EMISSIONS MONITORING SURVEY

Prepared for:

Biotage GB Ltd
Distribution Way, Dyffryn Industrial Estate
Ystard Mynach
CF82 7TS

Permit Number	**: EPR/DP3832EF**
Variation Number	**: N/A**
Installation	**: Ystrad Mynach**
Visit Details	**: Annual Emissions Compliance**
Job Number	**: P2251**
Report Number	**: R001**
Report Issue Date	**: 29th April 2015**
Survey Dates	**: 31st March – 1st April 2015**

Prepared by:

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Report Issue:		**FINAL**	
Report Prepared by:		**Report Reviewed & Approved by** **MCERTS Level Two** **Technical Endorsements TE1, TE2, TE3 & TE4**	
Name:	Sam Brookes	***Name:***	Craig Lewis
		MCERTS No:	MM 11 1148
		Signature:	
Date:	28/04/2015	***Date:***	11/05/2015

This report is not to be used for contractual or engineering purposes unless this approval sheet is signed where indicated by the approver and the report is designated "FINAL".

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

UKAS TESTING
2499

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Opinions and Interpretation expressed within this report are outside the scope of the UKAS accreditation.

MCERTS requirements mean that comparison of results with emissions limit values is not permitted within this report.

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PART 1 - EXECUTIVE SUMMARY

1 Monitoring Objectives

Environmental Compliance Ltd (ECL) was commissioned by **Biotage Ltd** to undertake an emission monitoring survey at their **Ystard Mynach installation**. This report presents the findings of the study.

The monitoring at this installation was carried out in accordance with our quotation reference **dhfb/P2251/Q001** for compliance check monitoring of emissions to air. The substances requested for monitoring at each emissions point are listed below:

Substances to be monitored	Emission Point Identification			
	A1	A2	A3	A4
Velocity / Flowrate	● U	● U	● U	● U
Oxides of Nitrogen (as NO_2)			● U	
Hydrogen Chloride	● U	● U		
Hydrogen Bromide				● U*
Methanol	● U*	● U*	● U*	

● Denotes the substances to be monitored.

U **Denotes UKAS accreditation is held for monitoring that substance, but does not mean that it has been claimed which will depend on whether the testing could be completed in accordance with the Standard Reference Method.**

* External laboratory does not hold UKAS accreditation for Hydrogen Bromide and Methanol

Special Requirements: *"Under normal operating conditions."*

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1.1 Monitoring Results

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Units	Uncertainty %	Reference Conditions 273 K, 101.3 kPa	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Tick if non-conforming test (see Sections 2 & 5)	Operating Status
A1 Main Building EP1	Volumetric Flowrate	N/A	0.42	m^3/sec	4	Stack Conditions	31/03/15	09:00 – 09:12	BS EN 16911-1	UKAS / MCERTS		Normal
	Volumetric Flowrate	N/A	0.39	m^3/sec	5	Wet Gas				UKAS / MCERTS		
	Hydrogen Chloride $	10	**106.08**	mg/m^3	13			09:34 – 10:34	BS EN 1911	UKAS / MCERTS		
	Methanol $	2700	<1.78	mg/m^3	10			09:30 – 10:30	BS EN 13649: 2002	NU		

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Units	Uncertainty %	Reference Conditions 273 K, 101.3 kPa	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Tick if non-conforming test (see Sections 2 & 5)	Operating Status
A2 Main Building EP2	Volumetric Flowrate	N/A	0.47	m^3/sec	4	Stack Conditions	01/04/15	06:30 – 06:42	BS EN 16911-1	UKAS / MCERTS		Normal
	Volumetric Flowrate	N/A	0.45	m^3/sec	5	Wet Gas				UKAS / MCERTS		
	Hydrogen Chloride $	29	**33.40**	mg/m^3	13			06:51 – 07:51	BS EN 1911	UKAS / MCERTS		
	Methanol $	27	<1.81	mg/m^3	10			06:53 – 07:53	BS EN 13649: 2002	NU		

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Units	Uncertainty %	Reference Conditions 273 K, 101.3 kPa	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Tick if non-conforming test (see Sections 2 & 5)	Operating Status
A3 Main Building EP3	Volumetric Flowrate	N/A	0.38	m^3/sec	4	Stack Conditions	01/04/15	11:55 – 12:07	BS EN 16911-1	UKAS / MCERTS		Normal
	Volumetric Flowrate	N/A	0.36	m^3/sec	5	Wet Gas				UKAS / MCERTS		
	Oxides of Nitrogen (as NO_2)	35.7	**56.71**	mg/m^3	4			12:48 – 13:47	BS EN 14792: 2005	UKAS / MCERTS		
	Methanol $	260	10.69	mg/m^3	10			12:14 – 13:14	BS EN 13649: 2002	NU		

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Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Units	Uncertainty %	Reference Conditions 273 K, 101.3 kPa	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Tick if non-conforming test (see Sections 2 & 5)	Operating Status
A4 Resin Shed EP4	Volumetric Flowrate	N/A	0.87	m^3/sec	5	Stack Conditions	01/04/15	08:30 – 08:42	BS EN 16911-1	UKAS / MCERTS		Normal
	Volumetric Flowrate	N/A	0.80	m^3/sec	5	Wet Gas				UKAS / MCERTS		
	Hydrogen Bromide $	0.2	**57.63**	mg/m^3	13			09:04 – 10:04	US EPA Method 26	NU	✓	

The volumetric flowrate shown above is that from the initial pitot traverse. Any other flow measurements made during isokinetic sampling and/ or repeat traverses are shown later in the tables section.

Notes

Emission Limit Value	The emission limit value is that stated in the permit and will be expressed as a concentration or a mass emission.
Periodic Monitoring Result	The result given is expressed in the same terms and units as the emission limit value.
Uncertainty	The uncertainty associated with the quoted result is at the 95% confidence interval. The Uncertainty results **DO NOT** take into account the effect of the sample location limitations.
Reference Conditions	All results are expressed at 273 K and 101.3kPa. The oxygen and moisture corrections are stated.
Monitoring Method Reference	The method stated is in accordance with the Environment Agency Technical Guidance Note M2, or other method approved by the Environment Agency.
Accreditation for use of Method	**The details indicate the accreditation for the use of the complete monitoring method, e.g. MCERTs, UKAS. If use of the method is not accredited "NA" is stated.**
Operating Status	The details indicate the feedstock and the loading rate of the plant during monitoring.
$	Chemical Analysis on sample reagents was performed by an External Laboratory as detailed in Section 4
NU	UKAS Accreditation Held but UKAS Accreditation cannot be claimed for the test as sampling did not comply with the Standard Reference Method (SRM), see section 2 & 5
NA	**Method is NOT UKAS Accredited.**

1.2 Operating Information

Emission Point Reference	Process Type	Process Duration	Fuel	Feedstock	Abatement	Load	Comparison of Operator CEMS and Periodic Monitoring Results					
							Parameter	Date	Time	CEMS Results	Periodic Monitoring Results	Units
A1	Batch	Early morning	N/A	N/A	None	N/A	...	...	...	NP	...	...
A2	Continuous	N/A	N/A	N/A	None	N/A	...	...	...	NP	...	...
A3	Continuous	N/A	N/A	N/A	None	N/A	...	...	...	NP	...	...
A4	Batch	Early morning	N/A	N/A	None	N/A	...	...	...	NP	...	...

Notes:

Process Type	State whether the process is a continuous or batch process.
Process Duration	If a batch process, state the duration, frequency and details of the portion of the batch sampled. If continuous state "NA"
Fuel	If applicable, state the fuel type If not applicable state "NA"
Feedstock	State the feedstock type
Abatement	State the type and whether operational during monitoring. If not applicable state "NA"
Load	State the normal load, throughput or rating of the plant
CEMS Data	Enter this data for each CEM installed if it is has been provided by operator otherwise state “NP” (NOT PROVIDED)

2 Monitoring Deviations

The objective of the survey was to measure the concentrations of pollutants from the processes / locations as detailed in Section 1. This survey meets the requirements of the site's **PPC Permit Number: EPR/DP3832EF,** where UKAS and MCERTS accreditation has and could be claimed for the testing in the monitoring results table.

There were no modifications to the sampling procedures (TPDs) listed in Section 4.

There were no substance deviations from the original and agreed emissions monitoring schedule.

Non-conforming tests are as follows:

- The blank concentration for Hydrogen Bromide on A4 was greater than 10% of the ELV. Consequently, UKAS/MCERTS cannot be claimed and the result shall be reported as "NU".
- The analytical laboratory is not accredited for the analysis of Hydrogen Bromide. Consequently, UKAS/MCERTS cannot be claimed and the result shall be reported as "NU".
- The analytical laboratory is not accredited for the analysis of Methanol. Consequently, UKAS/MCERTS cannot be claimed and the result shall be reported as "NU".

The Uncertainty of the reported concentrations for these pollutant results DOES NOT take into account the effect of non-conformities or sample location limitations.

Homogeneity tests have not been completed for pollutants at the following locations:

- A1, A2, A3 & A4 - Such tests are not applicable to these locations as the duct area is $< 1 m^2$ and they were not requested by the client.

PART 2 – SUPPORTING INFORMATION

3 SAMPLING STAFF DETAILS

Site Sampling Team

Names of Site Team	Dates on Site	MCERTS No.	LEVEL	Technical Endorsements
Craig Lewis	31/03/2015 and 01/04/2015	MM 11 1148	2	TE1, TE2, TE3, TE4
Ian Hick		MM 12 1192	1	…

Report Reviewer

Name	MCERTS No.	LEVEL	Technical Endorsements
Craig Lewis	MM 11 1148	2	TE1, TE2, TE3, TE4

Technical Endorsement Key:-

TE1 – Isokinetic Particulates, Temperature & Velocity Profiles, Oxygen.
TE2 – Isokinetic Extractive Pollutants:- Metals, Dioxin & Furans, PAHs, PCBs, HCl, HF.
TE3 – Non-Isokinetic Extractive Pollutants:- Speciated VOCs, HF, HCl, Cyanide.
TE4 – Continuous Analysers (Combustion Gases):- TVOC, CO, NOx, SO2.

4 SAMPLING PROTOCOLS / METHODOLOGIES

Any required modifications to the Technical Procedure Documents (TPDs) specified below will be detailed in section 2 of this report.

Pressure, Temperature and Velocity

Testing was carried out using a sampling system in accordance with **BS EN ISO 16911-1 & MID** and In-house technical procedure **ECL/TPD/022.**

Temperature was recorded using a thermocouple and digital temperature reader.

Velocity and pressure were recorded using an "L" type pitot and digital manometer, data being recorded in mm H_2O.

Combustion Gases (NO_x)

Measurements of combustion gases were carried out using an MCERTS Certified **Horiba PG 250** stack gas analyser. Continuous monitoring of emissions was undertaken over each test period recording minute averaged data (one measurement every 60 seconds). The measurement techniques for each determinand are as follows:

Determinand	Technique	SRM
• NO_x	Chemiluminescence	BS EN 14792: 2005

The analyser was set up with reference to the manufacturers operator handbook and the in-house technical procedure **ECL/TPD/033c**. The analyser was calibrated on site using certified gases which are traceable to ISO 17025. (with uncertainty $<2\%$). Zero measurements were performed using Nitrogen. The analyser was calibrated directly into the sample inlet and then checked through the entire sampling system (including sampling probe, heated & unheated gas transport lines and gas drying/ conditioning system).

Data is presented graphically in the Figures Section, and the minute averaged data is given in the Tables Section.

Halogen Halides & Halogens (Hydrogen Bromide Only)

Testing was carried out isokinetically using a Universal Stack Sampling system in accordance with **US EPA Method 26** and In-house technical procedure **ECL/TPD/035**. Non-isokinetic sampling can only take place if there are no droplets present in the stack gas.

In this method the stack gases are filtered to remove particulate matter then the gases are passed through a series of impingers. The first two impingers each containing 100ml of 0.1N Sulphuric Acid (0.1N H_2SO_4) the second set of impingers each containing 100ml of 0.1N Sodium Hydroxide (0.1N NaOH) and finally through an impinger containing a measured quantity of silica gel.

The first two impingers containing the 0.1N Sulphuric Acid are analysed for concentrations of Hydrogen Bromide.

Scientific Analysis Laboratories Ltd (SAL) who is situated in Manchester carried out the analysis of the samples. **SAL is not UKAS accredited** for this analysis. In addition to the survey samples, appropriate field blanks and efficiency checks are submitted as part of the technical procedure.

Hydrogen Chloride

Testing was carried out isokinetically using a Universal Stack Sampling system in accordance with **BS EN 1911** and In-house technical procedure **ECL/TPD/036**. Non-isokinetic sampling can only take place if there are no droplets present in the stack gas.

In this method the stack gases are filtered to remove particulate matter then the gases are passed through a series of impingers. The first two or three impingers each containing 100ml of De-ionised Water and finally through an impinger containing a measured quantity of silica gel.

The impingers containing the de-ionised water are analysed for concentrations of Hydrogen Chloride by IC (Ion Chromatography).

Scientific Analysis Laboratories Ltd (SAL) who is situated in Manchester carried out the analysis of the samples. **SAL** is UKAS accredited for this analysis. In addition to the survey samples, appropriate field blanks and efficiency checks are submitted as part of the technical procedure.

Speciated VOC (Methanol Only)

Non-continuous sampling for **Speciated VOC (Methanol)** was carried out in accordance with **BS EN 13649** and In-house technical procedure **ECL/TPD/084.** In this method a metered volume of stack gas is extracted through a standard charcoal sorbent tube.

Scientific Analysis Laboratories Ltd (SAL) who is situated in Manchester carried out the analysis of the samples. **SAL is not UKAS accredited** for the analysis of Methanol. In addition to the survey samples, appropriate field blanks and efficiency checks are submitted as part of the technical procedure.

Due to restrictions set out in BS EN 13649, MCERTS/UKAS accreditation can only be claimed when the target parameters are organic compounds, the sorbent tube used is a standard charcoal tube and when laboratory analysis is UKAS accredited and carried out by GC. If other tubes are used, or if analysis is by other means than GC, then usually only UKAS accreditation can be claimed, as long as the laboratory analysis is UKAS accredited. (MCERTS accreditation may still be claimed if prior approval is given for the modifications by the Environment Agency – details will be given in section 2 of this report).

Laboratory analysis **cannot** be UKAS accredited for "Total VOC" or "TOP 10 compounds".

For the subcontract laboratory to claim UKAS accreditation for analysis, the internal recovery of a spiking compound (desorption efficiency from tube) needs to be above 80%. If it falls below 80% this will be noted on the analysis certificate.

Water Vapour

Testing was carried out using a Universal Stack Sampling system in accordance with **BS EN 14790** and In-house technical procedure **ECL/TPD/082**.

In this method the stack gases are filtered (in-stack unheated filter or out-stack heated filter) to remove particulate matter. The gases are then passed through a **heated probe** and then to a cooled moisture trapping unit. All unheated parts of the sample train (outside the sample port) which come into contact with stack gas are weighed pre and post sampling in order to determine the weight gain.

After each test, a visual inspection of the last impinger is made to confirm that at least 50% of the silica gel column has not changed colour. This indicates satisfactory collection of water vapour.

5 SAMPLE POINT DESCRIPTIONS

The homogeneity test is applicable to combustion processes. This includes but is not restricted to, those regulated under the Waste Incineration Directive (**WID**) and the Large Combustion Plant Directive (**LCPD**).

Homogeneity testing has not been completed at these locations in accordance with the mandatory requirements of the regulatory authority.

The test is not usually required for stacks with sampling plane areas of $< 1m^2$ (below 1.13m in diameter for circular ducts).

The sample locations that were monitored are detailed below:-

A1

The sampling platform does meet the requirements detailed in *Technical Guidance Note (Monitoring) M1"Sampling requirements for stack-emission monitoring" Environment Agency,* and BS EN 13284-1.

The stack diameter is 200mm and the sample platform width back from the sample port is 2m.

There is one sample port but this is adequate for a duct of this size.

These sample ports is located at a height of approximately 0.75m from the working sample platform

All sampling was carried out non-isokinetically.

A2

The sampling platform does meet the requirements detailed in *Technical Guidance Note (Monitoring) M1"Sampling requirements for stack-emission monitoring" Environment Agency,* and BS EN 13284-1.

The stack diameter is 200mm and the sample platform width back from the sample port is 2m.

There is one sample port.

These sample port is located at a height of approximately 0.75m from the working sample platform

All sampling was carried out non-isokinetically.

A3

The sampling platform does meet the requirements detailed in *Technical Guidance Note (Monitoring) M1"Sampling requirements for stack-emission monitoring" Environment Agency,* and BS EN 13284-1.

The stack diameter is 200mm and the sample platform width back from the sample port is 2m.

There is one sample port.

These sample port is located at a height of approximately 0.75m from the working sample platform

All sampling was carried out non-isokinetically.

A4

The sampling platform does meet the requirements detailed in *Technical Guidance Note (Monitoring) M1"Sampling requirements for stack-emission monitoring" Environment Agency,* and BS EN 13284-1.

The stack diameter is 350mm and the sample platform width back from the sample port is 2.5m.

There is one sample port.

These sample port is located at a height of approximately 1.2m from the working sample platform

All sampling was carried out non-isokinetically.

EQUIPMENT IDs
(Pre site checklist from SSP)

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PRE SITE EQUIPMENT CHECKLIST/ EQUIPMENT USED

(Completed before departure to site and when on site in full)

Equipment	Equip. Type	ID No:	ID No:	ID No:	ID No:	ID No:	ID No:	ID No:	ID No:
MST console/pump	E001	U011							
MST Nozzle set		…							
MST "S" Type Pitot		…							
MST Probe		141							
MST Hot Box		977							
MST Impinger Arm		657							
		980							
Barometer		629							
Site Balance		368							
Site Check weights		598							
		599							
Horiba	E002	511							
Heated Probe / Filter		806							
Chiller		970							
Sonimix / MFC		934	761						
Heated Line		1013	1014						
FID	E003								
Heated Line									
Heated Probe / Filter									
Testo	E004								
FTIR	E005								
Heated Probe / Filter									
Heated Line									
Stackmite	E006	…							
"L" Type Pitot		491							
Digital Manometer		506	421						
Stack Thermocouple		464							
Thermocouple Reader		431							
Nozzle Set		…							
Workhorse Pumps	E007	164							
Low Flow Pumps									

Quantity of Ice Required / Used for Survey	4	Bags (2kg bags)

FIGURES

Biotage GB Ltd		Installation Name	: Ystrad Mynach
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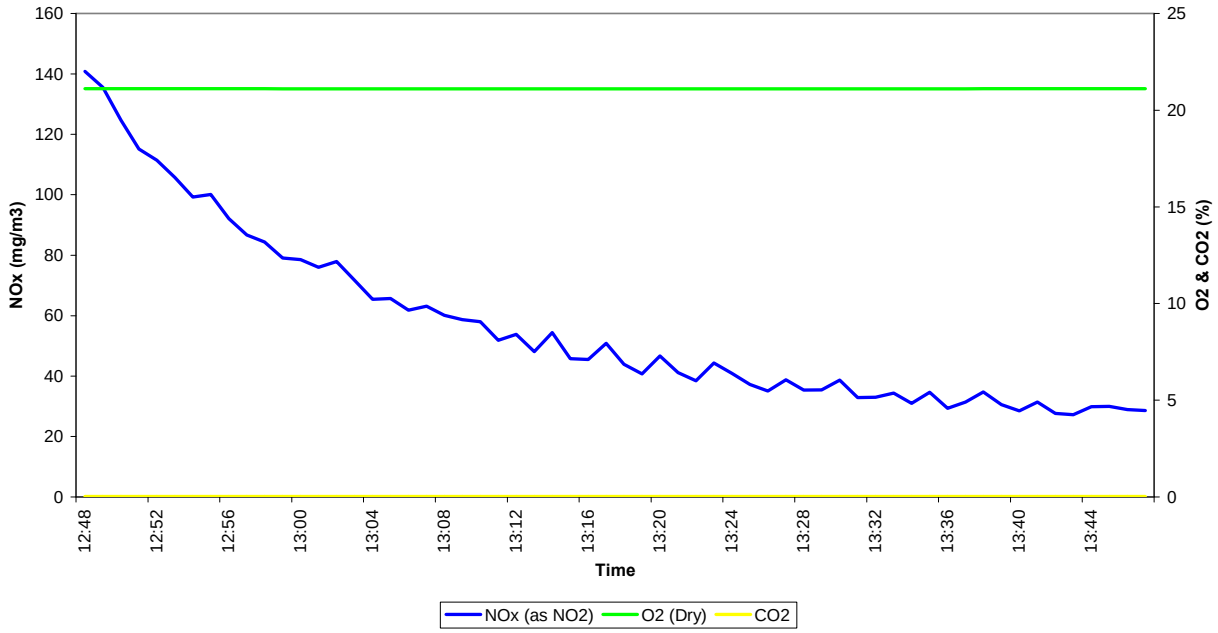
Figure 1

Data Recorded From Biotage GB Ltd, Ystrad Mynach, A3, EP3,
on 31/03/2015 Between 12:48 and 13:47
Data Presented at 273K, 101.3kPa, Wet Gas and No Correction for Oxygen



TABLES

Biotage GB Ltd
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Table 1 – HCl

Data Recorded from A1 - Main Building EP1

Emission Parameter	Units	HCl-1	Blank
Stack Diameter	metres	0.20	
Area of Sample Plane	m^2	0.031	
Moisture Content	%	1.01	
Oxygen Content	%	20.90	
Stack Temperature	^oC	13	
Gas Velocity (as Measured)	m/sec	12.53	
Gas Velocity (Reference Conditions)	m/sec*	11.75	
Volumetric Flowrate (as Measured)	m^3/sec	0.39	
Volumetric Flowrate (Reference Conditions)	m^3/sec*	0.37	
Dry Gas Molecular Weight	g/gmole	28.856	
Sample Date	...	31/03/2015	
Sample Period	...	09:34 - 10:34	
Sample Volume (reference Conditions)	m^3*	0.566	0.566
Sample Reference (ECL ID)	ECL/15/	1546/1547	1548
Mass of Hydrogen Chloride Collected	mg	60.04	0.01
Concentration of Hydrogen Chloride	mg/m^3*	**106.08**	0.02
Emission Rate of Hydrogen Chloride	g/hr	140.97	...
Expanded Uncertainty (% Relative)	%	13	...
Emission Limit Value (ELV)	mg/m^3*	10	...
Impinger Collection Efficiency	%	100	...
Blank Concentration as Percentage of ELV	%	...	<1.00%

*Reference Conditions (273K, 101.3kPa, Wet Gas)

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Table 2 – Methanol

Biotage GB LTD
Ystrad Mynach Main builiding EP1 A1

Emission Parameter	Units	Value
Stack Diameter	mm	200
Area of Sample Plane	m^2	0.031
Meter Temperature	°C	11.83
StackTemperature	°C	13.10
Sample Date	...	31.03.15
Sample Period	...	09:30 - 10:30
Sample Volume (as Measured)	m^3	0.0059
Sample Volume (reference Conditions)	m^3*	0.0056

Sample Tube Results		Speciated VOCs 1		Blank
Sample Reference ECL/15/1549	Units	Concentration*	Uncertainty	Concentration
Concentration of Methanol	mg/m^3	1.78	10.33%	1.78

*Reference Conditions: 273 K, 101.3 kPa, Wet Gas

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Table 3 – HCl

Data Recorded from A2 - Main Building EP2

Emission Parameter	Units	HCl-1	Blank
Stack Diameter	metres	0.20	
Area of Sample Plane	m^2	0.031	
Moisture Content	%	0.02	
Oxygen Content	%	20.90	
Stack Temperature	^oC	13	
Gas Velocity (as Measured)	m/sec	14.27	
Gas Velocity (Reference Conditions)	m/sec*	13.53	
Volumetric Flowrate (as Measured)	m^3/sec	0.45	
Volumetric Flowrate (Reference Conditions)	m^3/sec*	0.42	
Dry Gas Molecular Weight	g/gmole	28.856	
Sample Date	...	01/04/2015	
Sample Period	...	06:51 - 07:51	
Sample Volume (reference Conditions)	m^3*	0.577	0.577
Sample Reference (ECL ID)	ECL/15/	1553/1554	1555
Mass of Hydrogen Chloride Collected	mg	19.28	0.01
Concentration of Hydrogen Chloride	mg/m^3*	**33.40**	0.02
Emission Rate of Hydrogen Chloride	g/hr	51.10	...
Expanded Uncertainty (% Relative)	%	13	...
Emission Limit Value (ELV)	mg/m^3*	29	...
Impinger Collection Efficiency	%	100	...
Blank Concentration as Percentage of ELV	%	...	<1.00%

*Reference Conditions (273K, 101.3kPa, Wet Gas)

Table 4 – Methanol

Biotage GB LTD
Ystrad Mynach Main Building EP2 A2

Emission Parameter	Units	Value
Stack Diameter	mm	200
Area of Sample Plane	m^2	0.031
Meter Temperature	°C	6.17
StackTemperature	°C	12.55
Sample Date	...	01.04,15
Sample Period	...	06:53 - 07:53
Sample Volume (as Measured)	m^3	0.0057
Sample Volume (reference Conditions)	m^3*	0.0055

Sample Tube Results		Methanol 1		Blank
Sample Reference ECL/15/1556	Units	Concentration*	Uncertainty	Concentration
Concentration of Methanol	mg/m^3	1.81	10.33%	1.81

***Reference Conditions: 273 K, 101.3 kPa, Wet Gas**

Table 5 – Moisture

Data Recorded from A3 - Main Building EP3

Emission Parameter	Units	Moisture-1	Blank
Stack Diameter	metres	0.20	
Area of Sample Plane	m^2	0.031	
Moisture Content	%	0.03	
Oxygen Content	%	20.90	
Stack Temperature	°C	15	
Gas Velocity (as Measured)	m/sec	12.25	
Gas Velocity (Reference Conditions)	m/sec*	11.50	
Volumetric Flowrate (as Measured)	m^3/sec	0.38	
Volumetric Flowrate (Reference Conditions)	m^3/sec*	0.36	
Dry Gas Molecular Weight	g/gmole	28.856	
Sample Date	...	31/03/2015	
Sample Period	...	12:13 - 12:43	
Sample Volume (reference Conditions)	m^3*	0.447	0.447

***Reference Conditions (273K, 101.3kPa, Wet Gas)**

Table 6 – NOx

Data Recorded from A3 – Main Building EP3
Sample Period: 12:48 – 13:47 on the 1st April 2015

Volumetric Flowrate (Reference Conditions) = **0.36 m^3/sec ***

	Average	Emission Rate
	mg/m^3	Kg/hr
Oxides of Nitrogen (as NO_2) *	56.71	0.073

*** Reference Conditions (273K, 101.3 kPa & Wet Gas)**

Table 7 – Methanol

Biotage GB LTD
Ystrad Mynach Main Building EP3 A3

Emission Parameter	Units	Value
Stack Diameter	mm	200
Area of Sample Plane	m^2	0.031
Meter Temperature	°C	16.17
StackTemperature	°C	14.58
Sample Date	...	31.03.15
Sample Period	...	12:14 - 13:14
Sample Volume (as Measured)	m^3	0.0061
Sample Volume (reference Conditions)	m^3*	0.0057

Sample Tube Results		Methanol 1		Blank
Sample Reference ECL/15/1551	Units	Concentration*	Uncertainty	Concentration
Concentration of Methanol	mg/m^3	10.69	10.34%	1.75

***Reference Conditions: 273 K, 101.3 kPa, Wet Gas**

Biotage GB Ltd
Permit No : EPR/DP3832EF
Variation No : N/A
Report Ref : P2251 : R001

Installation Name : Ystrad Mynach
Visit Details : Annual Compliance Emissions
Survey Dates : 31st March – 1st April 2015
Report Issue Date : 29th April 2015

Table 8 – HBr

Data Recorded from A4 - Resin Shed

Emission Parameter	Units	Hydrogen Bromide 1	Blank
Stack Diameter	metres	0.20	
Area of Sample Plane	m^2	0.031	
Moisture Content	%	2.02	
Oxygen Content	%	20.90	
Stack Temperature	°C	23	
Gas Velocity (as Measured)	m/sec	9.04	
Gas Velocity (Reference Conditions)	m/sec*	8.30	
Volumetric Flowrate (as Measured)	m^3/sec	0.28	
Volumetric Flowrate (Reference Conditions)	m^3/sec*	0.26	
Dry Gas Molecular Weight	g/gmole	28.856	
Sample Date	...	01/04/2015	
Sample Period	...	09:04 - 10:04	
Sample Volume (reference Conditions)	m^3*	0.610	0.610
Sample Reference	ECL/15/	1558 & 1559	1562
Mass of Hydrogen Bromide Collected	mg	35.14	1.15
Concentration of Hydrogen Bromide	mg/m^3*	**57.63**	1.89
Emission Rate of Hydrogen Bromide	g/hr	54.11	...
Expanded Uncertainty (% Relative)	%	13	...
Emission Limit Value (ELV)	mg/m^3*	0.2	...
Impinger Collection Efficiency	%	97	...
Blank Concentration as Percentage of ELV	%	...	943.09

*Reference Conditions (273K, 101.3kPa, Wet Gas)

VELOCITY TRAVERSE PROFILES

Environmental Compliance Limited

Biotage GB Ltd
Permit No : EPR/DP3832EF
Variation No : N/A
Report Ref : P2251 : R001

Installation Name : Ystrad Mynach
Visit Details : Annual Compliance Emissions
Survey Dates : 31st March – 1st April 2015
Report Issue Date : 29th April 2015

Environmental Compliance Limited	Traverse Data Profoma	Date of Measurement	31/03/2015

Company	Biotage GB LTD	Stack Diameter Port A (mm)	200	Average Stack Diameter (mm)	200	Pitot tube coefficient	1.00
Site	Ystrad Mynach	Stack Diameter Port B (mm)		Port Length (mm)	0	Pitot Id	491
Location	Main Building EP1	Duct Length Port A (mm)		Average Duct Length (mm) L		Stack Thermocouple ID	464
Stack	A1	Duct Length Port B (mm)		Duct width (mm) B		Stack Temp Reader ID	431
Job No	P2251	Duct Length Port C (mm)		Barometric Pressure. (mb)	1001	Manometer ID	506
Operators	CL + IH	Duct Length Port D (mm)		Ave Static Press. (mm $H_2$0)	8.65	Barometer ID	629

Pre - Traverse Checks Carried Out	Time	Pass/ Fail
Pre - Traverse Visual Inspection	09:00:00	Pass
Pre - Traverse Pitot Leak Check	09:02:00	Pass

Smooth Walls

Static Pressure Readings (mm H_2O)			
Port A	Port B	Port C	Port D
8.65			

Port/ Point	Distance to Point (mm)	Time	Temperature Readings (°C) 1	2	3	(ΔP) Pitot Readings (mm H_2O) 1	2	3	Average Temp. (°C)	Average (ΔP) (mm H_2O)	Swirl Test ° From Reference
A1	100	09:04:00	15.0	14.8	14.9	11.2	11.0	10.9	14.9	11.0	3
Blockage Check @ A1 (L-Type Pitot Only)		09:10:00	14.9	14.9	14.8	11.1	11.2	11.1	14.9	11.0	Total
			Mean		14.9	Mean		11.1	14.9	11.0	Max
			Difference <5% from Initial ?		-0.01	Difference <5% from Initial ?		0.97	14.9	11.0	Min
									14.9	11.0	Average

Post - Traverse Checks Carried Out	Time	Pass/ Fail
Post - Traverse Visual Inspection	09:12:00	Pass

Stagnation Check (S-type Pitot Only)	Time	Reading
Static Pressure Via Positive Leg (mm H_2O)	n/a	.
Static Pressure Via Negative Leg (mm H_2O)	n/a	.
Difference (Pa) < 1 mm $H_2$0 ?		#VALUE!

Average temp (K)	287.900

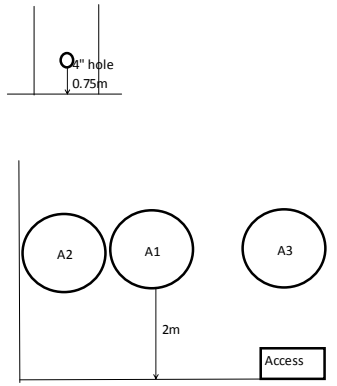
Suitability of Sampling Position	Actual Stack Conditions
Highest:lowest flow pressure ratio < 9:1?	1.01:1
Maximum deviation of flow from axis <15° ?	3
X-sectional area for stacks = πr2	0.03 m^2
X-sectional area for ducts = L x B	m^2
Suitability of Position for Sampling	Ok

Stack Moisture	1.01	%	Gas Velocity (as Measured) Adjusted for Smooth Walls	13.33820	m/sec
Measured Oxygen	20.9	%	Gas Velocity (Reference Conditions) Adjusted for Smooth Walls	12.50865	m/sec*
Measured Carbon Dioxide	0.1	%	Volumetric Flowrate (as Measured) Adjusted for Smooth Walls	0.41903	m^3/sec
Dry Gas Molecular Weight	28.85200	g/g mole	Volumetric Flowrate (Ref Cond) Adjusted for Smooth Walls	0.39297	m^3/sec*

*Reference Conditions: 273K, 101.3kPa, Wet Gas

NOTE: Velocity / volume flowrate calculations exclude contributions from the measurement point(s) where swirl > 15°

Diagram/ Description of Cross Section of Stack/Duct



Notes
Including expected or actual deviations from procedures / non-conformities

Only one port, but stack <0.357m so ok

Compliance With Positional Requirements?

Height of sample ports from Platform	0.75m
Number of sample ports	1
Width of platform (port back to handrail)	2m

Nearest downstream disturbance	Exit	3m
Nearest upstream disturbance	Bend	2.5m

Disturbances are classed as bends, fans or diameter variations

Environmental Compliance Limited

Biotage GB Ltd		**Installation Name**	**: Ystrad Mynach**
Permit No	**: EPR/DP3832EF**	**Visit Details**	**: Annual Compliance Emissions**
Variation No	**: N/A**	**Survey Dates**	**: 31st March – 1st April 2015**
Report Ref	**: P2251 : R001**	**Report Issue Date**	**: 29th April 2015**

Environmental Compliance Limited	Traverse Data Profoma	Date of Measurement	01/04/2015

Company	Biotage GB LTD	Stack Diameter Port A (mm)	200	Average Stack Diameter (mm)	200	Pitot tube coefficient	1.00
Site	Ystrad Mynach	Stack Diameter Port B (mm)		Port Length (mm)	0	Pitot Id	491
Location	Main Building EP2	Duct Length Port A (mm)		Average Duct Length (mm) L		Stack Thermocouple ID	464
Stack	A2	Duct Length Port B (mm)		Duct width (mm) B		Stack Temp Reader ID	431
Job No	P2251	Duct Length Port C (mm)		Barometric Pressure. (mb)	1005	Manometer ID	506
Operators	CL + IH	Duct Length Port D (mm)		Ave Static Press. (mm $H_2$0)	10.00	Barometer ID	629

Pre - Traverse Checks Carried Out	Time	Pass/ Fail
Pre - Traverse Visual Inspection	06:30:00	Pass
Pre - Traverse Pitot Leak Check	06:32:00	Pass

Smooth Walls

Static Pressure Readings (mm H_2O)			
Port A	Port B	Port C	Port D
10.00			

Port/ Point	Distance to Point (mm)	Time	Temperature Readings (°C)			(ΔP) Pitot Readings (mm H_2O)			Average Temp. (°C)	Average (ΔP) (mm H_2O)	Swirl Test ° From Reference
			1	2	3	1	2	3			
A2	100	06:34:00	13.4	12.9	12.8	14.3	14.0	14.2	13.0	14.2	3
Blockage Check @ A1 (L-Type Pitot Only)		06:40:00	13.1	13.0	13.1	14.2	14.0	14.2	13.0	14.2	Total
			Mean		13.1	Mean		14.1	13.0	14.2	Max
			Difference <5% from Initial ?		0.01	Difference <5% from Initial ?		-0.26	13.0	14.2	Min
									13.0	14.2	Average

Post - Traverse Checks Carried Out	Time	Pass/ Fail
Post - Traverse Visual Inspection	06:42:00	Pass

Stagnation Check (S-type Pitot Only)	Time	Reading
Static Pressure Via Positive Leg (mm H_2O)	n/a	.
Static Pressure Via Negative Leg (mm H_2O)	n/a	.
Difference (Pa) < 1 mm H_2O ?		#VALUE!

Average temp (K)	286.033

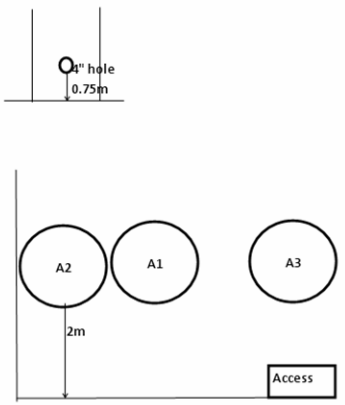
Suitability of Sampling Position	Actual Stack Conditions
Highest:lowest flow pressure ratio < 9:1?	1.01:1
Maximum deviation of flow from axis <15° ?	3
X-sectional area for stacks= πr2	0.03 m^2
X-sectional area for ducts = L x B	m^2
Suitability of Position for Sampling	Ok

Stack Moisture	0.02	%	Gas Velocity (as Measured) Adjusted for Smooth Walls	15.00511	m/sec
Measured Oxygen	20.9	%	Gas Velocity (Reference Conditions) Adjusted for Smooth Walls	14.22214	m/sec*
Measured Carbon Dioxide	0.1	%	Volumetric Flowrate (as Measured) Adjusted for Smooth Walls	0.47140	m^3/sec
Dry Gas Molecular Weight	28.85200	g/g mole	Volumetric Flowrate (Ref Cond) Adjusted for Smooth Walls	0.44680	m^3/sec*

*Reference Conditions: 273K, 101.3kPa, Wet Gas

NOTE: Velocity / volume flowrate calculations exclude contributions from the measurement point(s) where swirl >15°

Diagram/ Description of Cross Section of Stack/Duct



Notes
Including expected or actual deviations from procedures / non-conformities

Only one port but stack < 0.357m, ok

Compliance With Positional Requirements?

Height of sample ports from Platform	0.75m
Number of sample ports	1
Width of platform (port back to handrail)	2m

Nearest downstream disturbance	Exit	3m
Nearest upstream disturbance	Bend	2.5m

Disturbances are classed as bends, fans or diameter variations

Environmental Compliance Limited

Biotage GB Ltd
Permit No : EPR/DP3832EF
Variation No : N/A
Report Ref : P2251 : R001

Installation Name : Ystrad Mynach
Visit Details : Annual Compliance Emissions
Survey Dates : 31st March – 1st April 2015
Report Issue Date : 29th April 2015

Environmental Compliance Limited	Traverse Data Profoma	Date of Measurement	01/04/2015

Company	Biotage GB LTD	Stack Diameter Port A (mm)	200	Average Stack Diameter (mm)	200	Pitot tube coefficient	1.00
Site	Ystrad Mynach	Stack Diameter Port B (mm)		Port Length (mm)	0	Pitot Id	491
Location	Main Building EP3	Duct Length Port A (mm)		Average Duct Length (mm) L		Stack Thermocouple ID	464
Stack	A3	Duct Length Port B (mm)		Duct width (mm) B		Stack Temp Reader ID	431
Job No	P2251	Duct Length Port C (mm)		Barometric Pressure. (mb)	1001	Manometer ID	506
Operators	CL + IH	Duct Length Port D (mm)		Ave Static Press. (mm H_2O)	7.48	Barometer ID	629

Pre - Traverse Checks Carried Out	Time	Pass/ Fail
Pre - Traverse Visual Inspection	11:55:00	Pass
Pre - Traverse Pitot Leak Check	11:57:00	Pass

Smooth Walls

Static Pressure Readings (mm H_2O)			
Port A	Port B	Port C	Port D
7.48			

Port/ Point	Distance to Point (mm)	Time	Temperature Readings (°C)			(ΔP) Pitot Readings (mm H_2O)			Average Temp. (°C)	Average (ΔP) (mm H_2O)	Swirl Test ° From Reference
			1	2	3	1	2	3			
A2	100	11:59:00	14.6	14.4	14.6	9.3	9.5	9.3	14.5	9.4	4
Blockage Check @ A1 (L-Type Pitot Only)		12:05:00	14.5	14.5	14.5	9.5	9.8	9.5	14.5	9.4	Total
			Mean		14.5	Mean		9.6	14.5	9.4	Max
			Difference <5% from Initial ?		-0.01	Difference <5% from Initial ?		2.67	14.5	9.4	Min
									14.5	9.4	Average

Post - Traverse Checks Carried Out	Time	Pass/ Fail
Post - Traverse Visual Inspection	12:07:00	Pass

Stagnation Check (S-type Pitot Only)	Time	Reading
Static Pressure Via Positive Leg (mm H_2O)	n/a	.
Static Pressure Via Negative Leg (mm H_2O)	n/a	.
Difference (Pa) < 1 mm H_2O ?		#VALUE!

Average temp (K)	287.533

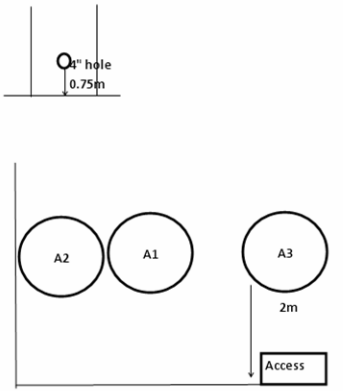
Suitability of Sampling Position	Actual Stack Conditions
Highest:lowest flow pressure ratio < 9:1?	1:1
Maximum deviation of flow from axis <15° ?	4
X-sectional area for stacks= πr2	0.03 m^2
X-sectional area for ducts = L x B	m^2
Suitability of Position for Sampling	Ok

Stack Moisture	0.03	%	Gas Velocity (as Measured) Adjusted for Smooth Walls	12.25257	m/sec
Measured Oxygen	20.9	%	Gas Velocity (Reference Conditions) Adjusted for Smooth Walls	11.50387	m/sec*
Measured Carbon Dioxide	0.1	%	Volumetric Flowrate (as Measured) Adjusted for Smooth Walls	0.38493	m^3/sec
Dry Gas Molecular Weight	28.85200	g/g mole	Volumetric Flowrate (Ref Cond) Adjusted for Smooth Walls	0.36140	m^3/sec*

*Reference Conditions: 273K, 101.3kPa, Wet Gas

NOTE: Velocity / volume flowrate calculations exclude contributions from the measurement point(s) where swirl >15°

Diagram/ Description of Cross Section of Stack/Duct



Notes
Including expected or actual deviations from procedures / non-conformities

Compliance With Positional Requirements?

Height of sample ports from Platform	0.75
Number of sample ports	1
Width of platform (port back to handrail)	2

Nearest downstream disturbance	Exit	3m
Nearest upstream disturbance	Bend	2.5m
Disturbances are classed as bends, fans or diameter variations		

Environmental Compliance Limited

Biotage GB Ltd
Permit No : EPR/DP3832EF
Variation No : N/A
Report Ref : P2251 : R001

Installation Name : Ystrad Mynach
Visit Details : Annual Compliance Emissions
Survey Dates : 31st March – 1st April 2015
Report Issue Date : 29th April 2015

Environmental Compliance Limited	Traverse Data Profoma	Date of Measurement	01/04/2015

Company	Biotage GB LTD	Stack Diameter Port A (mm)	350	Average Stack Diameter (mm)	350	Pitot tube coefficient	1.00
Site	Ystrad Mynach	Stack Diameter Port B (mm)		Port Length (mm)	0	Pitot Id	491
Location	Resin Shed	Duct Length Port A (mm)		Average Duct Length (mm) L		Stack Thermocouple ID	464
Stack	A4	Duct Length Port B (mm)		Duct width (mm) B		Stack Temp Reader ID	431
Job No	P2251	Duct Length Port C (mm)		Barometric Pressure. (mb)	1005	Manometer ID	506
Operators	CL + IH	Duct Length Port D (mm)		Ave Static Press. (mm $H_2$0)	3.64	Barometer ID	629

Pre - Traverse Checks Carried Out	Time	Pass/ Fail
Pre - Traverse Visual Inspection	08:30:00	Pass
Pre - Traverse Pitot Leak Check	08:32:00	Pass

Smooth Walls

Static Pressure Readings (mm H_2O)			
Port A	Port B	Port C	Port D
3.64			

Port/ Point	Distance to Point (mm)	Time	Temperature Readings (^oC)			(ΔP) Pitot Readings (mm H_2O)			Average Temp. (^oC)	Average (ΔP) (mm H_2O)	Swirl Test ^{o} From Reference
			1	2	3	1	2	3			
A1	175	08:36:00	22.1	22.3	22.2	4.9	4.9	5.0	22.2	4.9	3
Blockage Check @ A1 (L-Type Pitot Only)		08:40:00	22.1	22.2	22.1	5.0	5.0	5.0	22.2	4.9	Total
			Mean		22.1	Mean		5.0	22.2	4.9	Max
			Difference <5% from Initial ?		-0.02	Difference <5% from Initial ?		1.35	22.2	4.9	Min
									22.2	4.9	Average

Post - Traverse Checks Carried Out	Time	Pass/ Fail
Post - Traverse Visual Inspection	08:42:00	Pass

Stagnation Check (S-type Pitot Only)	Time	Reading
Static Pressure Via Positive Leg (mm H_2O)	n/a	.
Static Pressure Via Negative Leg (mm H_2O)	n/a	.
Difference (Pa) < 1 mm $H_2$0 ?		#VALUE!

Average temp (K)	295.200

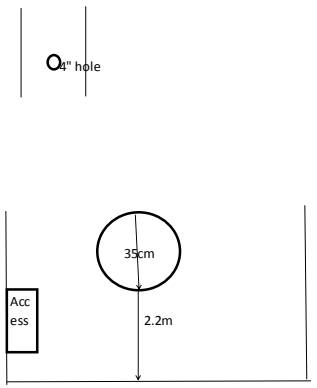
Suitability of Sampling Position	Actual Stack Conditions
Highest:lowest flow pressure ratio < 9:1?	1:1
Maximum deviation of flow from axis < 15^o ?	3
X-sectional area for stacks = πr2	0.10 m^2
X-sectional area for ducts = L x B	m^2
Suitability of Position for Sampling	Ok

Stack Moisture	2.02	%	Gas Velocity (as Measured) Adjusted for Smooth Walls	9.03931	m/sec
Measured Oxygen	21.1	%	Gas Velocity (Reference Conditions) Adjusted for Smooth Walls	8.29645	m/sec*
Measured Carbon Dioxide	0.02	%	Volumetric Flowrate (as Measured) Adjusted for Smooth Walls	0.86968	m^3/sec
Dry Gas Molecular Weight	28.84720	g/g mole	Volumetric Flowrate (Ref Cond) Adjusted for Smooth Walls	0.79821	m^3/sec*

*Reference Conditions: 273K, 101.3kPa, Wet Gas

NOTE: Velocity / volume flowrate calculations exclude contributions from the measurement point(s) where swirl > 15°

Diagram/ Description of Cross Section of Stack/Duct



Notes
Including expected or actual deviations from procedures / non-conformities

Only one port but stack <0.357m, ok

Compliance With Positional Requirements?

Height of sample ports from Platform	1.2M
Number of sample ports	1
Width of platform (port back to handrail)	2.5M

Nearest downstream disturbance	Exit	2m
Nearest upstream disturbance	Fan	2m
Disturbances are classed as bends, fans or diameter variations		

FIELD CALIBRATION AND SAMPLING DATA

A1 HCl Sampling Data

Environmental Compliance Limited	NON ISOKINETIC SAMPLING PROFORMA	Date of Measurement	31/03/2015	

If moisture was not measured see detailed notes below.

ECL/TPD/	36 B	Time taken to change Ports?	0
Start Time	09:34	End Time	10:34
Test Duration	60 mins		

Client	Biotage GB LTD	Stack Profile	Circular	Console id	u011	Barometer id	629
Site	Ystrad Mynach	Stack Area (m^2)	0.03	Pump id	u011	Nozzle Id	n/a
Location	Main Building EP1	Barometric Pressure (mb)	1001	Probe id	141	Nozzle size	n/a
Stack ID	A1	Static Pres. (mm $H_2$0)	8.65	DGM Yd	1.0321	Filter Id	n/a
Test No.	HCl-1	Pitot coefficient	n/a	ΔH@	42.88	Pitot ID	n/a
Job No	P2251	Probe Heater Setting (^{O}C)	160	Impinger Id	980	Hot Box ID	977
ECL Site Staff	CL & IH	Hot Box Setting (^{O}C)	160	Balance Id	368		

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	315230.5						
Final Volume	315806.7						
Total Volume	576.2	0.0	0.0	0.0	0.0	0.0	576.2

Required Sample Flowrate l/min	Suggested ΔH Entered Below
3	1
6	3
10	10
15	25
25	50
Initial ΔH	10
Reference Oxygen Percentage	20.9

Leak Check	First	Second	Third	Fourth	Fifth
Leak rate l/min	0				0
Vaccum "Hg	10				10
Time of Check	09:28				10:36
Set Rate l/min	10				10.0
Leak < 2%?	YES				YES

Dry O_2 Atmospheric)	21.00
Dry Carbon Dioxide %	0.10
Dry Carbon Monoxide ppm	

Traverse Point	A1	A1	A1	A1	A1	A1			Total
Time/Point (mins)	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60			
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)	10.00	10.00	10.00	10.00	10.00	10.00			10.00
Meter (Tm in)	9.50	12.40	13.90	14.60	15.30	15.60			13.55
Meter (Tm out)	9.50	12.40	13.90	14.60	15.30	15.60			13.55
Stack Temp (Ts)	12.90	11.80	12.10	12.40	13.10	12.90			12.53
Impinger T Outlet	10.00	9.00	9.00	8.00	8.00	9.00			8.83
Vaccum (" Hg)	2.00	2.00	2.00	2.00	2.00	2.00			2.00

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

Impinger 1	Di H20
SOL/	2714
Start Weight (g)	715.6
End Weight (g)	712.6
Total weight (g)	-3
Impinger 2	DI H20
SOL/	2714
Start Weight (g)	717
End Weight (g)	720.7
Total weight (g)	3.7
Impinger3	DI H20
SOL/	2714
Start Weight (g)	717.5
End Weight (g)	717.4
Total weight (g)	-0.1
Impinger 4	Empty
SOL/	...
Start Weight (g)	598.7
End Weight (g)	599.6
Total weight (g)	0.9
Impinger 5	Silica
SOL/	...
Start Weight (g)	765.8
End Weight (g)	768.9
Total weight (g)	3.1
Impinger 6	
SOL/	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Impinger 7	
SOL/	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Impinger 8	
SOL/	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Total (g)	4.60
Silica < 50% used at End of Test? Y/N	YES

Rinse Solutions used	
Solution	SOL NO
DI Water	2714
Acetone	...

Additional Moisture Weighings	
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0
Item Name	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

If moisture was not measured and gas was dried before entering the gas meter, impinger weights must be included to produce the moisture concentration used in the isokinetic calculations. If the gas was not dried before it entered the gas meter then impinger weights may be included to produce a nominal 0.1% moisture value.

Biotage GB Ltd		**Installation Name**	**: Ystrad Mynach**
Permit No	**: EPR/DP3832EF**	**Visit Details**	**: Annual Compliance Emissions**
Variation No	**: N/A**	**Survey Dates**	**: 31st March – 1st April 2015**
Report Ref	**: P2251 : R001**	**Report Issue Date**	**: 29th April 2015**

A1 Methanol Sampling Data

Environmental Compliance Limited				SAMPLE TUBE DATA SAMPLING PROFORMA	
Client	Biotage GB LTD	Circular / Rectangular / Loose		Barometer ID	629
Site	Ystrad Mynach	Stack Diameter (mm)	200	Balance ID	N/a
Location	Main builiding EP1			Pump ID	164
Stack ID	A1	Stack Area (m^2)	0.031	Meter ID	164
Test No.	Methanol 1	Barometric Pressure (mb)	1001	DGM Yd or ml/count	0.41
Job No	P2251	Heated Line ID	N/A	Was sample train upstream of sorbent tube condensation free for entire sample (y/n)	Y
ECL Site Staff	CL + IH	Impinger ID	N/A		

Date of Test	31.03.15
Sample Start Time	09:30
Sample End Time	10:30
Duration	60
Measured O2	
O2 Uncertainty %Vol	

Meter Units: ml / Litres

	Sample	Leak 1	Time (start/ end) (minimum 1 minute)	Leak 2	Time (start/ end) (minimum 1 minute)	Total
Start Volume	830249.0	830236.0	09:20:00	844794.0	10:33:00	
Final Volume	844755.0	830236.0	09:21:00	844794.0	10:34:00	
Total Volume	14506.0	0.0		0.0		14506.0

Impinger 1	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

Time Point	0-10	10-20 mins	20-30	30-40
Heated Line Temp ^{O}C	N/A	N/A	N/A	N/A
Tube Temp ^{O}C	17.2	18.5	19.7	20.2
Stack Temp ^{O}C	14.8	12.9	13	12.6
Meter Temp In ^{O}C	8	9	13	13
Meter Temp Out ^{O}C	8	9	13	13

Impinger 2	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

Time Point	40-50	50-60		
Heated Line Temp ^{O}C	N/A	N/A		
Tube Temp ^{O}C	20.6	21		
Stack Temp ^{O}C	13	12.3		
Meter Temp In ^{O}C	14	14		
Meter Temp Out ^{O}C	14	14		

Impinger3	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

Time Point				
Heated Line Temp ^{O}C				
Tube Temp ^{O}C				
Stack Temp ^{O}C				
Meter Temp In ^{O}C				
Meter Temp Out ^{O}C				

Silica	(IF USED)
< 50% Spent at end?	YES
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

Total	0

A2 HCl Sampling Data

Environmental Compliance Limited	NON ISOKINETIC SAMPLING PROFORMA	Date of Measurement	01/04/2015

If moisture was not measured see detailed notes below.

ECL/TPD/	36 B	Time taken to change Ports?	0	Start Time	06:51
End Time	07:51	Test Duration	60 mins		

Client	Biotage GB LTD	Stack Profile	Circular	Console id	u011	Barometer id	629
Site	Ystrad Mynach	Stack Area (m^2)	0.03	Pump id	u011	Nozzle Id	n/a
Location	Main Building EP2	Barometric Pressure (mb)	1006	Probe id	141	Nozzle size	n/a
Stack ID	A2	Static Pres. (mm H_20)	10	DGM Yd	1.0321	Filter Id	n/a
Test No.	HCl-1	Pitot coefficient	n/a	ΔH@	42.88	Pitot ID	n/a
Job No	P2251	Probe Heater Setting (^OC)	160	Impinger Id	657	Hot Box ID	977
ECL Site Staff	CL + IH	Hot Box Setting (^OC)	160	Balance Id	368		

Required Sample Flowrate l/min	Suggested ΔH Entered Below
3	1
6	3
10	10
15	25
25	50
Initial ΔH	10
Reference Oxygen Percentage	20.9

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	315230.5						
Final Volume	315806.7						
Total Volume	576.2	0.0	0.0	0.0	0.0	0.0	576.2

Leak Check	First	Second	Third	Fourth	Fifth
Leak rate l/min	0				0
Vaccum "Hg	10				10
Time of Check	06:35				07:54
Set Rate l/min	10				10.0
Leak < 2%?	YES				YES

Dry O_2 Atmospheric)	21.00
Dry Carbon Dioxide %	0.10
Dry Carbon Monoxide ppm	

Traverse Point	A1	A1	A1	A1	A1	A1			Total
Time/Point (mins)	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60			
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)	10.00	10.00	10.00	10.00	10.00	10.00			10.00
Meter (Tm in)	3.60	4.80	5.80	7.50	8.30	9.70			6.62
Meter (Tm out)	3.60	4.80	5.80	7.50	8.30	9.70			6.62
Stack Temp (Ts)	12.70	12.50	12.20	12.80	12.50	12.60			12.55
Impinger T Outlet	2.00	2.00	3.00	3.00	3.00	4.00			2.83
Vaccum (" Hg)	2.00	2.00	2.00	2.00	2.00	2.00			2.00

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

	Impinger 1	Impinger 2	Impinger3	Impinger 4	Impinger 5	Impinger 6	Impinger 7	Impinger 8
(Name)	Di H20	DI H20	DI H20	Empty	Silica			
SOL/	2714	2714	2714	...	...			
Start Weight (g)	710	697.2	711.4	599.6	768.8			
End Weight (g)	607.6	696.6	710.5	560	770.2			
Total weight (g)	-102.4	-0.6	-0.9	-39.6	1.4	0	0	0

Total (g)	0.10
Silica < 50% used at End of Test? Y/N	YES

Rinse Solutions used	
Solution	SOL NO
DI Water	2714
Acetone	...

Additional Moisture Weighings

	1	2	3	4	5	6	7	8	9	10
Item Name										
Start Weight (g)										
End Weight (g)										
Total weight (g)	0	0	0	0	0	0	0	0	0	0

If moisture was not measured and gas was dried before entering the gas meter, impinger weights must be included to produce the moisture concentration used in the isokinetic calculations. If the gas was not dried before it entered the gas meter then impinger weights may be included to produce a nominal 0.1% moisture value.

Biotage GB Ltd
Permit No : EPR/DP3832EF
Variation No : N/A
Report Ref : P2251 : R001

Installation Name : Ystrad Mynach
Visit Details : Annual Compliance Emissions
Survey Dates : 31st March – 1st April 2015
Report Issue Date : 29th April 2015

A2 Methanol Sampling Data

Environmental Compliance Limited	SAMPLE TUBE DATA SAMPLING PROFORMA

Client	Biotage GB LTD	Circular / Rectangular / Loose		Barometer ID	629
Site	Ystrad Mynach	Stack Diameter (mm)	200	Balance ID	N/a
Location	Main Building EP2			Pump ID	164
Stack ID	A2	Stack Area (m^2)	0.031	Meter ID	164
Test No.	Methanol 1	Barometric Pressure (mb)	1005	DGM Yd or ml/count	0.41
Job No	P2251	Heated Line ID	N/A	Was sample train upheated or sorbent tube condensation free for entire sample (y/n)	Y
ECL Site Staff	CL + IH	Impinger ID	N/A		

Date of Test	01.04.15
Sample Start Time	06:53
Sample End Time	07:53
Duration	60
Measured O2	
O2 Uncertainty %Vol	

Meter Units: ml / litres

	Sample	Leak 1	Time (start/ end) (minimum 1 minute)	Leak 2	Time (start/ end) (minimum 1 minute)	Total
Start Volume	861179.0	861168.0	06:28:00	875084.0	07:55:00	
Final Volume	875074.0	861168.0	06:29:00	875084.0	07:56:00	
Total Volume	13895.0	0.0		0.0		13895.0

Impinger 1	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

Time Point	0-10	10-20 mins	20-30	30-40
Heated Line Temp ^{O}C	N/A	N/A	N/A	N/A
Tube Temp ^{O}C	12.4	13.2	13.7	14.1
Stack Temp ^{O}C	12.7	12.4	12.6	12.2
Meter Temp In ^{O}C	3	3	5	7
Meter Temp Out ^{O}C	3	3	5	7

Impinger 2	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

Time Point	40-50	50-60		
Heated Line Temp ^{O}C	N/A	N/A		
Tube Temp ^{O}C	14.9	15.3		
Stack Temp ^{O}C	12.5	12.9		
Meter Temp In ^{O}C	9	10		
Meter Temp Out ^{O}C	9	10		

Impinger3	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

Time Point				
Heated Line Temp ^{O}C				
Tube Temp ^{O}C				
Stack Temp ^{O}C				
Meter Temp In ^{O}C				
Meter Temp Out ^{O}C				

Silica	(IF USED)
< 50% Spent at end?	YES
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

Total	0

Biotage GB Ltd		Installation Name	: Ystrad Mynach
Permit No	: EPR/DP3832EF	Visit Details	: Annual Compliance Emissions
Variation No	: N/A	Survey Dates	: 31st March – 1st April 2015
Report Ref	: P2251 : R001	Report Issue Date	: 29th April 2015

A3 NOx Field Calibration

	Horiba PG 250 Measurement Ranges:		
	NO as NO_2	O_2	CO_2
Units	205 mg/m^3	25 %Vol	20 %Vol
	Zero Values (Direct)		
Mean Initial Direct Zero	-0.03	-0.01	0.00
Mean Confirmation Direct Zero	0.96	-0.04	0.00
Difference in Direct Zero	0.99	0.03	0.00
Repeatability at Zero	2.05	0.20	0.20
<2 x Repeatability at Zero?	YES	YES	YES
	Pre Zero Values (System)		
Mean Pre Test Zero	0.04	0.19	0.00
% of Measurement Range?	0.02%	0.77%	0.00%
Detection Limit (LOD)	0.08	0.20	0.00

	Applied Span:		
	NO	O_2	CO_2
Actual Applied Span Concentration	102.40	15.03	5.06
	Pre Test System Zero Values		
Mean Pre Test System Zero	0.04	0.19	0.00
Difference ≤ ± 2% of Span Value (5% for SO_2)?	0.04%	1.28%	0.00%
	Post Zero Values (System)		
Mean Post Test Zero	0.21	0.06	0.00
% of Certified Range?	0.10%	0.23%	0.00%
	Pre Test System Span Values		
Mean Pre Test System Span	100.43	15.25	4.97
Difference ≤ ± 2% of Span Value (5% for SO_2)?	1.92%	1.47%	1.73%
	Post Test System Span Values		
Mean Post Test System Span	99.87	15.14	5.05
Span Drift ≤ ± 5% Span Value?	0.56%	0.72%	1.64%
	0.56%	0.89%	1.64%
	See Note 3	See Note 3	See Note 3

NOTE 1: Data Invalid! Contact Quality Manager!
NOTE 2: Correct test data for drift!
NOTE 3: No drift correction required.

A3 Moisture

Environmental Compliance Limited	NON ISOKINETIC SAMPLING PROFORMA	Date of Measurement	31/03/2015
ECL/TPD/ 82	Time taken to change Ports? 0	Start Time 12:13	End Time 12:43
		Test Duration	30 mins

Client	Biotage GB LTD	Stack Profile	Circular	Console id	u011	Barometer id	629
Site	Ystrad Mynach	Stack Area (m^2)	0.03	Pump id	u011	Nozzle Id	n/a
Location	Main Building EP3	Barometric Pressure (mb)	1001	Probe id	141	Nozzle size	n/a
Stack ID	A3	Static Pres. (mm H_20)	7.48	DGM Yd	1.0321	Filter Id	n/a
Test No.	Moisture-1	Pitot coefficient	n/a	ΔH@	42.88	Pitot ID	n/a
Job No	P2251	Probe Heater Setting (^OC)	120	Impinger Id	980	Hot Box ID	977
ECL Site Staff	CL + IH	Hot Box Setting (^OC)	120	Balance Id	368		

Required Sample Flowrate l/min	Suggested ΔH Entered Below
3	1
6	3
10	10
15	25
25	50
Initial ΔH	10
Reference Oxygen Percentage	20.9

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	315913.7						
Final Volume	316381.4						
Total Volume	467.7	0.0	0.0	0.0	0.0	0.0	467.7

Leak Check	First	Second	Third	Fourth	Fifth
Leak rate l/min	0				0
Vaccum "Hg	10				10
Time of Check	12:00				12:47
Set Rate l/min	10				10.0
Leak < 2%?	YES				YES

Dry O_2 (Atmospheric)	21.00
Dry Carbon Dioxide %	0.10
Dry Carbon Monoxide ppm	

Traverse Point	A3	A3	A3						Total
Time/Point (mins)	0 - 10	10 - 20	20 - 30						
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)	10.00	10.00	10.00						10.00
Meter (Tm in)	16.20	18.90	20.10						18.40
Meter (Tm out)	16.20	18.90	20.10						18.40
Stack Temp (Ts)	15.80	14.40	14.60						14.93
Impinger T Outlet	14.00	13.00	12.00						13.00
Vaccum (" Hg)	2.00	2.00	2.00						2.00

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

	Impinger 1	Impinger 2	Impinger3	Impinger 4	Impinger 5	Impinger 6	Impinger 7	Impinger 8
Contents	H20	H20	Empty	Silica				
SOL/								
Start Weight (g)	719.6	729.6	597.1	798.7				
End Weight (g)	717.4	728.7	597.4	801.4				
Total weight (g)	-2.2	-0.9	0.3	2.7	0	0	0	0

Total (g)	0.10
Silica < 50% used at End of Test? Y/N	YES

Rinse Solutions used	
Solution	SOL NO
DI Water	
Acetone	

If moisture was not measured see detailed notes below.

Additional Moisture Weighings										
Item Name										
Start Weight (g)										
End Weight (g)										
Total weight (g)	0	0	0	0	0	0	0	0	0	0

If moisture was not measured and gas was dried before entering the gas meter, impinger weights must be included to produce the moisture concentration used in the isokinetic calculations. If the gas was not dried before it entered the gas meter then impinger weights may be included to produce a nominal 0.1% moisture value.

A3 Methanol Sampling Data

Environmental Compliance Limited	SAMPLE TUBE DATA SAMPLING PROFORMA

Client	Biotage GB LTD	Circular / Rectangular / Ellipse		Barometer ID	629
Site	Ystrad Mynach	Stack Diameter (mm)	200	Balance ID	N/a
Location	Main Building EP3			Pump ID	164
Stack ID	A3	Stack Area (m^2)	0.031	Meter ID	164
Test No.	Methanol 1	Barometric Pressure (mb)	1001	DGM Yd or ml/count	0.41
Job No	P2251	Heated Line ID	N/A	Was sample train upstream of sorbent tube condensation free for entire sample (y/n)	Y
ECL Site Staff	CL + IH	Impinger ID	N/A		

Date of Test	31.03.15
Sample Start Time	12:14
Sample End Time	13:14
Duration	60
Measured O2	
O2 Uncertainty %Vol	

Meter Units: ml / litres

	Sample	Leak 1	Time (start/ end) (minimum 1 minute)	Leak 2	Time (start/ end) (minimum 1 minute)	Total
Start Volume	844850.0	844842.0	12:05:00	860808.0	13:16:00	
Final Volume	859762.0	844842.0	12:06:00	860808.0	13:17:00	
Total Volume	14912.0	0.0		0.0		14912.0

Time Point	0-10	10-20 mins	20-30	30-40
Heated Line Temp ^OC	N/A	N/A	N/A	N/A
Tube Temp ^OC	15.2	17.4	18	18.4
Stack Temp ^OC	15.6	14.8	14.4	14.2
Meter Temp In ^OC	13	14	16	16
Meter Temp Out ^OC	13	14	16	16

Time Point	40-50	50-60		
Heated Line Temp ^OC	N/A	N/A		
Tube Temp ^OC	19.6	20.4		
Stack Temp ^OC	14.6	13.9		
Meter Temp In ^OC	18	20		
Meter Temp Out ^OC	18	20		

Time Point				
Heated Line Temp ^OC				
Tube Temp ^OC				
Stack Temp ^OC				
Meter Temp In ^OC				
Meter Temp Out ^OC				

	Impinger 1	Impinger 2	Impinger3	Silica (IF USED)
< 50% Spent at end?				YES
Start Weight (g)				
End Weight (g)				
Total weight (g)	0	0	0	0

Total	0

A4 HBr Sampling Data

Environmental Compliance Limited	NON ISOKINETIC SAMPLING PROFORMA	Date of Measurement	01/04/2015

If moisture was not measured see detailed notes below.

ECL/TPD/	35 B	Time taken to change Ports?	0	Start Time	09:04	End Time	10:04
				Test Duration	60 mins		

Client	Biotage GB LTD	Stack Profile	Circular	Console id	u011	Barometer id	629
Site	Ystrad Mynach	Stack Area (m^2)	0.03	Pump id	u011	Nozzle Id	n/a
Location	Resin Shed	Barometric Pressure (mb)	1006	Probe id	141	Nozzle size	n/a
Stack ID	A4	Static Pres. (mm H_20)	10	DGM Yd	1.0321	Filter Id	n/a
Test No.	Hydrogen Bromide 1	Pitot coefficient	n/a	ΔH@	42.88	Pitot ID	n/a
Job No	P2251	Probe Heater Setting (^OC)	160	Impinger Id	657	Hot Box ID	977
ECL Site Staff	CL + IH	Hot Box Setting (^OC)	160	Balance Id	368		

Required Sample Flowrate l/min	Suggested ΔH Entered Below
3	1
6	3
10	10
15	25
25	50
Initial ΔH	10
Reference Oxygen Percentage	20.9

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	317925.7						
Final Volume	318532.6						
Total Volume	606.9	0.0	0.0	0.0	0.0	0.0	606.9

Leak Check	First	Second	Third	Fourth	Fifth
Leak rate l/min	0				0
Vaccum "Hg	10				8
Time of Check	08:45				10:06
Set Rate l/min	10				10.0
Leak < 2%?	YES				YES

Dry O_2 Atmospheric)	21.00
Dry Carbon Dioxide %	0.10
Dry Carbon Monoxide ppm	

Traverse Point	A1	A1	A1	A1	A1	A1			Total
Time/Point (mins)	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60			
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)	10.00	10.00	10.00	10.00	10.00	10.00			10.00
Meter (Tm in)	9.70	10.90	11.40	11.80	12.40	12.70			11.48
Meter (Tm out)	9.70	10.90	11.40	11.80	12.40	12.70			11.48
Stack Temp (Ts)	22.80	22.50	22.40	22.60	22.90	23.10			22.72
Impinger T Outlet	8.00	9.00	9.00	10.00	9.00	9.00			9.00
Vaccum (" Hg)	2.00	2.00	2.00	2.00	2.00	2.00			2.00

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
K factor	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ΔH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									

	Impinger 1	Impinger 2	Impinger3	Impinger 4	Impinger 5	Impinger 6	Impinger 7	Impinger 8
Reagent	H2SO4	H2SO4	NaOH	NaOH	Silica			
SOL/	2713	2713	2719	2719	...			
Start Weight (g)	727.1	716.9	709.4	770.1	770.1			
End Weight (g)	726.7	718.4	710.6	773.9	773.9			
Total weight (g)	-0.4	1.5	1.2	3.8	3.8	0	0	0

Total (g)	9.90
Silica < 50% used at End of Test? Y/N	YES

Rinse Solutions used	
Solution	SOL NO
DI Water	2714
Acetone	...

Additional Moisture Weighings

Item Name								
Start Weight (g)								
End Weight (g)								
Total weight (g)	0	0	0	0	0	0	0	0

If moisture was not measured and gas was dried before entering the gas meter, impinger weights must be included to produce the moisture concentration used in the isokinetic calculations. If the gas was not dried before it entered the gas meter then impinger weights may be included to produce a nominal 0.1% moisture value.

LABORATORY ANALYSIS RESULTS

Scientific Analysis Laboratories is a limited company registered in England and Wales (No 2514788) whose address is at Hadfield House, Hadfield Street, Manchester M16 9FE

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Fax : 0161 874 2404

Scientific Analysis Laboratories Ltd

Certificate of Analysis

Report Number: 468613-1

Date of Report: 20-Apr-2015

Customer: Environmental Compliance Ltd
Unit G1
Main Avenue
Treforest Industrial Estate
Pontypridd
CF37 5BF

Customer Contact: Mr Craig Lewis

Customer Job Reference: P2251
Customer Purchase Order: E3898
Date Job Received at SAL: 08-Apr-2015
Date Analysis Started: 16-Apr-2015
Date Analysis Completed: 20-Apr-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 QP22

UKAS TESTING 1549

Report checked and authorised by :
Michael Goodman
Project Management

Issued by :
Kayleigh McCann
Project Manager

Signature valid
Digitally signed by Kayleigh McCann
Date: 2015.04.29 17:03:01 BST
Reason: Issue
Location: SAL

Biotage GB Ltd		Installation Name	: Ystrad Mynach
Permit No	: EPR/DP3832EF	Visit Details	: Annual Compliance Emissions
Variation No	: N/A	Survey Dates	: 31st March – 1st April 2015
Report Ref	: P2251 : R001	Report Issue Date	: 29th April 2015

SAL Reference: 468613
Customer Reference: P2251

Impinger (sodium hydroxide) Analysed as Impinger (sodium hydroxide)
Miscellaneous

				SAL Reference	468613 019	468613 020	468613 022
				Customer Sample Reference	ECL/15/1560	ECL/15/1561	ECL/15/1563
				Test Sample	AR	AR	AR
				Date Sampled	01-APR-2015	01-APR-2015	01-APR-2015
Determinand	Method	LOD	Units	Symbol			
Hydrogen Bromide	IC	0.05	mg/l	U	(13) 2.8	(13) 0.30	(13) <0.05
Volume	Vol	1	ml	N	160	140	230

SAL Reference: 468613
Customer Reference: P2251

Impinger (0.1N Sulphuric Acid) Analysed as Impinger (0.1N Sulphuric Acid)
Miscellaneous

				SAL Reference	468613 017	468613 018	468613 021
				Customer Sample Reference	ECL/15/1558	ECL/15/1559	ECL/15/1562
				Test Sample	AR	AR	AR
				Date Sampled	01-APR-2015	01-APR-2015	01-APR-2015
Determinand	Method	LOD	Units	Symbol			
Hydrogen Bromide	IC	0.5	mg/l	N	(13) 180	(13) 5.2	(9) <5.0
Volume	Vol	1	ml	N	190	180	250

SAL Reference: 468613
Customer Reference: P2251

Impinger(DI water) Analysed as Impinger(DI water)
Miscellaneous

				SAL Reference	468613 001	468613 002	468613 003	468613 011	468613 012
				Customer Sample Reference	ECL/15/1546	ECL/15/1547	ECL/15/1548	ECL/15/1553	ECL/15/1554
				Test Sample	AR	AR	AR	AR	AR
				Date Sampled	31-MAR-2015	31-MAR-2015	31-MAR-2015	01-APR-2015	01-APR-2015
Determinand	Method	LOD	Units	Symbol					
Hydrogen Chloride	IC	0.05	mg/l	U	(195,13) 200	(13) 0.32	(13) <0.05	(13,195) 74	(13) 0.29
Volume	Vol	1	ml	U	300	120	260	260	130

SAL Reference: 468613
Customer Reference: P2251

Impinger(DI water) Analysed as Impinger(DI water)
Miscellaneous

				SAL Reference	468613 013
				Customer Sample Reference	ECL/15/1555
				Test Sample	AR
				Date Sampled	01-APR-2015
Determinand	Method	LOD	Units	Symbol	
Hydrogen Chloride	IC	0.05	mg/l	U	(13) <0.05
Volume	Vol	1	ml	U	240

Biotage GB Ltd		Installation Name	: Ystrad Mynach
Permit No	: EPR/DP3832EF	Visit Details	: Annual Compliance Emissions
Variation No	: N/A	Survey Dates	: 31st March – 1st April 2015
Report Ref	: P2251 : R001	Report Issue Date	: 29th April 2015

SAL Reference: 468613
Customer Reference: P2251

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Miscellaneous

				SAL Reference	468613 004	468613 005	468613 006	468613 007	468613 008
				Customer Sample Reference	ECL/15/1549 FRONT	ECL/15/1549 MIDDLE	ECL/15/1549 BACK	ECL/15/1550	ECL/15/1551 FRONT
				Test Sample	AR	AR	AR	AR	AR
				Date Sampled	31-MAR-2015	31-MAR-2015	31-MAR-2015	31-MAR-2015	31-MAR-2015
Determinand	Method	LOD	Units	Symbol					
Methanol	GC/MS	10	µg	N	<10	<10	<10	<10	(37) 61

SAL Reference: 468613
Customer Reference: P2251

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Miscellaneous

				SAL Reference	468613 009	468613 010	468613 014	468613 015	468613 016
				Customer Sample Reference	ECL/15/1551 BACK	ECL/15/1552	ECL/15/1556 FRONT	ECL/15/1556 BACK	ECL/15/1557
				Test Sample	AR	AR	AR	AR	AR
				Date Sampled	31-MAR-2015	31-MAR-2015	01-APR-2015	01-APR-2015	01-APR-2015
Determinand	Method	LOD	Units	Symbol					
Methanol	GC/MS	10	µg	N	<10	<10	<10	<10	<10

Index to symbols used in 468613-1

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
37	There was >10% found on the back section of the tube
13	Results have been blank corrected.
9	LOD raised due to dilution of sample
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited

UNCERTAINTY CALCULATIONS

A1 Volumetric Flowrate Uncertainty

Stack Reference A1

Measurement Uncertainty Calculations - Velocity at Stack Conditions

Contribution From	Standard u/c (mm H_2O)	
Pitot Calibration Uncertainty Contribution	0.055	A
Manometer Calibration Uncertainty Contribution	0.055	B
Variation in Actual Pitot reading at sample points	0.12	C
Combined u/c (mm H_2O) =	**Combined u/c (mm H_2O)**	
SQRT $(A/\sqrt{3})^2 + (B/\sqrt{3})^2 + (C/\sqrt{3})^2$	0.08	
Expanded Uncertainty of Flow Measurements (mm H_2O)	**0.16**	
	Standard u/c (K)	
Temperature Calibration (K)	1.44	D
Variation in Actual Temp reading at sample points	0.10	E
Combined u/c of Temp (K)	**Combined u/c (K)**	
SQRT $((D/\sqrt{3}^2) + (E/\sqrt{3})^2)$	0.83	
Expanded Uncertainty of Temp Measurements (K)	**1.67**	
Measured Average Velocity (m/s) at Stack Conds	13.41	
Maximum Average Velocity (m/s) at Stack Conds	13.54	
Standard Uncertainty Velocity at Stack Conditions (%)	1.02	
Expanded Uncertainty Velocity (at Stack Conditions)	**2.03 (%)**	

Measurement Uncertainty Calculations - Flowrate at Stack Conditions

Contribution From	Standard u/c (m^2)
Area (m2)	0.00031
Measured Average Flowrate (m^3/s) at Stack Conds	0.42
Maximum Average Flowrate (m^3/s) at Stack Conds	0.43
Standard Uncertainty Flowrate (m^3/s) at Stack Conditions (%)	2.03
Expanded Uncertainty Flowrate (m^3/s) at Stack Conditions	**4.05 (%)**

Measurement Uncertainty Calculations - Flowrate at STP & Wet Gas

Contribution From	Standard u/c (%)
Temperature Calibration (K)	0.5
Barometer Calibration	0.5
Measured Average Flowrate (m^3/s) at STP Wet	0.39
Maximum Average Flowrate (m^3/s) at STP Wet	0.40
Standard Uncertainty Flowrate (m^3/s) at STP Wet	2.51
Expanded Uncertainty Flowrate (m^3/s) at STP Wet	**5.02 (%)**

Biotage GB Ltd		**Installation Name**	**: Ystrad Mynach**
Permit No	**: EPR/DP3832EF**	**Visit Details**	**: Annual Compliance Emissions**
Variation No	**: N/A**	**Survey Dates**	**: 31st March – 1st April 2015**
Report Ref	**: P2251 : R001**	**Report Issue Date**	**: 29th April 2015**

A1 HCl Uncertainty

Site: Ystrad Mynach
Location: A1

$$u_{mass} = \sqrt{\sum (u_{filter})^2 + (u_{solution})^2}$$

Determinand	Filter mg	Solution mg	Recovered Mass mg	LAB Method Uncert (%) K=2 Filter mg	LAB Method Uncert (%) K=2 Solution mg	Standard Uncertainty Filter mg	Standard Uncertainty Solution mg	Combined Uncertainty mg
			HCl-1					
...	...	...	...	...	...	...	...	...
Hydrogen Chloride	...	60.04	60.04	...	7.80	...	3.90	3.90
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
				...				
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...

	HCl-1		Standard Uncertainty @ 95%		
Sampled Volume (V_m)	0.58	**m^3**	**uV_m**	0.001	**m^3**
Meter Correction Factor (Yd)	1.03	**...**		...	**...**
Meter Temperature (T_m)	286.55	**k**	**uT_m**	1.5	**k**
Average Differential Pressure (ΔH)	10.00	**mmH_2O**	**uΔH**	0.25	**mmH_2O**
Barometric Pressure (ρ_b)	750.81	**mmHg**	**$u\rho_b$**	3.8	**mmHg**
ΔH + ρs (ρ_m)	100.20	**kPa**		...	**...**
Oxygen content ($O_{2,m}$)	21.00	**% by volume**	$uO_{2,m} = \sigma/\sqrt{n}$	0.00	**% by volume**
Moisture Content (H_2O)	1.01	**% by volume**	**uH_2O**	0.27	**% by volume**

Note: In the following calculations, the sensitivity coefficient (C) is estimated using: $C_i = \frac{\partial f}{\partial x_i}$

For each factor, uncertainty is then calculated by $C_i u_i$ where C is the sensitivity coefficient, u is the standard uncertainty and i is the index identifying the contributing factor e.g. $i = uV_m$, uT_m etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

HCl-1:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1.01$$

Uncertainty in correction factor to STP due to measured ΔH uncertainty component (uΔH), measured stack pressure uncertainty component (up_s) & measured temperature of dry gas uncertainty component ($uT_{m\ Dry}$)

HCl-1:

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 0.982$$

	Maximum	Minimum	Sensitivity	ufstp
uΔH	0.98	0.98	0.0000961	0.0000240
$u\rho_b$	0.99	0.98	0.00131	0.00490
uT_m	0.99	0.98	0.00343	0.00514
H_2O	0.98	0.98	0.00992	0.00269

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00733$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uV_{std}) & volume uncertainty component (uV_m)

HCl-1:

$$V_{std} = V_{measured} \times f_s = \quad 0.566$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty (m^3)
Effect of uV_{std}	0.57	0.56	0.58	0.00422
Effect of uV_m	0.57	0.57	0.98	0.000982

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.00262$$

Uncertainty of Oxygen Correction Factor (%):-

HCl-1:

$$f_{O_2} = \frac{20.9\% - O_{2,\,ref}}{20.9\% - O_{2,\,measured}} = \quad 1.00$$

$$uCorr^n{}_{O_2} = \frac{20.9\% - O_{2,\,ref}}{(20.9\% - O_{2,\,measured}) x (20.9\% - O_{2,\,measured})} \; x\, Uncertainty\ of\ O_2\ Measurement = \quad 1.00$$

$$uf_{O_2} = \frac{uCorr^n{}_{O_2}}{f_{O_2}} x100 = \quad 0.00\ \%$$

Biotage GB Ltd		**Installation Name**	**: Ystrad Mynach**
Permit No	**: EPR/DP3832EF**	**Visit Details**	**: Annual Compliance Emissions**
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Report Ref	**: P2251 : R001**	**Report Issue Date**	**: 29th April 2015**

Uncertainty in final measurement @ reference conditions due to mass uncertainty component (uM)

Determinand	HCl-1: Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	uM mg/Nm³
...	...	...	...	...
Hydrogen Chloride	112.97	99.18	1.77	6.89
...	...	...	...	...
...	...	...	...	...

Uncertainty in final measurement @ reference conditions due to uncertainty component arrising from leak and/or loss (assumed 2% max) in the sample system (uL)

Determinand	HCl-1: uL mg/Nm³
...	...
Hydrogen Chloride	1.22
...	...
...	...

Uncertainty in final measurement @ Reference Conditions due to uVstp

Determinand	HCl-1: Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	uVstp mg/Nm³
...	...	...	...	...
Hydrogen Chloride	106.57	105.59	187.42	0.49
...	...	...	...	...
...	...	...	...	...

Combined Uncertainty excluding oxygen contribution

$$u_{combined} = \sqrt{\sum (u_M)^2 + (u_L)^2 + (uV_{stp})^2}$$

Determinand	HCl-1: Combined Uncertainty mg/Nm³	Expanded Uncertainty mg/Nm³	Measured Concentration mg/Nm³	Percent of Measured Concentration
...	...	...	...	...
Hydrogen Chloride	7.02	14.04	106.08	13.24
...	...	...	...	...
...	...	...	...	...

Combined Uncertainty including oxygen contribution

$$u_{combined} = \sqrt{\sum (uf_{o_2})^2 + (Uncertainty\ of\ Measurement\ of\ Determinand)^2}$$

Determinand	Measurement Uncertainty of Determinand	Measurement Uncertainty of Oxygen Corrn Factor	Overall Measurement Uncertainty inc O_2 Corrⁿ factor (Ucombined)
...	...	...	...
Hydrogen Chloride	13.24	0.00	13.24
...	...	...	...
...	...	...	...

Biotage GB Ltd		Installation Name	: Ystrad Mynach
Permit No	: EPR/DP3832EF	Visit Details	: Annual Compliance Emissions
Variation No	: N/A	Survey Dates	: 31st March – 1st April 2015
Report Ref	: P2251 : R001	Report Issue Date	: 29th April 2015

A1 Methanol Uncertainty

Site: Biotage GB LTD, Ystrad Mynach
Location: Main builiding EP1, Stack ID:A1

					Standard Uncertainty @ 95%		
Sampled Volume	V_m	0.01451	m^3	uV_m	0.000	m^3
Meter Correction Factor or ml/count	Yd	0.41	...	...	...	...
Meter Temperature	T_m	284.83	k	uT_m	1.5	k
Barometric Pressure	ρ_b	1001.00	mBar		10.0	mBar
Oxygen content	$O_{2,m}$	0.00	%Vol	$uO_{2,m}$	0.00	%Vol
Moisture	H_2O	0.00	%Vol	uH_2O		%Vol

Tubes					
Determinand	Recovered Mass		Standard Uncertainty		
Methanol	10.00	µg	uM	0.50	µg

Note: In the following calculations, the sensitivity coefficient (C) is estimated using: $C_i = \frac{\partial I}{\partial x_i}$

For each factor, uncertainty is then calculated by $C_i u_i$ where *C* is the sensitivity coefficient, *u* is the standa and *i* is the index identifying the contributing factor e.g. i = uV_m, uT_m etc.

Where results are required at wet conditions, the following correction factor is used to convert the data fro meter:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1.00$$

Uncertainty in correction factor to STP due to measured barometric pressure uncertainty component (uρb), measured temperature of dry gas uncertainty component (uT_m) & measured moisture (uH_2O) where required

$$f_s = \frac{273}{T_m} \times \frac{\rho}{101.3} = \quad 0.95$$

	Maximum	Minimum	Sensitivity	ufstp
$u\rho_b$	0.49	0.48	0.000483	0.00483
uT_m	0.95	0.94	0.00333	0.00499
uH_2O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{uP_b}{(P_b/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00648$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uVstd) & volume uncertainty component (uVm)

$$V_{std} = V_{measured} \times f_s = \quad 0.00563$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty m^3
Effect of uf_s	0.00567	0.00559	0.00595	0.0000385
Effect of uV_m	0.00564	0.00563	0.39	3.883E-06

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uf_s}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.0000335$$

Uncertainty of correction factor to reference conditions (excluding oxygen contribution) & Uncertainty in final measurement @ reference conditions due to uncertainty component arrising from leak and/or loss (assumed 2% max) in the sample system (uL)

$$uL = \frac{Conc \times \frac{2}{100}}{\sqrt{3}}$$

	Tubes uL mg/Nm^3	Condensate uL mg/Nm^3
Methanol	0.0205	...

$$Conc = \frac{M_{\text{Recovered}}}{V_m \times f_s \times f_{O_2}}$$

Uncertainty in final measurement @ Reference Conditions due to $uM_{Recovered}$

Charcoal Tube Results				
	Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	Standard Uncertainty mg/Nm³
Methanol	1.86	1.69	177.53	0.0888
Condensate Results				
	Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	Standard Uncertainty mg/Nm³
Methanol				

Uncertainty in final measurement @ Reference Conditions due to uV_{STD}

Charcoal Tube Results				
	Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	Standard Uncertainty mg/Nm³
Methanol	1.79	1.76	315.18	0.0106

Combined Uncertainty (excluding Oxygen contribution)

$$u_{combined} = \sqrt{\sum (u_M)^2 + (u_L)^2 + (uV_{stp})^2}$$

Charcoal Tubes: Determinand	Combined Uncertainty mg/Nm³	Expanded Uncertainty mg/Nm³	Measured Concentration mg/Nm³	Percent of Measured Concentration
Methanol	0.0917	0.18	1.78	10.33

A2 Volumetric Flowrate Uncertainty

Stack Reference A2

Measurement Uncertainty Calculations - Velocity at Stack Conditions

Contribution From	Standard u/c (mm H_2O)	
Pitot Calibration Uncertainty Contribution	0.071	A
Manometer Calibration Uncertainty Contribution	0.071	B
Variation in Actual Pitot reading at sample points	0.14	C
Combined u/c (mm H_2O) =	**Combined u/c (mm H_2O)**	
SQRT $(A/\sqrt{3})^2 + (B/\sqrt{3})^2 + (C/\sqrt{3})^2$	0.10	
Expanded Uncertainty of Flow Measurements (mm H_2O)	**0.20**	
	Standard u/c (K)	
Temperature Calibration (K)	1.43	D
Variation in Actual Temp reading at sample points	0.30	E
Combined u/c of Temp (K)	**Combined u/c (K)**	
SQRT $((D/\sqrt{3})^2) + (E/\sqrt{3})^2)$	0.84	
Expanded Uncertainty of Temp Measurements (K)	**1.69**	
Measured Average Velocity (m/s) at Stack Conds	15.08	
Maximum Average Velocity (m/s) at Stack Conds	15.23	
Standard Uncertainty Velocity at Stack Conditions (%)	1.00	
Expanded Uncertainty Velocity (at Stack Conditions)	**1.99 (%)**	

Measurement Uncertainty Calculations - Flowrate at Stack Conditions

Contribution From	Standard u/c (m^2)
Area (m2)	0.00031
Measured Average Flowrate (m^3/s) at Stack Conds	0.47
Maximum Average Flowrate (m^3/s) at Stack Conds	0.48
Standard Uncertainty Flowrate (m^3/s) at Stack Conditions (%)	2.01
Expanded Uncertainty Flowrate (m^3/s) at Stack Conditions	**4.01 (%)**

Measurement Uncertainty Calculations - Flowrate at STP & Wet Gas

Contribution From	Standard u/c (%)
Temperature Calibration (K)	0.5
Barometer Calibration	0.5
Measured Average Flowrate (m^3/s) at STP Wet	0.45
Maximum Average Flowrate (m^3/s) at STP Wet	0.46
Standard Uncertainty Flowrate (m^3/s) at STP Wet	2.49
Expanded Uncertainty Flowrate (m^3/s) at STP Wet	**4.99 (%)**

Biotage GB Ltd		**Installation Name**	**: Ystrad Mynach**
Permit No	**: EPR/DP3832EF**	**Visit Details**	**: Annual Compliance Emissions**
Variation No	**: N/A**	**Survey Dates**	**: 31st March – 1st April 2015**
Report Ref	**: P2251 : R001**	**Report Issue Date**	**: 29th April 2015**

A2 HCl Uncertainty

Site: Ystrad Mynach
Location: A2

$$u_{mass} = \sqrt{\sum (u_{filter})^2 + (u_{solution})^2}$$

Determinand	Filter mg	Solution mg	Recovered Mass mg	LAB Method Uncert (%) K=2 Filter mg	LAB Method Uncert (%) K=2 Solution mg	Standard Uncertainty Filter mg	Standard Uncertainty Solution mg	Combined Uncertainty mg
			HCl-1					
...	...	...	...	...	...	...	...	...
Hydrogen Chloride	...	19.28	19.28	...	2.51	...	1.25	1.25
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
			...					
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...

	HCl-1		Standard Uncertainty @ 95%		
Sampled Volume (V_m)	0.58	**m^3**	**uV_m**	0.001	**m^3**
Meter Correction Factor (Yd)	1.03	**...**		...	**...**
Meter Temperature (T_m)	279.62	**k**	**uT_m**	1.5	**k**
Average Differential Pressure (ΔH)	10.00	**mmH_2O**	**uΔH**	0.25	**mmH_2O**
Barometric Pressure (ρ_b)	754.56	**mmHg**	**$u\rho_b$**	3.8	**mmHg**
ΔH + ρs (ρ_m)	100.70	**kPa**		...	**...**
Oxygen content ($O_{2,m}$)	21.00	**% by volume**	$uO_{2,m} = \sigma/\sqrt{n}$	0.00	**% by volume**
Moisture Content (H_2O)	0.0216	**% by volume**	**uH_2O**	0.26	**% by volume**

Note: In the following calculations, the sensitivity coefficient (C) is estimated using: $C_i = \frac{\partial f}{\partial x_i}$

For each factor, uncertainty is then calculated by $C_i u_i$ where C is the sensitivity coefficient, u is the standard uncertainty and i is the index identifying the contributing factor e.g. i = uV_m, uT_m etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

HCl-1:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1.00$$

Uncertainty in correction factor to STP due to measured ΔH uncertainty component (uΔH), measured stack pressure uncertainty component (up_s) & measured temperature of dry gas uncertainty component ($uT_{m\ Dry}$)

HCl-1:

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 1.002$$

	Maximum	Minimum	Sensitivity	ufstp
uΔH	1.00	1.00	0.0000975	0.0000244
$u\rho_b$	1.01	1.00	0.00133	0.00497
uT_m	1.01	1.00	0.00358	0.00537
H_2O	1.00	1.00	0.0100	0.00265

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00773$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uV_{std}) & volume uncertainty component (uV_m)

HCl-1:

$$V_{std} = V_{measured} \times f_s = \quad 0.577$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty (m^3)
Effect of uV_{std}	0.58	0.57	0.58	0.00446
Effect of uV_m	0.58	0.58	1.00	0.00100

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.00276$$

Uncertainty of Oxygen Correction Factor (%):-

HCl-1:

$$f_{O_2} = \frac{20.9\% - O_{2,\,ref}}{20.9\% - O_{2,\,measured}} = \quad 1.00$$

$$uCorr^n{}_{O_2} = \frac{20.9\% - O_{2,\,ref}}{(20.9\% - O_{2,\,measured}) x (20.9\% - O_{2,\,measured})} \; x\, Uncertainty\ of\ O_2\ Measurement = \quad 1.00$$

$$uf_{O_2} = \frac{uCorr^n{}_{O_2}}{f_{O_2}} x100 = \quad 0.00\ \%$$

Biotage GB Ltd		Installation Name	: Ystrad Mynach
Permit No	: EPR/DP3832EF	Visit Details	: Annual Compliance Emissions
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Report Ref	: P2251 : R001	Report Issue Date	: 29th April 2015

Uncertainty in final measurement @ reference conditions due to mass uncertainty component (uM)

Determinand	HCl-1: Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	uM mg/Nm³
...	...	...	...	...
Hydrogen Chloride	35.57	31.23	1.73	2.17
...	...	...	...	...
...	...	...	...	...

Uncertainty in final measurement @ reference conditions due to uncertainty component arrising from leak and/or loss (assumed 2% max) in the sample system (uL)

Determinand	HCl-1: uL mg/Nm³
...	...
Hydrogen Chloride	0.39
...	...
...	...

Uncertainty in final measurement @ Reference Conditions due to uVstp

Determinand	HCl-1: Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	uVstp mg/Nm³
...	...	...	...	...
Hydrogen Chloride	33.56	33.24	57.87	0.16
...	...	...	...	...
...	...	...	...	...

Combined Uncertainty excluding oxygen contribution

$$u_{combined} = \sqrt{\sum (u_M)^2 + (u_L)^2 + (uV_{stp})^2}$$

Determinand	HCl-1: Combined Uncertainty mg/Nm³	Expanded Uncertainty mg/Nm³	Measured Concentration mg/Nm³	Percent of Measured Concentration
...	...	...	...	...
Hydrogen Chloride	2.21	4.42	33.40	13.24
...	...	...	...	...
...	...	...	...	...

Combined Uncertainty including oxygen contribution

$$u_{combined} = \sqrt{\sum (uf_{o_2})^2 + (Uncertainty\ of\ Measurement\ of\ Determinand)^2}$$

Determinand	Measurement Uncertainty of Determinand	Measurement Uncertainty of Oxygen Corrn Factor	Overall Measurement Uncertainty inc O_2 Corrⁿ factor (Ucombined)
...	...	...	...
Hydrogen Chloride	13.24	0.00	13.24
...	...	...	...
...	...	...	...

Biotage GB Ltd		Installation Name	: Ystrad Mynach
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A2 Methanol Uncertainty

Site: Biotage GB LTD, Ystrad Mynach
Location: Main Building EP2, Stack ID:A2

				Standard Uncertainty @ 95%		
Sampled Volume	V_m	0.01390	m^3	uV_m	0.000	m^3
Meter Correction Factor or ml/count	Yd	0.41	...	...	...	...
Meter Temperature	T_m	279.17	k	uT_m	1.5	k
Barometric Pressure	ρ_b	1005.00	mBar		10.0	mBar
Oxygen content	$O_{2,m}$	0.00	%Vol	$uO_{2,m}$	0.00	%Vol
Moisture	H_2O	0.00	%Vol	uH_2O		%Vol

Tubes				
Determinand	Recovered Mass		Standard Uncertainty		
Methanol	10.00	µg	uM	0.50	µg

Note: In the following calculations, the sensitivity coefficient (C) is estimated using: $C_i = \frac{\partial f}{\partial x_i}$

For each factor, uncertainty is then calculated by $C_i u_i$ where C is the sensitivity coefficient, u is the standa
and i is the index identifying the contributing factor e.g. i = uV_m, uT_m etc.

Where results are required at wet conditions, the following correction factor is used to convert the data fro
meter:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1.00$$

Uncertainty in correction factor to STP due to measured barometric pressure uncertainty component (uρb), measured temperature of dry gas uncertainty component (uT_m) & measured moisture (uH_2O) where required

$$f_s = \frac{273}{T_m} \times \frac{\rho}{101.3} = \quad 0.97$$

	Maximum	Minimum	Sensitivity	ufstp
$u\rho_b$	0.50	0.49	0.000488	0.00488
uT_m	0.98	0.97	0.0035	0.0052
uH_2O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{uP_b}{(P_b/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.01$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uVstd) & volume uncertainty component (uVm)

$$V_{std} = V_{measured} \times f_s = \quad 0.0055$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty m^3
Effect of uf_s	0.0056	0.0055	0.00570	0.00004
Effect of uV_m	0.0055	0.0055	0.40	0.0000040

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uf_s}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.000032$$

Uncertainty of correction factor to reference conditions (excluding oxygen contribution) & Uncertainty in final measurement @ reference conditions due to uncertainty component arrising from leak and/or loss (assumed 2% max) in the sample system (uL)

$$uL = \frac{Conc \times \frac{2}{100}}{\sqrt{3}}$$

	Tubes uL mg/Nm³	Condensate uL mg/Nm³
Methanol	0.02089	...

$$Conc = \frac{M_{\text{Recovered}}}{V_m \times f_s \times f_{O_2}}$$

Uncertainty in final measurement @ Reference Conditions due to $uM_{Recovered}$

Charcoal Tube Results				
	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	Standard Uncertainty mg/Nm^3
Methanol	1.90	1.72	180.93	0.09046
Condensate Results				
	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	Standard Uncertainty mg/Nm^3
Methanol				

Uncertainty in final measurement @ Reference Conditions due to uV_{STD}

Charcoal Tube Results				
	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	Standard Uncertainty mg/Nm^3
Methanol	1.82	1.80	327.35	0.01032

Combined Uncertainty (excluding Oxygen contribution)

$$u_{combined} = \sqrt{\sum (u_M)^2 + (u_L)^2 + (uV_{stp})^2}$$

Charcoal Tubes: Determinand	Combined Uncertainty mg/Nm^3	Expanded Uncertainty mg/Nm^3	Measured Concentration mg/Nm^3	Percent of Measured Concentration
Methanol	0.09342	0.1868	1.81	10.33

A3 Volumetric Flowrate Uncertainty

Stack Reference A3

Measurement Uncertainty Calculations - Velocity at Stack Conditions

Contribution From	Standard u/c (mm H_2O)	
Pitot Calibration Uncertainty Contribution	0.047	A
Manometer Calibration Uncertainty Contribution	0.047	B
Variation in Actual Pitot reading at sample points	0.12	C
Combined u/c (mm H_2O) =	**Combined u/c (mm H_2O)**	
SQRT $(A/\sqrt{3})^2 + (B/\sqrt{3})^2 + (C/\sqrt{3})^2$	0.08	
Expanded Uncertainty of Flow Measurements (mm H_2O)	**0.15**	
	Standard u/c (K)	
Temperature Calibration (K)	1.44	D
Variation in Actual Temp reading at sample points	0.10	E
Combined u/c of Temp (K)	**Combined u/c (K)**	
SQRT $((D/\sqrt{3})^2) + (E/\sqrt{3})^2)$	0.83	
Expanded Uncertainty of Temp Measurements (K)	**1.66**	
Measured Average Velocity (m/s) at Stack Conds	12.31	
Maximum Average Velocity (m/s) at Stack Conds	12.45	
Standard Uncertainty Velocity at Stack Conditions (%)	1.11	
Expanded Uncertainty Velocity (at Stack Conditions)	**2.21 (%)**	

Measurement Uncertainty Calculations - Flowrate at Stack Conditions

Contribution From	Standard u/c (m^2)
Area (m2)	0.00031
Measured Average Flowrate (m^3/s) at Stack Conds	0.39
Maximum Average Flowrate (m^3/s) at Stack Conds	0.40
Standard Uncertainty Flowrate (m^3/s) at Stack Conditions (%)	2.12
Expanded Uncertainty Flowrate (m^3/s) at Stack Conditions	**4.24 (%)**

Measurement Uncertainty Calculations - Flowrate at STP & Wet Gas

Contribution From	Standard u/c (%)
Temperature Calibration (K)	0.5
Barometer Calibration	0.5
Measured Average Flowrate (m^3/s) at STP Wet	0.36
Maximum Average Flowrate (m^3/s) at STP Wet	0.37
Standard Uncertainty Flowrate (m^3/s) at STP Wet	2.60
Expanded Uncertainty Flowrate (m^3/s) at STP Wet	**5.21 (%)**

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A3 NOx Measurement Uncertainty

Measurement Uncertainty Calculations Part 1

Horiba PG 250 Performance Characteristics	Standard Uncertainty (% of Range)	Distributiuon	Minimum Certified Range (R_i) NO 0 - 125 mg/m³	O_2 0 - 25 %Vol	CO_2 0 - 20 %Vol
Lack of fit(1)	u_{lof}	Rectangular (Divisor = √3)	0.40	0.13	0.60
Span drift(2)	$u_{d,s}$	Rectangular (Divisor = √3)	0.27	0.029	0.24
Repeatability Standard Deviation (span)(3)	u_r	Normal (Divisor = 1)	0.33	0.29	0.22
Losses / leakage in the sample system(4)	u_{loss}	Rectangular (Divisor = √3)	1.58	0.89	0.44
Temperature dependant span drift(5)	u_t	Rectangular (Divisor = √3)	0.18	0.070	0.040
Interferents(1)	u_i	Rectangular (Divisor = √3)	1.20	0.56	0.010
Uncertainty of Reference Gas(6)	u_{ref}	Rectangular (Divisor = √3)	1.77	0.15	0.088

Note:

$$when\ \left|(x_{i,\max} - x_{i,adj})\right| = \left|(x_{i,\min} - x_{i,adj})\right|, then\ u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$$

1 Expressed as a percentage of the certified range
2 Expressed as a percentage of the certified range as maximum drift per 24hr period
3 Expressed as a percentage of the certified range
4 Expressed as a percentage of the certified range
5 Expressed as a percentage of the certified range per one degree centigrade
6 Expressed as standard uncertainty in units of measurement i.e. mg/m³ / %Vol inc additional uncertainty of 2% for gas blending
7 Applies to TVOC only

Measurement Uncertainty Calculations Part 2

Horiba PG 250 Performance Characteristics	Uncertainty	Value of Standard Uncertainty	NO 0 - 125 mg/m³	O_2 0 - 25 %Vol	CO_2 0 - 20 %Vol
Lack of fit	u_{lof}	$u(x_i) = \frac{u_{lof} \times R_i}{\sqrt{3}} =$	0.29	0.019	0.07
Span drift	$u_{d,s}$	$u(x_i) = \frac{u_{d,s} \times R_i}{\sqrt{3}} =$	0.20	0.0041	0.0280
Repeatability Standard Deviation (span)	u_r	$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} =$	0.33	0.29	0.22
Losses / leakage in the sample system	u_{loss}	$u(x_i) = \frac{u_{loss} \times R_i}{\sqrt{3}} =$	1.14	0.13	0.05
Temperature dependant span drift	u_t	$u(x_i) = \frac{u_t}{100} \times R_i \times \sqrt{\frac{(x_{i,max} - x_{adj})^2 + (x_{i,min} - x_{adj})(x_{i,max} - x_{adj}) + (x_{i,min} - x_{adj})^2}{3}}$	0.052	0.0040	0.002
Interferents	u_i	$u(x_i) = \frac{u_i \times R_i}{\sqrt{3}} =$	0.87	0.081	0.01
Uncertainty of Reference Gas	u_{ref}	$u(x_i) = \frac{u_{ref}}{\sqrt{3}} =$	1.02	0.087	0.05
Combined Standard Uncertainty		$u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2}$	1.82	0.33	0.24
Expanded measurement uncertainty (at 95% confidence)		$U_{EXP} = 2 \times u_c$	3.65	0.67	0.49
Applied Span Concentration			102.40	15.03	5.06
Measured Span Concentration, STP Dry Gas			100.19	15.19	5.01
Expanded measurement uncertainty as % of Applied Span			4%	4%	10%

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A3 NOx Uncertainty of Measurement

Uncertainty of Measurement Results - Calculations Part 1

Horiba PG 250 Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Divisor	Minimum Certified Range (R_i) NO 0 - 125 mg/m³	O_2 0 - 25 %Vol	CO_2 0 - 20 %Vol
Lack of fit(1)	u_{lof}	Rectangular		0.40	0.13	0.60
Span drift(2)	$u_{d,s}$			0.27	0.029	0.24
Losses / leakage in the sample system(4)	u_{loss}			1.58	0.89	0.44
Temperature dependant span drift(5)	u_t		$\sqrt{3}$	0.18	0.070	0.040

Notes:

For rectangular distributions, $u(x_i) = \frac{u \times R_i}{\sqrt{3}}$

For $u(x_i) = \Delta x_i \sqrt{\frac{(x_{i,\max} - x_{i,adj})^2 + (x_{i,\min} - x_{i,adj})(x_{i,\max} - x_{i,adj}) + (x_{i,\min} - x_{i,adj})^2}{3}}$, when $\left|(x_{i,\max} - x_{i,adj})\right| = \left|(x_{i,\min} - x_{i,adj})\right|$, then $u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$

Where $u(x_i) = \frac{\sigma}{\sqrt{n}}$ (See note 6 below), $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$

Horiba PG 250 Performance Characteristics	Uncertainty (Units of final measurement)	Distribution	Divisor	NO 0 - 125 mg/m³	O_2 0 - 25 %Vol	CO_2 0 - 20 %Vol
Lack of fit	u_{lof}	Rectangular		0.29	0.019	0.069
Span drift	$u_{d,s}$			0.20	0.0041	0.028
Temperature dependant span drift	u_t		$\sqrt{3}$	0.060	0.0046	0.00
Interferents	u_i			0.87	0.081	...

Uncertainty of Measurement Results - Calculations Part 1

Horiba PG 250 Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Divisor	Minimum Certified Range (R_i) NO 0 - 125 mg/m³	O_2 0 - 25 %Vol	CO_2 0 - 20 %Vol
Lack of fit(1)	u_{lof}	Rectangular		0.40	0.13	0.60
Span drift(2)	$u_{d,s}$			0.27	0.029	0.24
Losses / leakage in the sample system(4)	u_{loss}			1.58	0.89	0.44
Temperature dependant span drift(5)	u_t		$\sqrt{3}$	0.18	0.070	0.040

Notes:

For rectangular distributions, $u(x_i) = \frac{u \times R_i}{\sqrt{3}}$

For $u(x_i) = \Delta x_i \sqrt{\frac{(x_{i,\max} - x_{i,adj})^2 + (x_{i,\min} - x_{i,adj})(x_{i,\max} - x_{i,adj}) + (x_{i,\min} - x_{i,adj})^2}{3}}$, when $\left|(x_{i,\max} - x_{i,adj})\right| = \left|(x_{i,\min} - x_{i,adj})\right|$, then $u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$

Where $u(x_i) = \frac{\sigma}{\sqrt{n}}$ (See note 6 below), $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$

Horiba PG 250 Performance Characteristics	Uncertainty (Units of final measurement)	Distribution	Divisor	NO 0 - 125 mg/m³	O_2 0 - 25 %Vol	CO_2 0 - 20 %Vol
Lack of fit	u_{lof}	Rectangular		0.29	0.019	0.069
Span drift	$u_{d,s}$			0.20	0.0041	0.028
Temperature dependant span drift	u_t		$\sqrt{3}$	0.060	0.0046	0.00
Interferents	u_i			0.87	0.081	...

Where oxygen or moisture correction is required, uncertainty based on the standard error of the measured peripheral value is converted to units of final measurement using a sensitivity coefficient C,

$\therefore u(x_i) = C_i u_i$ where $C_i = \frac{\partial f}{\partial x_i}$

Uncertainty of Measurement Results - Calculations Part 3

Horiba PG 250 Uncertainty	Date & Time	NOx (as NO2) 0 - 125 mg/m³	O_2 0 - 25 %Vol	CO_2 0 - 20 %Vol
Measured Concentration	31/03/15 12:48 - 13:47	56.73	21.10	0.020
Expanded Uncertainty as Percentage of Measured Concentration		14%	2%	> 100%

Combined Standard Uncertainty $u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2 + u_v^2 + u_{syn}^2}$

Expanded uncertainty (at 95% confidence) $U_{Exp} = 2 \times u_c$

1 Expressed as a percentage of the certified range
2 Expressed as a percentage of the certified range as maximum drift per 24hr period
3 Expressed as a percentage of the certified range
4 Expressed as a percentage of the certified range
5 Expressed as a percentage of the certified range per one degree centigrade
6 Where the uncertainty of Moisture is taken from the manual extractive test calculations
7 If no value for uncertainty is presented above, the uncertainty is considered to be > 100%

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A3 Moisture Uncertainty

Site: Ystrad Mynach
Location: A3

$$u_{mass} = \sqrt{\sum (u_{filter})^2 + (u_{solution})^2}$$

Determinand	Filter mg	Solution mg	Recovered Mass mg	LAB Method Uncert (%) K=2 Filter mg	LAB Method Uncert (%) K=2 Solution mg	Standard Uncertainty Filter mg	Standard Uncertainty Solution mg	Combined Uncertainty mg
Moisture-1								
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
…				…				
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…

	Moisture-1			Standard Uncertainty @ 95%		
Sampled Volume (V_m)	0.47	**m^3**		**uV_m**	0.001	**m^3**
Meter Correction Factor (Yd)	1.03	**…**			…	**…**
Meter Temperature (T_m)	291.40	**k**		**uT_m**	1.5	**k**
Average Differential Pressure (ΔH)	10.00	**mmH_2O**		**uΔH**	0.25	**mmH_2O**
Barometric Pressure (ρ_b)	750.81	**mmHg**		**up$_b$**	3.8	**mmHg**
ΔH + ρs (ρ_m)	100.20	**kPa**			…	**…**
Oxygen content ($O_{2,m}$)	21.00	**% by volume**	$uO_{2,m} = \sigma/\sqrt{n}$		0.00	**% by volume**
Moisture Content (H_2O)	0.0278	**% by volume**		**uH_2O**	0.34	**% by volume**

Note: In the following calculations, the sensitivity coefficient (C) is estimated using: $C_i = \frac{\partial f}{\partial x_i}$

For each factor, uncertainty is then calculated by $C_i u_i$ where *C* is the sensitivity coefficient, *u* is the standard uncertainty and *i* is the index identifying the contributing factor e.g. *i* = uV_m, uT_m etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

Moisture-1:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1.00$$

Uncertainty in correction factor to STP due to measured ΔH uncertainty component (uΔH), measured stack pressure uncertainty component (up$_s$) & measured temperature of dry gas uncertainty component ($uT_{m\ Dry}$)

Moisture-1:

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 0.956$$

	Maximum	Minimum	Sensitivity	ufstp
uΔH	0.96	0.96	0.0000936	0.0000234
up$_b$	0.96	0.95	0.00127	0.00477
uT_m	0.96	0.95	0.00328	0.00492
H_2O	0.96	0.95	0.00957	0.00326

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00711$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uV_{std}) & volume uncertainty component (uV_m)

Moisture-1:

$$V_{std} = V_{measured} \times f_s = \quad 0.447$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty (m^3)
Effect of uV_{std}	0.45	0.44	0.47	0.00332
Effect of uV_m	0.45	0.45	0.96	0.000956

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.00180$$

Uncertainty of Oxygen Correction Factor (%):-

Moisture-1:

$$f_{o_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = \quad 1.00$$

$$uCorr^n_{o_2} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured}) x (20.9\% - O_{2,measured})} x Uncertainty\ of\ O_2\ Measurement = \quad 1.00$$

$$uf_{o_2} = \frac{uCorr^n_{o_2}}{f_{o_2}} x100 = \quad 0.00\ \%$$

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A3 Methanol Uncertainty

Site: Biotage GB LTD, Ystrad Mynach
Location: Main Building EP3, Stack ID:A3

					Standard Uncertainty @ 95%		
Sampled Volume	V_m	0.01491	m^3		uV_m	0.000	m^3
Meter Correction Factor or ml/count	Yd	0.41	...		...	...	...
Meter Temperature	T_m	289.17	k		uT_m	1.5	k
Barometric Pressure	ρ_b	1001.00	mBar			10.0	mBar
Oxygen content	$O_{2,m}$	0.00	%Vol		$uO_{2,m}$	0.00	%Vol
Moisture	H_2O	0.00	%Vol		uH_2O		%Vol

Tubes					
Determinand	Recovered Mass		Standard Uncertainty		
Methanol	61.00	µg	uM	3.05	µg

Note: In the following calculations, the sensitivity coefficient (C) is estimated using: $C_i = \frac{\partial f}{\partial x_i}$

For each factor, uncertainty is then calculated by $C_i u_i$ where *C* is the sensitivity coefficient, *u* is the standa
and *i* is the index identifying the contributing factor e.g. i = uV_m, uT_m etc.

Where results are required at wet conditions, the following correction factor is used to convert the data fro
meter:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1.00$$

Uncertainty in correction factor to STP due to measured barometric pressure uncertainty component ($u\rho b$), measured temperature of dry gas uncertainty component (uT_m) & measured moisture (uH_2O) where required

$$f_s = \frac{273}{T_m} \times \frac{\rho}{101.3} = \quad 0.93$$

	Maximum	Minimum	Sensitivity	ufstp
$u\rho_b$	0.48	0.48	0.000479	0.00479
uT_m	0.94	0.93	0.00323	0.00484
uH_2O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{uP_b}{(P_b/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00622$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uVstd) & volume uncertainty component (uVm)

$$V_{std} = V_{measured} \times f_s = \quad 0.00570$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty m^3
Effect of uf_s	0.00574	0.00567	0.00611	0.0000380
Effect of uV_m	0.00571	0.00570	0.38	3.825E-06

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uf_s}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.0000349$$

Uncertainty of correction factor to reference conditions (excluding oxygen contribution) & Uncertainty in final measurement @ reference conditions due to uncertainty component arrising from leak and/or loss (assumed 2% max) in the sample system (uL)

$$uL = \frac{Conc \times \frac{2}{100}}{\sqrt{3}}$$

	Tubes uL mg/Nm^3	Condensate uL mg/Nm^3
Methanol	0.12	...

$$Conc = \frac{M_{\text{Recovered}}}{V_m \times f_s \times f_{O_2}}$$

Uncertainty in final measurement @ Reference Conditions due to $uM_{Recovered}$

Charcoal Tube Results				
	Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	Standard Uncertainty mg/Nm³
Methanol	11.23	10.16	175.32	0.53
Condensate Results				
	Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	Standard Uncertainty mg/Nm³
Methanol				

Uncertainty in final measurement @ Reference Conditions due to uV_{STD}

Charcoal Tube Results				
	Maximum mg/Nm³	Minimum mg/Nm³	Sensitivity	Standard Uncertainty mg/Nm³
Methanol	10.76	10.63	1875.12	0.0654

Combined Uncertainty (excluding Oxygen contribution)

$$u_{combined} = \sqrt{\sum (u_M)^2 + (u_L)^2 + (uV_{stp})^2}$$

Charcoal Tubes: Determinand	Combined Uncertainty mg/Nm³	Expanded Uncertainty mg/Nm³	Measured Concentration mg/Nm³	Percent of Measured Concentration
Methanol	0.55	1.11	10.69	10.34

A4 Volumetric Flowrate Uncertainty

Stack Reference A4

Measurement Uncertainty Calculations - Velocity at Stack Conditions

Contribution From	Standard u/c (mm H_2O)	
Pitot Calibration Uncertainty Contribution	0.025	A
Manometer Calibration Uncertainty Contribution	0.025	B
Variation in Actual Pitot reading at sample points	0.07	C
Combined u/c (mm H_2O) =	**Combined u/c (mm H_2O)**	
SQRT $(A/\sqrt{3})^2 + (B/\sqrt{3})^2 + (C/\sqrt{3})^2$	0.05	
Expanded Uncertainty of Flow Measurements (mm H_2O)	**0.10**	
	Standard u/c (K)	
Temperature Calibration (K)	1.48	D
Variation in Actual Temp reading at sample points	0.10	E
Combined u/c of Temp (K)	**Combined u/c (K)**	
SQRT $((D/\sqrt{3})^2) + (E/\sqrt{3})^2)$	0.85	
Expanded Uncertainty of Temp Measurements (K)	**1.71**	
Measured Average Velocity (m/s) at Stack Conds	9.08	
Maximum Average Velocity (m/s) at Stack Conds	9.20	
Standard Uncertainty Velocity at Stack Conditions (%)	1.25	
Expanded Uncertainty Velocity (at Stack Conditions)	**2.51 (%)**	

Measurement Uncertainty Calculations - Flowrate at Stack Conditions

Contribution From	Standard u/c (m^2)
Area (m2)	0.00096
Measured Average Flowrate (m^3/s) at Stack Conds	0.87
Maximum Average Flowrate (m^3/s) at Stack Conds	0.89
Standard Uncertainty Flowrate (m^3/s) at Stack Conditions (%)	2.27
Expanded Uncertainty Flowrate (m^3/s) at Stack Conditions	**4.53 (%)**

Measurement Uncertainty Calculations - Flowrate at STP & Wet Gas

Contribution From	Standard u/c (%)
Temperature Calibration (K)	0.5
Barometer Calibration	0.5
Measured Average Flowrate (m^3/s) at STP Wet	0.80
Maximum Average Flowrate (m^3/s) at STP Wet	0.82
Standard Uncertainty Flowrate (m^3/s) at STP Wet	2.74
Expanded Uncertainty Flowrate (m^3/s) at STP Wet	**5.48 (%)**

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A4 HBr Uncertainty

Site: Ystrad Mynach
Location: A4

$$u_{mass} = \sqrt{\sum (u_{filter})^2 + (u_{solution})^2}$$

Determinand	Filter mg	Solution mg	Recovered Mass mg	LAB Method Uncert (%) K = 2 Filter mg	Solution mg	Standard Uncertainty Filter mg	Solution mg	Combined Uncertainty mg
			Hydrogen Bromide 1					
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
Hydrogen Bromide	...	35.14	35.14	...	4.57	...	2.28	2.28
...	...	...	...	...	...	...	...	...
				...				
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...

	Hydrogen Bromide 1			Standard Uncertainty @ 95%		
Sampled Volume (V_m)	0.61	**m^3**	**uV_m**	0.001	**m^3**	
Meter Correction Factor (Yd)	1.03	**...**		...	**...**	
Meter Temperature (T_m)	284.48	**k**	**uT_m**	1.5	**k**	
Average Differential Pressure (ΔH)	10.00	**mmH_2O**	**uΔH**	0.25	**mmH_2O**	
Barometric Pressure (ρ_b)	754.56	**mmHg**	**uρ_b**	3.8	**mmHg**	
ΔH + ρs (ρ_m)	100.70	**kPa**		...	**...**	
Oxygen content ($O_{2,m}$)	21.00	**% by volume**	$uO_{2,m} = \sigma/\sqrt{n}$	0.000698		**% by volume**
Moisture Content (H_2O)	2.02	**% by volume**	**uH_2O**	0.26		**% by volume**

Note: In the following calculations, the sensitivity coefficient (C) is estimated using: $C_i = \frac{\partial f}{\partial x_i}$

For each factor, uncertainty is then calculated by $C_i u_i$ where C is the sensitivity coefficient, u is the standard uncertainty and i is the index identifying the contributing factor e.g. i = uV_m, uT_m etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

Hydrogen Bromide 1:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1.02$$

Uncertainty in correction factor to STP due to measured ΔH uncertainty component (uΔH), measured stack pressure uncertainty component (up_s) & measured temperature of dry gas uncertainty component ($uT_{m\,Dry}$)

Hydrogen Bromide 1:

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 1.005$$

	Maximum	Minimum	Sensitivity	ufstp
uΔH	1.00	1.00	0.0000978	0.0000245
uρ_b	1.01	1.00	0.00133	0.00499
uT_m	1.01	1.00	0.00353	0.00530
H_2O	1.01	1.00	0.0103	0.00262

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00763$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uV_{std}) & volume uncertainty component (uV_m)

Hydrogen Bromide 1:

$$V_{std} = V_{measured} \times f_s = \quad 0.610$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty (m^3)
Effect of uV_{std}	0.61	0.61	0.61	0.00463
Effect of uV_m	0.61	0.61	1.00	0.00100

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.00298$$

Uncertainty of Oxygen Correction Factor (%):-

Hydrogen Bromide 1:

$$f_{o_2} = \frac{20.9\% - O_{2,\,ref}}{20.9\% - O_{2,\,measured}} = \quad 1.00$$

$$uCorr^n_{o_2} = \frac{20.9\% - O_{2,\,ref}}{(20.9\% - O_{2,\,measured}) x (20.9\% - O_{2,\,measured})} x\, Uncertainty\ of\ O_2\ Measurement = \quad 1.00$$

$$uf_{o_2} = \frac{uCorr^n_{o_2}}{f_{o_2}} x100 = \quad 0.00\ \%$$

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Uncertainty in final measurement @ reference conditions due to mass uncertainty component (uM)

Determinand	Hydrogen Bromide 1:			
	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uM mg/Nm^3
...	...	...	...	...
...	...	...	...	...
Hydrogen Bromide	61.37	53.88	1.64	3.75
...	...	...	...	...

Uncertainty in final measurement @ reference conditions due to uncertainty component arrising from leak and/or loss (assumed 2% max) in the sample system (uL)

Determinand	Hydrogen Bromide 1:
	uL mg/Nm^3
...	...
...	...
Hydrogen Bromide	0.67
...	...

Uncertainty in final measurement @ Reference Conditions due to uVstp

Determinand	Hydrogen Bromide 1:			
	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uVstp mg/Nm^3
...	...	...	...	...
...	...	...	...	...
Hydrogen Bromide	57.91	57.35	94.52	0.28
...	...	...	...	...

Combined Uncertainty excluding oxygen contribution

$$u_{combined} = \sqrt{\sum (u_M)^2 + (u_L)^2 + (uV_{stp})^2}$$

Determinand	Hydrogen Bromide 1:			
	Combined Uncertainty mg/Nm^3	Expanded Uncertainty mg/Nm^3	Measured Concentration mg/Nm^3	Percent of Measured Concentration
...	...	...	...	...
...	...	...	...	...
Hydrogen Bromide	3.81	7.63	57.63	13.24
...	...	...	...	...

Combined Uncertainty including oxygen contribution

$$u_{combined} = \sqrt{\sum (uf_{o_2})^2 + (Uncertainty\ of\ Measurement\ of\ Determinand)^2}$$

Determinand	Measurement Uncertainty of Determinand	Measurement Uncertainty of Oxygen Corrn Factor	Overall Measurement Uncertainty inc O_2 Corr^n factor (Ucombined)
...	...	...	...
...	...	...	...
Hydrogen Bromide	13.24	0.00	13.24
...	...	...	...