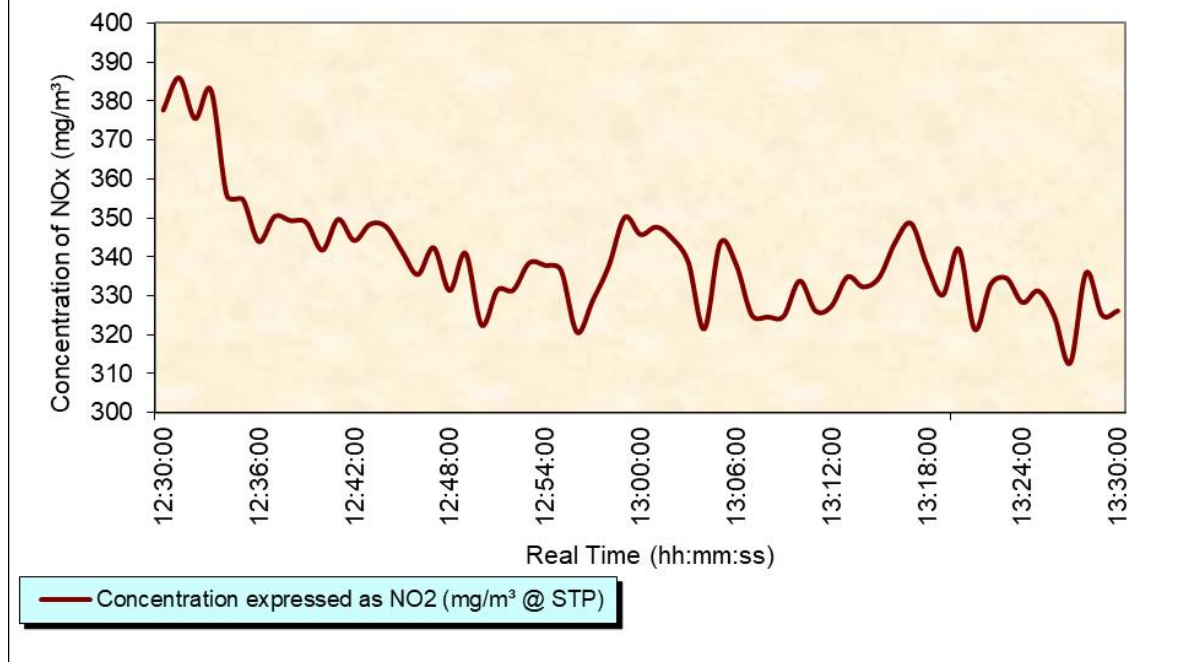
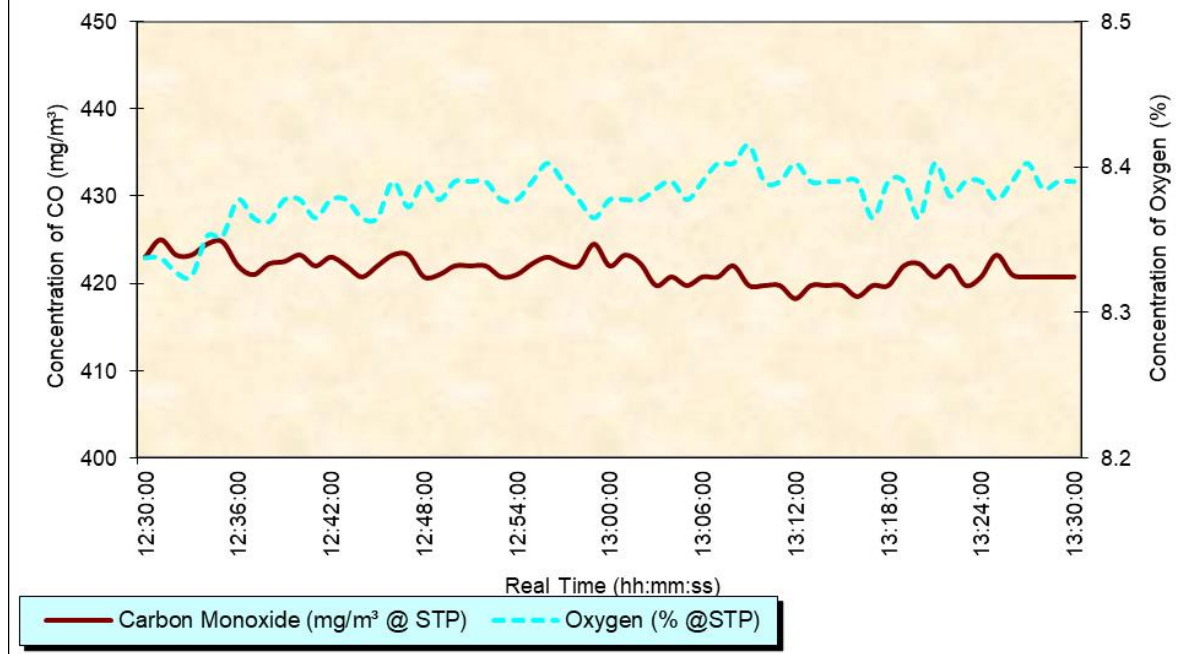
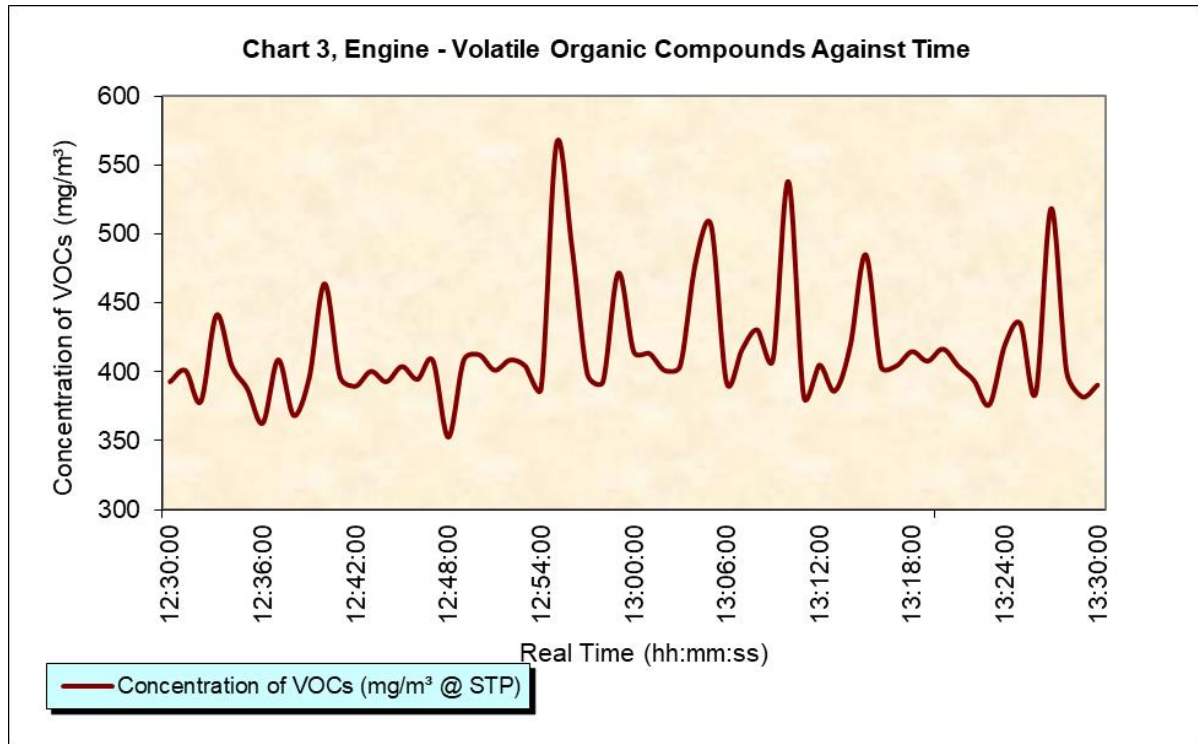


Chart 2, Engine - Oxygen & Carbon Monoxide Against Time



**Table 1 – Engine, Raw Data**

Time	Oxygen (%) (Dry Gas)	VOC (mgC/m³) (Wet Gas)	CO (mg/m³) (Dry Gas)	Nox (mg/m³) (Dry Gas)	Comment
12:30:00	8.3	392.8	423.0	377.7	
12:31:00	8.3	401.0	425.0	386.0	
12:32:00	8.3	378.6	423.3	375.5	
12:33:00	8.3	441.2	423.3	382.8	
12:34:00	8.4	404.4	424.5	355.8	
12:35:00	8.4	387.6	424.8	354.8	
12:36:00	8.4	362.9	422.0	344.0	
12:37:00	8.4	408.7	421.0	350.3	
12:38:00	8.4	368.4	422.3	349.3	
12:39:00	8.4	395.5	422.5	348.8	
12:40:00	8.4	464.0	423.3	341.7	
12:41:00	8.4	396.3	422.0	349.6	
12:42:00	8.4	389.6	423.0	344.2	
12:43:00	8.4	400.3	422.0	348.4	
12:44:00	8.4	392.8	420.8	347.8	
12:45:00	8.4	403.9	422.0	341.4	
12:46:00	8.4	394.6	423.3	335.5	
12:47:00	8.4	408.2	423.3	342.3	

Time	Oxygen (%) (Dry Gas)	VOC (mgC/m ³) (Wet Gas)	CO (mg/m ³) (Dry Gas)	Nox (mg/m ³) (Dry Gas)	Comment
12:48:00	8.4	352.6	420.8	331.3	
12:49:00	8.4	408.5	421.0	340.9	
12:50:00	8.4	412.4	422.0	322.5	
12:51:00	8.4	401.1	422.0	331.4	
12:52:00	8.4	408.5	422.0	331.4	
12:53:00	8.4	404.0	420.8	338.4	
12:54:00	8.4	387.8	421.0	337.8	
12:55:00	8.4	565.4	422.3	336.6	
12:56:00	8.4	490.7	423.0	320.7	
12:57:00	8.4	398.3	422.3	328.9	
12:58:00	8.4	392.6	422.0	337.6	
12:59:00	8.4	471.7	424.5	350.1	
13:00:00	8.4	414.5	422.0	345.7	
13:01:00	8.4	413.4	423.3	347.7	
13:02:00	8.4	401.0	422.3	344.7	
13:03:00	8.4	404.2	419.8	338.6	
13:04:00	8.4	479.6	420.8	321.5	
13:05:00	8.4	506.3	419.8	343.5	
13:06:00	8.4	392.5	420.8	338.1	
13:07:00	8.4	416.1	420.8	325.0	
13:08:00	8.4	430.4	422.0	324.6	
13:09:00	8.4	408.7	419.8	324.8	
13:10:00	8.4	538.1	419.8	333.8	
13:11:00	8.4	382.0	419.8	326.1	
13:12:00	8.4	404.8	418.3	327.3	
13:13:00	8.4	386.0	419.8	334.8	
13:14:00	8.4	418.7	419.8	332.3	
13:15:00	8.4	485.0	419.8	334.7	
13:16:00	8.4	403.6	418.5	343.7	
13:17:00	8.4	404.4	419.8	348.6	
13:18:00	8.4	414.6	419.8	337.8	
13:19:00	8.4	407.7	422.0	330.2	
13:20:00	8.4	416.6	422.3	342.0	
13:21:00	8.4	404.0	420.8	321.4	
13:22:00	8.4	393.8	422.0	332.9	
13:23:00	8.4	376.2	419.8	334.5	
13:24:00	8.4	419.3	420.8	328.3	
13:25:00	8.4	434.9	423.3	331.2	
13:26:00	8.4	384.8	421.0	324.8	
13:27:00	8.4	518.5	420.8	312.8	
13:28:00	8.4	399.9	420.8	335.9	
13:29:00	8.4	381.9	420.8	325.1	
13:30:00	8.4	390.4	420.8	326.1	

Table 2 – Engine, Analyser 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.	VCEB21291			Air
Span Gas	Cylinder No.	VC2106C	VC2106C	VCBT5258	VCBT5258
	Certified Value	251.6	1200	7.97	564
Zero Check	Value	0.4	2	0.09	5
<2 x repeatability (Yes/No)		YES	YES	YES	YES
Down Line Zero & Span Check					
Zero Gas	Value	0.6	2	0.12	3
	<2% of span	YES	YES	YES	YES
Span Gas	Value	252.7	1197	8	561
	Within 2% of span	YES	YES	YES	YES
Post Sampling Drift Check					
Zero Gas	Value	3.7	2	0.13	11
	Drift (%)	1.2	0.0	0.1	1.4
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required
Span Gas	Value	251.7	1193	7.91	566
	Drift (%)	0.4	0.3	1.1	0.9
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required

2.3 Appendix III: 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_{rit}	2.37	
Drift		U_{odr}	7.88	
volume or pressure flow dependence		U_{spres}	0.06	
atmospheric pressure dependence		U_{apres}	0.59	
ambient temperature dependence		U_{temp}	0.52	
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}	1.57	
losses in the line (leak)		U_{leak}	3.92	
Uncertainty of calibration gas		U_{calib}	3.92	
NOx Measurement uncertainty		Result	339.58	mg/m ³
Combined uncertainty			10.09	mg/m ³
Expanded uncertainty		k = 2	20.18	mg/m ³
Uncertainty corrected to std conds			20.18	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%	4.04 % ELV	
Expanded uncertainty		expressed with a level of confidence of 95%	20.18 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_{rit}	5.77	
Drift		U_{odr}	16.87	
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		-	2.00	
losses in the line (leak)		U_{leak}	4.87	
Uncertainty of calibration gas		U_{calib}	4.87	
CO Measurement uncertainty		Result	421.57	mg/m ³
Combined uncertainty			19.25	mg/m ³
Expanded uncertainty		k = 2	38.50	mg/m ³
Uncertainty corrected to std conds			38.50	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%	2.75 % ELV	
Expanded uncertainty		expressed with a level of confidence of 95%	38.50 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 _{fit}	0.10	
Drift		U _{odr}	0.12	
volume or pressure flow dependence		U _{spres}	0.00	
atmopserhic pressure dependence		U _{apres}	0.01	
ambient temperature dependence		U _{temp}	0.08	
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}	0.10	
Error in Logger voltage		-	0.03	
Uncertainty of calibration gas		U _{calib}	0.10	
O2 Measurement uncertainty		Result	8.38	%vol
Combined uncertainty			0.23	%vol
% of value			2.77	%
Expanded uncertainty		expressed with a level of confidence of 95%		5.53 % of value
Expanded uncertainty		expressed with a level of confidence of 95%		0.46 % vol

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}	11.75
volume or pressure flow dependence			U _{spres}	0.00
atmosphseric pressure dependence			U _{apres}	0.75
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}	4.80
Uncertainty of calibration gas			U _{calib}	4.80
VOC Measurement uncertainty		Result	415.44	mg/m ³
Combined uncertainty			14.13	mg/m ³
Expanded uncertainty	k =	2	28.26	mg/m ³
Uncertainty corrected to std conds			28.26	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%	2.83 % ELV	
Expanded uncertainty		expressed with a level of confidence of 95%	28.26 mg.m ⁻³ of result	

Sulphur Dioxide						
Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution	Uncertainty as %
Corrected Volume (standard conditi	V	0.50	m ³	366.74	2.30 mg.m ⁻³	1.26 %
Mass	m	161.00	mg	1.14	5.51 mg.m ⁻³	3.01 %
Factor for O ₂ Correction	fc	1.27		144.28	0.00 mg.m ⁻³	0.00 %
Leak	L	2.11	mg.m ⁻³	1.00	2.11 mg.m ⁻³	1.15 %
Combined uncertainty					6.33 mg.m ⁻³	

Expanded uncertainty as percentage of measured value	6.92	% measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)
Expanded uncertainty in units of measurement	12.66	mg.m ⁻³	
Expanded uncertainty as percentage of limit value	3.62	% ELV	

2.4 Appendix IV: Moisture Calculations

Test No	T1			Site	Biogen		
Date	9-5-18				Bryn Pica		
pbar (mbar)	972			Stack	Engine		
pbar (mmHg)	729			Job Number:	R18084		
Nozzle Diameter (mm)	n/a			Site Team:	YS & DVG		
Temp of Meter (in)/(out) deg. C	16			Data Entered By:	DVG		
ΔH_{ave} (mmH ₂ O)	10.0						
DGM Cal Factor (Y)	1.0310						
				Enter Data into coloured cells only			
Start Volume Reading	3565.1992	m ³		Start time	12:30	hr:min	
End Volume Reading	3565.8254	m ³		End time	13:30	hr:min	
Volume Sampled	0.6456	m ³		Total time	01:00	hr:min	
IMPINGER	1	2	3	4	Initials of Analyst		
Absorber Solution (Type):	0.3% H ₂ O ₂				SILICA		
Sample No:	T1-F		T1-B	n/a			
Analysis Required:	Sulphate			n/a			
Initial Weight of Impingers plus absorber (g)	877.6	781.9	780.2	893.3	DVG		
Final Weight of Impingers plus absorber (g)	931.6	783.6	780.4	902.6	DVG		
Weight Gain (g)	54.0	1.7	0.2	9.3			
Total Weight Gain (1+2+3+4) (g)	65.2						
Gas Volume of water at 0 °C (l)	81.17						
Gas Meter volume at 0 °C (l)	586.79						
Moisture content of Gases (%)	12.2						

2.5 Appendix V: Acid Gas (SO₂) Calculations

SUMMARY OF ACID GAS IMPINGEMENT SAMPLING		
Stack ID		Engine
Stack Dimensions (m)		0.30
Date of Test		09-May-18
TEST NUMBER		T1
	Applied Standard	14791
Start Time	(hh:mm)	12:30
Stop Time	(hh:mm)	13:30
Duration	(minutes)	60
Sampled Gas Volume	(m3)	0.6262
Mean Temperature DGM	(oC)	15.50
Mean Sample Pressure	(mm H2O)	10.00
Mean Stack Temperature	(oC)	446.00
Corrected Sampled Gas Vol.	(Sm3@20oC)	0.6300
Corrected Sampled Gas Vol.	(Nm3@STP)	0.5870
Average Flowrate	(l/m @STP)	9.78
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)	350.0
Solution Sample Volume	(ml)	460.0
Measured concentration(Back)	(ug/ml)	0.9
Solution Sample Volume	(ml)	240.0
	Efficiency of Capture (%)	99.87%
Total Determinand Mass	(mg)	161.204
Moles of Determinand (mol)	(mol)	1.679
Mass of Pollutant	(mg)	107.47
Concentration (@ STP, Dry)	(mg/m3)	183.08
Stack Moisture	(%)v/v	12.14
Moisture Correction	dim'less	1.14
Stack Oxygen	(%)v/v	8.38
Oxygen Correction Factor	dim'less	1.27
	Net Correction Factor	1.27
Concentration @ Ref	(mg/(N)m3)	232.31
Sample as a percentage of ELV	(%)	66.38%
Blank Value	(mg/(N)m3)	0.15
Is Blank value < 10% of ELV		Yes