

**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: 1st May 2015

Job Number: **R15012R**

Version: 1

Address: Biogen Ltd
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Monitoring Organisation: **EnviroDat Ltd.**

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Date of Report: 12th May 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 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/DP3735NP, are summarised below:

Substances to be monitored	Emission Point Identification
	Engine
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 (mg/m³)	Periodic Monitoring Result (mg/m³)	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	350	347.8	±32.8	mg(N)m ⁻³	101.3 kPa, 273K, dry gas, 5% O ₂	01/05/15	10:48-11:48	BS EN 14791	B	At 100% MCR
	Oxygen	-	7.33	±0.40	%	101.3 kPa, 273K, dry gas			BS EN 14789	A	
	Moisture	-	12.7	n/a	%				BS EN 14790	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).

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	01/05/15	Combustion	Continuous	Biogas	N/A	None	Producing 1,064kW (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

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, stainless steel 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 SO₂ results table and analytical results can be seen in Appendix V and the uncertainty can be seen in Appendix III. The absorption efficiency of the primary impingers was 99.97%. This values meet the requirement of greater than 95% of the standard. The bank value was 0.49mg/m³, also meeting the standard requirements.

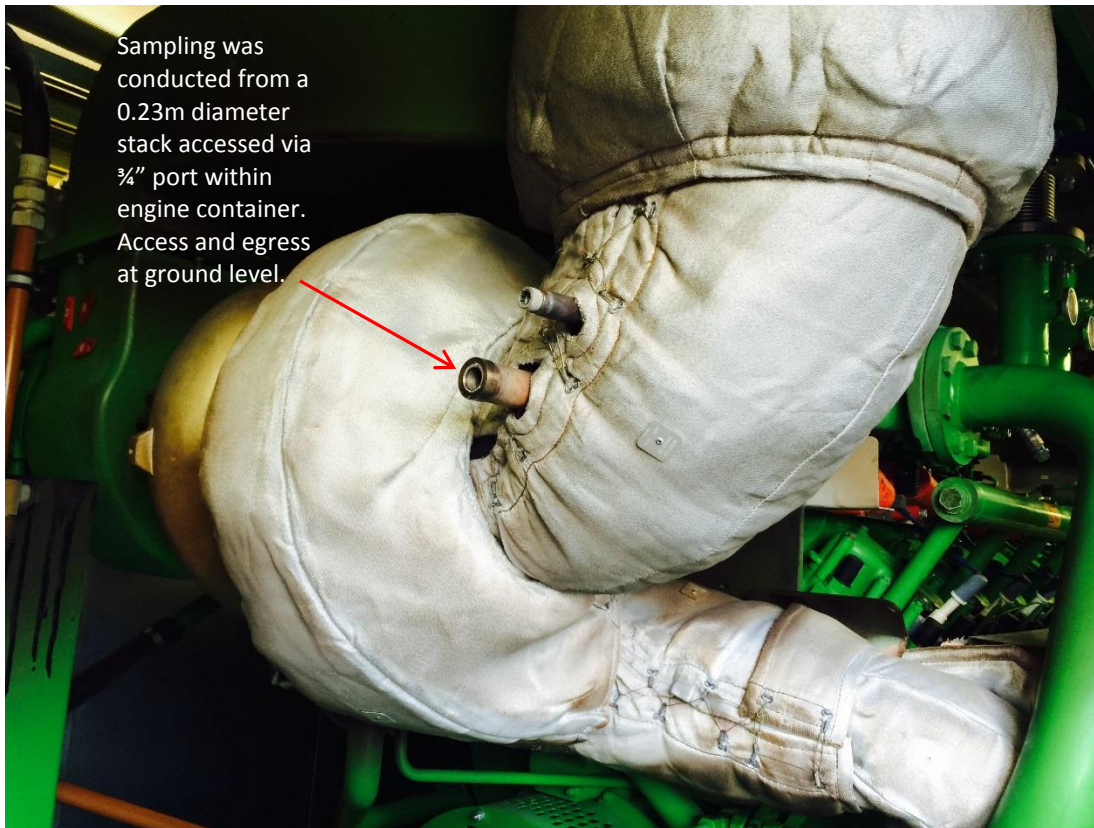
2.1.3 Monitoring organisation equipment and gas check list references

EQUIPMENT			
Item	Reference	Calibration Due	PAT Due
Portable Gas Analyser	PGA#05	02-Nov-15	Oct-15
Gas Conditioner	COND#01	04-Feb-16	Oct-15
Data Logger	DL#05	04-Nov-15	-
Digital Barometer	DB#11	22-Aug-15	-
Balance	BAL#03	01-Apr-16	-
Heated Line ¹	HL#03B	08-Jan-16	-
Heated Line Controller ¹	HLC#06	08-Jan-16	Oct-15
Heated Filter Holder	HFH#01	26-Mar-16	Oct-15
'Apex' Kit	APEX#03	See each item	Oct-15
Dry Gas Meter ('Apex')	DGM#06	28-Aug-15	-
Timepiece ¹ ('Apex')	TP#12	28-Aug-15	-
Timepiece ²	TP#07	29-Apr-15	-
Thermocouple ²	TC#28	06-Nov-15	-
Thermocouple ³ ('Apex' Dogleg Exit)	TC#20	28-Aug-15	-
Thermocouple ³ ('Apex' Dry Gas Meter)	TC#30	28-Aug-15	-
Thermocouple Reader ('Apex') ¹	TCR#12	28-Aug-15	-
Thermocouple Reader ²	TCR#09	05-Oct-15	-
Transformer ¹	-	-	Oct-15
Cable Reel/Splitter ¹	-	-	Oct-15

GAS CYLINDERS -			
	Certificate No.	Level (ppm)	Validity
'Zero' Gas (%)	VC2714098	99.999%	-
Oxygen Span Gas (%)	VC80253	8.01%	22-Jan-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 Chart 1 and in Table 2 is expressed in % @ STP. Calibration data is shown in Table 1.

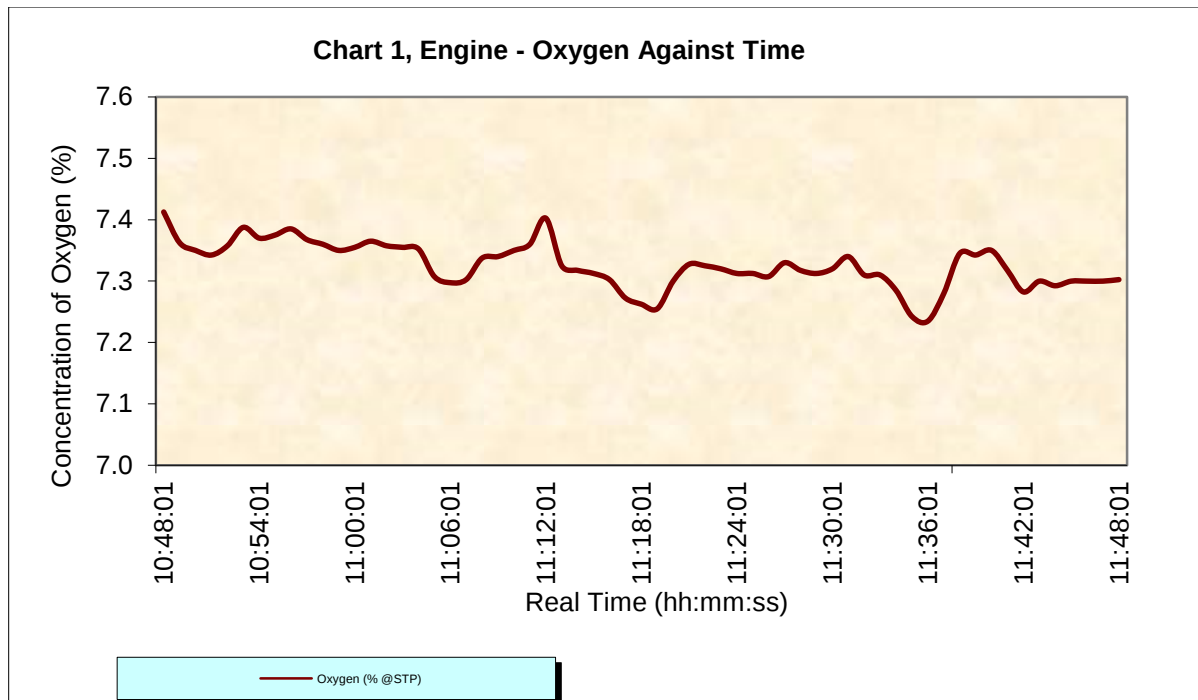


Table 1 – Calibration Data

ANALYSER CALIBRATION DATA					
Pre Sampling Check					
		NO (ppm)	CO (ppm)	O2 (%)	VOC's (ppm)
Range				25	
Zero Gas	Cylinder No.	VC2687162			
Span Gas	Cylinder No.			VC80253	
	Certified Value			8.01	
Zero Check	Value			-0.01	
<2 x repeatability (Yes/No)				YES	
Down Line Zero & Span Check					
Zero Gas	Value			0.08	
	<2% of span	REJECT	REJECT	YES	REJECT
Span Gas	Value			8	
	Within 2% of span	#DIV/0!	#DIV/0!	YES	#DIV/0!
Post Sampling Drift Check					
Zero Gas	Value			0.06	
	Drift (%)	#DIV/0!	#DIV/0!	0.2	#DIV/0!
	Validation	#DIV/0!	#DIV/0!	No Correction Required	#DIV/0!
Span Gas	Value			7.95	
	Drift (%)	#DIV/0!	#DIV/0!	0.6	#DIV/0!
	Validation	#DIV/0!	#DIV/0!	No Correction Required	#DIV/0!

Table 2 – Engine, Raw data

Time	Oxygen (%)	Comment
10:48:01	7.4	
10:49:01	7.4	
10:50:01	7.4	
10:51:01	7.3	
10:52:01	7.4	
10:53:01	7.4	
10:54:01	7.4	
10:55:01	7.4	
10:56:01	7.4	
10:57:01	7.4	
10:58:01	7.4	
10:59:01	7.4	
11:00:01	7.4	
11:01:01	7.4	
11:02:01	7.4	
11:03:01	7.4	
11:04:01	7.4	
11:05:01	7.3	
11:06:01	7.3	
11:07:01	7.3	
11:08:01	7.3	
11:09:01	7.3	
11:10:01	7.4	
11:11:01	7.4	
11:12:01	7.4	
11:13:01	7.3	
11:14:01	7.3	
11:15:01	7.3	
11:16:01	7.3	
11:17:01	7.3	
11:18:01	7.3	
11:19:01	7.3	
11:20:01	7.3	
11:21:01	7.3	
11:22:01	7.3	
11:23:01	7.3	
11:24:01	7.3	
11:25:01	7.3	
11:26:01	7.3	
11:27:01	7.3	
11:28:01	7.3	
11:29:01	7.3	
11:30:01	7.3	
11:31:01	7.3	
11:32:01	7.3	
11:33:01	7.3	

Time	Oxygen (%)	Comment
11:34:01	7.3	
11:35:01	7.2	
11:36:01	7.2	
11:37:01	7.3	
11:38:01	7.3	
11:39:01	7.3	
11:40:01	7.4	
11:41:01	7.3	
11:42:01	7.3	
11:43:01	7.3	
11:44:01	7.3	
11:45:01	7.3	
11:46:01	7.3	
11:47:01	7.3	
11:48:01	7.3	

2.3 Appendix III: Uncertainty Calculation

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}	0.08
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}	0.00
CO2 (15%)			-	0.00
NO(300)			-	0.06
NO2(30)			-	0.00
dependence on voltage			U_{vdt}	0.02
losses in the line (leak)			U_{leak}	0.08
Error in Logger voltage			-	0.03
Uncertainty of calibration gas			U_{calib}	0.08
O2 Measurement uncertainty		Result	7.33	%vol
Combined uncertainty			0.20	%vol
% of value			2.71	%
Expanded uncertainty		expressed with a level of confidence of 95%	5.42 % of value	
Expanded uncertainty		expressed with a level of confidence of 95%	0.40 % vol	

Sulphur Dioxide						
Parameter		Value	Units	Sensitivity coeff	Uncertainty contribution	Uncertainty as %
Corrected Volume (standard conditi	V		0.45 m ³	656.63	1.73 mg.m ⁻³	0.58 %
Mass	m		169.78 mg	1.75	15.36 mg.m ⁻³	5.17 %
Factor for O2 Correction	fc		1.17	253.63	4.36 mg.m ⁻³	1.47 %
Leak	L		3.43 mg.m ⁻³	1.00	3.43 mg.m ⁻³	1.15 %
Combined uncertainty					16.42 mg.m ⁻³	
Expanded uncertainty as percentage of measured value			11.06	% measured of value		
Expanded uncertainty in units of measurement			32.84	mg.m ⁻³		
Expanded uncertainty as percentqge of limit value			9.38	% ELV		

2.4 Appendix V: Moisture Calculations

Test No	T1		Site	Biogen		
Date	1-5-15			Waen		
pbar (mbar)	999		Stack	Engine		
pbar (mmHg)	749		Job Number:	R15012R		
Nozzle Diameter (mm)	n/a		Site Team:	DL		
Temp of Meter (in)/(out) deg. C	24		Data Entered By:	DL		
ΔH_{ave} (mmH ₂ O)	12.5					
DGM Cal Factor (Y)	0.9950					
			Enter Data into coloured cells only			
Start Volume Reading	0.0000	m ³	Start time	10:48	hr:min	
End Volume Reading	0.6327	m ³	End time	11:48	hr:min	
Volume Sampled	0.6295	m ³	Total time	01:00	hr:min	
IMPINGER	1	2	3	4	5	Initials of Analyst
Absorber Solution (Type):	H2O2	H2O2	H2O2	KO IMP	SILICA	
Sample No:	T1A		T1B		n/a	
Analysis Required:	Sulphate				n/a	
Initial Weight of Impingers plus absorber (g)	931.6	824.2	689.0	692.4	832.0	DL
Final Weight of Impingers plus absorber (g)	981.7	831.9	689.7	693.0	839.5	DL
Weight Gain (g)	50.1	7.7	0.7	0.6	7.5	
Total Weight Gain (1+2+3+4) (g)	66.6					
Gas Volume of water at 0 °C (l)	82.92					
Gas Meter volume at 0 °C (l)	571.37					
Moisture content of Gases (%)	12.7					

2.5 Appendix V: Sulphur Dioxide Calculations & Lab Results

SUMMARY OF ACID GAS IMPINGEMENT SAMPLING		
Stack ID		Engine
Stack Dimensions (m)		0.23
Date of Test		01-May-15
TEST NUMBER		T1
	Applied Standard	14791
Start Time	(hh:mm)	10:48
Stop Time	(hh:mm)	11:48
Duration	(minutes)	60
Sampled Gas Volume	(m3)	0.6327
Mean Temperature DGM	(oC)	24.00
Mean Sample Pressure	(mm H2O)	12.50
Mean Stack Temperature	(oC)	
Corrected Sampled Gas Vol.	(Sm3@20oC)	0.6135
Corrected Sampled Gas Vol.	(Nm3@STP)	0.5716
Average Flowrate	(l/m @STP)	9.53
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)	670.0
Solution Sample Volume	(ml)	380.0
Measured concentration(Back)	(ug/ml)	0.4
Solution Sample Volume	(ml)	170.0
	Efficiency of Capture (%)	99.97%
Total Determinand Mass	(mg)	254.666
Moles of Determinand (mol)	(mol)	2.653
Mass of Pollutant	(mg)	169.78
Concentration (@ STP, Dry)	(mg/m3)	297.01
Stack Moisture	(%)v/v	12.66
Moisture Correction	dim'less	1.14
Stack Oxygen	(%)v/v	7.33
Oxygen Correction Factor	dim'less	1.17
	Net Correction Factor	1.17
Concentration @ Ref	(mg/(N)m3)	347.82



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Report Number: 474585-1

Date of Report: 11-May-2015

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Customer Contact: Mr David Littlewood

Customer Job Reference: R15012R
Date Job Received at SAL: 01-May-2015
Date Analysis Started: 06-May-2015
Date Analysis Completed: 11-May-2015

The results reported relate to samples received in the laboratory
Opinions and interpretations expressed herein are outside the scope of UKAS accreditation
This report should not be reproduced except in full without the written approval of the laboratory
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 :
Mary Drury
Project Manager

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Mary Drury
Project Manager

Validity unknown
Digitally signed by Mary Drury
Date: 2015.05.11 17:56:05 BST
Reason: Issue
Location: SAL

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SAL Reference: 474585													
Customer Reference: R15012R													
Impinger(peroxide)		Analysed as Impinger(peroxide)											
New Group													
SAL Reference				474585 001		474585 002		474585 003		474585 004		474585 005	
Customer Sample Reference				TIA		TIB		BIA		BIB		REAGENT	
Test Sample				AR		AR		AR		AR		AR	
Date Sampled				01-MAY-2015		01-MAY-2015		01-MAY-2015		01-MAY-2015		01-MAY-2015	
Determinand		Method	LOD	Units	Symbol								
Volume		Vol	1	ml	U	64	58	47	44	52			

SAL Reference: 474585													
Customer Reference: R15012R													
Impinger(peroxide)		Analysed as Impinger(peroxide)											
Miscellaneous													
SAL Reference				474585 001		474585 002		474585 003		474585 004		474585 005	
Customer Sample Reference				TIA		TIB		BIA		BIB		REAGENT	
Test Sample				AR		AR		AR		AR		AR	
Date Sampled				01-MAY-2015		01-MAY-2015		01-MAY-2015		01-MAY-2015		01-MAY-2015	
Determinand		Method	LOD	Units	Symbol								
Sulphate		IC	0.05	mg/l	U	(195,13) 670	(13) 0.39	(13) 0.39	(13) 0.53	(13) 0.33			

Index to symbols used in 474585-1

Value	Description
AR	As Received
13	Results have been blank corrected.
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
U	Analysis is UKAS accredited