2499

EMISSIONS MONITORING SURVEY

Prepared for:

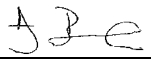
Western Bio-Energy Ltd.

Longlands Lane
Margam
Port Talbot
SA13 2NR

Permit Number	**: EPR/ZP3939GL**
Variation Number	**: V005**
Installation	**: Biomass Plant**
Visit Details	**: Compliance July 2023**
Job Number	**: P5520**
Report Number	**: R004**
Report Issue Date	**: 21st August 2023**
Survey Dates	**: 17th to 19th July 2023**

Prepared by:

Environmental Compliance Limited
Unit G1
Main Avenue
Treforest Industrial Estate
Pontypridd
CF37 5BF.
Tel: 01443 801215

Report Issue:		**FINAL**	
Report Prepared by:		**Report Reviewed & Approved by** **MCERTS Level Two** **Technical Endorsements TE1, TE2, TE3 & TE4**	
Name:	Harry Round	***Name:***	Andy Barnes
		MCERTS No:	MM 03 235
		Signature:	
Date:	17/08/2023	***Date:***	21/08/2023

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".

This report has been prepared by Environmental Compliance Limited (ECL) in their professional capacity as Environmental Consultants. The contents of the report reflect the conditions that prevailed and the information available or supplied at the time of its preparation. The report, and the information contained therein, is provided by ECL solely for use and reliance by the Client in performance of ECLs duties and liabilities under its contract with the Client. Until ECL has received payment in full as detailed in the quotation or contract the contents of this report remain the legal property of ECL. The contents of the report do not, in any way, purport to include any manner of legal advice or opinion.

Any operating information and CEMS data used in this report has been supplied by the client.

This report should not be reproduced, (except in full) without the written approval of the laboratory.

Should the Client wish to release this report to a Third Party for the party's reliance, Environmental Compliance Ltd may, at its discretion, agree to such release provided that:

- Environmental Compliance Ltd gives written agreement prior to such release and ECL has received payment in full for all works/services undertaken;
- By release of the report to the Third Party, that Third Party does not acquire any rights, contractual or otherwise, whatsoever against Environmental Compliance Ltd and, accordingly, Environmental Compliance Ltd assume no duties, liabilities or obligations to that Third Party;
- Environmental Compliance Ltd accepts no responsibility for any loss or damage incurred by the Client or for any conflict of Environmental Compliance Ltd interests arising out of the Clients' release of this report to the Third Party.

In the event that a report is revised and re-issued, the client shall ensure that any earlier versions of the report, and any copies thereof, are void and such copies should be marked with the words "superseded and revised".

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.

TABLE OF CONTENTS

PART 1 - EXECUTIVE SUMMARY

1 Monitoring Objectives

Environmental Compliance Ltd (ECL) was commissioned by **Western Bio-Energy Ltd.** to undertake an emission monitoring survey at their **Margam, Port Talbot** facility. This report presents the findings of the study.

The monitoring at this installation was carried out in accordance with our quotation reference **DHFB/P5520/Q002**, 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
	Biomass Plant (Main Stack)
Velocity / Flowrate	● U
Particulates	● U
Oxides of Nitrogen (as NO_2)	● U
Sulphur Dioxide	● U
Carbon Monoxide	● U
Oxygen	● U
Total Organic Carbon (TVOC)	● U
Hydrogen Chloride	● U
Hydrogen Fluoride	● U
Chlorinated Dioxins / Furans (PCDDs & PCDFs)	● U
Heavy Metals (Cd, Tl, Sb, As, Pb, Cr, Co, Cu, Mn, Ni & V)	● U
Mercury	● U
Nitrous Oxide (N_2O)	● U
Ammonia	● 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.**

Special Requirements: Normal operating conditions

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 Claimed For Test Result	Tick if non-conforming test (see Section 2	Operating Status
A1 Main Stack	Volumetric Flowrate	...	44.34869	m^3/sec	3	Stack Conditions	17/07/2023	10:43 – 11:06	BS EN 16911-1:2013 & MID	UKAS / MCERTS		Normal
	Volumetric Flowrate	...	23.31804	m^3/sec	6	Dry & 6% O2	17/07/2023	10:43 – 11:06	BS EN 16911-1:2013 & MID	UKAS / MCERTS		Normal
	Particulates $	15	1.93	mg/m^3	33	Dry & 6% O2	19/07/2023	09:00 – 10:02	BS EN 13284-1:2017 & MID	UKAS / MCERTS		Normal
	Hydrogen Chloride $	...	41.77	mg/m^3	14	Dry & 6% O2	19/07/2023	09:00 – 10:02	BS EN 1911:2010	UKAS / MCERTS		Normal
	Hydrogen Fluoride $	...	0.06	mg/m^3	14	Dry & 6% O2	19/07/2023	09:00 – 10:02	PD CEN/TS 17340:2020	UKAS / MCERTS		Normal
	Ammonia $	10	2.05	mg/m^3	13	Dry & 6% O2	19/07/2023	14:10 – 15:10	BS EN ISO 21877:2019	UKAS / MCERTS		Normal
	Sulphur Dioxide $	...	47.85	mg/m^3	14	Dry & 6% O2	17/07/2023	11:30 – 15:30	BS EN 14791:2017	UKAS / MCERTS		Normal
	PCDDs & PCDFs $	...	0.013	ng/m^3	12	Dry & 6% O2	18/07/2023	08:45 – 14:50	BS EN 1948-1:2006 & MID	UKAS / MCERTS		Normal
	Heavy Metals * $	...	0.030	mg/m^3	4	Dry & 6% O2	19/07/2023	10:45 – 11:47	BS EN 14385:2004 & MID	UKAS / MCERTS		Normal
	Cadmium / Thallium $	...	0.0013	mg/m^3	5	Dry & 6% O2	19/07/2023	10:45 – 11:47	BS EN 14385:2004 & MID	UKAS / MCERTS		Normal
	Mercury $	...	0.00067	mg/m^3	11	Dry & 6% O2	19/07/2023	12:35 – 13:37	BS EN 13211:2001	UKAS / MCERTS		Normal
	TVOC as Carbon	...	0.53	mgC/m^3	4	Dry & 6% O2	18/07/2023	11:55 – 12:55	BS EN 12619:2013	UKAS / MCERTS		Normal
	Oxides of Nitrogen (as NO_2)	300	294.94	mg/m^3	3	Dry & 6% O2	17/07/2023	12:10 – 13:10	BS EN 14792: 2017	UKAS / MCERTS		Normal
	Carbon Monoxide	250	141.08	mg/m^3	3	Dry & 6% O2	17/07/2023	12:10 – 13:10	BS EN 15058: 2017	UKAS / MCERTS		Normal
	Oxygen (Paramagnetic)	...	6.48	%	2	Dry Gas	17/07/2023	12:10 – 13:10	BS EN 14789: 2017	UKAS / MCERTS		Normal
	Nitrous Oxide (N_2O)	...	0.63	mg/m^3	9	Dry & 6% O2	19/07/2023	14:10 – 15:10	PD CEN/TS 17337:2019	UKAS / MCERTS		Normal

(* Sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni & V)

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.

Western Bio-Energy Ltd.		**Installation Name**	**: Biomass Plant**
Permit No	**: EPR/ZP3939GL**	**Visit Details**	**: Compliance July 2023**
Variation No	**: V005**	**Survey Dates**	**: 17th to 19th July 2023**
Report Ref	**: P5520 : R004**	**Report Issue Date**	**: 21st August 2023**

Notes

The uncertainty figures presented in Table 1.1 for NO_x, CO, O_2 & TVOC are "measurement uncertainty" figures, which do not take into account the variability of the measured sample values. The "uncertainty of measurement results" figures, which do include this contribution, are presented in the appendices of the report for these determinands.

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

Any operating information and CEMS data below has been supplied by the client.

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
Biomass Plant	Continuous	Continuous	Wood Chip & Natural Gas	...	Bag Filters	Normal	...	...	...	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/ZP3939GL** where UKAS and MCERTS accreditation has and could be claimed for the testing in the monitoring results table.

There were modifications to the sampling procedures (TPDs) listed in section 4, these are as follows:

The concentration of the span check gas used for FTIR sampling of N_2O has not been verified by analysis accredited to ISO 17025 with uncertainty <2%. Such analysis is not currently available. A gravimetrically prepared mixture was used instead. This deviation from the procedure has been sanctioned by the Environment Agency, until 17025 accredited gas does become available.

Due to high duct gas velocity, in order to maintain isokinetic sampling, it was necessary to use a nozzle with diameter smaller than the recommended minimum of 8mm minimum stated in BS EN 13284-1:2017. Note that there is no absolute minimum nozzle size stated in the standard, as long as the uncertainty of the nozzle area is <5%. **So this does not need to be described as a non-conforming test.**

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

Non-conforming tests are as follows:

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

The following tests appears to fail efficiency checks (>5% in final impinger): **A1 – HF.** For HF, the concentration in the final impinger was very low (at or below the analytical LOD/ blank value), so the efficiency check is not required.

Homogeneity tests have not been completed for pollutants at the following locations: **A1 Main Stack.** Such tests 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
Peter Brockway	17th to 19th July 2023	MM 17 1459	2	TE1, TE2, TE3, TE4
Llion Preskett Hughes		MM 22 1689	1	…

Report Reviewer

Name	MCERTS No.	LEVEL	Technical Endorsements
Andy Barnes	MM 03 235	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

Details of the substances monitored, the standard methods used and the Environmental Compliance Limited Technical Procedures used during this survey are shown in the table below. Detailed sampling protocols are included in a separate document which will be sent with the report.

In all cases, where analysis of collected samples was required, the analysis was by a subcontract laboratory. Details of the sub-contract laboratory are shown on the analysis certificates in this report. The UKAS/MCERTs accreditation status of the analysis is also indicated on the certificates.

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

Determinand	External Reference Method	ECL Technical Procedure Number
Velocity and Flowrate	BS EN 16911-1:2013 & MID	ECL/ TPD/ 022A
Particulates (MST)	BS EN 13284-1:2017 & MID	ECL / TPD / 027
Metals (without mercury)	BS EN 14385:2004 & MID	ECL / TPD / 028
Mercury (without other metals)	BS EN 13211:2001	ECL / TPD / 030
PCDDs & PCDFs	BS EN 1948-1 to 3:2006 & MID	ECL / TPD / 031
TVOC (Signal 3030PM)	BS EN 12619: 2013	ECL / TPD / 032A
Oxygen (PG350 E /EU)	BS EN 14789: 2017	ECL / TPD / 033D
Carbon Monoxide (PG350E)	BS EN 15058: 2017	ECL / TPD / 033D
Oxides of Nitrogen (PG350 E)	BS EN 14792: 2017	ECL / TPD / 033D
Hydrogen Chloride	BS EN 1911:2010	ECL / TPD / 081
Ammonia	BS EN ISO 21877:2019	ECL / TPD / 034
Sulphur Dioxide	BS EN 14791:2017	ECL / TPD / 039
Moisture	BS EN 14790: 2017	ECL / TPD / 082
Hydrogen Fluoride	PD CEN/TS 17340:2020	ECL / TPD / 081
Nitrous Oxide (N_2O) (FTIR 204M)	PD CEN/TS 17337:2019	ECL / TPD / 097

5 SAMPLE POINT DESCRIPTIONS

The homogeneity test is applicable to combustion processes, but may also be requested by the regulator for non-combustion processes.

Homogeneity testing has not been completed at this location.

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

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

The sample location that was monitored is detailed below:

Biomass Plant – Main Stack

The stack diameter is 1.60m and the sample platform width back from the sample ports is 3.0m.

Two sample ports are located on the stack at 90 degrees to each other and are located on the same plane.

These sample ports are located at a height of approximately 0.70m from the working sample platform.

Sampling for Particulates was carried out using an out-of-stack filter system.

Access to the sample platform was attained by means of hooped ladder accessed on the outside of the chimney.

EQUIPMENT IDs
(Pre site checklist from SSP)

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

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	U001							
MST Nozzle set		335							
MST "S" Type Pitot		602							
MST Probe		405	145						
MST Hot Box		192							
MST Impinger Arm		660							
Barometer		1320							
Site Balance		1225							
Site Check weights		1226							
		1227							
Horiba	E002	1065							
Heated Probe / Filter		921							
Chiller		1345							
MFC									
Heated Line		303	302						
FID	E003	211							
Heated Line		1184	1185						
Heated Probe / Filter		1190							
Testo	E004								
FTIR	E005	566							
Heated Probe / Filter		1190							
Heated Line		1184	1185						
Stackmite	E006								
"L" Type Pitot									
Digital Manometer									
Stack Thermocouple									
Thermocouple Reader									
Nozzle Set									
Workhorse Pumps	E007								
Stack Thermocouple									
Tube Thermocouple									
Meter Thermocouple									
High Vac Gauge									
Dioxin Thermocouple		939							

Quantity of Ice Required / Used for Survey	25	Bags (2kg bags)

FIGURES

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

Figure 1 - TVOC

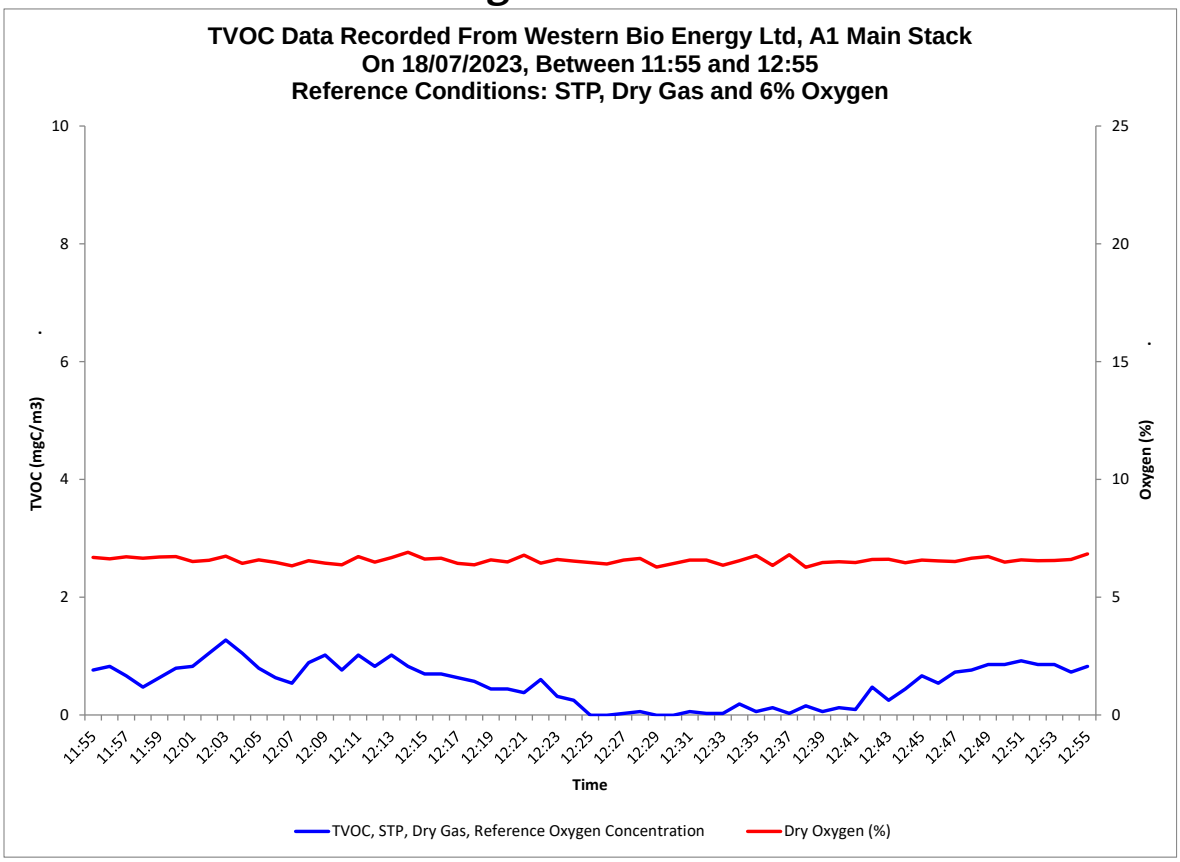


Figure 2 – Combustion Gases

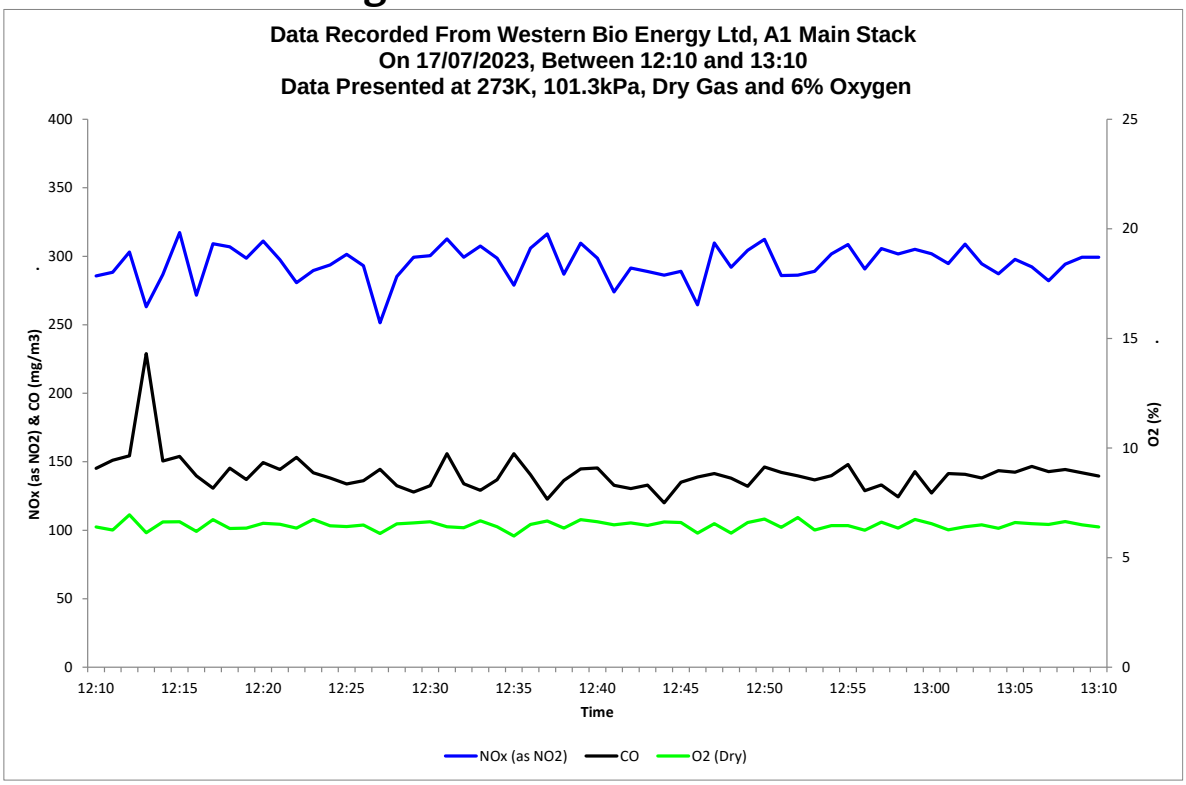
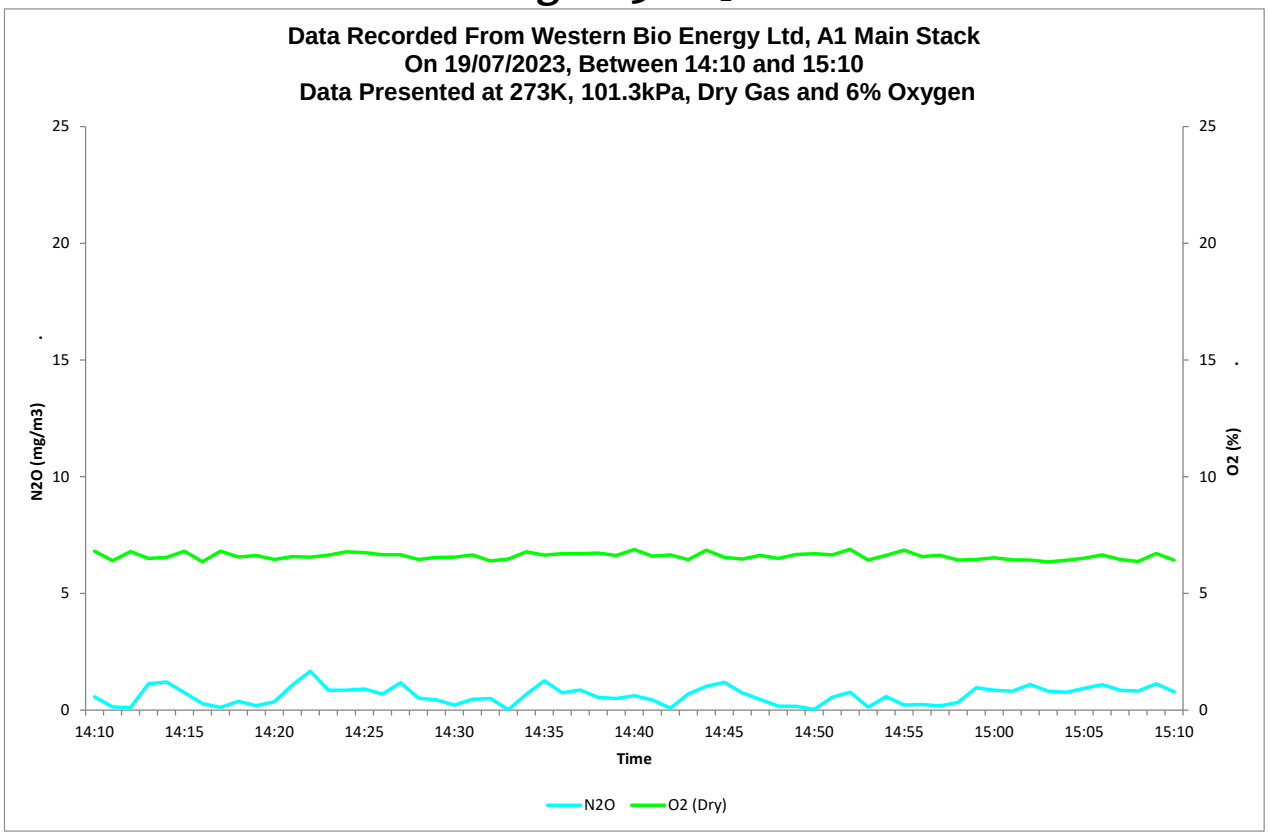


Figure 3 – N_2O


Data Recorded From Western Bio Energy Ltd, A1 Main Stack
On 19/07/2023, Between 14:10 and 15:10
Data Presented at 273K, 101.3kPa, Dry Gas and 6% Oxygen
N2O (mg/m3)
O2 (%)
25
20
15
10
5
0
14:10
14:15
14:20
14:25
14:30
14:35
14:40
14:45
14:50
14:55
15:00
15:05
15:10
Time
N2O
O2 (Dry)

TABLES

Table 1 – TVOC

Data Recorded from Biomass Plant (Main Stack)

Sample Period: 11:55 - 12:55 on the 18th July 2023

Volumetric Flowrate (Reference Conditions) = 23.31804 m³/sec *

	Average	Emission Rate
	mg/m³	Kg/hr
TVOC (as carbon) *	0.53	0.045

*** Reference Conditions (273K, 101.3 kPa, 6% Oxygen & Dry Gas)**

Table 2 – Combustion Gases

Data Recorded from Biomass Plant (Main Stack)

Sample Period: 12:10 - 13:10 on the 17th July 2023

Volumetric Flowrate (Reference Conditions) = 23.31804 m³/sec *

	Average	Emission Rate
	mg/m³	Kg/hr
Oxides of Nitrogen (as NO_2) *	294.94	24.76
Carbon Monoxide *	141.08	11.84
Oxygen (%)	6.48	...

*** Reference Conditions (273K, 101.3 kPa, 6% Oxygen & Dry Gas)**

Table 3 – Nitrous Oxide

Data Recorded from Biomass Plant (Main Stack)

Sample Period: 14:10 - 15:10 on the 19th July 2023

Volumetric Flowrate (Reference Conditions) = 23.31804 m³/sec *

	Average	Emission Rate
	mg/m³	Kg/hr
Nitrous Oxide (N_2O)	0.63	0.053

*** Reference Conditions (273K, 101.3 kPa, 6% Oxygen & Dry Gas)**

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Table 4 – Particulates, Hydrogen Chloride & Hydrogen Fluoride

Data Recorded from Main Stack - Biomass Plant

Emission Parameter	Units	TPM 1, HCl & HF	Blank
Stack Diameter	metres	1.60	…
Area of Sample Plane	m^2	2.011	…
Moisture Content	%	19.49	…
Oxygen Content	%	8.17	…
Stack Temperature	^oC	119	…
Gas Velocity (as Measured. Adjusted for Smooth Walls)	m/sec	21.6928	…
Gas Velocity (Reference Conditions)	m/sec*	10.4392	…
Volumetric Flowrate (as Measured)	m^3/sec	43.6159	…
Volumetric Flowrate (Reference Conditions)	m^3/sec*	20.9893	…
Dry Gas Molecular Weight	g/gmole	30.4948	
Sample Date	…	19/07/2023	…
Sample Period	…	09:00 - 10:02	…
Sample Volume (reference Conditions)	m^3*	0.805	0.805
Isokinetic Sampling Rate	%	104.62	…
Sample Reference (ECL ID)	ECL/23/	3928 & 3929	3930 & 3931
Mass of Particulate Matter Collected	mg	1.55	0.60
Concentration of Particulate Matter	mg/m^3*	**1.93**	0.75
Emission Rate of Particulate Matter	g/hr	145.49	...
Expanded Uncertainty (% Relative)	%	33	...
Emission Limit Value (ELV)	mg/m^3*	15	…
Blank Concentration as Percentage of ELV	%	…	4.97
Sample Reference (ECL ID)	ECL/23/	3934/3935	3936
Mass of Hydrogen Chloride Collected	mg	33.62	0.02
Concentration of Hydrogen Chloride	mg/m^3*	**41.77**	0.02
Emission Rate of Hydrogen Chloride	g/hr	3156.13	...
Expanded Uncertainty (% Relative)	%	14	...
Impinger Collection Efficiency	%	100	...
Sample Reference	ECL/23/	3934/3935	3936
Mass of Hydrogen Fluoride Collected	mg	0.05	0.03
Concentration of Hydrogen Fluoride	mg/m^3*	**0.06**	0.03
Emission Rate of Hydrogen Fluoride	g/hr	4.80	...
Expanded Uncertainty (% Relative)	%	14	...
Impinger Collection Efficiency	%	75	...

***Reference Conditions (273K, 101.3kPa, 6% Oxygen, Dry Gas)**

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Table 5 – Ammonia

Data Recorded from Main Stack - A1 - Biomass Plant

Emission Parameter	Units	Ammonia	Blank	
Stack Diameter	metres	1.60		
Area of Sample Plane	m^2	2.011		
Moisture Content	%	19.82		
Oxygen Content	%	6.60		
Stack Temperature	°C	137		
Gas Velocity (as Measured)	m/sec	25.06		
Gas Velocity (Reference Conditions)	m/sec*	12.83		
Volumetric Flowrate (as Measured)	m^3/sec	50.38		
Volumetric Flowrate (Reference Conditions)	m^3/sec*	25.79		
Dry Gas Molecular Weight	g/gmole	30.43180328		
Sample Date	…	19/07/2023		
Sample Period	…	14:10 - 15:10		
Sample Volume (reference Conditions)	m^3*	0.844	0.844	
Sample Reference (ECL ID)	ECL/23/	3938/3939	3940/3941	
Mass of Ammonia Collected	mg	1.73	0.05	
Concentration of Ammonia	mg/m^3*	**2.05**	0.06	
Emission Rate of Ammonia	g/hr	190.62	...	
Expanded Uncertainty (% Relative)	%	13	...	
Emission Limit Value (ELV)	mg/m^3*	10	…	
Impinger Collection Efficiency	%	98	...	(Conc < 30% ELV)
Blank Concentration as Percentage of ELV	%	…	<1.00%	

***Reference Conditions (273K, 101.3kPa, 6% Oxygen, Dry Gas)**

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

Table 6 – Sulphur Dioxide

Data Recorded from A1 - Main Stack

Emission Parameter	Units	SO2 - 1	Blank
Stack Diameter	metres	1.60	
Area of Sample Plane	m^2	2.011	
Moisture Content	%	18.09	
Oxygen Content	%	6.62	
Stack Temperature	^oC	139	
Gas Velocity (as Measured)	m/sec	25.06	
Gas Velocity (Reference Conditions)	m/sec*	13.17	
Volumetric Flowrate (as Measured)	m^3/sec	50.38	
Volumetric Flowrate (Reference Conditions)	m^3/sec*	26.49	
Dry Gas Molecular Weight	g/gmole	30.43290456	
Sample Date	…	17/07/2023	
Sample Period	…	11:30 - 15:30	
Sample Volume (reference Conditions)	m^3*	3.186	3.186
Sample Reference	ECL/23/	3944/3945	3946
Mass of Sulphur Dioxide Collected	mg	152.46	0.10
Concentration of Sulphur Dioxide	mg/m^3*	**47.85**	0.03
Emission Rate of Sulphur Dioxide	g/hr	4562.50	...
Expanded Uncertainty (% Relative)	%	14	...
Impinger Collection Efficiency	%	100	...

***Reference Conditions (273K, 101.3kPa, 6% Oxygen, Dry Gas)**

Table 7a – Dioxins & Furans

Data Recorded from Biomass Plant - Stack Main Stack

Emission Parameter	Units	Chlorinated D & F
Stack Diameter	**metres**	1.6
-	-	-
Area of sample plane	**m^2**	2.011
Moisture Content	**%**	18.22
Moisture Expanded Uncertainty	%(Relative)	5.23
Stack Temperature	**^oC**	139
Oxygen Concentration	**%**	6.57
Gas velocity (as Measured)	**m/sec**	22.2332
Gas velocity (Reference Conditions)	**m/sec***	11.6705
Volumetric Flowrate (as Measured)	**m^3/sec**	44.7025
Volumetric Flowrate (Reference	**m^3/sec***	23.4650
Sample Date	18/07/2023	
Sample Period	08:45 - 14:50	
Sample Reference	ECL/23/3922-3924	
Sample Volume (Reference Conditions)	**m^3 ***	5.11
Isokinetic Sampling Rate	**%**	**99.20**

Species	Sample Reference: ECL/23/3922-3924		Blank Reference: ECL/23/3925-3927	
	Conc. ng/m³*	TEQ ng/m³*	Conc. ng/m³*	TEQ ng/m³*
Chlorinated Dioxins 2,3,7,8 Isomers	**0.19**	**0.0038**	**0.0022**	**0.000071**
Total Chlorinated Dioxins Non – Targeted Isomers	**0.00**	**…**	**0.00**	**…**
Chlorinated Furans 2,3,7,8 Isomers	**0.17**	**0.0093**	**0.00080**	***0.000046***
Total Chlorinated Furans Non – Targeted Isomers	**0.00**	**…**	**0.00**	**…**
TOTAL	**…**	**0.013**	**…**	**0.00012**
Range	**…**	**0.013 - 0.013**	**Blank <10% of ELV?**	**YES**
% Uncertainty	**…**	**12**		

***Reference Conditions 273K, 101.3kPa, 6% Oxygen, Dry Gas. NB: For each congener, where the blank concentration exceeds or equals the measured concentration, the blank value has been substituted. Refer to the table of individual congeners for more detailed information.**

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Table 7b – Dioxins & Furans

Data Recorded from Biomass Plant - Stack Main Stack on the 18/07/23, 08:45 - 14:50

Species	Blank Reference: ECL/23/3925-3927 TEQ ng/m³*	EEC Toxic Equivalent Factor (TEF)	Sample Ref.: ECL/23/3922-3924 Concentration ng/m³*	Sample Ref.: ECL/23/3922-3924 TEQ ng/m³*	WHO Humans & Mammals (TEF)	Humans & Mammals TEQ ng/m³*	WHO Fish (TEF)	Fish TEQ ng/m³*	WHO Birds (TEF)	Birds TEQ ng/m³*
Chlorinated Dioxins - 2,3,7,8 Isomers										
2,3,7,8 - TCDD	0.000033	1	**0.00024**	**0.00024**	1	**0.00024**	1	**0.00024**	1	**0.00024**
1,2,3,7,8 - PCDD	0.000023	0.5	**0.0016**	**0.00080**	1	**0.0016**	1	**0.0016**	1	**0.0016**
1,2,3,4,7,8 - HxCDD	0.000004	0.1	**0.0044**	**0.00044**	0.1	**0.00044**	0.5	**0.0022**	0.05	**0.00022**
1,2,3,6,7,8 - HxCDD	0.000004	0.1	**0.0078**	**0.00078**	0.1	**0.00078**	0.01	**0.000078**	0.01	**0.000078**
1,2,3,7,8,9 - HxCDD	0.000004	0.1	**0.0069**	**0.00069**	0.1	**0.00069**	0.01	**0.000069**	0.1	**0.00069**
1,2,3,4,6,7,8 - HpCDD	0.000000	0.01	**0.074**	**0.00074**	0.01	**0.00074**	0.001	**0.000074**	0.001	**0.000074**
OCDD	0.000002	0.001	**0.094**	**0.000094**	0.0001	**0.000009**	0	**…**	0	**…**
Total Chlorinated Dioxins - Non - Targeted Isomers										
TCDD	…	0	0.000000	…	0	…	0	…	0	…
PCDD	…	0	0.000000	…	0	…	0	…	0	…
HxCDD	…	0	0.000000	…	0	…	0	…	0	…
HpCDD	…	0	0.000000	…	0	…	0	…	0	…
Chlorinated Furans - 2,3,7,8 Isomers										
2,3,7,8 - TCDF	0.000007	0.1	**0.0020**	**0.00020**	0.1	**0.00020**	0.05	**0.000100**	1	**0.0020**
1,2,3,7,8 - PCDF	0.000002	0.05	**0.0039**	**0.00020**	0.05	**0.00020**	0.05	**0.00020**	0.1	**0.00039**
2,3,4,7,8 - PCDF	0.000020	0.5	**0.0075**	**0.0038**	0.5	**0.0038**	0.5	**0.0038**	1	**0.0075**
1,2,3,4,7,8 - HxCDF	0.000003	0.1	**0.011**	**0.0011**	0.1	**0.0011**	0.1	**0.0011**	0.1	**0.0011**
1,2,3,6,7,8 - HxCDF	0.000003	0.1	**0.012**	**0.0012**	0.1	**0.0012**	0.1	**0.0012**	0.1	**0.0012**
2,3,4,6,7,8 - HxCDF	0.000003	0.1	**0.019**	**0.0019**	0.1	**0.0019**	0.1	**0.0019**	0.1	**0.0019**
1,2,3,7,8,9 - HxCDF	0.000003	0.1	**0.00051**	**0.000051**	0.1	**0.000051**	0.1	**0.000051**	0.1	**0.000051**
1,2,3,4,6,7,8 - HpCDF	0.000005	0.01	**0.083**	**0.00083**	0.01	**0.00083**	0.01	**0.00083**	0.01	**0.00083**
1,2,3,4,7,8,9 - HpCDF	0.000000	0.01	**0.0070**	**0.000070**	0.01	**0.000070**	0.01	**0.000070**	0.01	**0.000070**
OCDF	0.000000	0.001	**0.026**	**0.000026**	0.0001	**0.000003**	0.0001	**0.000003**	0.0001	**0.000003**
Total Chlorinated Furans - Non - Targeted Isomers										
TCDF	…	0	0.000000	…	0	…	0	…	0	…
PCDF	…	0	0.000000	…	0	…	0	…	0	…
HxCDF	…	0	0.000000	…	0	…	0	…	0	…
HpCDF	…	0	0.000000	…	0	…	0	…	0	…
TOTAL	**0.00012**	**…**	**…**	**0.013**	**…**	**0.014**	**…**	**0.013**	**…**	**0.018**
Range	**…**	**…**	**…**	**0.013 - 0.013**	**…**	**0.014 - 0.014**	**…**	**0.013 - 0.013**	**…**	**0.018 - 0.018**
% Uncertainty	**…**	**…**	**…**	**12**	**…**	**11**	**…**	**12**	**…**	**15**

***Reference Conditions 273K, 101.3kPa, 6% Oxygen, Dry Gas. NB: For each congener, where the blank concentration exceeds or equals the measured concentration, the blank value has been substituted.This is presented as shaded cells. Where the Limit of Detection applies, concentrations are presented in italics.**

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Table 8a – Heavy Metals

Sampling Location: Biomass Plant Main Stack

Test Heavy Metals					
Stack Profile:	Circular	Units	Gas velocity (as Measured. Adjusted for Smooth Walls):	21.6386	m/sec
Diameter:	1.60	m	Gas velocity (Reference Conditions):	11.7890	m/sec *
			Volumetric Flowrate (as Measured):	43.5070	m^3/sec
Area of sample plane:	2.011	m^2	Volumetric Flowrate (Reference Conditions):	23.7033	m^3/sec *
Moisture Content:	18.99	%	Sample Date:	19/07/2023	
Stack Temperature:	121	°C	Sample Period:	10:45 - 11:47	
Barometric Pressure:	1016	mbar	Sample Volume:	0.969	m^3
Measured Oxygen:	6.49	%	Isokinetic Rate (95% < ISOKx > 115%):	111.67	%

***Reference Conditions: (273K, 101.3kPa, 6% Oxygen, Dry Gas)**

Trace Element	Symbol	Mass (mg)			ECL/23/3948 - 3951 Concentration (mg/m^3)*			Emission Rate (g/hr)*	Uncertainty (%)	ECL/23/3952 - 3955 Blank	
		Particulate Phase	Vapour Phase	Total Element Phase	Particulate Phase	Vapour Phase	Total Element Phase		Total Element Phase	Mass (mg)	Conc. (mg/m^3)
Antimony	Sb	0.00060	0.00016	0.00076	0.00062	0.00016	**0.00078**	**0.067**	13	0.00069	0.00071
Arsenic	As	0.00050	0.00024	0.00074	0.00052	0.00024	**0.00076**	**0.065**	10	0.00063	0.00065
Cadmium	Cd	0.00050	0.00016	0.00066	0.00052	0.00016	**0.00068**	**0.058**	11	0.00059	0.00061
Chromium	Cr	0.0024	0.00049	0.0029	0.0025	0.00051	**0.0030**	**0.25**	11	0.00069	0.00071
Cobalt	Co	0.00050	0.00016	0.00066	0.00052	0.00016	**0.00068**	**0.058**	11	0.00059	0.00061
Copper	Cu	0.0024	0.00076	0.0032	0.0025	0.00078	**0.0033**	**0.28**	10	0.00077	0.00080
Lead	Pb	0.0071	0.0027	0.0098	0.0073	0.0028	**0.010**	**0.86**	11	0.00059	0.00061
Manganese	Mn	0.0025	0.00032	0.0028	0.0026	0.00033	**0.0029**	**0.25**	15	0.00059	0.00061
Nickel	Ni	0.0074	0.00062	0.0080	0.0076	0.00064	**0.0083**	**0.71**	12	0.00073	0.00075
Thallium	Tl	0.00040	0.00016	0.00056	0.00041	0.00016	**0.00057**	**0.049**	12	0.00049	0.00050
Vanadium	V	0.00040	0.000079	0.00048	0.00041	0.000081	**0.00049**	**0.042**	11	0.00044	0.00046
Cadmium & Thallium		0.00090	0.00031	0.0012	0.00093	0.00032	**0.0013**	**0.11**	5	0.0011	0.0011
Antimony, Arsenic, Chromium, Cobalt, Copper, Lead, Manganese, Nickel & Vanadium		0.024	0.0055	0.029	0.025	0.0057	**0.030**	**2.58**	4	0.0057	0.0059

No ELV Entered!

No ELV Entered!

Note: Uncertainty for each metals group is based on the summation in quadrature of the individual standard uncertainties (in mg/m^3) of each contributing metal. Combined standard uncertainty of each group is converted to 95% confidence (multiplication by k = 2) before being expressed as a percentage of the combined group concentration.

Table 8b – Heavy Metals Efficiencies

Metals groups have been selected. Efficiencies will only be displayed for individual elements if the group total concentration is greater than 30% of the associated ELV.

Recovery in the final impinger must be <10% of the total combined element mass (i.e. filter, probe rinse & impingers) to pass - ONLY if the element makes up >1% of the total mass of all metals collected

Trace Element	Symbol	Final Impinger (%)	<10%?	<1% of Total?
Antimony	Sb	6.05	PASS	NO
Arsenic	As	9.34	PASS	NO
Cadmium	Cd	6.97	PASS	NO
Chromium	Cr	1.58	PASS	NO
Cobalt	Co	6.97	PASS	NO
Copper	Cu	2.90	PASS	NO
Lead	Pb	0.47	PASS	NO
Manganese	Mn	1.62	PASS	NO
Nickel	Ni	0.86	PASS	NO
Thallium	Tl	8.22	PASS	NO
Vanadium	V	4.79	PASS	NO

Combined Groups	ELV mg/m^3	Result <30% ELV?
Cadmium & Thallium	0	NO
Antimony, Arsenic, Chromium, Cobalt, Copper, Lead, Manganese, Nickel & Vanadium	0	NO

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Table 9 – Mercury

Sampling Location: Biomass Plant Main Stack

Test Mercury					
Stack Profile:	Circular	Units	Gas velocity (as Measured. Adjusted for Smooth Walls):	22.1940	m/sec
Diameter:	1.60	m	Gas velocity (Reference Conditions):	11.3430	m/sec *
			Volumetric Flowrate (as Measured):	44.6237	m^3/sec
Area of sample plane:	2.011	m^2	Volumetric Flowrate (Reference Conditions):	22.8064	m^3/sec *
Moisture Content:	20.47	%	Sample Date:	19/07/2023	
Stack Temperature:	135	°C	Sample Period:	12:35 - 13:37	
Barometric Pressure:	1016	mbar	Sample Volume:	0.950	m^3
Measured Oxygen:	6.66	%	Isokinetic Rate (95% < ISOKx > 115%):	113.81	%

***Reference Conditions: (273K, 101.3kPa, 6% Oxygen, Dry Gas)**

Trace Element	Symbol	Mass (mg)			ECL/23/3956 - 3959 Concentration (mg/m^3)*			Emission Rate (g/hr)*	Uncertainty (%)	ECL/23/3960 - 3963 Blank	
		Particulate Phase	Vapour Phase	Total Element Phase	Particulate Phase	Vapour Phase	Total Element Phase		Total Element Phase	Mass (mg)	Conc. (mg/m^3)
Mercury	Hg	0.000085	0.00055	0.00063	0.000089	0.00058	**0.00067**	**0.055**	11	0.00031	0.00032

No ELV Entered!

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Table 9b – Mercury Efficiencies

Groups have been selected. Efficiencies will only be displayed for mercury if the concentration is greater than 30% of the associated ELV.

Recovery in the final impinger must be <5% of the total combined element mass in both impingers to pass - ONLY if the final impinger has a concentration greated than 2µg/m^3

Trace Element	Symbol	Final Impinger (%)	<5%?	Final Impinger <2 µg/m^3?
Mercury	Hg	N/A	N/A	YES

Combined Groups	ELV mg/m^3	Result <30% ELV?
Mercury	0	NO

VELOCITY TRAVERSE PROFILES

Environmental Compliance Limited

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Environmental Compliance Limited	Traverse Data Profoma	Date of Measurement	17/07/2023

Company	Western Bio-Energy Limited	Stack Diameter Port A (mm)	1600	Average Stack Diameter (mm)	1600	Pitot tube coefficient	0.83
Site	Margam	Stack Diameter Port B (mm)	1600	Port Length (mm)	210	Pitot Id	602
Location	Biomass Plant	Duct Length Port A (mm)		Average Duct Length (mm) L		Stack Thermocouple ID	456
Stack	Main Stack	Duct Length Port B (mm)		Duct width (mm) B		Stack Temp Reader ID	U001
Job No	P5520	Duct Length Port C (mm)		Barometric Pressure. (mb)	1020	Manometer ID	U001
Operators	PB & LPH	Duct Length Port D (mm)		Ave Static Press. (mm H_2O)	17.00	Barometer ID	1320

Pre - Traverse Checks Carried Out	Time	Pass/ Fail
Pre - Traverse PITOT Visual Inspection	10:38:00	Pass
Pre - Traverse PITOT Leak Check	10:40:00	Pass

Smooth Walls

Static Pressure Readings (mm H_2O)			
Port A	Port B	Port C	Port D
17.00	17.00		

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	70	10:43:00	138.0	138.0	138.0	32.00	32.00	32.00	138.0	32.00	7
A2	234	10:45:00	138.0	138.0	138.0	30.00	30.00	30.00	138.0	30.00	7
A3	473	10:47:00	139.0	139.0	139.0	30.00	30.00	30.00	139.0	30.00	7
A4	1127	10:49:00	139.0	139.0	139.0	30.00	30.00	30.00	139.0	30.00	7
A5	1366	10:51:00	139.0	139.0	138.0	30.00	30.00	30.00	138.7	30.00	8
A6	1530	10:53:00	138.0	138.0	138.0	30.00	30.00	30.00	138.0	30.00	8
B1	70	10:56:00	138.0	138.0	138.0	34.00	34.00	34.00	138.0	34.00	7
B2	234	10:58:00	138.0	137.0	137.0	32.00	32.00	32.00	137.3	32.00	7
B3	473	11:00:00	137.0	137.0	137.0	30.00	30.00	30.00	137.0	30.00	7
B4	127	11:02:00	137.0	138.0	137.0	30.00	30.00	30.00	137.3	30.00	8
B5	1366	11:04:00	138.0	138.0	138.0	30.00	30.00	30.00	138.0	30.00	8
B6	1530	11:06:00	138.0	139.0	139.0	30.00	30.00	30.00	138.7	30.00	8
Blockage Check @ A1 (L-Type Pitot Only)									1657.0	368.0	Total
			Mean			Mean			139.0	34.0	Max
			Difference <5% from Initial ?			Difference <5% from Initial ?			137.0	30.0	Min
									138.1	30.7	Average

Stagnation Check (S-type Pitot Only)	Time	Reading
Static Pressure Via Positive Leg (mm H_2O)	11:09:00	17.00
Static Pressure Via Negative Leg (mm H_2O)	11:11:00	17.00
Difference (Pa) < 1 mm H_20 ?		0.00

Post - Traverse Checks Carried Out	Time	Pass/ Fail
Post - Traverse PITOT Visual Inspection	11:13:00	Pass
Post - Traverse PITOT Leak Check	11:15:00	Pass

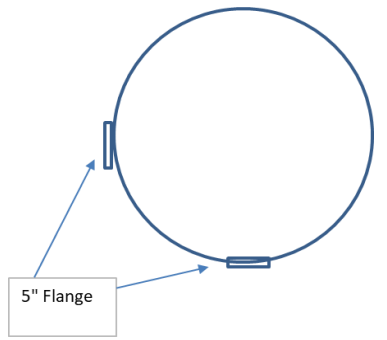
Average temp (K)	411.083

Suitability of Sampling Position	Actual Stack Conditions
Highest:lowest flow pressure ratio < 9:1?	1.13:1
Maximum deviation of flow from axis <15^o ?	8
X-sectional area for stacks= πr2	2.01 m^2
X-sectional area for ducts = L x B	m^2
Suitability of Position for Sampling	OK

Stack Moisture	18.09	%	Gas Velocity (as Measured) Adjusted for Smooth Walls	22.05723	m/sec
Measured Oxygen	6.62	%	Gas Velocity (Reference Conditions) Adjusted for Smooth Walls	11.59744	m/sec*
Measured Carbon Dioxide	13.55	%	Volumetric Flowrate (as Measured) Adjusted for Smooth Walls	44.34869	m^3/sec
Dry Gas Molecular Weight	30.43280	g/g mole	Volumetric Flowrate (Ref Cond) Adjusted for Smooth Walls	23.31804	m^3/sec*

*Reference Conditions: 273K, 101.3kPa, 6% Oxygen, Dry 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	0.7m
Number of sample ports	2
Width of platform (port back to handrail)	3.0m

Nearest downstream disturbance	Exit	15m
Nearest upstream disturbance	Bend	>5m

Disturbances are classed as bends, fans or diameter variations

FIELD CALIBRATION AND SAMPLING DATA

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

TVOC Field Data Sheet – 18/07/2023

TVOC - FIELD DATA SHEET

Client	Western Bio-Energy Limited
Site	Margam
Date	18/07/2023
Location	Biomass Plant
Stack ID	Main Stack
Stack Temp °C	140
Ambient Temp (sampling)	1= 15 2= 16 3= 15
Ambient Temp (sampling)	4= 15 5= 15 6= 15
Job No	P5520
Operators	PB & LPH

Barometric Pressure mb	1018	
Barometer ID	1320	
Analyser ID	ECL/ID/211	
Sonimix/ MFC ID	ECL/ID/…	
Heated Line/ Controller ID	ECL/ID/ 1184/1185	
Heated Line Set Temp °C	180	YES
Heated Line Length	30	m
Heated Probe Filter ID	ECL/ID/ 1190	
Heated Filter Set Temp °C	180	YES
Logger ID	928	

Calibration Gas Details

Calibration Gas	Gas Bottle ID	Gas Value	Uncertainty of Gas (k=2)
Zero Gas (Synthetic Air)	Gas/ 2914	…	…
Hydrogen / Helium	Gas/ 2889	…	…
Propane (In Air)	Gas/ 2923	91.85 ppm	1%

	Analyser Range	Span Gas value used
Propane	100 ppm	91.85 ppm

Analyser Range should be not less than the expected peak emissions.

Span Gas Values should be **either** *approximately the half-hourly ELV* **OR** ***50%*** *to* ***90%*** *of the Selected Analyser Range.*

	Direct Calibration (Rear of Analyser)					
	Zero Cal		Span Gas Cal		Zero Check	
	Start Time	End Time	Start Time	End Time	Start Time	End Time
ZERO /SPAN/ ZERO	11:23	11:25	11:29	11:31	11:33	11:35

NOTE: RESPONSE TIME

Response Time to be carried out at the same time as "Span Check" on system verification (via the sample probe)
Start Time = when gas turned on. 90% Time = when analyser displays 90% of span gas value used. Response must be within 200 seconds.

Pre-Cal Ambient Temp °C		PRE System Verification Check (Down Line)			
Max	Min	Zero Check		Span Check	
		Start Time	End Time	Start Time	End Time
16	15				
ZERO / SPAN		11:39	11:41	11:45	11:47

Response Time SYSTEM Span Gas Cal		
Start Time	90% Time	less than 200s (Y/N)
11:44:00	11:44:25	Y

	Start Time	End Time	Location	Production Details
Sample Period	11:55	12:55	Main Stack	Normal
Sample Period				
Sample Period				
Sample Period				
Sample Period				
Sample Period				

Post-Cal Ambient Temp °C		POST System Verification Check (Down Line)			
Max	Min	Zero Check		Span Check	
		Start Time	End Time	Start Time	End Time
16	15				
ZERO / SPAN		13:01	13:03	13:07	13:09

Process Details / Comments

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

TVOC Calibration Summary – 18/07/2023

Calibration Summary		TVOC ppm
Analyser Range		100
Repeatability at Zero		2
Span Gas Concentration Applied		91.85
Zero Gas Concentration Applied		0
Direct Cal	Zero	0.00
	Span	91.9
	Zero	0.07
Difference (Zero)		0.0725
< 2× Repeatability @ Zero?		YES
Pre Test (System)	Zero	-0.05
	Span	90.1
Difference (Zero)		0.0486
< 2% Relative to Direct Span		YES
Difference (Span)		1.7989
< 2% Relative to Direct Span		YES
Post Test (System)	Zero	-0.20
	Span	89.4
Difference (Zero)		0.1510
Zero Drift < 2% of Applied Span?		YES
Difference (Span)		0.6664
Span Drift < 2% of Applied Span?		YES
Zero and Span Drift < 5% of Applied Span?		YES

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Combustion Gases Calibration Summary – 17/07/2023

	Horiba PG 350 E Ranges:		
	NO as NO_2	CO	O_2
Units	512.5 mg/m^3	625 mg/m^3	25 %Vol
	Zero Values (Direct)		
Mean Initial Direct Zero	-0.01	-0.39	-0.01
Mean Confirmation Direct Zero	-0.02	-0.82	-0.03
Difference in Direct Zero	0.01	0.43	0.01
Repeatability at Zero	4.10	2.50	0.20
<2 x Repeatability at Zero?	YES	YES	YES
	Pre Zero Values (System)		
Mean Pre Test Zero	0.05	1.08	0.11
% of Measurement Range?	0.01%	0.17%	0.43%
Detection Limit (LOD)	0.23	0.65	0.20
	Applied Span:		
	NO	CO	O_2
Actual Applied Span Concentration	315.50	365.75	15.12
	Pre Test System Zero Values		
Mean Pre Test System Zero	0.05	1.08	0.11
Difference ≤ ± 2% of Span Value?	0.02%	0.30%	0.71%
	Post Test Direct Zero Values		
Mean Post Test Direct Zero	0.02	0.22	-0.07
% of Certified Range?	0.00%	0.03%	-0.28%
Zero Drift ≤ ± 5% of Applied Span?	0.01%	0.17%	0.37%
	Pre Test System Span Values		
Mean Pre Test System Span	311.58	358.97	15.12
Difference ≤ ± 2% of Span Value ?	1.24%	1.85%	0.02%
	Post Test Direct Span Values		
Mean Post Test Direct Span	310.18	358.98	15.09
Span Drift ≤ ± 5% Span Value?	1.69%	1.85%	0.22%

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

Oxygen Calibration Summary – 18/07/2023

	Horiba PG 350 E Ranges:
	O_2
	25
Units	%Vol
	Zero Values (Direct)
Mean Initial Direct Zero	-0.01
Mean Confirmation Direct Zero	-0.03
Difference in Direct Zero	0.01
Repeatability at Zero	0.20
<2 x Repeatability at Zero?	YES
	Pre Zero Values (System)
Mean Pre Test Zero	0.11
% of Measurement Range?	0.43%
Detection Limit (LOD)	0.20
	Applied Span:
	O_2
Actual Applied Span Concentration	15.12
	Pre Test System Zero Values
Mean Pre Test System Zero	0.11
Difference ≤ ± 2% of Span Value?	0.71%
	Post Test Direct Zero Values
Mean Post Test Direct Zero	-0.01
% of Certified Range?	-0.05%
Zero Drift ≤ ± 5% of Applied Span?	0.00%
	Pre Test System Span Values
Mean Pre Test System Span	15.12
Difference ≤ ± 2% of Span Value ?	0.02%
	Post Test Direct Span Values
Mean Post Test Direct Span	15.10
Span Drift ≤ ± 5% Span Value?	0.15%

Western Bio-Energy Ltd.			Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL		Visit Details	: Compliance July 2023
Variation No	: V005		Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520	: R004	Report Issue Date	: 21st August 2023

Oxygen Calibration Summary – 19/07/2023

	Horiba PG 350 E Ranges:
	O_2
	25
Units	%Vol
	Zero Values (Direct)
Mean Initial Direct Zero	-0.01
Mean Confirmation Direct Zero	-0.03
Difference in Direct Zero	0.01
Repeatability at Zero	0.20
<2 x Repeatability at Zero?	YES
	Pre Zero Values (System)
Mean Pre Test Zero	0.11
% of Measurement Range?	0.43%
Detection Limit (LOD)	0.20
	Applied Span:
	O_2
Actual Applied Span Concentration	15.12
	Pre Test System Zero Values
Mean Pre Test System Zero	0.11
Difference ≤ ± 2% of Span Value?	0.71%
	Post Test Direct Zero Values
Mean Post Test Direct Zero	-0.03
% of Certified Range?	-0.13%
Zero Drift ≤ ± 5% of Applied Span?	0.13%
	Pre Test System Span Values
Mean Pre Test System Span	15.12
Difference ≤ ± 2% of Span Value ?	0.02%
	Post Test Direct Span Values
Mean Post Test Direct Span	15.07
Span Drift ≤ ± 5% Span Value?	0.31%

Western Bio-Energy Ltd.			Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL		Visit Details	: Compliance July 2023
Variation No	: V005		Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520	: R004	Report Issue Date	: 21st August 2023

N2O Calibration Summary – 19/07/2023

	Certified Ranges:
	N_2O
Upper Limit of Certified Range	39
Units	mg/m^3
	Pre System Zero Values
Mean Pre Test Zero	0.04
% of Certified Range?	0.11%
Detection Limit (LOD)	0.01
LOD as % of Range (Maximum Allowed 2%)	0.02
	Post System Zero Values
Mean Post Test Zero	0.10
% of Certified Range?	0.26%
	0.17%

	Applied Span:
	N_2O
Actual Applied Span Concentration	34.30
	Pre System Span Values
Mean Pre Test Span	33.41
Difference ≤ ± 5% Applied Concentration?	2.60%
Losses Due to Sampling System ≤ 5%?	n/a
	Post System Span Values
Mean Post Test Span	33.02
Span Drift ≤ ± 5% Span Value?	1.16%

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

Particulates, Hydrogen Chloride & Hydrogen Fluoride

Environmental Compliance Limited	PARTICULATE DATA SAMPLING PROFORMA	Date of Measurement	19/07/2023
ECL/TPD/ 027 & 081	Time taken to change Ports? 2	Start Time 09:00	End Time 10:02
		Test Duration 60 mins	

Client	Western Bio-Energy Limited	Stack Profile	Circular	Console id	U001	Barometer id	1320
Site	Margam	Stack Area (m^2)	2.01	Pump id	U001	Nozzle Id	335
Location	Biomass Plant	Barometric Pressure (mb)	1016	Probe id	405	Nozzle size	5.09
Stack ID	Main Stack	Static Pres. (mm H_20)	17	DGM Yd	1.032	Filter Id	4346 255767
Test No.	TPM 1, HCl & HF	Pitot coefficient	0.83	ΔH@	37.32	Pitot ID	6.02
Job No	P5520	Probe Heater Setting (^OC)	160	Impinger Id	660	Hot Box ID	192
ECL Site Staff	PB & LPH	Hot Box Setting (^OC)	160	Balance Id	1225		

IF SAMPLING FOR PARTICULATES NO LEAK CHECKS ARE ALLOWED AFTER SAMPLING HAS STARTED (NOT EVEN IF TRAIN IS BROKEN DOWN)
'OR OTHER SAMPLING (WITHOUT PARTICULATES) LEAK CHECKS ARE ALLOWED AFTER SAMPLING HAS STARTED (BUT ARE NOT MANDATORY

Silica <50% Spent at End of Test? YES

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	714207.8						
Final Volume	715194.6						
Total Volume	986.8	0.0	0.0	0.0	0.0	0.0	986.8

Original K Factor Settings	
Meter Temp.	30
Stack Temp	140
%Moisture	20.00

Leak Check	First	Second	Third	Fourth	Fifth
Leak rate l/min	0.2				
Vaccum "Hg	6				
Time of Check	08:50				
Set Rate l/min	18				
Leak <2%?	YES				

Dry O_2 (☐ Atmospheric)	8.17	K factor	0.7
Dry Carbon Dioxide %	13.55	Reference Oxygen Percentage	6

Smooth Walls

Traverse Point	A1	A2	A3	A4	A5	A6	B1	B2	Total
Time/Point (mins)	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	30 - 35	35 - 40	
ΔP (mm H20)	32.00	32.00	30.00	30.00	30.00	30.00	34.00	32.00	31.25
K factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
ΔH (Orifice)	22.40	22.40	21.00	21.00	21.00	21.00	23.80	22.40	21.88
Meter (Tm in)	23.00	24.00	25.00	26.00	26.00	27.00	27.00	28.00	25.75
Meter (Tm out)	17.00	18.00	19.00	20.00	21.00	21.00	22.00	22.00	20.00
Stack Temp (Ts)	118.00	118.00	118.00	118.00	119.00	119.00	119.00	119.00	118.50
Impinger T Outlet	5.00	5.00	5.00	6.00	6.00	6.00	7.00	7.00	5.88
Vaccum (" Hg)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Traverse Point	B3	B4	B5	B6					Total
Time/Point(mins)	40 - 45	45 - 50	50 - 55	55 - 60					
ΔP (mm H20)	30.00	30.00	30.00	30.00					30.00
K factor	0.70	0.70	0.70	0.70					
ΔH (Orifice)	21.00	21.00	21.00	21.00					21.00
Meter (Tm in)	28.00	29.00	29.00	29.00					28.75
Meter (Tm out)	22.00	23.00	23.00	23.00					22.75
Stack Temp (Ts)	120.00	120.00	119.00	120.00					119.75
Impinger T Outlet	8.00	9.00	10.00	12.00					9.75
Vaccum (" Hg)	3.00	3.00	3.00	3.00					3.00

Traverse Point									Total
Time/Point(mins)									
ΔP (mm H20)									
K factor									
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)									
K factor									
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	Di H2O	Di H2O	Di H2O	Empty	Silica			
SOL/	4960	4960	4960					
Start Weight (g)	613.6	623.6	616.3	481.5	788.5			
End Weight (g)	730.3	678.4	620.5	484.2	793.2			
Total weight (g)	116.7	54.8	4.2	2.7	4.7	0	0	0

Total (g) 183.10

Rinse Solutions used	
Solution	SOL NO
DI Water	4960
Acetone	4827

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.

Additional Moisture Weighings

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

PRE-Sample PITOT Visual Inspection	
Time	08:46
Pass ? (Y/N)	Y

PRE-Sample PITOT Leak Check	
Time	08:48
Pass ? (Y/N)	Y

Post-Sample Blockage Check (L-type)	
Time	
Reading (mm H_2O)	
Pass (<5%) ?	

POST-Sample PITOT Visual Inspection	
Time	10:04
Pass ? (Y/N)	Y

POST-Sample PITOT Leak Check	
Time	10:06
Pass ? (Y/N)	Y

Ammonia

Environmental Compliance Limited	NON ISOKINETIC SAMPLING PROFORMA	Date of Measurement	19/07/2023
ECL/TPD/ 034	Time taken to change Ports? 0	Start Time 14:10	End Time 15:10
		Test Duration 60 mins	

If moisture was not measured see detailed notes below.

Client	Western Bio-Energy Limitied	Stack Profile	Circular	Console id	U001	Barometer id	1320
Site	Margam	Stack Area (m^2)	2.01	Pump id	U001	Nozzle Id	n/a
Location	Biomass Plant	Barometric Pressure (mb)	1016	Probe id	145	Nozzle size	n/a
Stack ID	Main Stack - A1	Static Pres. (mm H_20)	17	DGM Yd	1.032	Filter Id	UW QMA
Test No.	Ammonia	Pitot coefficient	n/a	ΔH@	37.32	Pitot ID	n/a
Job No	P5520	Probe Heater Setting (^OC)	160	Impinger Id	660	Hot Box ID	192
ECL Site Staff	PB & LPH	Hot Box Setting (^OC)	160	Balance Id	1225		

For all parameters a leak check is OPTIONAL at the end of the test.
(and when moving between sample ports if any disconnections are required).

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	719886.8						
Final Volume	720819.8						
Total Volume	933.0	0.0	0.0	0.0	0.0	0.0	933.0

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

Leak Check	First	Second	Third	Fourth	Fifth
Leak rate l/min	0.2				
Vaccum "Hg	8				
Time of Check	14:05				
Set Rate l/min	15				
Leak <2%?	YES				

Dry O_2 (☐ Atmospheric)	6.60		
Dry Carbon Dioxide %	13.55	Reference Oxygen Percentage	6
Dry Carbon Monoxide ppm			

Traverse Point	A2	A2	A2	A2	A2	A2			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)	25.00	25.00	25.00	25.00	25.00	25.00			25.00
Meter (Tm in)	27.00	28.00	29.00	30.00	30.00	30.00			29.00
Meter (Tm out)	24.00	25.00	26.00	27.00	27.00	27.00			26.00
Stack Temp (Ts)	136.00	136.00	137.00	137.00	137.00	138.00			136.83
Impinger T Outlet	10.00	10.00	11.00	13.00	15.00	16.00			12.50
Vaccum (" Hg)	3.00	3.00	3.00	3.00	3.00	3.00			3.00

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	0.1N H2SO4	0.1N H2SO4	0.1N H2SO4	Empty	Silica			
SOL/	4959	4959	4959	...	...			
Start Weight (g)	628.8	635.9	622.5	476.8	783.4			
End Weight (g)	724.5	688.1	635.8	481.1	792.6			
Total weight (g)	95.7	52.2	13.3	4.3	9.2	0	0	0

Total (g) 174.70

Silica <50% used at End of Test? Y/N: YES

Rinse Solutions used	
Solution	SOL NO
DI Water	4960
Acetone	

Additional Moisture Weighings

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

Sulphur Dioxide

Environmental Compliance Limited	NON ISOKINETIC SAMPLING PROFORMA	Date of Measurement	17/07/2023

If moisture was not measured see detailed notes below.

ECL/TPD/	039	Time taken to change Ports?	0	Start Time	11:30	End Time	15:30
				Test Duration	240	mins	

Client	Western BioEnergy Limited	Stack Profile	Circular	Console id	U001	Barometer id	1320
Site	Margam	Stack Area (m^2)	2.01	Pump id	U001	Nozzle Id	n/a
Location	Main Stack	Barometric Pressure (mb)	1020	Probe id	145	Nozzle size	n/a
Stack ID	A1	Static Pres. (mm H_20)	17	DGM Yd	1.032	Filter Id	UW QMA
Test No.	SO2 - 1	Pitot coefficient	n/a	ΔH@	37.32	Pitot ID	n/a
Job No	P5520	Probe Heater Setting (^oC)	160	Impinger Id	660	Hot Box ID	192
ECL Site Staff	PB & LPH	Hot Box Setting (^oC)	160	Balance Id	1225		

For all parameters a leak check is OPTIONAL at the end of the test.
(and when moving between sample ports if any disconnections are required).

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	702488.0						
Final Volume	706001.2						
Total Volume	3513.2	0.0	0.0	0.0	0.0	0.0	3513.2

Leak Check	First	Second	Third	Fourth	Fifth
Leak rate l/min	0.2				
Vaccum "Hg	8				
Time of Check	11:25				
Set Rate l/min	15				
Leak <2%?	YES				

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

Dry O_2 (Atmospheric)	6.62	Reference Oxygen Percentage	6
Dry Carbon Dioxide %	13.55		
Dry Carbon Monoxide ppm			

Traverse Point	A2	A2	A2	A2	A2	A2	A2	A2	Total
Time/Point (mins)	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	70 - 80	
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)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Meter (Tm in)	22.00	23.00	24.00	25.00	26.00	27.00	28.00	29.00	25.50
Meter (Tm out)	18.00	19.00	20.00	21.00	22.00	22.00	24.00	25.00	21.38
Stack Temp (Ts)	138.00	138.00	139.00	140.00	140.00	140.00	139.00	138.00	139.00
Impinger T Outlet	12.00	12.00	13.00	14.00	14.00	14.00	15.00	15.00	13.63
Vaccum (" Hg)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Traverse Point	A2	A2	A2	A2	A2	A2	A2	A2	Total
Time/Point(mins)	80 - 90	90 - 100	100 - 110	110 - 120	120 - 130	130 - 140	140 - 150	150 - 160	
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)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Meter (Tm in)	30.00	31.00	31.00	31.00	31.00	31.00	31.00	32.00	31.00
Meter (Tm out)	26.00	27.00	27.00	27.00	27.00	27.00	27.00	28.00	27.00
Stack Temp (Ts)	138.00	138.00	139.00	139.00	140.00	140.00	140.00	139.00	139.13
Impinger T Outlet	12.00	12.00	12.00	14.00	15.00	15.00	12.00	12.00	13.00
Vaccum (" Hg)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Traverse Point	A2	A2	A2	A2	A2	A2	A2	A2	Total
Time/Point(mins)	160 - 170	170 - 180	180 - 190	190 - 200	200 - 210	210 - 220	220 - 230	230 - 240	
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)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Meter (Tm in)	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00
Meter (Tm out)	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00	28.00
Stack Temp (Ts)	138.00	138.00	137.00	138.00	138.00	139.00	139.00	139.00	138.25
Impinger T Outlet	9.00	14.00	15.00	15.00	12.00	12.00	13.00	15.00	13.13
Vaccum (" Hg)	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.88

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	3% H2O2	3% H2O2	3% H2O2	Empty	Silica			
SOL/	4958	4958	4958	...	...			
Start Weight (g)	635.65	629.7	619.1	476.5	762.5			
End Weight (g)	824.2	823.5	778.4	495.3	791.9			
Total weight (g)	188.55	193.8	159.3	18.8	29.4	0	0	0

Total (g)	589.85
Silica <50% used at End of Test? Y/N	YES

Rinse Solutions used	
Solution	SOL NO
DI Water	4960
Acetone	...

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.

Dioxins & Furans

	DIOXIN & FURANS DATA SAMPLING PROFORMA	Date of Measurement	18/07/2023

ECL/TPD/	31	Time taken to change Ports?	5	Start Time	08:45	End Time	14:50
				Sample Time (mins)	360		

Client	Western Bio-Energy Limited	Stack Profile	Circular	Console ID	U001	Barometer ID	1320
Site	Margam	Stack Area (m^2)	2.011	Pump ID	U001	Nozzle ID	335
Location	Biomass Plant	Barometric Pressure (mb)	1018	Probe ID	405	Nozzle size	5.09
Stack ID	Main Stack	Static Pres. (mm H_20)	17	DGM Yd	1.032	Filter ID	ECL/23/3922
Test No.	Chlorinated D & F	Pitot coefficient	0.83	DH@	37.32	Pitot ID	602
Job No	P5520	Probe Heater Setting (°C)	120	Impinger ID	660	Hot Box ID	192
Operators	PB & LPH	Hot Box Setting (°C)	120	Balance ID	1225	XAD Therm ID	939

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	708187.8	710981.5					
Final Volume	713775.2	711017.3					
Total Volume	5587.4	35.8	0.0	0.0	0.0	0.0	5551.6

Leak Check	First	Second	Third	Fourth	Fifth
Leak rate l/min	0.2	0.2	0.2		
Vaccum "Hg	20	20	20		
Time of Check	08:43	11:47	14:52		
Set Rate l/min	18	16	17		
Leak <4%?	YES	YES	YES		

Original K Factor Settings	
Meter Temp.	30
Stack Temp	140
%Moisture	20.00
Silica <50% Spent at End of Test?	Yes
K factor	0.7
Reference Oxygen Percentage	6

Smooth Walls

Dry O_2 (Atmospheric)	6.57
Dry Carbon Dioxide %	13.55

Leak check ALWAYS needs to be performed when moving between sample ports.
Leak check IS ALWAYS required on completion of the sample.

Traverse Point	A1	A1	A2	A2	A3	A3	A4	A4	Total
Time/Point(mins)	0 - 15	15 - 30	30 - 45	45 - 60	60 - 75	75 - 90	90 - 105	105 - 120	
DP (mm H20)	34.0	34.0	32.0	32.0	30.0	30.0	30.0	30.0	31.5
K factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
DH (Orifice)	23.80	23.80	22.40	22.40	21.00	21.00	21.00	21.00	22.1
Meter (Tm in)	21.00	23.00	24.00	25.00	25.00	26.00	26.00	26.00	24.5
Meter (Tm out)	17.00	19.00	20.00	21.00	21.00	22.00	22.00	22.00	20.5
Stack Temp (Ts)	139.00	138.00	138.00	138.00	140.00	140.00	140.00	139.00	139.0
Impinger T Outlet	11.00	12.00	13.00	15.00	11.00	13.00	14.00	14.00	12.9
Vaccum (" Hg)	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.0
XAD Temperature (°C)	4.00	5.00	6.00	6.00	5.00	5.00	5.00	6.00	5.3
Traverse Point	A5	A5	A6	A6	B1	B1	B2	B2	Total
Time/Point(mins)	120 - 135	135 - 150	150 - 165	165 - 180	180 - 195	195 - 210	210 - 225	225 - 240	
DP (mm H20)	30.0	30.0	30.0	30.0	34.0	34.0	32.0	32.0	31.5
K factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
DH (Orifice)	21.00	21.00	21.00	21.00	23.80	23.80	22.40	22.40	22.1
Meter (Tm in)	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
Meter (Tm out)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Stack Temp (Ts)	138.0	139.0	138.0	139.0	139.0	140.0	140.0	140.0	139.1
Impinger T Outlet	10.0	11.0	13.0	14.0	12.0	12.0	15.0	16.0	12.9
Vaccum (" Hg)	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
XAD Temperature (°C)	4.00	5.00	6.00	6.00	5.00	5.00	6.00	7.00	5.5
Traverse Point	B3	B3	B4	B4	B5	B5	B6	B6	Total
Time/Point(mins)	240 - 255	255 - 270	270 - 285	285 - 300	300 - 315	315 - 330	330 - 345	345 - 360	
DP (mm H20)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
K factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
DH (Orifice)	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.0
Meter (Tm in)	26.0	26.0	26.0	25.0	25.0	25.0	25.0	25.0	25.4
Meter (Tm out)	22.0	22.0	22.0	21.0	21.0	21.0	21.0	21.0	21.4
Stack Temp (Ts)	138.0	138.0	140.0	138.0	138.0	138.0	138.0	139.0	138.4
Impinger T Outlet	11.0	12.0	13.0	15.0	10.0	11.0	14.0	16.0	12.8
Vaccum (" Hg)	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
XAD Temperature (°C)	3.00	5.00	6.00	6.00	4.00	4.00	6.00	7.00	5.1
Traverse Point									Total
Time/Point(mins)									
DP (mm H20)									
K factor									
DH (Orifice)									
Meter (Tm in)									
Meter (Tm out)									
Stack Temp (Ts)									
Impinger T Outlet									
Vaccum (" Hg)									
XAD Temperature (°C)									

	Impinger 1	Impinger 2	Impinger3	Impinger 4	Impinger 5	Impinger 6	Impinger 7	Impinger 8
Contents	XAD	Condenser	Empty	Empty	Silica			
TRAP ID	595							
Start Weight (g)	218.8	363.9	497.6	485.3	749.1			
End Weight (g)	219.3	962.8	809.5	487.7	787			
Total weight (g)	0.5	598.9	311.9	2.4	37.9	0	0	0

Total (g)	951.6

Rinse Solutions used	
Solution	SOL NO
DCM	4750
Acetone	4827
Toluene	4828

Additional Moisture Weighings

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

PRE-Sample PITOT **Visual Inspection**	
Time	08:39
Pass ? (Y/N)	Y

PRE-Sample PITOT **Leak Check**	
Time	08:41
Pass ? (Y/N)	Y

Post-Sample Blockage Check (L-type)	
Time	
Reading (mm H_2O)	
Pass (<5%) ?	

POST-Sample PITOT **Visual Inspection**	
Time	14:54
Pass ? (Y/N)	Y
POST-Sample PITOT **Leak Check**	
Time	14:56
Pass ? (Y/N)	Y

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Heavy Metals

METALS DATA SAMPLING PROFORMA				Date of Measurement	19/07/2023
ECL/TPD/	28	Time taken to change Ports?	2	Start Time	10:45
				Test Duration	60 mins
				End Time	11:47

Client	Western Bio-Energy Limited	Stack Profile	Circular	Console id	U001	Barometer id	1320
Site	Margam	Stack Area (m^2)	2.01	Pump id	U001	Nozzle Id	335
Location	Biomass Plant	Barometric Pressure (mb)	1016	Probe Id	405	Nozzle size	5.09
Stack ID	Main Stack	Static Pres. (mm $H^2$0)	17	DGM Yd	1.032	Filter Id	UW QMA
Test No.	Heavy Metals	Pitot coefficient	0.83	ΔH@	37.32	Pitot ID	602
Job No	P5520	Probe Heater Setting (^{C})	180	Impinger Id	660	Hot Box ID	192
ECL Site Staff	PB & LPH	Hot Box Setting (^{C})	180	Balance Id	1225		

Rinse Solutions used	
Solution	SOL NO
25% HNO3	...
5% HNO3	4956
3% H202	...

NB: Leak Check - Record Actual leak rate or '0' but not 'less than' values

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	715892.0						
Final Volume	716953.0						
Total Volume	1061.0	0.0	0.0	0.0	0.0	0.0	1061.0
Leak Check	First	Second	Third	Fourth	Fifth		
Leak rate l/min	0.2						
Vaccum "Hg	6						
Time of Check	10:40						
Set Rate l/min	16.4						
Leak <2%?	YES						

Original K Factor Settings	
Meter Temp.	30
Stack Temp	140
%Moisture	20.00
Silica <50% Spent at End of Test?	YES
K factor	0.7
Reference Oxygen Percentage	6

Smooth Walls

Dry O_2 ☐ Atmospheric) 6.49
Dry Carbon Dioxide % 13.55

Leak checks DO NOT NEED to be performed (BUT ARE ALLOWED) at the and of the test or when moving between sample ports, EVEN when disconnections are made.

Traverse Point	A1	A2	A3	A4	A5	A6	B1	B2	Total
Time/Point (mins)	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	30 - 35	35 - 40	
ΔP (mm H20)	30.00	32.00	30.00	30.00	30.00	30.00	32.00	32.00	30.8
K factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
ΔH (Orifice)	21.00	22.40	21.00	21.00	21.00	21.00	22.40	22.40	21.5
Meter (Tm in)	27.00	27.00	28.00	28.00	29.00	29.00	29.00	29.00	28.3
Meter (Tm out)	22.00	23.00	24.00	24.00	25.00	26.00	26.00	26.00	24.5
Stack Temp (Ts)	120.00	121.00	121.00	121.00	120.00	121.00	121.00	120.00	120.6
Impinger T Outlet	6.00	5.00	6.00	6.00	7.00	7.00	8.00	8.00	6.6
Vaccum (" Hg)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3

Traverse Point	B3	B4	B5	B6					Total
Time/Point(mins)	40 - 45	45 - 50	50 - 55	55 - 60					
ΔP (mm H20)	30.00	30.00	30.00	30.00					30.0
K factor	0.70	0.70	0.70	0.70					
ΔH (Orifice)	21.00	21.00	21.00	21.00					21.0
Meter (Tm in)	29.00	29.00	29.00	29.00					29.0
Meter (Tm out)	26.00	26.00	26.00	26.00					26.0
Stack Temp (Ts)	122.00	122.00	123.00	124.00					122.8
Impinger T Outlet	9.00	10.00	11.00	13.00					10.8
Vaccum (" Hg)	3.00	3.00	3.00	3.00					3

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

Impinger 1	HNO_3 / H_2O_2
SOL/	4955
Start Weight (g)	632.7
End Weight (g)	750.5
Total weight (g)	117.8

Impinger 2	HNO_3 / H_2O_2
SOL/	4955
Start Weight (g)	629.9
End Weight (g)	688.2
Total weight (g)	58.3

Impinger3	HNO_3 / H_2O_2
SOL/	4955
Start Weight (g)	622.2
End Weight (g)	627.8
Total weight (g)	5.6

Impinger 4	Empty
SOL/	...
Start Weight (g)	481.6
End Weight (g)	483.2
Total weight (g)	1.6

Impinger 5	Silica
SOL/	...
Start Weight (g)	793.2
End Weight (g)	798.7
Total weight (g)	5.5

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

Total (g)	188.8

Pitot Quality Control Checks	
PRE-Sample PITOT Visual Inspection	
Time	10:04
Pass ? (Y/N)	Y
PRE-Sample PITOT Leak Check	
Time	10:06
Pass ? (Y/N)	Y
Post-Sample Blockage Check (L-Type ONLY)	
Time	
Reading (mm H_2O)	
Pass (<5%) ?	
POST-Sample PITOT Visual Inspection	
Time	11:49
Pass ? (Y/N)	Y
POST-Sample PITOT Leak Check	
Time	11:51
Pass ? (Y/N)	Y

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

Mercury

METALS DATA SAMPLING PROFORMA				Date of Measurement	19/07/2023
ECL/TPD/	030	Time taken to change Ports?	2	Start Time	12:35
				Test Duration	60 mins
				End Time	13:37

Client	Western Bio-Energy Limited	Stack Profile	Circular	Console id	U001	Barometer id	1320
Site	Margam	Stack Area (m^2)	2.01	Pump id	U001	Nozzle Id	335
Location	Biomass Plant	Barometric Pressure (mb)	1016	Probe Id	405	Nozzle size	5.09
Stack ID	Main Stack	Static Pres. (mm $H^2$0)	17	DGM Yd	1.032	Filter Id	UW QMA
Test No.	Mercury	Pitot coefficient	0.83	ΔH@	37.32	Pitot ID	6.02
Job No	P5520	Probe Heater Setting (^{C})	180	Impinger Id	660	Hot Box ID	192
ECL Site Staff	PB & LPH	Hot Box Setting (^{C})	180	Balance Id	1225		

Rinse Solutions used	
Solution	SOL NO
5% HNO3	4956
$KMnO_4$ / H_2SO_4	4957
3% H202	4958

NB: Leak Check - Record Actual leak rate or '0' but not 'less than' values

	Sample	Leak 1	Leak 2	Leak 3	Leak 4	Leak 5	Total
Start Volume	718194.6						
Final Volume	719248.2						
Total Volume	1053.6	0.0	0.0	0.0	0.0	0.0	1053.6
Leak Check	First	Second	Third	Fourth	Fifth		
Leak rate l/min	0.2						
Vaccum "Hg	6						
Time of Check	12:30						
Set Rate l/min	16.4						
Leak <2%?	YES						

Original K Factor Settings	
Meter Temp.	30
Stack Temp	140
%Moisture	20.00
Silica <50% Spent at End of Test?	YES
K factor	0.7
Reference Oxygen Percentage	6

Smooth Walls

Dry O_2 ☐ Atmospheric) 6.66
Dry Carbon Dioxide % 13.55

Leak checks DO NOT NEED to be performed (BUT ARE ALLOWED) at the and of the test or when moving between sample ports, EVEN when disconnections are made.

Traverse Point	A1	A2	A3	A4	A5	A6	B1	B2	Total
Time/Point (mins)	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	30 - 35	35 - 40	
ΔP (mm H20)	32.00	32.00	30.00	30.00	30.00	30.00	34.00	32.00	31.3
K factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
ΔH (Orifice)	22.40	22.40	21.00	21.00	21.00	21.00	23.80	22.40	21.9
Meter (Tm in)	26.00	27.00	27.00	28.00	28.00	28.00	29.00	29.00	27.8
Meter (Tm out)	22.00	23.00	24.00	25.00	25.00	25.00	26.00	26.00	24.5
Stack Temp (Ts)	135.00	135.00	134.00	134.00	135.00	134.00	133.00	134.00	134.3
Impinger T Outlet	6.00	6.00	7.00	7.00	8.00	8.00	8.00	9.00	7.4
Vaccum (" Hg)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3

Traverse Point	B3	B4	B5	B6					Total
Time/Point(mins)	40 - 45	45 - 50	50 - 55	55 - 60					
ΔP (mm H20)	30.00	30.00	30.00	30.00					30.0
K factor	0.70	0.70	0.70	0.70					
ΔH (Orifice)	21.00	21.00	21.00	21.00					21.0
Meter (Tm in)	30.00	30.00	30.00	30.00					30.0
Meter (Tm out)	27.00	27.00	27.00	27.00					27.0
Stack Temp (Ts)	135.00	136.00	136.00	136.00					135.8
Impinger T Outlet	10.00	12.00	13.00	15.00					12.5
Vaccum (" Hg)	3.00	3.00	3.00	3.00					3

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

Impinger 1	$KMnO_4$ / H_2SO_4
SOL/	4957
Start Weight (g)	641.2
End Weight (g)	764.2
Total weight (g)	123

Impinger 2	$KMnO_4$ / H_2SO_4
SOL/	4957
Start Weight (g)	632.2
End Weight (g)	701.3
Total weight (g)	69.1

Impinger3	Empty
SOL/	
Start Weight (g)	558.9
End Weight (g)	563.7
Total weight (g)	4.8

Impinger 4	Silica
SOL/	
Start Weight (g)	814.7
End Weight (g)	823.5
Total weight (g)	8.8

Impinger 5	
SOL/	
Start Weight (g)	
End Weight (g)	
Total weight (g)	0

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

Total (g)	205.7

Pitot Quality Control Checks	
PRE-Sample PITOT Visual Inspection	
Time	11:49
Pass ? (Y/N)	Y
PRE-Sample PITOT Leak Check	
Time	11:51
Pass ? (Y/N)	Y
Post-Sample Blockage Check (L-Type ONLY)	
Time	
Reading (mm H_2O)	
Pass (<5%) ?	
POST-Sample PITOT Visual Inspection	
Time	13:39
Pass ? (Y/N)	Y
POST-Sample PITOT Leak Check	
Time	13:41
Pass ? (Y/N)	Y

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

LABORATORY ANALYSIS RESULTS

Laboratory analysis for Particulates, Hydrogen Chloride, Hydrogen Fluoride, Ammonia, Heavy Metals and Mercury was subcontracted to RPS laboratories, a UKAS Accredited Testing Laboratory, Number 0605.

RPS DO hold UKAS & MCERTS accreditation for this analysis.

As required by the MCERTS Performance Standard for Organisations, the analysis results are shown below.

Laboratory analysis for Dioxins and Furans was subcontracted to Marchwood, a UKAS Accredited Testing Laboratory, Number 1668.

Marchwood DO hold UKAS & MCERTS accreditation for this analysis.

As required by the MCERTS Performance Standard for Organisations, the analysis results are shown below.

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Particulates Results Summary

Results Summary

Report No.: 23-08190-1

Customer Reference: 2023 Stack Preferential Rates

Customer Order No: E0745 P5520

Customer Sample No	ECL/23/3928 - 255767	ECL/23/3929	ECL/23/3930 - 255766	ECL/23/3931	ECL/23/3932 - 255765	ECL/23/3933
RPS Sample No	194339	194340	194341	194342	194343	194344
Sample Matrix	FILTER	SOLUTION	FILTER	SOLUTION	FILTER	SOLUTION
Sampling Date	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023

Determinand	CAS No	Codes	SOP	RL	Units						
particulates		UM	D9	0.04	mg	0.95		<0.1		<0.1	
particulates		UM	D9	0.5	mg		0.6		< 0.5		< 0.5

Hydrogen Chloride and Hydrogen Fluoride Results Summary

Results Summary

Report No.: 23-08204-1

Customer Reference: 2023 Stack Preferential Rates

Customer Order No: E0745 P5520

Customer Sample No	ECL/23/3934	ECL/23/3935	ECL/23/3936	ECL/23/3937
RPS Sample No	194421	194422	194423	194424
Sample Matrix	SOLUTION	SOLUTION	SOLUTION	SOLUTION
Sampling Date	19/07/2023	19/07/2023	19/07/2023	19/07/2023

Determinand	CAS No	Codes	SOP	RL	Units				
volume of sample supplied		U	N/A	n/a	ml	551	252	327	282
hydrogen chloride	7647-01-0	UM	C27	0.05	ug/mL	61.0	< 0.05	< 0.05	< 0.05
hydrogen fluoride	7664-39-3	UM	C27	0.05	ug/mL	0.07	< 0.05	0.08	0.05

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Sulphur Dioxide and Ammonia Results Summary

Results Summary

Report No.: 23-08194-1

Customer Reference: 2023 Stack Preferential Rates

Customer Order No: E0745 P5520

Customer Sample No	ECL/23/3938	ECL/23/3939	ECL/23/3940	ECL/23/3941	ECL/23/3942	ECL/23/3943	ECL/23/3944	ECL/23/3945	ECL/23/3946	ECL/23/3947
RPS Sample No	194345	194346	194347	194348	194349	194350	194351	194352	194353	194354
Sample Matrix	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION	SOLUTION
Sampling Date	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023	17/07/2023	17/07/2023	17/07/2023	17/07/2023

Determinand	CAS No	Codes	SOP	RL	Units										
volume of sample supplied		U	N/A	n/a	ml	568	297	358	167	297	134	901	443	386	182
ammonia	7664-41-7	UM	A6	0.1	ug/mL	3.0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1				
sulphur dioxide	7446-09-5	UM	C27	0.05	ug/mL							169	0.42	0.27	0.24

Mercury Results Summary

Results Summary

Report No.: 23-08200-1

Customer Reference: 2023 Stack Preferential Rates

Customer Order No: E0745 P5520

Customer Sample No	ECL/23/3956	ECL/23/3957	ECL/23/3958	ECL/23/3959	ECL/23/3960	ECL/23/3961	ECL/23/3962	ECL/23/3963
RPS Sample No	194377	194378	194379	194380	194381	194382	194383	194384
Sample Matrix	FILTER	SOLUTION	SOLUTION	SOLUTION	FILTER	SOLUTION	SOLUTION	SOLUTION
Sampling Date	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023

Determinand	CAS No	Codes	SOP	RL	Units								
volume of sample supplied		U	N/A	n/a	ml		110	677	421		100	241	214
mercury	7439-97-6	UM	M112	0.03	ug	< 0.03				< 0.03			
mercury	7439-97-6	UM	M112	0.5	ug/l			< 0.5	< 0.5			< 0.5	< 0.5
mercury	7439-97-6	UM	M112	0.5	ug/l		< 0.50				< 0.50		

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Heavy Metals Results Summary

Results Summary

Report No.: 23-08200-1

Customer Reference: 2023 Stack Preferential Rates

Customer Order No: E0745 P5520

Customer Sample No	ECL/23/3948	ECL/23/3949	ECL/23/3950	ECL/23/3951	ECL/23/3952	ECL/23/3953	ECL/23/3954	ECL/23/3955
RPS Sample No	194369	194370	194371	194372	194373	194374	194375	194376
Sample Matrix	FILTER	SOLUTION	SOLUTION	SOLUTION	FILTER	SOLUTION	SOLUTION	SOLUTION
Sampling Date	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023	19/07/2023

Determinand	CAS No	Codes	SOP	RL	Units								
volume of sample supplied		U	N/A	n/a	ml		147	556	229		99	293	142
arsenic	7440-38-2	UM	M31	0.2	ug	< 0.2				< 0.2			
cadmium	7440-43-9	UM	M31	0.2	ug	< 0.2				< 0.2			
cobalt	7440-48-4	UM	M31	0.2	ug	< 0.2				< 0.2			
chromium	7440-47-3	UM	M31	0.3	ug	0.5				0.3			
copper	7440-50-8	UM	M31	0.2	ug	0.2				< 0.2			
manganese	7439-96-5	UM	M31	0.2	ug	0.5				0.3			
nickel	7440-02-0	UM	M31	0.5	ug	< 0.5				< 0.5			
lead	7439-92-1	UM	M31	0.3	ug	1.4				< 0.3			
antimony	7440-36-0	UM	M31	0.4	ug	< 0.4				< 0.4			
thallium	7440-28-0	UM	M31	0.2	ug	< 0.2				< 0.2			
vanadium	7440-62-2	UM	M31	0.2	ug	< 0.2				< 0.2			
arsenic	7440-38-2	UM	M31	0.3	ug		< 0.3				< 0.3		
cadmium	7440-43-9	UM	M31	0.3	ug		< 0.3				< 0.3		
cobalt	7440-48-4	UM	M31	0.3	ug		< 0.3				< 0.3		
chromium	7440-47-3	UM	M31	0.3	ug		1.9				< 0.3		
copper	7440-50-8	UM	M31	0.4	ug		2.2				< 0.4		
manganese	7439-96-5	UM	M31	0.2	ug		2.0				< 0.2		
nickel	7440-02-0	UM	M31	0.1	ug		6.9				< 0.1		
lead	7439-92-1	UM	M31	0.2	ug		5.7				< 0.2		
antimony	7440-36-0	UM	M31	0.2	ug		< 0.2				< 0.2		
thallium	7440-28-0	UM	M31	0.2	ug		< 0.2				< 0.2		
vanadium	7440-62-2	UM	M31	0.2	ug		< 0.2				< 0.2		
arsenic	7440-38-2	UM	M31	0.3	ug/L			< 0.3	< 0.3			< 0.3	< 0.3
cadmium	7440-43-9	UM	M31	0.2	ug/L			< 0.2	< 0.2			< 0.2	< 0.2
cobalt	7440-48-4	UM	M31	0.2	ug/L			< 0.2	< 0.2			< 0.2	< 0.2
chromium	7440-47-3	UM	M31	0.2	ug/L			0.8	< 0.2			< 0.2	< 0.2
copper	7440-50-8	UM	M31	0.4	ug/L			1.2	< 0.4			< 0.4	< 0.4
manganese	7439-96-5	UM	M31	0.2	ug/L			0.5	< 0.2			< 0.2	< 0.2
nickel	7440-02-0	UM	M31	0.3	ug/L			1.0	< 0.3			< 0.3	< 0.3
lead	7439-92-1	UM	M31	0.2	ug/L			4.8	< 0.2			< 0.2	< 0.2
antimony	7440-36-0	UM	M31	0.2	ug/L			< 0.2	< 0.2			< 0.2	< 0.2
thallium	7440-28-0	UM	M31	0.2	ug/L			< 0.2	< 0.2			< 0.2	< 0.2
vanadium	7440-62-2	UM	M31	0.1	ug/L			< 0.1	< 0.1			< 0.1	0.1

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Dioxins Results

323935 Dioxin Results

Sample Type : Stack
MSS Sample Ref : 323935
Customer Sample Ref : ECL/23/3922 - ECL/23/3924
Sample Condition : Conforming
Test Method : 2002b

Congener	LOD	Detected	Lower Bound	Upper Bound	Recovery	Sampling Recovery	UKAS
Dioxins/Furans	ng/Sample	ng/Sample	ng/Sample	ng/Sample	%	%	
2378-TCDD	0.00088	0.00121	0.00121	0.00121	106		M
12378-PeCDD	0.00150	0.00822	0.00411	0.00411	100		M
123478-HxCDD	0.00254	0.0224	0.00224	0.00224	93		M
123678-HxCDD	0.00257	0.0398	0.00398	0.00398	88		M
123789-HxCDD	0.00247	0.0353	0.00353	0.00353			M
1234678-HpCDD	0.00144	0.379	0.00379	0.00379	77		M
OCDD	0.0007	0.480	0.00048	0.00048	92		M
Dioxins Total			**0.0193**	**0.0193**			M
2378-TCDF	0.00124	0.0102	0.00102	0.00102	87		M
12378-PeCDF	0.00184	0.0201	0.00100	0.00100		102	M
23478-PeCDF	0.00181	0.0386	0.0193	0.0193	97		M
123478-HxCDF	0.00189	0.0560	0.00560	0.00560	78		M
123678-HxCDF	0.00187	0.0597	0.00597	0.00597	79		M
234678-HxCDF	0.00179	0.0948	0.00948	0.00948	81		M
123789-HxCDF	0.00149	0.00261	0.00026	0.00026		76	M
1234678-HpCDF	0.00123	0.424	0.00424	0.00424	67		M
1234789-HpCDF	0.00151	0.0357	0.00036	0.00036		88	M
OCDF	0.00055	0.134	0.00013	0.00013	79		M
Furans Total			**0.0473**	**0.0473**			M
Dioxin/Furan Total			**0.0667**	**0.0667**			M

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

323936 Dioxin Results

Sample Type : Stack
MSS Sample Ref : 323936
Customer Sample Ref : ECL/23/3925 -ECL/23/3927
Sample Condition : Conforming
Test Method : 2002b

Congener	LOD	Detected	Lower Bound	Upper Bound	Recovery	Sampling Recovery	UKAS
Dioxins/Furans	ng/Sample	ng/Sample	ng/Sample	ng/Sample	%	%	
2378-TCDD	0.00017	< 0.00017	0.0000	0.00017	104		M
12378-PeCDD	0.00024	< 0.00024	0.0000	0.00012	96		M
123478-HxCDD	0.00019	< 0.00019	0.0000	0.00002	97		M
123678-HxCDD	0.00021	< 0.00021	0.0000	0.00002	92		M
123789-HxCDD	0.00020	< 0.00020	0.0000	0.00002			M
1234678-HpCDD	0.00021	< 0.00021	0.0000	0.00000	82		M
OCDD	0.0004	0.00999	0.00001	0.00001	101		M
Dioxins Total			**0.00001**	**0.00036**			M
2378-TCDF	0.00037	< 0.00037	0.0000	0.00004	81		M
12378-PeCDF	0.00020	< 0.00020	0.0000	0.00001		106	M
23478-PeCDF	0.00020	< 0.00020	0.0000	0.00010	89		M
123478-HxCDF	0.00016	< 0.00016	0.0000	0.00002	85		M
123678-HxCDF	0.00015	< 0.00015	0.0000	0.00002	86		M
234678-HxCDF	0.00016	< 0.00016	0.0000	0.00002	85		M
123789-HxCDF	0.00013	< 0.00013	0.0000	0.00001		79	M
1234678-HpCDF	0.00011	0.00244	0.00002	0.00002	70		M
1234789-HpCDF	0.00014	< 0.00014	0.0000	0.00000		97	M
OCDF	0.00012	< 0.00012	0.0000	0.00000	88		M
Furans Total			**0.00002**	**0.00023**			M
Dioxin/Furan Total			**0.00003**	**0.00059**			M

UNCERTAINTY CALCULATIONS

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

TVOC Measurement Uncertainty

Main Stack - TVOC - Measurement Uncertainty - Uncertainty Calculations Table 1

Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Min Certified Ranges TVOC 0 - 15 mgC/m³
Lack of fit[1]	u_{lof}	Rectangular (Divisor = √3)	0.73
Span drift[2]	$u_{d,s}$	Rectangular (Divisor = √3)	0.35
Repeatability Standard Deviation (span)[3]	u_r	Normal (Divisor = 1)	12.16
Losses / leakage in the sample system[4]	u_{loss}	Rectangular (Divisor = √3)	11.99
Temperature dependant span drift[5]	u_t	Rectangular (Divisor = √3)	0.30
Interferents[1]	u_i	Rectangular (Divisor = √3)	4.39
Uncertainty of Reference Gas[6]	u_{ref}	Rectangular (Divisor = √3)	2.56
Effect of Voltage Fluctuation[7]	u_v	Rectangular (Divisor = √3)	1.80
Effect of Oxygen Synergism[7]	u_{syn}	Rectangular (Divisor = √3)	4.60

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 maximum drift per 24hr period as percentage of the certified range
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 taking account of an additional uncertainty of 2% for gas blending
7 Expressed as a percentage of the certified range

Main Stack - TVOC - Measurement Uncertainty - Uncertainty Calculations Table 2

Performance Characteristics	Uncertainty	Value of Standard Uncertainty	* TVOC 0 - 15 mgC/m³
Lack of fit	u_{lof}	$u(x_i) = \frac{u_{lof} \times R_i}{\sqrt{3}} =$	0.064
Span drift	$u_{d,s}$	$u(x_i) = \frac{u_{d,s} \times R_i}{\sqrt{3}} =$	0.031
Repeatability Standard Deviation (span)	u_r	$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} =$	1.82
Losses / leakage in the sample system	u_{loss}	$u(x_i) = \frac{u_{loss} \times R_i}{\sqrt{3}} =$	1.04
Temperature dependant span drift	u_t	$u(x_i) = \frac{u_t}{100} \times R_i \times \sqrt{\frac{(x_{i,max} - x_{adj})^2 + (x_{i,min} - x_{adj})(x_{i,max} - x_{adj}) + (x_{i,min} - x_{adj})^2}{3}}$	0.013
Interferents	u_i	$u(x_i) = \frac{u_i \times R_i}{\sqrt{3}} =$	0.38
Uncertainty of Reference Gas	u_{ref}	$u(x_i) = \frac{u_{ref}}{\sqrt{3}} =$	1.48
Effect of Voltage Fluctuation	u_v	$u(x_i) = \frac{u_v \times R_i}{\sqrt{3}} =$	0.16
Effect of Oxygen Synergism	u_{syn}	$u(x_i) = \frac{u_{syn} \times R_i}{\sqrt{3}} =$	0.40
Combined Standard Uncertainty		$u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2}$	2.63
Expanded measurement uncertainty (at 95% confidence)		$U_{EXP} = 2 \times u_c$	5.26
Applied Span Concentration			147.60
Measured Span Concentration, STP Dry Gas			145.55
Expanded measurement uncertainty as % of Applied Span			4 %

* Signal 3030 FID

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

TVOC Uncertainty of Measurement Results

Main Stack - TVOC - Uncertainty of Measurement Results - Calculations Part 1

Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Divisor	Min Certified Range O_2 0 - 25 %Vol	Min Certified Range TVOC 0 - 15 mgC/m^3
Lack of fit[1]	u_{lof}	Rectangular	$\sqrt{3}$	0.13	0.73
Span drift[2]	$u_{d,s}$			0.029	0.35
Losses / leakage in the sample system[4]	u_{loss}			1.00	1.96
Temperature dependant span drift[5]	u_t			0.070	0.30
Interferents[1]	u_i			0.56	4.39
Effect of Voltage Fluctuation[7]	u_v			...	1.80
Effect of Oxygen Synergism[7]	u_{syn}			...	4.60

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

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

Performance Characteristics	Uncertainty (Units of final measurement)	Distribution	Divisor	O_2 0 - 25 %Vol	TVOC 0 - 15 mgC/m^3
Lack of fit	u_{lof}	Rectangular	$\sqrt{3}$	0.019	0.064
Span drift	$u_{d,s}$			0.0041	0.031
Temperature dependant span drift	u_t			0.0051	0.013
Interferents	u_i			0.081	0.38
Effect of Voltage Fluctuation (See Note)	u_v			...	0.16
Effect of Oxygen Synergism (See Note)	u_{syn}			...	0.40

Main Stack - TVOC - Uncertainty of Measurement Results - Calculations Part 2

Performance Characteristics	Uncertainty (Units of final measurement)	Date & Time	O_2 0 - 25 %Vol	TVOC 0 - 15 mgC/m^3
Losses / leakage in the sample system	u_{loss}	18/07/23 11:55 - 12:55	0.066	0.010
Standard Error of Measured Value	u_{SE}	18/07/23 11:55 - 12:55	0.018	0.036
Uncertainty due to Moisture Correction[6]	u_{H2O}	18/07/23 11:55 - 12:55	0.18	0.012

Effect on Uncertainty Caused by Oxygen

$$uCorr^{n}_{o_2} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured})(20.9\% - O_{2,measured})} \times \text{Uncertainty of } O_2 \text{ Meas} = 0.03$$

$$f_{o_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = 1.0394$$

$$uf_{o_2} = \frac{uCorr^{n}_{o_2}}{f_{o_2}} x100 = 2.51 \%$$

The effect of oxygen on the overall uncertainties (below) is incorporated using the following equation:-

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

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 $C_i = \frac{\partial f}{\partial x_i}$

Main Stack - TVOC - Uncertainty of Measurement Results - Calculations Part 3

Uncertainty	Date & Time	O_2 0 - 25 %Vol	*TVOC 0 - 15 mgC/m^3
Measured Concentration	18/07/23 11:55 - 12:55	6.56	0.53
Expanded Uncertainty as Percentage of Measured Concentration		6 %	> 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 applied span concentration
5 Expressed as a percentage of the certified range per one degree centigrade
6 Where the uncertainty of moisture is taken from the manual extract test calculations.
7 Expressed as a percentage of the certified range
8 Where no uncertainty is presented above, the uncertainty is > 100%

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Combustion Gases Measurement Uncertainty – 17/07/2023

Measurement Uncertainty Calculations Part 1

Horiba PG 350 E Performance Characteristics	Standard Uncertainty (% of Range)	Distributiuon	Minimum Certified Range (R_i) NO 0 - 134 mg/m³	CO 0 - 75 mg/m³	O_2 0 - 25 %Vol
Lack of fit[1]	u_{lof}	Rectangular (Divisor = √3)	0.75	0.61	0.10
Span drift[2]	$u_{d,s}$	Rectangular (Divisor = √3)	0.094	0.056	0.0057
Repeatability Standard Deviation (span)[3]	u_r	Normal (Divisor = 1)	0.58	0.27	0.083
Losses / leakage in the sample system[4]	u_{loss}	Rectangular (Divisor = √3)	2.92	9.04	0.013
Temperature dependant span drift[5]	u_t	Rectangular (Divisor = √3)	0.051	0.057	0.014
Interferents[1]	u_i	Rectangular (Divisor = √3)	0.52	0.87	0.010
Uncertainty of Reference Gas[6]	u_{ref}	Rectangular (Divisor = √3)	5.46	6.33	0.15
Effect of Voltage Fluctuation[7]	u_v	Rectangular (Divisor = √3)	0.40	0.50	0.020
Effect of Sample Gas Flow/ Pressure[7]	u_{sg}	Rectangular (Divisor = √3)	0.10	0.10	0.10

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 Expressed as a percentage of the certified range

Measurement Uncertainty Calculations Part 2

Horiba PG 350 E Performance Characteristics	Uncertainty	Value of Standard Uncertainty	NO 0 - 134 mg/m³	CO 0 - 75 mg/m³	O_2 0 - 25 %Vol
Lack of fit	u_{lof}	$u(x_i) = \frac{u_{lof} \times R_i}{\sqrt{3}} =$	0.58	0.26	0.014
Span drift	$u_{d,s}$	$u(x_i) = \frac{u_{d,s} \times R_i}{\sqrt{3}} =$	0.073	0.024	0.00082
Repeatability Standard Deviation (span)	u_r	$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} =$	0.58	0.27	0.083
Losses / leakage in the sample system	u_{loss}	$u(x_i) = \frac{u_{loss} \times R_i}{\sqrt{3}} =$	2.26	3.92	0.0019
Temperature dependant span drift	u_t	$u(x_i) = \frac{u_t}{100} \times R_i \times \sqrt{\frac{(x_{i,max} - x_{adj})^2 + (x_{i,min} - x_{adj})(x_{i,max} - x_{adj}) + (x_{i,min} - x_{adj})^2}{3}}$	0.060	0.037	0.0031
Interferents	u_i	$u(x_i) = \frac{u_i \times R_i}{\sqrt{3}} =$	0.40	0.38	0.0014
Uncertainty of Reference Gas	u_{ref}	$u(x_i) = \frac{u_{ref}}{\sqrt{3}} =$	3.15	3.66	0.087
Effect of Voltage Fluctuation [7]	u_v	$u(x_i) = \frac{u_v \times R_i}{\sqrt{3}} =$	0.23	0.29	0.012
Effect of Sample Gas Flow / Pressure [7]	u_{sg}	$u(x_i) = \frac{usg \times R_i}{\sqrt{3}} =$	0.058	0.058	0.058
Combined Standard Uncertainty		$u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2} + u2v + u2sg$	3.99	5.39	0.13
Expanded measurement uncertainty (at 95% confidence)		$U_{EXP} = 2 \times u_c$	7.99	10.79	0.27
Applied Span Concentration			315.50	365.75	15.12
Measured Span Concentration, STP Dry Gas			310.98	358.97	15.11
Expanded measurement uncertainty as % of Applied Span			3%	3%	2%

Western Bio-Energy Ltd.		**Installation Name**	**: Biomass Plant**
Permit No	**: EPR/ZP3939GL**	**Visit Details**	**: Compliance July 2023**
Variation No	**: V005**	**Survey Dates**	**: 17th to 19th July 2023**
Report Ref	**: P5520 : R004**	**Report Issue Date**	**: 21st August 2023**

Combustion Gases Uncertainty of Measurement Results – 17/07/2023

Uncertainty of Measurement Results - Calculations Part 1

Horiba PG 350 E Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Divisor	Minimum Certified Range (R_i) NO 0 - 134 mg/m³	CO 0 - 75 mg/m³	O_2 0 - 25 %Vol
Lack of fit[1]	u_{lof}	Rectangular	$\sqrt{3}$	0.75	0.61	0.10
Span drift[2]	$u_{d,s}$			0.094	0.056	0.0057
Losses / leakage in the sample system[4]	u_{loss}			2.92	9.04	0.013
Temperature dependant span drift[5]	u_t			0.051	0.057	0.014
Interferents[1]	u_i			0.52	0.87	0.010
Effect of Voltage Fluctuation[7]	u_v			0.40	0.50	0.020
Sample Gas Pressure/ Flow[7]	u_{sg}			0.10	0.10	0.10

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 $|(x_{i,\max} - x_{i,adj})| = |(x_{i,\min} - x_{i,adj})|$, 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 350 E Performance Characteristics	Uncertainty (Units of final measurement)	Distribution	Divisor	NO 0 - 134 mg/m³	CO 0 - 75 mg/m³	O_2 0 - 25 %Vol
Lack of fit	u_{lof}	Rectangular	$\sqrt{3}$	0.58	0.26	0.014
Span drift	$u_{d,s}$			0.073	0.024	0.00082
Temperature dependant span drift	u_t			0.053	0.033	0.0027
Interferents	u_i			0.40	0.38	0.0014
Effect of Voltage Fluctuation[7]	u_v			0.31	0.22	0.0029
Sample Gas Pressure/ Flow[7]	u_{sg}			0.077	0.043	0.014

Uncertainty of Measurement Results - Calculations Part 2

Horiba PG 350 E Performance Characteristics	Uncertainty (Units of final measurement)	Date & Time	NO 0 - 134 mg/m³	CO 0 - 75 mg/m³	O_2 0 - 25 %Vol
Losses / leakage in the sample system	u_{loss}	17/07/23 12:10 - 13:10	8.61	12.76	0.00086
Standard Error of Measured Value	u_{SE}	17/07/23 12:10 - 13:10	1.62	1.74	0.025

Effect on Uncertainty Caused by Oxygen $uCorr^{n}_{O_2} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured})x(20.9\% - O_{2,measured})} x\, Uncertainty\ of\ O_2\ Measurement =$ 0.026

$f_{o_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} =$ 2.2990 $uf_{o_2} = \frac{uCorr^{n}_{o_2}}{f_{o_2}} x100 =$ 1.12 **%**

The effect of oxygen on the overall uncertainties (below) is incorporated using the following equation:-

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

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 350 E Uncertainty	Date & Time	NOx (as NO2) 0 - 134 mg/m³	CO 0 - 75 mg/m³	O_2 0 - 25 %Vol
Measured Concentration	17/07/23 12:10 - 13:10	294.94	141.08	6.48
Expanded Uncertainty as Percentage of Measured Concentration		6%	18%	1%

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

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 as the standard error of the time averaged value used to correct to Dry Conditions
7 If no value for uncertainty is presented above, the uncertainty is considered to be > 100%

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

Oxygen Measurement Uncertainty – 18/07/2023

Measurement Uncertainty Calculations Part 1

Horiba PG 350 E Performance Characteristics	Standard Uncertainty (% of Range)	Distributiuon	Minimum Certified Range (R_i) O_2 0 - 25 %Vol
Lack of fit[1]	u_{lof}	Rectangular (Divisor = √3)	0.10
Span drift[2]	$u_{d,s}$	Rectangular (Divisor = √3)	0.0057
Repeatability Standard Deviation (span)[3]	u_r	Normal (Divisor = 1)	0.067
Losses / leakage in the sample system[4]	u_{loss}	Rectangular (Divisor = √3)	0.013
Temperature dependant span drift[5]	u_t	Rectangular (Divisor = √3)	0.014
Interferents[1]	u_i	Rectangular (Divisor = √3)	0.010
Uncertainty of Reference Gas[6]	u_{ref}	Rectangular (Divisor = √3)	0.15
Effect of Voltage Fluctuation[7]	u_v	Rectangular (Divisor = √3)	0.020
Effect of Sample Gas Flow/ Pressure[7]	u_{sg}	Rectangular (Divisor = √3)	0.10

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 Expressed as a percentage of the certified range

Measurement Uncertainty Calculations Part 2

Horiba PG 350 E Performance Characteristics	Uncertainty	Value of Standard Uncertainty	O_2 0 - 25 %Vol
Lack of fit	u_{lof}	$u(x_i) = \frac{u_{lof} \times R_i}{\sqrt{3}} =$	0.014
Span drift	$u_{d,s}$	$u(x_i) = \frac{u_{d,s} \times R_i}{\sqrt{3}} =$	0.00082
Repeatability Standard Deviation (span)	u_r	$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} =$	0.067
Losses / leakage in the sample system	u_{loss}	$u(x_i) = \frac{u_{loss} \times R_i}{\sqrt{3}} =$	0.0019
Temperature dependant span drift	u_t	$u(x_i) = \frac{u_t}{100} \times R_i \times \sqrt{\frac{(x_{i,max} - x_{adj})^2 + (x_{i,min} - x_{adj})(x_{i,max} - x_{adj}) + (x_{i,min} - x_{adj})^2}{3}}$	0.0010
Interferents	u_i	$u(x_i) = \frac{u_i \times R_i}{\sqrt{3}} =$	0.0014
Uncertainty of Reference Gas	u_{ref}	$u(x_i) = \frac{u_{ref}}{\sqrt{3}} =$	0.087
Effect of Voltage Fluctuation [7]	u_v	$u(x_i) = \frac{u_v \times R_i}{\sqrt{3}} =$	0.012
Effect of Sample Gas Flow / Pressure [7]	u_{sg}	$u(x_i) = \frac{usg \times R_i}{\sqrt{3}} =$	0.058
Combined Standard Uncertainty		$u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2} + u2v + u2sg$	0.13
Expanded measurement uncertainty (at 95% confidence)		$U_{EXP} = 2 \times u_c$	0.25
Applied Span Concentration			15.12
Measured Span Concentration, STP Dry Gas			15.11
Expanded measurement uncertainty as % of Applied Span			2%

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Oxygen Measurement Uncertainty – 19/07/2023

Measurement Uncertainty Calculations Part 1

Horiba PG 350 E Performance Characteristics	Standard Uncertainty (% of Range)	Distributiuon	Minimum Certified Range (R_i) O_2 0 - 25 %Vol
Lack of fit[1]	u_{lof}	Rectangular (Divisor = √3)	0.10
Span drift[2]	$u_{d,s}$	Rectangular (Divisor = √3)	0.0057
Repeatability Standard Deviation (span)[3]	u_r	Normal (Divisor = 1)	0.11
Losses / leakage in the sample system[4]	u_{loss}	Rectangular (Divisor = √3)	0.013
Temperature dependant span drift[5]	u_t	Rectangular (Divisor = √3)	0.014
Interferents[1]	u_i	Rectangular (Divisor = √3)	0.010
Uncertainty of Reference Gas[6]	u_{ref}	Rectangular (Divisor = √3)	0.15
Effect of Voltage Fluctuation[7]	u_v	Rectangular (Divisor = √3)	0.020
Effect of Sample Gas Flow/ Pressure[7]	u_{sg}	Rectangular (Divisor = √3)	0.10

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 Expressed as a percentage of the certified range

Measurement Uncertainty Calculations Part 2

Horiba PG 350 E Performance Characteristics	Uncertainty	Value of Standard Uncertainty	O_2 0 - 25 %Vol
Lack of fit	u_{lof}	$u(x_i) = \frac{u_{lof} \times R_i}{\sqrt{3}} =$	0.014
Span drift	$u_{d,s}$	$u(x_i) = \frac{u_{d,s} \times R_i}{\sqrt{3}} =$	0.00082
Repeatability Standard Deviation (span)	u_r	$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} =$	0.11
Losses / leakage in the sample system	u_{loss}	$u(x_i) = \frac{u_{loss} \times R_i}{\sqrt{3}} =$	0.0019
Temperature dependant span drift	u_t	$u(x_i) = \frac{u_t}{100} \times R_i \times \sqrt{\frac{(x_{i,max} - x_{adj})^2 + (x_{i,min} - x_{adj})(x_{i,max} - x_{adj}) + (x_{i,min} - x_{adj})^2}{3}}$	0.0021
Interferents	u_i	$u(x_i) = \frac{u_i \times R_i}{\sqrt{3}} =$	0.0014
Uncertainty of Reference Gas	u_{ref}	$u(x_i) = \frac{u_{ref}}{\sqrt{3}} =$	0.087
Effect of Voltage Fluctuation [7]	u_v	$u(x_i) = \frac{u_v \times R_i}{\sqrt{3}} =$	0.012
Effect of Sample Gas Flow / Pressure [7]	u_{sg}	$u(x_i) = \frac{usg \times R_i}{\sqrt{3}} =$	0.058
Combined Standard Uncertainty		$u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2} + u2v + u2sg$	0.15
Expanded measurement uncertainty (at 95% confidence)		$U_{EXP} = 2 \times u_c$	0.31
Applied Span Concentration			15.12
Measured Span Concentration, STP Dry Gas			15.10
Expanded measurement uncertainty as % of Applied Span			2%

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

N2O Measurement Uncertainty

Measurement Uncertainty Calculations Part 1

Protir 204M FTIR Performance Characteristics	Standard Uncertainty	Distributiuon	n Certified R
			N_2O 0 - 39 mg/m³
Lack of fit[1]	u_{lof}	Rectangular (Divisor = √3)	0.67
Span drift[2]	$u_{d,s}$	Rectangular (Divisor = √3)	0.57
Repeatability Standard Deviation (span)[3]	u_r	Normal (Divisor = 1)	0.55
Losses / leakage in the sample system[4]	u_{loss}	Rectangular (Divisor = √3)	2.29
Temperature dependant span drift[5]	u_t	Rectangular (Divisor = √3)	0.30
Interferents[1]	u_i	Rectangular (Divisor = √3)	5.16
Uncertainty of Reference Gas[6]	u_{ref}	Rectangular (Divisor = √3)	0.97

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 Not Available

Measurement Uncertainty Calculations Part 2

Protir 204M FTIR Performance Characteristics	Uncertainty	Value of Standard Uncertainty	N_2O 0 - 39 mg/m³
Lack of fit	u_{lof}	$u(x_i) = \frac{u_{lof} \times R_i}{\sqrt{3}} =$	0.15
Span drift	$u_{d,s}$	$u(x_i) = \frac{u_{d,s} \times R_i}{\sqrt{3}} =$	0.13
Repeatability Standard Deviation (span)	u_r	$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} =$	0.55
Losses / leakage in the sample system	u_{loss}	$u(x_i) = \frac{u_{loss} \times R_i}{\sqrt{3}} =$	0.39
Temperature dependant span drift	u_t	$u(x_i) = \frac{u_t}{100} \times R_i \times \sqrt{\frac{(x_{i,max} - x_{adj})^2 + (x_{i,min} - x_{adj})(x_{i,max} - x_{adj}) + (x_{i,min} - x_{adj})^2}{3}}$	0.034
Interferents	u_i	$u(x_i) = \frac{u_i \times R_i}{\sqrt{3}} =$	1.16
Uncertainty of Reference Gas	u_{ref}	$u(x_i) = \frac{u_{ref}}{\sqrt{3}} =$	0.56
Combined Standard Uncertainty		$u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2}$	1.47
Expanded measurement uncertainty (at 95% confidence)		$U_{EXP} = 2 \times u_c$	2.94
Applied Span Concentration			34.30
Measured Span Concentration, STP Dry Gas			33.22
Expanded measurement uncertainty as % of Applied Span			9%

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

N2O Uncertainty of Measurement Results

Uncertainty of Measurement Results - Calculations Part 1

Protir 204M FTIR Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Divisor	Minimum Certified Range (R_i) N_2O 0 - 39 mg/m³	Minimum Certified Range (R_i) O_2 0 - 21 %Vol
Lack of fit[1]	u_{lof}	Rectangular	$\sqrt{3}$	0.67	0.19
Span drift[2]	$u_{d,s}$			0.57	0.029
Losses / leakage in the sample system[4]	u_{loss}			2.29	
Temperature dependant span drift[5]	u_t			0.30	0.13

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), $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$

Protir 204M FTIR Performance Characteristics	Uncertainty (Units of final measurement)	Distribution	Divisor	N_2O 0 - 39 mg/m³	O_2 0 - 21 %Vol
Lack of fit	u_{lof}	Rectangular	$\sqrt{3}$	0.15	0.023
Span drift	$u_{d,s}$			0.13	0.0034
Temperature dependant span drift	u_t			0.034	0.0078
Interferents	u_i			1.16	0.012

Uncertainty of Measurement Results - Calculations Part 2

Protir 204M FTIR Performance Characteristics	Uncertainty (Units of final measurement)	Date & Time	N_2O 0 - 39 mg/m³	O_2 0 - 21 %Vol
Losses / leakage in the sample system	u_{loss}	19/07/23 14:10 - 15:10	0.014	#VALUE!
Standard Error of Measured Value	u_{SE}	19/07/23 14:10 - 15:10	0.037	0.015
Uncertainty due to Moisture Correction[6]	u_{H2O}	19/07/23 14:10 - 15:10	0.016	0.16

Effect on Uncertainty Caused by Oxygen $uCorr^n_{o_2} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured})x(20.9\% - O_{2,measured})} x\, Uncertainty\ of\ O_2\ Measurement =$ 0.022

$f_{o_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} =$ 2.8177 $uf_{o_2} = \frac{uCorr^n_{o_2}}{f_{o_2}} x100 =$ 0.78 %

The effect of oxygen on the overall uncertainties (below) is incorporated using the following equation:-

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

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

Protir 204M FTIR Uncertainty	Date & Time	N_2O 0 - 39 mg/m³	O_2 0 - 21 %Vol
Measured Concentration	19/07/23 14:10 - 15:10	0.63	6.60

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 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 extract test calculations.
7 Not available
8 If no value for uncertainty is presented above, the uncertainty is considered to be > 100%

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

Flowrate Uncertainty

Stack Reference Main Stack

Measurement Uncertainty Calculations - Velocity at Stack Conditions

Contribution From	Standard u/c (mm H_2O)	
Pitot Calibration Uncertainty Contribution	0.153	A
Manometer Calibration Uncertainty Contribution	0.153	B
Variation in Actual Pitot reading at sample points	0.00	C
Combined u/c (mm H_2O) =	**Combined u/c (mm H_2O)**	
SQRT $(A/\sqrt{3})^2 + (B/\sqrt{3})^2 + (C/\sqrt{3})^2$)	0.13	
Expanded Uncertainty of Flow Measurements (mm H_2O)	**0.25**	
	Standard u/c (K)	
Temperature Calibration (K)	2.06	D
Variation in Actual Temp reading at sample points	0.17	E
Combined u/c of Temp (K)	**Combined u/c (K)**	
SQRT $((D/\sqrt{3^2}) + (E/\sqrt{3})^2$)	1.19	
Expanded Uncertainty of Temp Measurements (K)	**2.38**	
Measured Average Velocity (m/s) at Stack Conds	22.17	
Maximum Average Velocity (m/s) at Stack Conds	22.32	
Standard Uncertainty Velocity at Stack Conditions (%)	0.70	
Expanded Uncertainty Velocity (at Stack Conditions)	**1.40 (%)**	

Measurement Uncertainty Calculations - Flowrate at Stack Conditions

Contribution From	Standard u/c (m^2)
Area (m2)	0.02011
Measured Average Flowrate (m^3/s) at Stack Conds	44.57
Maximum Average Flowrate (m^3/s) at Stack Conds	45.33
Standard Uncertainty Flowrate (m^3/s) at Stack Conditions (%)	1.70
Expanded Uncertainty Flowrate (m^3/s) at Stack Conditions	**3.41 (%)**

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	29.80
Maximum Average Flowrate (m^3/s) at STP Wet	30.41
Standard Uncertainty Flowrate (m^3/s) at STP Wet	2.04
Expanded Uncertainty Flowrate (m^3/s) at STP Wet	**4.08 (%)**

Measurement Uncertainty Calculations - Flowrate at STP & Dry Gas

Contribution From	Standard u/c (%)
Moisture Uncertainty (% v/v)	0.24
Measured Average Flowrate (m^3/s) at STP Dry	24.41
Maximum Average Flowrate (m^3/s) at STP Dry	24.98
Standard Uncertainty Flowrate (m^3/s) at STP Dry	2.33
Expanded Uncertainty Flowrate (m^3/s) at STP Dry	**4.67 (%)**

Measurement Uncertainty Calculations - Flowrate at STP, Dry Gas & Ref Oxygen

Contribution From	Standard u/c (%)
Oxygen Uncertainty (% v/v)	0.066
Measured Average Flowrate (m^3/s) at STP Dry & Ref Oxygen	23.40
Maximum Average Flowrate (m^3/s) at STP Dry & Ref Oxygen	24.06
Standard Uncertainty Flowrate (m^3/s) at STP Dry & Ref Oxygen	2.81
Expanded Uncertainty Flowrate (m^3/s) at STP Dry & Ref O_2	**5.61 (%)**

Western Bio-Energy Ltd.		**Installation Name**	**: Biomass Plant**
Permit No	**: EPR/ZP3939GL**	**Visit Details**	**: Compliance July 2023**
Variation No	**: V005**	**Survey Dates**	**: 17th to 19th July 2023**
Report Ref	**: P5520 : R004**	**Report Issue Date**	**: 21st August 2023**

Particulates, Hydrogen Chloride & Hydrogen Fluoride Uncertainty

Site: Margam
Location: Main Stack

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

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
			TPM 1, HCl & HF					
Particulates	0.95	0.60	1.55	0.10	0.50	0.0500	0.25	0.25
Hydrogen Chloride	…	33.62	33.62	…	4.37	…	2.19	2.19
Hydrogen Fluoride	…	0.0512	0.0512	…	0.00665	…	0.00333	0.00333
…	…	…	…	…	…	…	…	…

	TPM 1, HCl & HF			Standard Uncertainty @ 95%		
Sampled Volume (V_m)	0.99	m^3	uV_m	0.001	m^3	
Meter Correction Factor (Yd)	1.03	…		…	…	
Meter Temperature (T_m)	296.83	k	uT_m	1.5	k	
Average Differential Pressure (ΔH)	21.58	mmH_2O	uΔH	0.25	mmH_2O	
Barometric Pressure (p_b)	762.06	mmHg	up_b	3.8	mmHg	
ΔH + ρs (ρ_m)	101.81	kPa		…	…	
Oxygen content ($O_{2,m}$)	8.17	% by volume	$uO_{2,m} = \sigma/\sqrt{n}$	0.0240		% by volume
Moisture Content (H_2O)	19.49	% by volume	uH_2O	0.53		% 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:

TPM 1, HCl & HF:

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

Uncertainty in correction factor to STP due to measured ΔH uncertainty component (uΔH), measured stack pressure uncertainty component (up_b) & measured temperature of dry gas uncertainty component (uT_{mDry})

TPM 1, HCl & HF:

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 0.954$$

	Maximum	Minimum	Sensitivity	ufstp
uΔH	0.95	0.95	0.0000918	0.0000230
up_b	0.96	0.95	0.00125	0.00468
uT_m	0.96	0.95	0.00321	0.00482
H_2O	…	…	…	…

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00614$$

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

TPM 1, HCl & HF:

$$V_{std} = V_{measured} \times f_s = \quad 0.941$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty (m^3)
Effect of uV_{std}	0.95	0.94	0.99	0.00605
Effect of uV_m	0.94	0.94	0.95	0.000954

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.00604$$

Uncertainty of Oxygen Correction Factor (%):-

TPM 1, HCl & HF:

$$f_{o_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = \quad 1.17$$

$$uCorr^n{}_{o_2} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured})x(20.9\% - O_{2,measured})} \; x \; Uncertainty \; of \; O_2 \; Measurement = \quad 0.0331$$

$$uf_{o_2} = \frac{uCorr^n{}_{o_2}}{f_{o_2}} x100 \quad 2.83\ \%$$

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

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

Determinand	TPM 1, HCl & HF:			
	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uM mg/Nm^3
Particulates	2.24	1.61	1.24	0.32
Hydrogen Chloride	44.53	39.10	1.24	2.72
Hydrogen Fluoride	0.0678	0.0595	1.24	0.00414
Ammonia	...	...	...	...

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	TPM 1, HCl & HF:
	uL mg/Nm^3
Particulates	0.0223
Hydrogen Chloride	0.48
Hydrogen Fluoride	0.000735
Ammonia	...

Uncertainty in final measurement @ Reference Conditions due to uVstp

Determinand	TPM 1, HCl & HF:			
	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uVstp mg/Nm^3
Particulates	1.94	1.92	2.05	0.0124
Hydrogen Chloride	42.09	41.55	44.44	0.27
Hydrogen Fluoride	0.0640	0.0632	0.0676	0.000409
Ammonia	...	...	...	...

Measurement Uncertainty of Determinand (excluding correction for oxygen)

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

Determinand	TPM 1, HCl & HF:				
	Measurement Uncertainty mg/Nm^3	Expanded Uncertainty mg/Nm^3	Measured Concentration mg/Nm^3	Percent of Measured Concentration	Uncertainty as Percentage of ELV
Particulates	0.32	0.64	1.93	33.00	4.24
Hydrogen Chloride	2.77	5.55	41.82	13.27	
Hydrogen Fluoride	0.00422	0.00844	0.0636	13.27	
Ammonia	...	...	...	...	

$$u_{combined} = \sqrt{\sum (uf_{O_2})^2 + (Uncertainty\ of\ Measurement\ of\ Determinand)^2}$$

Determinand	TPM 1, HCl & HF:		
	Measurement Uncertainty of Determinand	Measurement Uncertainty of Oxygen Corr^n Factor	Overall Measurement Uncertainty inc O_2 Corr^n factor (*Ucombined*)
Particulates	33.00	2.83	33.12
Hydrogen Chloride	13.27	2.83	13.56
Hydrogen Fluoride	13.27	2.83	13.56
Ammonia	...	...	...

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

Ammonia Uncertainty

Site: Margam
Location: Main Stack - 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	Solution mg	Standard Uncertainty Filter mg	Solution mg	Combined Uncertainty mg
				Ammonia				
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
Ammonia	...	1.73	1.73	...	0.23	...	0.11	0.11
				...				
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...

	Ammonia			Standard Uncertainty @ 95%		
Sampled Volume (V_m)	0.93	m^3	uV_m	0.001	m^3	
Meter Correction Factor (Yd)	1.03	...		...	...	
Meter Temperature (T_m)	300.50	k	uT_m	1.5	k	
Average Differential Pressure (ΔH)	25.00	mmH_2O	$u\Delta H$	0.25	mmH_2O	
Barometric Pressure (ρ_b)	762.06	mmHg	up_b	3.8	mmHg	
ΔH + ρs (ρ_m)	101.84	kPa		...	...	
Oxygen content ($O_{2,m}$)	6.60	% by volume	$uO_{2,m} = \sigma/\sqrt{n}$	0.0185		% by volume
Moisture Content (H_2O)	19.82	% by volume	uH_2O	0.54		% 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:

Ammonia:

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

Uncertainty in correction factor to STP due to measured ΔH uncertainty component ($u\Delta H$), measured stack pressure uncertainty component (up_s) & measured temperature of dry gas uncertainty component (uT_{mDry})

Ammonia:

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 0.942$$

	Maximum	Minimum	Sensitivity	ufstp
$u\Delta H$	0.94	0.94	0.0000907	0.0000227
up_b	0.95	0.94	0.00123	0.00463
uT_m	0.95	0.94	0.00314	0.00470
H_2O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00592$$

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

Ammonia:

$$V_{std} = V_{measured} \times f_s = \quad 0.879$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty (m^3)
Effect of uV_{std}	0.88	0.87	0.93	0.00552
Effect of uV_m	0.88	0.88	0.94	0.000942

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.00523$$

Uncertainty of Oxygen Correction Factor (%):-

Ammonia:

$$f_{o_2} = \frac{20.9\% - O_{2,\,ref}}{20.9\% - O_{2,\,measured}} = \quad 1.04$$

$$uCorr^n{}_{o_2} = \frac{20.9\% - O_{2,\,ref}}{(20.9\% - O_{2,\,measured}) x (20.9\% - O_{2,\,measured})} x Uncertainty\ of\ O_2\ Measurement = \quad 0.0262$$

$$uf_{o_2} = \frac{uCorr^n{}_{o_2}}{f_{o_2}} x100 = \quad 2.52\ \%$$

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

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

Determinand	Ammonia: Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uM mg/Nm^3
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
Ammonia	2.19	1.92	1.18	0.13

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	Ammonia: uL mg/Nm^3
...	...
...	...
...	...
Ammonia	0.0237

Uncertainty in final measurement @ Reference Conditions due to uVstp

Determinand	Ammonia: Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uVstp mg/Nm^3
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
Ammonia	2.07	2.04	2.34	0.0122

Combined Uncertainty excluding oxygen contribution

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

Determinand	Ammonia: Combined Uncertainty mg/Nm^3	Expanded Uncertainty mg/Nm^3	Measured Concentration mg/Nm^3	Percent of Measured Concentration
...	...	...	...	...
...	...	...	...	...
...	...	...	...	...
Ammonia	0.14	0.27	2.05	13.26

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)
...	...	...	...
...	...	...	...
...	...	...	...
Ammonia	13.26	2.52	13.49

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Sulphur Dioxide Uncertainty

Site: Margam
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
				SO2 - 1				
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
Sulphur Dioxide	...	152.46	152.46	...	19.82	...	9.91	9.91
...	...	...	...	...	...	...	...	...
				...				
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...

	SO2 - 1			Standard Uncertainty @ 95%		
Sampled Volume (V_m)	3.51	m^3	uV_m	0.001	m^3	
Meter Correction Factor (Yd)	1.03	...		...	...	
Meter Temperature (T_m)	300.48	k	uT_m	1.5	k	
Average Differential Pressure (ΔH)	25.00	mmH_2O	uΔH	0.25	mmH_2O	
Barometric Pressure (ρ_b)	765.06	mmHg	up_b	3.8	mmHg	
ΔH + ρs (ρ_m)	102.24	kPa		...	...	
Oxygen content ($O_{2,m}$)	6.62	% by volume	$uO_{2,m} = \sigma/\sqrt{n}$	0.0898		% by volume
Moisture Content (H_2O)	18.09	% by volume	uH_2O	0.47		% 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:

SO2 - 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_{mDry})

SO2 - 1:

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 0.946$$

	Maximum	Minimum	Sensitivity	ufstp
uΔH	0.95	0.95	0.0000907	0.0000227
up_b	0.95	0.94	0.00123	0.00463
uT_m	0.95	0.94	0.00315	0.00472
H_2O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00594$$

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

SO2 - 1:

$$V_{std} = V_{measured} \times f_s = \quad 3.324$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty (m^3)
Effect of uV_{std}	3.34	3.30	3.51	0.0209
Effect of uV_m	3.32	3.32	0.95	0.000946

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.0733$$

Uncertainty of Oxygen Correction Factor (%):-

SO2 - 1:

$$f_{o_2} = \frac{20.9\% - O_{2,\,ref}}{20.9\% - O_{2,\,measured}} = \quad 1.04$$

$$uCorr^n{}_{o_2} = \frac{20.9\% - O_{2,\,ref}}{(20.9\% - O_{2,\,measured}) x (20.9\% - O_{2,\,measured})} x Uncertainty\ of\ O_2\ Measurement = \quad 0.0263$$

$$uf_{o_2} = \frac{uCorr^n{}_{o_2}}{f_{o_2}} x100 = \quad 2.52\ \%$$

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

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

Determinand	SO2 - 1: Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uM mg/Nm^3
...	...	...	...	...
...	...	...	...	...
Sulphur Dioxide	50.98	44.75	0.31	3.11
...	...	...	...	...

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	SO2 - 1: uL mg/Nm^3
...	...
...	...
Sulphur Dioxide	0.55
...	...

Uncertainty in final measurement @ Reference Conditions due to uVstp

Determinand	SO2 - 1: Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uVstp mg/Nm^3
...	...	...	...	...
...	...	...	...	...
Sulphur Dioxide	48.95	46.83	14.41	1.06
...	...	...	...	...

Combined Uncertainty excluding oxygen contribution

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

Determinand	SO2 - 1: Combined Uncertainty mg/Nm^3	Expanded Uncertainty mg/Nm^3	Measured Concentration mg/Nm^3	Percent of Measured Concentration
...	...	...	...	...
...	...	...	...	...
Sulphur Dioxide	3.33	6.66	47.87	13.92
...	...	...	...	...

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)
...	...	...	...
...	...	...	...
Sulphur Dioxide	13.92	2.52	14.15
...	...	...	...

Western Bio-Energy Ltd.		**Installation Name**	**: Biomass Plant**
Permit No	**: EPR/ZP3939GL**	**Visit Details**	**: Compliance July 2023**
Variation No	**: V005**	**Survey Dates**	**: 17th to 19th July 2023**
Report Ref	**: P5520 : R004**	**Report Issue Date**	**: 21st August 2023**

Dioxins & Furans Uncertainty

Site: Margam
Location: Main Stack

Dioxin	Recovered Mass ng	LOD ng	LAB Method Uncert (%) K= 2 %age	as Mass (ng)	Standard Uncertainty Symbol	ng
2,3,7,8 - TCDD	0.00121	0.000170	50	0.000605	**u2,3,7,8 - TCDD**	0.000303
1,2,3,7,8 - PCDD	0.00822	0.000240	30	0.00247	**u1,2,3,7,8 - PCDD**	0.00123
1,2,3,4,7,8 - HxCDD	0.0224	0.000190	30	0.00672	**u1,2,3,4,7,8 - HxCDD**	0.00336
1,2,3,6,7,8 - HxCDD	0.0398	0.000210	30	0.0119	**u1,2,3,6,7,8 - HxCDD**	0.00597
1,2,3,7,8,9 - HxCDD	0.0353	0.000200	30	0.0106	**u1,2,3,7,8,9 - HxCDD**	0.00530
1,2,3,4,6,7,8 - HpCDD	0.379	0.000210	30	0.114	**u1,2,3,4,6,7,8 - HpCDD**	0.0569
OCDD	0.480	0.000400	30	0.144	**uOCDD**	0.0720
2,3,7,8 - TCDF	0.0102	0.000370	30	0.00306	**u2,3,7,8 - TCDF**	0.00153
1,2,3,7,8 - PCDF	0.0201	0.000200	30	0.00603	**u1,2,3,7,8 - PCDF**	0.00302
2,3,4,7,8 - PCDF	0.0386	0.000200	30	0.0116	**u2,3,4,7,8 - PCDF**	0.00579
1,2,3,4,7,8 - HxCDF	0.0560	0.000160	30	0.0168	**u1,2,3,4,7,8 - HxCDF**	0.00840
1,2,3,6,7,8 - HxCDF	0.0597	0.000150	30	0.0179	**u1,2,3,6,7,8 - HxCDF**	0.00896
2,3,4,6,7,8 - HxCDF	0.0948	0.000160	30	0.0284	**u2,3,4,6,7,8 - HxCDF**	0.0142
1,2,3,7,8,9 - HxCDF	0.00261	0.000130	30	0.000783	**u1,2,3,7,8,9 - HxCDF**	0.000392
1,2,3,4,6,7,8 - HpCDF	0.424	0.000110	30	0.127	**u1,2,3,4,6,7,8 - HpCDF**	0.0636
1,2,3,4,7,8,9 - HpCDF	0.0357	0.000140	30	0.0107	**u1,2,3,4,7,8,9 - HpCDF**	0.00536
OCDF	0.134	0.000120	30	0.0402	**uOCDF**	0.0201

	Measured Values			Standard Uncertainty @ 95%	
Sampled Volume (V_m)	5.552	**m^3**	**uV_m**	0.001	**m^3**
Meter Correction Factor (Yd)	1.032	**...**		...	**...**
Meter Temperature (T_m)	296.292	**k**	**uTm**	1.5	**k**
Average Differential Pressure (ΔH)	21.700	**mmH_2O**	**uDH**	0.25	**mmH_2O**
Barometric Pressure (p_b)	763.560	**mmHg**	**up$_b$**	3.8	**mmHg**
ΔH + ρs (p_m)	102.012	**kPa**		...	**...**
Oxygen content ($O_{2,m}$)	6.567	**% by volume**	$uO_{2,m} = \sigma/\sqrt{n}$	0.01	**% by volume**
Moisture Content (H_2O)	18.222	**% by volume**	**uH_2O**	0.48	**% by volume**

Note: In the following calculations, the sensitivity coefficient (C) is estimated using:

$$C_i = \frac{\partial f}{\partial x_i}$$

stack pressure uncertainty component (up$_s$) & measured temperature of dry gas uncertainty component (uT_{mDry})

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 0.957$$

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

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1$$

	Maximum	Minimum	Sensitivity	ufstp
uΔH	0.957	0.957	0.0000920	0.0000230
up$_b$	0.962	0.953	0.00125	0.00469
uT_m	0.962	0.953	0.00323	0.00485
H_2O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00618$$

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

$$V_{std} = V_{measured} \times f_s = \quad 5.315$$

	Maximum m^3	Minimum m^3	Sensitivity	Standard Uncertainty m^3
Effect of uV_{std}	5.349	5.280	5.552	0.0343
Effect of uV_m	5.316	5.314	0.957	0.000957

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.1905$$

Uncertainty of oxygen correction factor (ufO_2)

$$f_{o_2} = \frac{20.9\% - O_{2,\,ref}}{20.9\% - O_{2,\,measured}} = \quad 1.039 \qquad uCorr^n{}_{o_2} = \frac{20.9\% - O_{2,\,ref}}{(20.9\% - O_{2,\,measured})x(20.9\% - O_{2,\,measured})} \; x\, Uncertainty\ of\ O_2\ Measurement =$$

$$\therefore uf_{o_2} = \frac{uCorr^n{}_{o_2}}{f_{o_2}} x100 = \quad 2.51\ \%$$

Western Bio-Energy Ltd.		**Installation Name**	**: Biomass Plant**
Permit No	**: EPR/ZP3939GL**	**Visit Details**	**: Compliance July 2023**
Variation No	**: V005**	**Survey Dates**	**: 17th to 19th July 2023**
Report Ref	**: P5520 : R004**	**Report Issue Date**	**: 21st August 2023**

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

Dioxin	Maximum ng/Nm^3	Minimum ng/Nm^3	Sensitivity	uM ng/Nm^3
2,3,7,8 - TCDD	0.000296	0.000177	0.196	0.0000592
1,2,3,7,8 - PCDD	0.00185	0.00137	0.196	0.000241
1,2,3,4,7,8 - HxCDD	0.00504	0.00372	0.196	0.000657
1,2,3,6,7,8 - HxCDD	0.00895	0.00662	0.196	0.00117
1,2,3,7,8,9 - HxCDD	0.00794	0.00587	0.196	0.00104
1,2,3,4,6,7,8 - HpCDD	0.0852	0.0630	0.196	0.0111
OCDD	0.108	0.0798	0.196	0.0141
2,3,7,8 - TCDF	0.00229	0.00170	0.196	0.000299
1,2,3,7,8 - PCDF	0.00452	0.00334	0.196	0.000590
2,3,4,7,8 - PCDF	0.00868	0.00642	0.196	0.00113
1,2,3,4,7,8 - HxCDF	0.0126	0.00931	0.196	0.00164
1,2,3,6,7,8 - HxCDF	0.0134	0.00992	0.196	0.00175
2,3,4,6,7,8 - HxCDF	0.0213	0.0158	0.196	0.00278
1,2,3,7,8,9 - HxCDF	0.000587	0.000434	0.196	0.0000766
1,2,3,4,6,7,8 - HpCDF	0.0953	0.0705	0.196	0.0124
1,2,3,4,7,8,9 - HpCDF	0.00803	0.00593	0.196	0.00105
OCDF	0.0301	0.0223	0.196	0.00393

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

Dioxin	uL ng/Nm^3
2,3,7,8 - TCDD	2.732E06
1,2,3,7,8 - PCDD	0.0000186
1,2,3,4,7,8 - HxCDD	0.0000506
1,2,3,6,7,8 - HxCDD	0.0000899
1,2,3,7,8,9 - HxCDD	0.0000797
1,2,3,4,6,7,8 - HpCDD	0.000856
OCDD	0.00108
2,3,7,8 - TCDF	0.0000230
1,2,3,7,8 - PCDF	0.0000454
2,3,4,7,8 - PCDF	0.0000872
1,2,3,4,7,8 - HxCDF	0.000126
1,2,3,6,7,8 - HxCDF	0.000135
2,3,4,6,7,8 - HxCDF	0.000214
1,2,3,7,8,9 - HxCDF	5.893E-06
1,2,3,4,6,7,8 - HpCDF	0.000957
1,2,3,4,7,8,9 - HpCDF	0.0000806
OCDF	0.000303

Uncertainty in final measurement @ Reference Conditions due to uVstp

Dioxin	Maximum ng/Nm^3	Minimum ng/Nm^3	Sensitivity	uVstp mg/Nm^3
2,3,7,8 - TCDD	0.000245	0.000228	0.0000446	8.491E-06
1,2,3,7,8 - PCDD	0.00167	0.00155	0.000303	0.0000577
1,2,3,4,7,8 - HxCDD	0.00454	0.00423	0.000825	0.000157
1,2,3,6,7,8 - HxCDD	0.00807	0.00751	0.00147	0.000279
1,2,3,7,8,9 - HxCDD	0.00716	0.00666	0.00130	0.000248
1,2,3,4,6,7,8 - HpCDD	0.0769	0.0715	0.0140	0.00266
OCDD	0.0974	0.0906	0.0177	0.00337
2,3,7,8 - TCDF	0.00207	0.00193	0.000376	0.0000716
1,2,3,7,8 - PCDF	0.00408	0.00379	0.000741	0.000141
2,3,4,7,8 - PCDF	0.00783	0.00729	0.00142	0.000271
1,2,3,4,7,8 - HxCDF	0.0114	0.0106	0.00206	0.000393
1,2,3,6,7,8 - HxCDF	0.0121	0.0113	0.00220	0.000419
2,3,4,6,7,8 - HxCDF	0.0192	0.0179	0.00349	0.000665
1,2,3,7,8,9 - HxCDF	0.000529	0.000493	0.0000962	0.0000183
1,2,3,4,6,7,8 - HpCDF	0.0860	0.0800	0.0156	0.00298
1,2,3,4,7,8,9 - HpCDF	0.00724	0.00674	0.00132	0.000251
OCDF	0.0272	0.0253	0.00494	0.000940

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

Dioxin	Combined Uncertainty ng/Nm^3	Expanded Uncertainty ng/Nm^3	Measured Concentration ng/Nm^3	% of Measured Concentration
2,3,7,8 - TCDD	0.0000598	0.000120	0.000237	50.565
1,2,3,7,8 - PCDD	0.000249	0.000497	0.00161	30.933
1,2,3,4,7,8 - HxCDD	0.000677	0.00135	0.00438	30.933
1,2,3,6,7,8 - HxCDD	0.00120	0.00241	0.00778	30.933
1,2,3,7,8,9 - HxCDD	0.00107	0.00214	0.00690	30.933
1,2,3,4,6,7,8 - HpCDD	0.0115	0.0229	0.0741	30.933
OCDD	0.0145	0.0290	0.0939	30.933
2,3,7,8 - TCDF	0.000308	0.000617	0.00199	30.933
1,2,3,7,8 - PCDF	0.000608	0.00122	0.00393	30.933
2,3,4,7,8 - PCDF	0.00117	0.00233	0.00755	30.933
1,2,3,4,7,8 - HxCDF	0.00169	0.00339	0.0110	30.933
1,2,3,6,7,8 - HxCDF	0.00181	0.00361	0.0117	30.933
2,3,4,6,7,8 - HxCDF	0.00287	0.00573	0.0185	30.933
1,2,3,7,8,9 - HxCDF	0.0000789	0.000158	0.000510	30.933
1,2,3,4,6,7,8 - HpCDF	0.0128	0.0256	0.0829	30.933
1,2,3,4,7,8,9 - HpCDF	0.00108	0.00216	0.00698	30.933
OCDF	0.00405	0.00811	0.0262	30.933
		Total (ng/Nm^3)	0.360	12.9

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

Dioxin	% of Measured Concentration	Measurement Uncertainty of Oxygen Corr^n Factor	Overall Measurement Uncertainty inc O_2 Corr^n factor (*Ucombined*)	New Combined Uncertainty ng/Nm^3
2,3,7,8 - TCDD	50.565	2.510	50.627	0.0000599
1,2,3,7,8 - PCDD	30.933	2.510	31.034	0.000249
1,2,3,4,7,8 - HxCDD	30.933	2.510	31.034	0.000678
1,2,3,6,7,8 - HxCDD	30.933	2.510	31.034	0.00120
1,2,3,7,8,9 - HxCDD	30.933	2.510	31.034	0.00107
1,2,3,4,6,7,8 - HpCDD	30.933	2.510	31.034	0.0115
OCDD	30.933	2.510	31.034	0.0145
2,3,7,8 - TCDF	30.933	2.510	31.034	0.000309
1,2,3,7,8 - PCDF	30.933	2.510	31.034	0.000609
2,3,4,7,8 - PCDF	30.933	2.510	31.034	0.00117
1,2,3,4,7,8 - HxCDF	30.933	2.510	31.034	0.00170
1,2,3,6,7,8 - HxCDF	30.933	2.510	31.034	0.00181
2,3,4,6,7,8 - HxCDF	30.933	2.510	31.034	0.00287
1,2,3,7,8,9 - HxCDF	30.933	2.510	31.034	0.0000790
1,2,3,4,6,7,8 - HpCDF	30.933	2.510	31.034	0.0128
1,2,3,4,7,8,9 - HpCDF	30.933	2.510	31.034	0.00108
OCDF	30.933	2.510	31.034	0.00406

Western Bio-Energy Ltd.
Permit No : EPR/ZP3939GL
Variation No : V005
Report Ref : P5520 : R004

Installation Name : Biomass Plant
Visit Details : Compliance July 2023
Survey Dates : 17th to 19th July 2023
Report Issue Date : 21st August 2023

Uncertainty - Adjusted for TEQ / TEF

Dioxin	TEQ ng/m³*	Uncertainty ng/Nm³	Conc ng/Nm³	WHO Humans & Mammals (TEF)	Uncertainty ng/Nm³	Conc ng/Nm³	WHO Fish (TEF)	Uncertainty ng/Nm³	Conc ng/Nm³	WHO Birds (TEF)	Uncertainty ng/Nm³	Conc ng/Nm³
2,3,7,8 - TCDD	1	0.000120	0.000237	1	0.000120	0.000237	1	0.000120	0.000237	1	0.000120	0.000237
1,2,3,7,8 - PCDD	0.5	0.000249	0.000804	1	0.000498	0.00161	1	0.000498	0.00161	1	0.000498	0.00161
1,2,3,4,7,8 - HxCDD	0.1	0.000136	0.000438	0.1	0.000136	0.000438	0.5	0.000678	0.00219	0.05	0.0000678	0.000219
1,2,3,6,7,8 - HxCDD	0.1	0.000241	0.000778	0.1	0.000241	0.000778	0.01	0.0000241	0.0000778	0.01	0.0000241	0.0000778
1,2,3,7,8,9 - HxCDD	0.1	0.000214	0.000690	0.1	0.000214	0.000690	0.01	0.0000214	0.0000690	0.1	0.000214	0.000690
1,2,3,4,6,7,8 - HpCDD	0.01	0.000229	0.000741	0.01	0.000229	0.000741	0.001	0.0000229	0.0000741	0.001	0.0000229	0.0000741
OCDD	0.001	0.0000291	0.0000939	0.0001	2.906E06	9.386E06	...	...	...	...	...	...
2,3,7,8 - TCDF	0.1	0.0000618	0.000199	0.1	0.0000618	0.000199	0.05	0.0000309	0.0000997	1	0.000618	0.00199
1,2,3,7,8 - PCDF	0.05	0.0000609	0.000197	0.05	0.0000609	0.000197	0.05	0.0000609	0.000197	0.1	0.000122	0.000393
2,3,4,7,8 - PCDF	0.5	0.00117	0.00377	0.5	0.00117	0.00377	0.5	0.00117	0.00377	1	0.00234	0.00755
1,2,3,4,7,8 - HxCDF	0.1	0.000339	0.00110	0.1	0.000339	0.00110	0.1	0.000339	0.00110	0.1	0.000339	0.00110
1,2,3,6,7,8 - HxCDF	0.1	0.000361	0.00117	0.1	0.000361	0.00117	0.1	0.000361	0.00117	0.1	0.000361	0.00117
2,3,4,6,7,8 - HxCDF	0.1	0.000574	0.00185	0.1	0.000574	0.00185	0.1	0.000574	0.00185	0.1	0.000574	0.00185
1,2,3,7,8,9 - HxCDF	0.1	0.0000158	0.0000510	0.1	0.0000158	0.0000510	0.1	0.0000158	0.0000510	0.1	0.0000158	0.0000510
1,2,3,4,6,7,8 - HpCDF	0.01	0.000257	0.000829	0.01	0.000257	0.000829	0.01	0.000257	0.000829	0.01	0.000257	0.000829
1,2,3,4,7,8,9 - HpCDF	0.01	0.0000216	0.0000698	0.01	0.0000216	0.0000698	0.01	0.0000216	0.0000698	0.01	0.0000216	0.0000698
OCDF	0.001	8.114E06	0.0000262	0.0001	8.114E07	2.620E06	0.0001	8.114E07	2.620E06	0.0001	8.114E07	2.620E06
TOTAL	...	0.002	0.013	...	0.002	0.014	...	0.002	0.013	...	0.003	0.018
% Uncertainty	...	...	11.542	...	...	11.396	...	...	12.348	...	...	14.6

Western Bio-Energy Ltd.		**Installation Name**	**: Biomass Plant**
Permit No	**: EPR/ZP3939GL**	**Visit Details**	**: Compliance July 2023**
Variation No	**: V005**	**Survey Dates**	**: 17th to 19th July 2023**
Report Ref	**: P5520 : R004**	**Report Issue Date**	**: 21st August 2023**

Heavy Metals Uncertainty

Site: Margam
Location: Main Stack

$$u_{phase(mg/m^3)} = \frac{u_{method} \times Mass_{\mu g}}{200000} \qquad u_{mass} = \sqrt{\sum (u_{particulate})^2 + (u_{vapour})^2}$$

Metal	Particulate	Vapour	LAB Method Uncert (%) K= 2		Standard Uncertainty Particulate Phase	Standard Uncertainty Vapour Phase	Combined Standard Uncertainty of Measured Mass	
	mg	mg	Particulate Phase	Vapour Phase	mg/m³	mg/m³	Symbol	mg/m³
Antimony	0.600	0.157	15	16	0.0000450	0.0000126	uMSb	0.0000467
Arsenic	0.500	0.236	11	12	0.0000275	0.0000141	uMAs	0.0000309
Cadmium	0.500	0.157	12	10	0.0000300	7.850E-06	uMCd	0.0000310
Chromium	2.400	0.491	12	10	0.000144	0.0000245	uMCr	0.000146
Cobalt	0.500	0.157	12	10	0.0000300	7.850E-06	uMCo	0.0000310
Copper	2.400	0.759	12	10	0.000144	0.0000379	uMCu	0.000149
Lead	7.100	2.715	13	16	0.000462	0.000217	uMPb	0.000510
Manganese	2.500	0.324	16	10	0.000200	0.0000162	uMMn	0.000201
Nickel	7.400	0.625	12	9	0.000444	0.0000281	uMNi	0.000445
Thallium	0.400	0.157	14	14	0.0000280	0.0000110	uMTl	0.0000301
Vanadium	0.400	0.0785	12	9	0.0000240	3.533E-06	uMV	0.0000243

				Standard Uncertainty @ 95%		
Sampled Volume (V_m)	1.061	**m³**		**uV_m**	0.001	**m³**
Meter Correction Factor (Yd)	1.032	**...**			...	**...**
Meter Temperature (T_m)	299.75	**K**		**uTm**	1.5	**k**
Average Differential Pressure (ΔH)	21.35	**mmH₂O**		**uDH**	0.25	**mmH₂O**
Barometric Pressure (ρ_b)	762.06	**mmHg**		**up$_s$**	3.8	**mmHg**
ΔH + ρs (ρ_m)	101.81	**kPa**			...	**...**
Oxygen content ($O_{2,m}$)	6.49	**% by volume**	$uO_{2,m} = \sigma/\sqrt{n}$		0.02	**% by volume**
Moisture Content (H_2O)	18.99	**% by volume**		**uH₂O**	0.51	**% by volume**

Note: In the following calculations, the sensitivity coefficient (C) is estimated using:

$$C_i = \frac{\partial f}{\partial x_i}$$

measured stack pressure uncertainty component (up$_s$) & measured temperature of dry gas uncertainty component (uT_{mDry})

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 0.944$$

	Maximum	Minimum	Sensitivity	ufstp
uΔH	0.944	0.944	0.0000909	0.0000227
up$_s$	0.949	0.940	0.00124	0.00464
uT$_m$	0.949	0.940	0.00315	0.00473
H₂O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00596$$

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

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1$$

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

$$V_{std} = V_{measured} \times f_s = \quad 1.002$$

	Maximum m³	Minimum m³	Sensitivity	Standard Uncertainty m³
Effect of uV_{std}	1.008	0.996	1.061	0.00632
Effect of uV_m	1.003	1.001	0.944	0.000944

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.00677$$

Uncertainty of oxygen correction factor (uf_{O2})

$$f_{O_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = \quad 0.69$$

$$uCorr^n{}_{O_2} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured}) x (20.9\% - O_{2,measured})} x \, Uncertainty \, of \, O_2 \, Measurement = \quad 0.03$$

$$\therefore uf_{O_2} = \frac{uCorr^n{}_{O_2}}{f_{O_2}} x 100 = \quad 3.76\ \%$$

Western Bio-Energy Ltd.		Installation Name	: Biomass Plant
Permit No	: EPR/ZP3939GL	Visit Details	: Compliance July 2023
Variation No	: V005	Survey Dates	: 17th to 19th July 2023
Report Ref	: P5520 : R004	Report Issue Date	: 21st August 2023

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

Metal	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uM mg/Nm^3
Antimony	0.000551	0.000487	0.686	0.0000320
Arsenic	0.000526	0.000483	0.686	0.0000212
Cadmium	0.000472	0.000429	0.686	0.0000213
Chromium	0.00208	0.00188	0.686	0.000100
Cobalt	0.000472	0.000429	0.686	0.0000213
Copper	0.00227	0.00206	0.686	0.000102
Lead	0.00708	0.00638	0.686	0.000350
Manganese	0.00207	0.00180	0.686	0.000138
Nickel	0.00581	0.00520	0.686	0.000305
Thallium	0.000403	0.000361	0.686	0.0000206
Vanadium	0.000345	0.000311	0.686	0.0000166

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

Metal	uL mg/Nm^3
Antimony	5.994E-06
Arsenic	5.824E-06
Cadmium	5.202E-06
Chromium	0.0000229
Cobalt	5.202E-06
Copper	0.0000250
Lead	0.0000777
Manganese	0.0000224
Nickel	0.0000635
Thallium	4.410E-06
Vanadium	3.789E-06

Uncertainty in final measurement @ Reference Conditions due to uVstp

Metal	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uVstp mg/Nm^3
Antimony	0.000523	0.000516	0.000518	3.507E-06
Arsenic	0.000508	0.000501	0.000503	3.407E-06
Cadmium	0.000454	0.000447	0.000450	3.044E-06
Chromium	0.00200	0.00197	0.00198	0.0000134
Cobalt	0.000454	0.000447	0.000450	3.044E-06
Copper	0.00218	0.00215	0.00216	0.0000146
Lead	0.00678	0.00668	0.00672	0.0000455
Manganese	0.00195	0.00192	0.00193	0.0000131
Nickel	0.00554	0.00547	0.00549	0.0000372
Thallium	0.000385	0.000379	0.000381	2.580E-06
Vanadium	0.000330	0.000326	0.000327	2.217E-06

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

Metal	Combined Uncertainty mg/Nm^3	Expanded Uncertainty mg/Nm^3	Measured Concentration mg/Nm^3	Percent of Measured Concentration
Antimony	0.0000328	0.0000656	0.000519	12.630
Arsenic	0.0000222	0.0000445	0.000504	8.823
Cadmium	0.0000221	0.0000442	0.000451	9.812
Chromium	0.000104	0.000207	0.00198	10.455
Cobalt	0.0000221	0.0000442	0.000451	9.812
Copper	0.000106	0.000212	0.00217	9.801
Lead	0.000361	0.000722	0.00673	10.732
Manganese	0.000140	0.000280	0.00194	14.461
Nickel	0.000314	0.000628	0.00550	11.406
Thallium	0.0000212	0.0000425	0.000382	11.127
Vanadium	0.0000172	0.0000344	0.000328	10.487

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

Metal	% of Measured Concentration	Measurement Uncertainty of Oxygen Corr^n Factor	Overall Measurement Uncertainty inc O_2 Corr^n factor (*Ucombined*)	New Combined Uncertainty mg/Nm^3
Antimony	12.630	3.760	13.178	0.000034
Arsenic	8.823	3.760	9.591	0.000024
Cadmium	9.812	3.760	10.508	0.000024
Chromium	10.455	3.760	11.111	0.000110
Cobalt	9.812	3.760	10.508	0.000024
Copper	9.801	3.760	10.497	0.000114
Lead	10.732	3.760	11.372	0.000383
Manganese	14.461	3.760	14.942	0.000145
Nickel	11.406	3.760	12.010	0.000330
Thallium	11.127	3.760	11.745	0.000022
Vanadium	10.487	3.760	11.140	0.000018

.

Note: Uncertainty for each metals group is based on the summation in quadrature of the individual standard uncertainties (in mg/m3) of each contributing metal. Combined standard uncertainty of each group is converted to 95% confidence (multiplication by k = 2) before being expressed as a percentage of the combined group concentration.

Western Bio-Energy Ltd.		**Installation Name**	**: Biomass Plant**
Permit No	**: EPR/ZP3939GL**	**Visit Details**	**: Compliance July 2023**
Variation No	**: V005**	**Survey Dates**	**: 17th to 19th July 2023**
Report Ref	**: P5520 : R004**	**Report Issue Date**	**: 21st August 2023**

Mercury Uncertainty

Site: Margam
Location: Main Stack

$$u_{phase(mg/m^3)} = \frac{u_{method} \times Mass_{\mu g}}{200000} \qquad u_{mass} = \sqrt{\sum (u_{particulate})^2 + (u_{vapour})^2}$$

Metal	Particulate	Vapour	LAB Method Uncert (%) K= 2		Standard Uncertainty Particulate Phase	Standard Uncertainty Vapour Phase	Combined Standard Uncertainty of Measured Mass	
	mg	mg	Particulate Phase	Vapour Phase	mg/m³	mg/m³	Symbol	mg/m³
Mercury	0.0850	0.549	10	12	4.250E-06	0.0000329	uMHg	0.0000332

			Standard Uncertainty @ 95%		
Sampled Volume (V_m)	1.054	**m³**	**uV_m**	0.001	**m³**
Meter Correction Factor (Yd)	1.032	**...**		...	**...**
Meter Temperature (T_m)	299.92	**k**	**uTm**	1.5	**k**
Average Differential Pressure (ΔH)	21.58	**mmH₂O**	**uDH**	0.25	**mmH₂O**
Barometric Pressure (ρ_b)	762.06	**mmHg**	**uρ_s**	3.8	**mmHg**
ΔH + ρs (ρ_m)	101.81	**kPa**		...	**...**
Oxygen content ($O_{2,m}$)	6.66	**% by volume**	$uO_{2,m} = \sigma/\sqrt{n}$	0.01	**% by volume**
Moisture Content (H_2O)	20.47	**% by volume**	**uH_2O**	0.55	**% by volume**

Note: In the following calculations, the sensitivity coefficient (C) is estimated using:

$$C_i = \frac{\partial f}{\partial x_i}$$

measured stack pressure uncertainty component (up$_s$) & measured temperature of dry gas uncertainty component (uT$_{mDry}$)

$$f_s = \frac{273}{760} \times \frac{P_b + \frac{\Delta H}{13.6}}{T_m} \times Y_d = \quad 0.944$$

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

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = \quad 1$$

	Maximum	Minimum	Sensitivity	ufstp
uΔH	0.944	0.944	0.0000909	0.0000227
uρ_s	0.949	0.939	0.00124	0.00464
uT$_m$	0.949	0.939	0.00315	0.00472
H₂O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{\sqrt{(u\Delta H)^2 + (uP_s)^2}}{(P_m/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100/(100 - H_2O)}\right)^2} = \quad 0.00595$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uV$_{std}$) & volume uncertainty component (uV$_m$)

$$V_{std} = V_{measured} \times f_s = \quad 0.994$$

	Maximum m³	Minimum m³	Sensitivity	Standard Uncertainty m³
Effect of uV$_{std}$	1.001	0.988	1.054	0.00627
Effect of uV$_m$	0.995	0.994	0.944	0.000944

Combined Standard Uncertainty

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uV_{std}}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = \quad 0.00667$$

Uncertainty of oxygen correction factor (uf$_{O2}$)

$$f_{o_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = \quad 0.70$$

$$uCorr^n{}_{o_2} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured}) x (20.9\% - O_{2,measured})} x\, Uncertainty\ of\ O_2\ Measurement = \quad 0.03$$

$$\therefore uf_{o_2} = \frac{uCorr^n{}_{o_2}}{f_{o_2}} x100 = \quad 3.81\ \%$$

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

Metal	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uM mg/Nm^3
Mercury	0.000467	0.000420	0.699	0.0000232

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

Metal	uL mg/Nm^3
Mercury	5.120E-06

Uncertainty in final measurement @ Reference Conditions due to uVstp

Metal	Maximum mg/Nm^3	Minimum mg/Nm^3	Sensitivity	uVstp mg/Nm^3
Mercury	0.000446	0.000440	0.000446	2.972E-06

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

Metal	Combined Uncertainty mg/Nm^3	Expanded Uncertainty mg/Nm^3	Measured Concentration mg/Nm^3	Percent of Measured Concentration
Mercury	0.0000240	0.0000479	0.000443	10.812

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

Metal	% of Measured Concentration	Measurement Uncertainty of Oxygen Corr^n Factor	Overall Measurement Uncertainty inc O_2 Corr^n factor ($Ucombined$)	New Combined Uncertainty mg/Nm^3
Mercury	10.812	3.810	11.464	0.000025

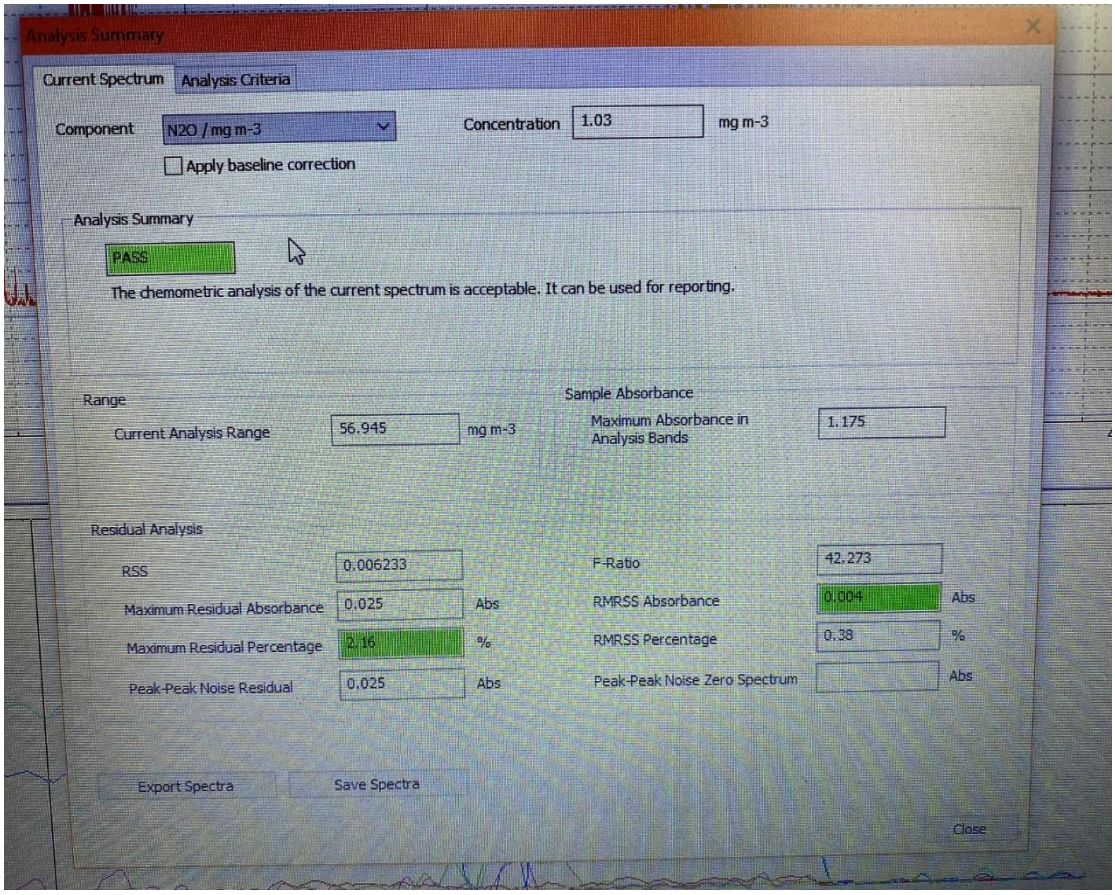
.

Note: Uncertainty for each metals group is based on the summation in quadrature of the individual standard uncertainties (in mg/m3) of each contributing metal. Combined standard uncertainty of each group is converted to 95% confidence (multiplication by k = 2) before being expressed as a percentage of the combined group concentration.

RESULTS OF FTIR DAILY SPECTRAL RESIDUALS CHECKS

Nitrous Oxide

Allowed limit is 5% so a pass at 2.16%



FTIR SUMMARY OF ANALYTICAL BANDS

SUMMARY OF ANALYTICAL BANDS – PROTEA FTIR 204M

Gas Species	Primary Method Band / cm^{-1}	Secondary Method Band / cm^{-1}	Tertiary Method Band / cm^{-1}
H_2O	3319.374 – 3404.709		
CO_2	2043.693 – 2091.905 902.523 – 997.018		
CO	2132.885 – 2201.345	2021.034 – 2201.345	2021.034 – 2201.345
NO	1872.060 – 1905.326	2012.838 – 1851.329 (sub-set of smaller bands in this region)	3388.317 – 3404.709 1905.326 - 1872.060
NO_2	1548.077 – 1677.284	1605.931 - 1583.754; 2810.741 – 3160.276	2810.259 – 2936.091
N_2O	2113.600 – 2223.041	2528.703 – 2651.160 2113.600 – 2223.041	
SO_2	1295.448 – 1414.531	3388.317 – 3404.709 1342.695 – 1360.052 1019.195 – 1233.737	2810.259 – 2936.091
NH_3	899.148 – 969.055		
HCl	2587.521 – 2884.023	2587.521 – 2884.023	