

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 March 2016

Job Number: **R15264R**

Version: 1

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

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Date of Report: 10th March 2016

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	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	350	187.1	±18.7	mg(N)m ⁻³	101.3kPa, 273K, dry gas, 5% Oxygen	01/03/2016	11:05-12:05	BS EN 14791	B	At 100% MCR
	Moisture	-	12.6	n/a	%	101.3kPa, 273K, dry gas			BS EN 14790	A	
	Oxygen	-	7.13	±0.4	%				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).

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	01/03/16	Combustion	Continuous	Biogas	N/A	None	Producing 1064kW (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
Dean Kyle, Assistant – 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% O₂.

2.1.2.2 O₂

A sample of the duct gas was passed via a short high temperature, titanium 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 $Conc_{meas}$ was the measured concentration, O_{2ref} is the oxygen reference conditions and O_{2meas} 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:

$$\frac{(100-[H_2O]reference)}{(100-[H_2O]measured)}$$

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 impinger was 99.93%. This values meet the requirement of greater than 95% of the standard. The bank value was 0.15mg/m³, also meeting the standard requirements.

2.1.3 Monitoring organisation equipment and gas check list references

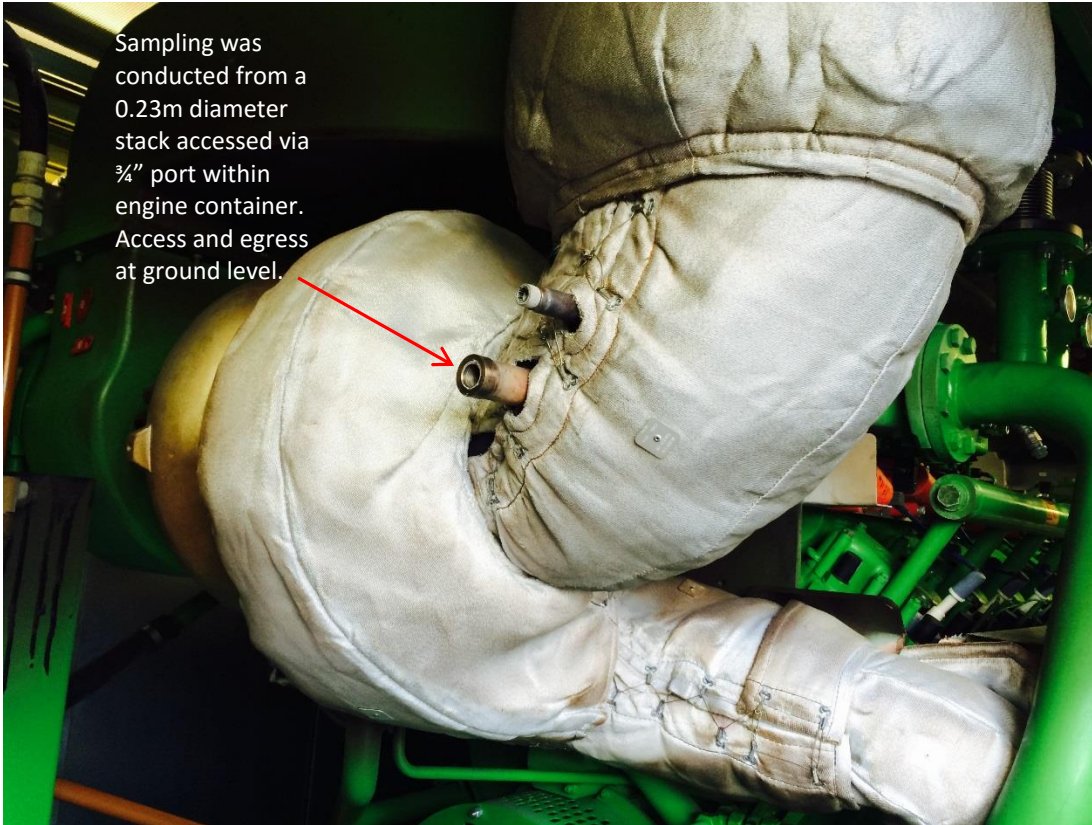
EQUIPMENT -			
Item	Reference	Calibration Due	PAT Due
Portable Gas Analyser	PGA#01	27-Apr-16	Oct-16
Gas Conditioner	COND#02	05-Feb-16	Oct-16
Data Logger	DL#05	04-Nov-16	-
Digital Barometer	DB#15	27-Feb-17	-
Digital Barometer	DB#17	05-Feb-17	
Balance	BAL#03	01-Apr-16	-
Heated Line ¹	HL#03B	04-Jan-17	-
Heated Line ²	HL#05	04-Jan-17	-
Heated Line Controller ¹	HLC#06	04-Jan-17	Oct-16
Heated Line Controller ²	HLC#04	04-Jan-17	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	08-Oct-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%	-
Oxygen Span Gas (%) ¹	11787910	7.94	01-Jul-16

2.2 Appendix II: Emission Point Reference Data & Results

2.2.1 Photograph of Sampling Location on Engine



Sampling was conducted from a 0.23m diameter stack accessed via 3/4" port within engine container. Access and egress at ground level.

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.

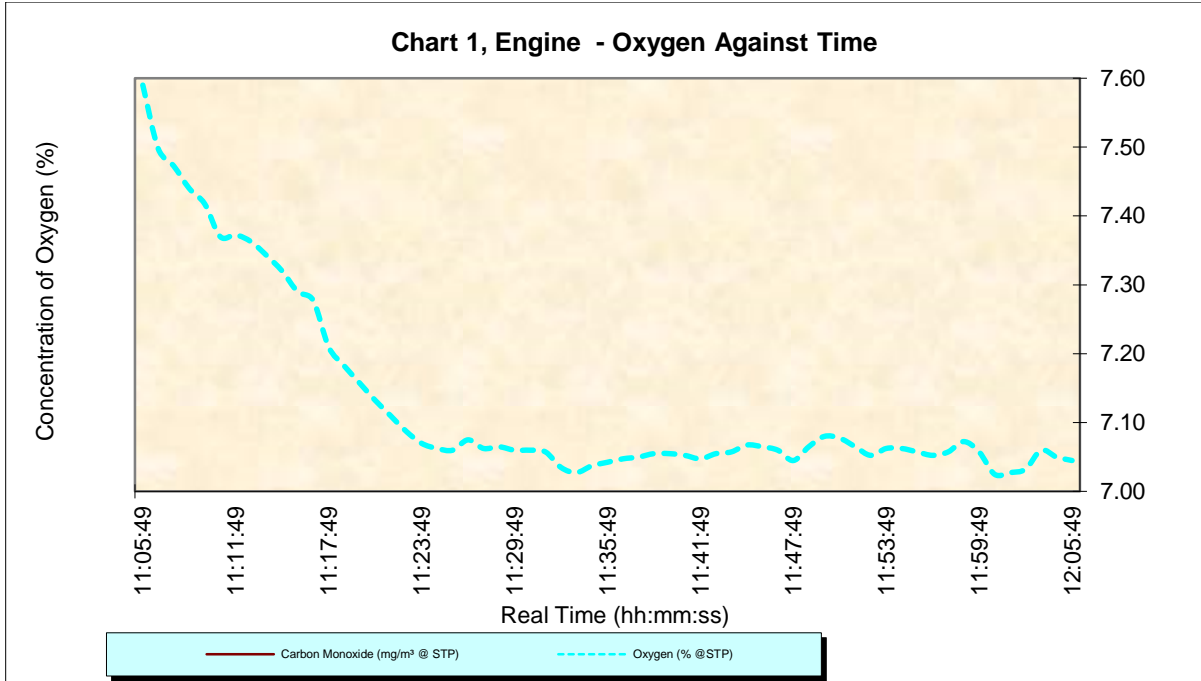


Table 1 – Calibration Data

ANALYSER CALIBRATION DATA		
Pre Sampling Check		
		O2 (%)
Range		25
Zero Gas	Cylinder No.	VC7905216
Span Gas	Cylinder No.	11787910
	Certified Value	7.94
Zero Check	Value	0.02
<2 x repeatability (Yes/No)		YES
Down Line Zero & Span Check		
Zero Gas	Value	0.14
	<2% of span	YES
Span Gas	Value	7.97
	Within 2% of span	YES
Post Sampling Drift Check		
Zero Gas	Value	0.12
	Drift (%)	0.3
	Validation	No Correction Required
Span Gas	Value	7.91
	Drift (%)	0.8
	Validation	No Correction Required

Table 2 – Engine, Raw data

Time	Oxygen (%)
11:05:49	7.6
11:06:49	7.5
11:07:49	7.5
11:08:49	7.4
11:09:49	7.4
11:10:49	7.4
11:11:49	7.4
11:12:49	7.4
11:13:49	7.3
11:14:49	7.3
11:15:49	7.3
11:16:49	7.3
11:17:49	7.2
11:18:49	7.2
11:19:49	7.2

Time	Oxygen (%)
11:20:49	7.1
11:21:49	7.1
11:22:49	7.1
11:23:49	7.1
11:24:49	7.1
11:25:49	7.1
11:26:49	7.1
11:27:49	7.1
11:28:49	7.1
11:29:49	7.1
11:30:49	7.1
11:31:49	7.1
11:32:49	7.0
11:33:49	7.0
11:34:49	7.0
11:35:49	7.0
11:36:49	7.0
11:37:49	7.1
11:38:49	7.1
11:39:49	7.1
11:40:49	7.1
11:41:49	7.0
11:42:49	7.1
11:43:49	7.1
11:44:49	7.1
11:45:49	7.1
11:46:49	7.1
11:47:49	7.0
11:48:49	7.1
11:49:49	7.1
11:50:49	7.1
11:51:49	7.1
11:52:49	7.1
11:53:49	7.1
11:54:49	7.1
11:55:49	7.1
11:56:49	7.1
11:57:49	7.1
11:58:49	7.1
11:59:49	7.1
12:00:49	7.0
12:01:49	7.0
12:02:49	7.0
12:03:49	7.1
12:04:49	7.1
12:05:49	7.0

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_{Rf}	0.08	
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}	0.03	
CO ₂ (15%)	-	0.00	
NO(300)	-	0.06	
NO ₂ (30)	-	0.00	
dependence on voltage	U_{volt}	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			
Combined uncertainty	Result	7.13	%vol
		0.20	%vol
% of value		2.77	%
Expanded uncertainty	expressed with a level of confidence of 95%	5.54 % 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)	V _r	0.35	m ³	462.73	1.08 mg.m ⁻³	0.67 %
Mass	m	70.28	mg	2.31	8.64 mg.m ⁻³	5.33 %
Factor for O ₂ Correction	fc	1.15		140.43	2.81 mg.m ⁻³	1.74 %
Leak	L	1.87	mg.m ⁻³	1.00	1.87 mg.m ⁻³	1.15 %
Combined uncertainty					9.34 mg.m⁻³	
Expanded uncertainty as percentage of measured value		11.53		% measured of value		expressed with a level of confidence of 95% (Using a coverage factor k=2)
Expanded uncertainty in units of measurement		18.68		mg.m ⁻³		
Expanded uncertainty as percentage of limit value		5.34		% ELV		

2.4 Appendix V: Moisture Calculations

*

Test No	1					Site	Biogen		
Date	1-3-16						Waen		
pbar (mbar)	998					Stack	Engine		
pbar (mmHg)	749					Job Number:	R15264R		
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	11:05	hr:min	
End Volume Reading	0.4826	m ³				End time	12:05	hr:min	
Volume Sampled	0.4684	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)	839.1	808.6	560.3	759.8	DL + DK				
Final Weight of Impingers plus absorber (g)	879.4	810.8	561.4	766.6	DL + DK				
Weight Gain (g)	40.3	2.2	1.1	6.8					
Total Weight Gain (1+2+3+4) (g)	50.4								
Gas Volume of water at 0 °C (l)	62.75								
Gas Meter volume at 0 °C (l)	433.36								
Moisture content of Gases (%)	12.6								

2.5 Appendix V: Sulphur Dioxide Calculations & Lab Results

SUMMARY OF ACID GAS IMPINGMENT SAMPLING		
Stack ID		Engine
Stack Dimensions (m)		0.23
<i>Date of Test</i>		01/13/2016
TEST NUMBER		T1
	<i>Applied Standard</i>	14791
Start Time	(hh:mm)	11:05
Stop Time	(hh:mm)	12:05
Duration	(minutes)	60
Sampled Gas Volume	(m3)	0.4826
Mean Temperature DGM	(oC)	18.00
Mean Sample Pressure	(mm H2O)	10.00
Mean Stack Temperature	(oC)	492.00
Corrected Sampled Gas Vol.	(Sm3@20oC)	0.4653
Corrected Sampled Gas Vol.	(Nm3@STP)	0.4336
Average Flowrate	(l/m @STP)	7.23
Required Pollutant (<i>eg:HCl, HF or SO₂</i>)		SO2
Molecular Weight Pollutant		64
Determinant Species		Sulphate
Molecular Weight Determinand		96
	<i>Analysing Laboratory UKAS No.</i>	1549
Measured concentration(<i>Front</i>)	(ug/ml)	390.0
Solution Sample Volume	(ml)	270.0
Measured concentration(<i>Back</i>)	(ug/ml)	0.7
Solution Sample Volume	(ml)	172.0
	<i>Efficiency of Capture (%)</i>	99.89%
Total Determinand Mass	(mg)	105.414
Moles of Determinand (mol)	(mol)	1.098
Mass of Pollutant	(mg)	70.28
Concentration (@ STP, Dry)	(mg/m3)	162.09
Stack Moisture	(%)v/v	12.63
Moisture Correction	dim'less	1.14
Stack Oxygen	(%)v/v	7.13
Oxygen Correction Factor	dim'less	1.15
Concentration @ Ref	(mg/(N)m3)	187.07
<i>Sample as a percentage of ELV</i>	(%)	53.45%
<i>Blank Value</i>	<i>(mg/(N)m3)</i>	0.11
Is Blank value < 10% of ELV		Yes



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Report Number: 552159-1

Date of Report: 09-Mar-2016

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Customer Contact: Mr David Littlewood

Customer Job Reference: R15664/R
Date Job Received at SAL: 03-Mar-2016
Date Analysis Started: 04-Mar-2016
Date Analysis Completed: 08-Mar-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
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 Hughes
Senior Project Manager

Issued by :
Mary Hughes
Senior Project Manager

Validity unknown
Digitally signed by Mary Hughes
Date: 2016.03.09 17:09:05 GMT
Reason: Issue
Location: SAL

SAL Reference: 552159								
Customer Reference: R15664/R								
Impinger(peroxide) Analysed as Impinger(peroxide)								
Miscellaneous								
SAL Reference		552159 001	552159 002	552159 003	552159 004			
Customer Sample Reference		BIA	BIB	TIA	TIB			
Test Sample		AR	AR	AR	AR			
Date Sampled		01-MAR-2016	01-MAR-2016	01-MAR-2016	01-MAR-2016			
Determinand	Method	LOD	Units	Symbol				
Sulphate	IC	0.05	mg/l	U	(13) 0.11	(13) 0.07	(13,195) 390	(13) 0.66
Volume	Vol	1	ml	U	50	40	67	46

Index to symbols used in 552159-1

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

