

**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



4251

Monitoring dates: 4th July 2016

Job Number: **R16239**

Version: 1

Address: **Biogen (UK) Ltd**

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Monitoring Organisation: **EnviroDat Ltd**

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Date of Report: 20th July 2016

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 re-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 CHP 1
Sulphur Dioxide (SO ₂)	✓
Oxygen (for correction)	✓
Moisture (for information)	✓
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	Sulphur Dioxide (SO ₂)	350	202	±11	mg(N)m ⁻³	101.3kPa, 273K, dry gas, 5% Oxygen	04/07/2016	11:02-12:02	BS EN 14791	B	At 100% MCR
	Moisture	-	11.6	n/a	%	101.3kPa, 273K, dry gas			BS EN 14790	A	
	Oxygen	-	7.95	±0.44	%				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 MCerts/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 MCerts/UKAS 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	04/07/2016	Combustion	Continuous	Anaerobic Digestion Gas	N/A	None	Producing 1190kWe (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

Assistant, Danny Gibbons – MCerts Trainee MM15 1326

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% O₂.

2.1.2.2 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.

2.1.2.3 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.

2.1.2.4 Sulphur Dioxide

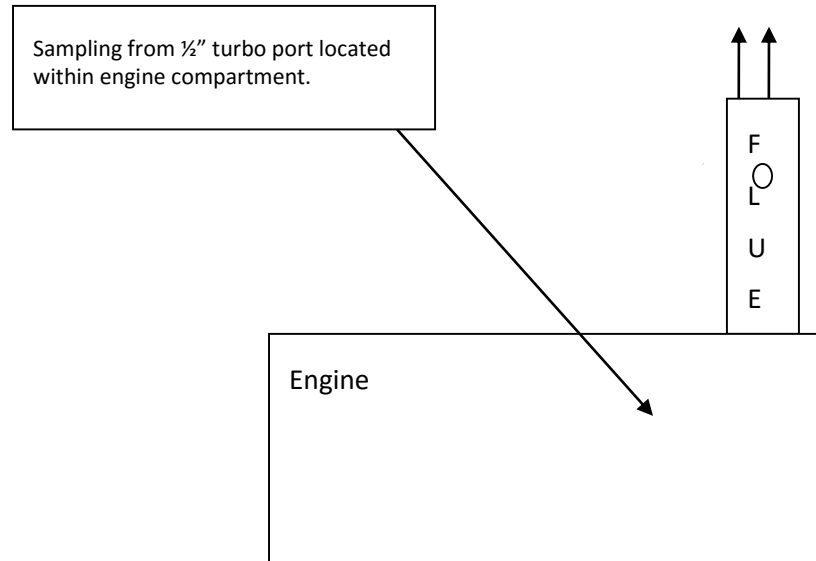
Sulphur Dioxide was performed with accordance with EnviroDat Ltd. documented procedure SP14792 based on BSEN14792 (2005). The procedure incorporates the equipment used in moisture sampling, as described above, with the addition of a 0.3% Hydrogen Peroxide solution in the impinger train. Solutions were sent to SAL Ltd for analysis by Ion Chromatography. The SO_2 calculations data can be seen in Appendix V and analytical results in Appendix VI.

2.1.3 Monitoring organisation equipment and gas check list references

EQUIPMENT - (BJ15 JKF)			
Item	Reference	Calibration Due	PAT Due
Portable Gas Analyser	PGA#06	18-Apr-17	Oct-16
Gas Conditioner	COND#01	28-Oct-16	Oct-16
NOx Converter	CONV#03	08-Mar-17	Oct-16
Data Logger	DL#04	22-Nov-16	-
Digital Barometer	DB#18	11-Aug-17	-
Balance	BAL#05	03-Apr-17	-
Heated Line	HL#13	10-Nov-16	-
Heated Line Controller	HLC#13	10-Nov-16	Oct-16
'Apex' Kit	APEX#04	See each item	Oct-16
Dry Gas Meter ('Apex')	DGM#11	13-Oct-16	-
Timepiece ('Apex')	TP#15	08-Oct-16	-
Thermocouple ('Apex')	TC#35	13-Oct-16	-
Thermocouple Reader ('Apex')	TCR#16	13-Oct-16	-
Thermocouple Reader ('Apex')	TCR#17	13-Oct-16	-
Thermocouple Reader ('Apex')	TCR#18	13-Oct-16	-
Manometer ('Apex' Orange)	MAN#08	08-Oct-16	-
Manometer ('Apex' Red)	MAN#09	08-Oct-16	-
Thermocouple ('Apex' Dogleg Exit)	TC#03	28-Oct-16	-
Thermocouple (Stack Temperature Check)	TC#44	04-Jan-17	-
Timepiece	TP#17	05-Feb-17	-
GAS CYLINDERS – (BJ15 JKF)			
	Certificate No.	Level (ppm)	Validity
'Zero' Gas (%)	GU93FNZ	99.999%	n/a
Oxygen Span Gas (%)	DW75BEU	7.87	13-Mar-17

2.2 Appendix II: Emission Point Reference Data & Results

2.2.1 Diagram of Sampling Location on Engine



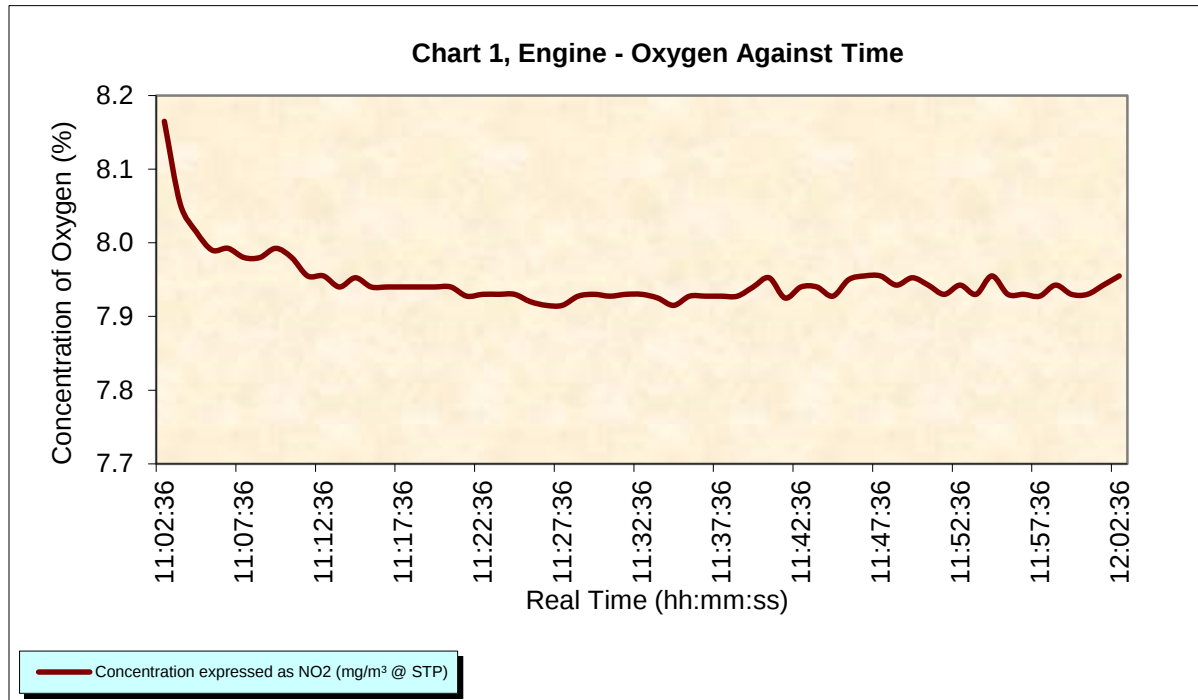
2.2.2 Homogeneity testing

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 and single point sampling acceptable

2.2.3 Gas analyser site measurements and calibrations

The data in Chart 1 and in Table 1 are expressed in mgm^{-3} @ STP. Calibration data is shown in Table 2.

**Table 1 - Engine CHP 1, Raw Data**

Time	Oxygen (%) (Dry Gas)	Comment
11:02:36	8.2	
11:03:36	8.1	
11:04:36	8.0	
11:05:36	8.0	
11:06:36	8.0	
11:07:36	8.0	
11:08:36	8.0	
11:09:36	8.0	
11:10:36	8.0	
11:11:36	8.0	
11:12:36	8.0	
11:13:36	7.9	
11:14:36	8.0	
11:15:36	7.9	
11:16:36	7.9	
11:17:36	7.9	
11:18:36	7.9	
11:19:36	7.9	
11:20:36	7.9	
11:21:36	7.9	

Time	Oxygen (%) (Dry Gas)	Comment
11:22:36	7.9	
11:23:36	7.9	
11:24:36	7.9	
11:25:36	7.9	
11:26:36	7.9	
11:27:36	7.9	
11:28:36	7.9	
11:29:36	7.9	
11:30:36	7.9	
11:31:36	7.9	
11:32:36	7.9	
11:33:36	7.9	
11:34:36	7.9	
11:35:36	7.9	
11:36:36	7.9	
11:37:36	7.9	
11:38:36	7.9	
11:39:36	7.9	
11:40:36	8.0	
11:41:36	7.9	
11:42:36	7.9	
11:43:36	7.9	
11:44:36	7.9	
11:45:36	8.0	
11:46:36	8.0	
11:47:36	8.0	
11:48:36	7.9	
11:49:36	8.0	
11:50:36	7.9	
11:51:36	7.9	
11:52:36	7.9	
11:53:36	7.9	
11:54:36	8.0	
11:55:36	7.9	
11:56:36	7.9	
11:57:36	7.9	
11:58:36	7.9	
11:59:36	7.9	
12:00:36	7.9	
12:01:36	7.9	
12:02:36	8.0	

Table 2 – 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.	GU93FNZ			AIR
Span Gas	Cylinder No.	GU93DEQ		DW75BEU	
	Certified Value	256.7	1276	7.87	614
Zero Check	Value	0.2	-3	0.03	-3
<2 x repeatability (Yes/No)		YES	YES	YES	YES
Down Line Zero & Span Check					
Zero Gas	Value	0.2	-6	0.1	-6
	<2% of span	YES	YES	YES	YES
Span Gas	Value	256.6	1275	7.87	608
	Within 2% of span	YES	YES	YES	YES
Post Sampling Drift Check					
Zero Gas	Value	3.1	-1	0.13	-4
	Drift (%)	1.1	0.4	0.4	0.3
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required
Span Gas	Value	257.1	1281	7.85	606
	Drift (%)	0.2	0.5	0.3	0.3
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required

2.3 Appendix III: Uncertainty Calculations

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}	0.09	
Drift		U_{odr}	0.12	
volume or pressure flow dependence		U_{spres}	0.00	
atmospheric pressure dependence		U_{apres}	0.00	
ambient temperature dependence		U_{temp}	0.06	
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	7.95	%vol
Combined uncertainty		0.22	%vol	
% of value		2.75	%	
Expanded uncertainty		expressed with a level of confidence of 95%		5.51 % of value
Expanded uncertainty		expressed with a level of confidence of 95%		0.44 % vol

Sulphur Dioxide						
Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution	Uncertainty as %
Corrected Volume (standard conditic	V	0.46	m ³	359.95	2.05 mg.m ⁻³	1.24 %
Mass	m	131.10	mg	1.26	4.97 mg.m ⁻³	3.01 %
Factor for O2 Correction	fc	1.23		134.38	0.00 mg.m ⁻³	0.00 %
Leak	L	1.90	mg.m ⁻³	1.00	1.90 mg.m ⁻³	1.15 %
Combined uncertainty					5.70 mg.m ⁻³	
Expanded uncertainty as percentage of measured value		6.92		% measured of value		
Expanded uncertainty in units of measurement		11.41		mg.m ⁻³		
Expanded uncertainty as percentqge of limit value		3.26		% ELV		
				expressed with a level of confidence of 95% (Using a coverage factor k=2)		

2.4 Appendix IV: Moisture Calculations Data

Test No	T2		Site	Biogen		
Date	4-7-16			Bryn Pica		
pbar (mbar)	980		Stack	Engine		
pbar (mmHg)	735		Job Number:	R16239		
Nozzle Diameter (mm)	n/a		Site Team:	YS + DG		
Temp of Meter (in)/(out) deg. C	22		Data Entered By:	Yu Shen		
ΔH_{ave} (mmH ₂ O)	10.0		Enter Data into coloured cells only			
DGM Cal Factor (Y)	1.0256					
Start Volume Reading	734.1614	m ³	Start time	11:02	hr:min	
End Volume Reading	734.7410	m ³	End time	12:02	hr:min	
Volume Sampled	0.5944	m ³	Total time	01:00	hr:min	
IMPINGER	1	2	3	4	Initials of Analyst	
Absorber Solution (Type):	H2O2	H2O2	H2O2	SILICA		
Sample No:	S2-F		S2-B	n/a		
Analysis Required:	Sulphate			n/a		
Initial Weight of Impingers plus absorber (g)	689.6	797.0	740.9	852.0	YS	
Final Weight of Impingers plus absorber (g)	736.8	800.2	740.7	858.0	DG	
Weight Gain (g)	47.2	3.2	-0.2	6.0		
Total Weight Gain (1+2+3+4) (g)	56.2					
Gas Volume of water at 0 °C (l)	69.97					
Gas Meter volume at 0 °C (l)	531.96					
Moisture content of Gases (%)	11.6					

2.5 Appendix V: Sulphur Dioxide Calculations Data

SUMMARY OF ACID GAS IMPINGEMENT SAMPLING		
Stack ID		Engine
Stack Dimensions (m)		0.23
Date of Test		04-Jul-16
TEST NUMBER		T2/S2
	Applied Standard	14791
Start Time	(hh:mm)	11:02
Stop Time	(hh:mm)	12:02
Duration	(minutes)	60
Sampled Gas Volume	(m3)	0.5796
Mean Temperature DGM	(oC)	22.42
Mean Sample Pressure	(mm H2O)	10.00
Mean Stack Temperature	(oC)	440.00
Corrected Sampled Gas Vol.	(Sm3@20oC)	0.5712
Corrected Sampled Gas Vol.	(Nm3@STP)	0.5322
Average Flowrate	(l/m @STP)	8.87
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)	380.0
Solution Sample Volume	(ml)	345.0
Measured concentration(Back)	(ug/ml)	3.8
Solution Sample Volume	(ml)	140.0
	Efficiency of Capture (%)	99.60%
Total Determinand Mass	(mg)	131.632
Moles of Determinand (mol)	(mol)	1.371
Mass of Pollutant	(mg)	87.75
Concentration (@ STP, Dry)	(mg/m3)	164.88
Stack Moisture	(%)v/v	11.61
Moisture Correction	dim'less	1.13
Stack Oxygen	(%)v/v	7.95
Oxygen Correction Factor	dim'less	1.23
Concentration @ Ref	(mg/(N)m3)	202.30
Sample as a percentage of ELV	(%)	57.80%
Blank Value	(mg/(N)m3)	1.22
Is Blank value < 10% of ELV		Yes

2.6 Appendix VI: Sulphur Dioxide Analytical Data



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Report Number: 583315-1

Date of Report: 14-Jul-2016

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Customer Contact: Mr Yu Shen

Customer Job Reference: R16239
Date Job Received at SAL: 06-Jul-2016
Date Analysis Started: 11-Jul-2016
Date Analysis Completed: 14-Jul-2016

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 :
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Trainee Project Manager

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Trainee Project Manager
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Reason: Issue
Location: SAL

Page 1 of 2
583315-1

SAL Reference: 583315				
Customer Reference: R16239				
Impinger(peroxide) Analysed as Impinger(peroxide)				
Miscellaneous				
SAL Reference		583315 001	583315 002	583315 003
Customer Sample Reference		R16239/S1-F	R16239/S1-B	R16239/S2-F
Test Sample		AR	AR	AR
Date Sampled		04-JUL-2016	04-JUL-2016	04-JUL-2016
Determinand	Method	LOD	Units	Symbol
Sulphate	IC	0.05	mg/l	U
Volume	Vol	1	ml	U

Index to symbols used in 583315-1

Value	Description
AR	As Received
195	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

