4279

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Stack Emissions Testing Report Commissioned by
Vale Bio-Energy

Installation Name & Address
Vale Bio-Energy
Pancross AD Plant
Pancross Farm
Llancarfan
CF62 3AJ

EPR Permit: EPR/HB3935AE/V02

Stack Reference
Engine 1

Dates of the Monitoring Campaign
12th March 2021

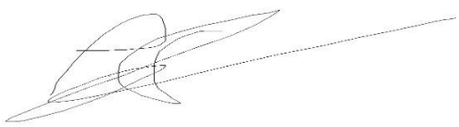
Job Reference Number
EMT-00590

Report Written by
Darren Price Team Leader MCERTS Level 2 MM 03 176 TE1 TE2 TE3 TE4

Report Approved by
Phil Soley Assistant Operations Manager MCERTS Level 2 MM 12 1187 TE1 TE2 TE3 TE4

Report Date
30th March 2021

Version
Version 1

Signature of Report Approver


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Opinions and interpretations expressed herein are outside the scope of Element's ISO 17025 accreditation.

MONITORING OBJECTIVES

Vale Bio-Energy, Llancarfan
Engine 1
12th March 2021

Overall Aim of the Monitoring Campaign

Element were commissioned by Vale Bio-Energy to carry out stack emissions testing on the Engine 1 at Llancarfan.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Permit.

Special Requirements

There were no special requirements.

Target Parameters

Sulphur Dioxide, Total VOCs (as Carbon), Oxides of Nitrogen (as NO_2), Carbon Monoxide

Executive Summary

MONITORING RESULTS

Vale Bio-Energy, Llancarfan
Engine 1
12th March 2021

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
Sulphur Dioxide [1]	mg/m³	223	17.8	350	g/hr	353	36.8	-
Total VOCs (as Carbon) [1]	mg/m³	1109	45.8	1000	g/hr	1760	138	-
Oxides of Nitrogen (as NO_2) [1]	mg/m³	409	15.6	500	g/hr	649	50.0	-
Carbon Monoxide [1]	mg/m³	902	33.8	1400	g/hr	1431	110	-
Oxygen	% v/v	**Dry** 8.6	0.21					
Water Vapour	% v/v	15.4	0.69					
Stack Gas Temperature	°C	195						
Stack Gas Velocity	m/s	21.6	1.1					
Volumetric Flow Rate (ACTUAL)	m³/hr	4120	275					
Volumetric Flow Rate (REF) [1]	m³/hr	1587	106					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

[1] Reference Conditions (REF) are: 273K, 101.3kPa, dry gas, 5% oxygen.

Executive Summary

MONITORING DATE(S) & TIMES

Vale Bio-Energy, Llancarfan
Engine 1
12th March 2021

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Sulphur Dioxide	R1	mg/m³	223	g/hr	353	12/03/2021	11:20 - 12:20	60
Total VOCs (as Carbon)	R1	mg/m³	1109	g/hr	1760	12/03/2021	11:20 - 12:20	60
Oxides of Nitrogen (as NO_2)	R1	mg/m³	409	g/hr	649	12/03/2021	11:20 - 12:20	60
Carbon Monoxide	R1	mg/m³	902	g/hr	1431	12/03/2021	11:20 - 12:20	60
Oxygen	R1	% v/v	8.6			12/03/2021	11:20 - 12:20	60
Velocity Traverse	R1					12/03/2021	10:25 - 10:30	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Vale Bio-Energy, Llancarfan
Engine 1
12th March 2021

Standard Operating Conditions

Parameter	Value
Process Status	Operating
Capacity (of 100%) and Tonnes / Hour	100%
Continuous or Batch Process	Continuous
Feedstock (if applicable)	N/A
Abatement System	None
Abatement System Running Status	N/A
Fuel	Bio gas
Plume Appearance	No plume visible

Executive Summary

MONITORING & ANALYTICAL METHODS

Vale Bio-Energy, Llancarfan
Engine 1
12th March 2021

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**Sampling Status**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**Analysis Status**	**Analysis Lab**	**Overall Status**	**LOD (Average)**
Sulphur Dioxide	EN 14791	CAT-TP-09	MCERTS	EET	CAT-AP-01	IC	MCERTS	EET	MCERTS	0.17 mg/m³
Water Vapour	EN 14790	CAT-TP-05	MCERTS	EET	CAT-TP-05	Gravimetric	MCERTS	EET	MCERTS	0.10 % v/v
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20	MCERTS	EET	Flame Ionisation Detection by Sick 3006 FID				MCERTS	1.16 mg/m³
Oxides of Nitrogen (as NO_2)	EN 14792	CAT-TP-39	MCERTS	EET	Chemiluminescence by Horiba PG-350E				MCERTS	0.41 mg/m³
Carbon Monoxide	EN 15058	CAT-TP-39	MCERTS	EET	NDIR by Horiba PG-350E				MCERTS	0.25 mg/m³
Oxygen	EN 14789	CAT-TP-39	MCERTS	EET	Dry Paramagnetic Cell by Horiba PG-350E				MCERTS	0.1 %
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	MCERTS	EET	Pitot Tube and Thermocouple				MCERTS	3.0 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Element Materials Technology (EET)	ISO 17025 Accreditation Number: 4279

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All	All	There are no deviations associated with the sampling employed.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.26
Width	m	-
Area	m²	0.05
Port Depth	cm	12
Orientation of Duct	-	Vertical
Number of Ports	-	1
Sample Port Size	-	4" Flange

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	On Ground
Inside / Outside	Outside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	N/A
Platform has vertical base boards (approx. 0.25m high)	N/A
Platform has chains / self closing gates at top of ladders	N/A
There are no obstructions present which hamper insertion of sampling equipment	N/A
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and EN 15259, and therefore there are no improvement recommendations.

EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	240.0	> 5 Pa	Yes
Mean Velocity	m/s	21.55	-	-
Lowest Gas Velocity	m/s	21.55	-	-
Highest Gas Velocity	m/s	21.55	-	-
Ratio of Above	: 1	1.00	< 3 : 1	Yes
Maximum Angle of Swirl	°	0.00	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

Executive Summary

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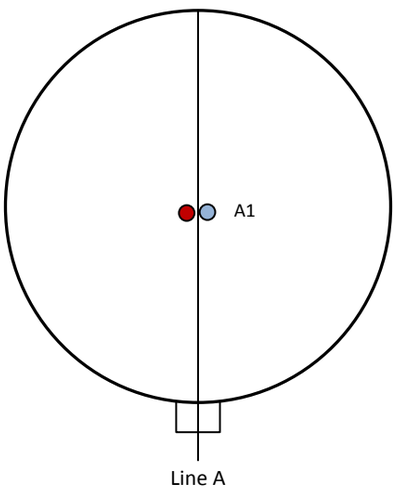
PLANT PHOTOS

Photo 1

Photo 2

Photo 3

SAMPLE POINTS



where
- ○ = isokinetic point sampled at
- ● = isokinetic point not sampled at
- ● = combustion gases sample point
- ● = non-isokinetic sample point

APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Darren Price	MCERTS Level 2	MM 03 176	TE1 TE2 TE3 TE4
Technician	Craig Price	MCERTS Level 1	MM 20 1588	None

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	-
Control Box DGM (2)	-
Box Thermocouples (1)	-
Box Thermocouples (2)	-
Umbilical (1)	-
Umbilical (2)	-
Oven Box (1)	-
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	-
Heated Probe (3)	-
S-Pitot (1)	CAT 21S.18
S-Pitot (2)	-
L-Pitot	-
Site Balance	CAT 17.14
500g / 1Kg Check Weights	CAT 17.14
Last Impinger Arm	CAT 4.82
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250 SRM	CAT 9.14
Horiba PG-250	-
Servomex 5200 MP	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
JCT JCC P1 Cooler	CAT 4.204
Gasmet DX4000	-
Gasmet Sampling System	-
Bernath 3006 FID	-
M&C PSS	CAT 12.91
Mass Flow Controller (1)	CAT 6.34
Mass Flow Controller (2)	CAT 6.35
Mass View (1)	CAT 25.78
Mass View (2)	CAT 25.79
Easylogger EN-EL-12 Bit	-
Hioki 5031 (mA)	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.55
Digital Manometer (2)	-
Digital Temperature Meter	CAT 3.55
Stopwatch	-
Barometer	CAT 13.3
Stack Thermocouple (1)	CAT 4.919
Stack Thermocouple (2)	-
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	-
20m Heated Line (1)	CAT 20.139
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	CAT 20.139
Laboratory Balance	
Tape Measure	CAT 16.144

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Sulphur Dioxide	EN 14791	CAT-TP-09
Water Vapour	EN 14790	CAT-TP-05
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20
Oxides of Nitrogen (as NO_2)	EN 14792	CAT-TP-39
Carbon Monoxide	EN 15058	CAT-TP-39
Oxygen	EN 14789	CAT-TP-39
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.26
Stack Width, W	m	-
Stack Area, A	m^2	0.05
Average Stack Gas Temperature, T_a	°C	195.0
Average Stack Gas Pressure	Pa	240.0
Average Stack Static Pressure, P_{static}	kPa	0.055
Average Barometric Pressure, P_b	kPa	101.8
Average Pitot Tube Calibration Coefficient, C_p	-	0.85

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m³ p	Conc kg/m³ p_i
CO_2 (Estimated)	-	12.20	10.32	0.1220	44.01	1.9635	0.23955
O_2	-	8.58	7.26	0.0858	32.00	1.4277	0.12253
N_2	-	79.22	67.03	0.7922	28.01	1.2498	0.99010
Moisture (H_2O)	-	-	15.39	0.1539	18.02	0.8037	0.12369

Where: $p = M / 22.41$

$p_i = r \times p$

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m³	1.352
Wet Density (STP), P_{STW}	kg/m³	1.268
Dry Density (Actual), P_{Actual}	kg/m³	0.793
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	0.744

Where: P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m³ (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) $= P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	195.0	0.0
Total Pressure	kPa	101.9	101.3
Moisture	%	15.39	0.00
Oxygen (Dry)	%	8.6	5.0

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	4120
Gas Volumetric Flowrate (STP, Wet)	m³/hr	2417
Gas Volumetric Flowrate (STP, Dry)	m³/hr	2045
Gas Volumetric Flowrate REF [1]	m³/hr	1587

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)

(1 of 1)

Parameter	Units	Value
Date of Survey	-	12/03/2021
Time of Survey	-	10:25 - 10:30
Atmospheric Pressure	kPa	101.8
Average Stack Static Pressure	Pa	55
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 200 (10000Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.85
Number of Lines Available	-	1
Number of Lines Used	-	1

Sampling Line A

Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °
STATIC (Units: Pa)		*55.0*				
Mean		**240.0**	**195.0**	**0.744**	**21.55**	
1	0.13	240.0	195.0	0.744	21.55	0.0

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	u(k)	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	u(Δpi)	7.369	Pa
- Resolution	u(res)	0.08677	
- Calibration	u(cal)	5.998	
- Drift	u(drift)	33.333	
- Lack of Fit	u(fit)	13.879	
- Overall corrections to dynamic measurements	u(Cf)	53.297	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00010	-
- $\varphi O_2,w$	-	7.262	
- $\varphi CO_2,w$	-	10.323	
- Oxygen, dry	u(ϕO_2,d)	0.263	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.373	
- Water Vapour	u(ϕH_2O)	0.785	
- Oxygen, wet	u(ϕO_2,w)	0.232	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.330	
Standard uncertainty associated with the stack temperature	u(Tc)	2.388	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.846	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	7.369	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00401	-
Standard uncertainty associated with the local velocities	u(vi)	0.540	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.540	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	1.059	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	4.91	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	275.2	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00116	
- $u^2(qV,w)$	-	19713	
- u(qV,w)	-	140.4	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	6.68	%

SULPHUR DIOXIDE: RESULTS SUMMARY

Vale Bio-Energy, Llancarfan

Engine 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	223		223
Uncertainty	±mg/m³	17.8		17.8
Mass Emission	g/hr	353		353
Uncertainty	±g/hr	36.8		36.8

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	15.4		15.4
Uncertainty	±% v/v	0.69		0.69

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.16		< 0.16

General Sampling Information

Parameter	Value	
Standard	EN 14791	
Technical Procedure	CAT-TP-09	
Name of Analytical Laboratory	EET	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	MCERTS	
Date of Sample Analysis	17/03/2021	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Polyethylene	
Absorption Solution	0.3% Hydrogen Peroxide	
Positioning of Filter	Out Stack Heated Head	
Filter Size and Material	0.1µm Glass Fibre	
Number of Sampling Lines Used	1/1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1/1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 5% oxygen.

SULPHUR DIOXIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1
Sampling Times	-	11:20 - 12:20
Sampling Dates	-	12/03/2021
Sampling Device	-	MFC / MV
Duration	mins	60
Volume Sampled (STP, Dry)	m^3	0.1192
Volume Sampled (STP, Wet)	m^3	0.1409
Volume Sampled (REF)	m^3	0.0925
Sample Flow Rate	l/min	1.91
Laboratory Result for Front Impingers	µg/ml	96.87
Laboratory Result for Back Impinger	µg/ml	0.32
Volume in Front Impingers	ml	212.4
Volume in Back Impinger	ml	102.3
Mass in Front Impingers	µg	20575.2
Mass in Back Impinger	µg	32.7
Total Mass Collected	µg	20607.9
Calculated Concentration	mg/m^3	222.70
Liquid Trap Start Mass	g	1536.1
Liquid Trap End Mass	g	1549.1
Silica Trap Start Mass	g	1441.6
Silica Trap End Mass	g	1446.0
Total Mass Of Water Vapour	g	17.4
Calculated Water Vapour	% v/v	15.39

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1
Blank Dates	-	11/12/2021
Average Volume Sampled (REF)	m^3	0.0925
Laboratory Result for Impingers	µg/ml	< 0.05
Volume in Impingers	ml	304.7
Total Mass Collected	µg	< 15.2
Calculated Concentration	mg/m^3	< 0.16

SULPHUR DIOXIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1
Mean Sampling Rate	l/min	1.9
Pre-Sampling Leak Rate	l/min	0.00
Post-Sampling Leak Rate	l/min	0.00
Allowable Leak Rate	l/min	0.04
Leak Test Acceptable	-	Yes

Absorption Efficiency	Units	Run 1
Absorption Efficiency	%	99.8
Allowable Absorption Efficiency	%	95
Absorption Efficiency Acceptable	-	Yes

Water Droplets	Units	Run 1
Are Water Droplets Present	-	No

MU (Concurrent Water Vapour)	Units	Run 1
Measurement Uncertainty (MU)	%	4.5
Allowable MU	%	20.0
MU Acceptable	%	Yes

Silica Gel (Concurrent Water Vapour)	Units	Run 1
Less than 50% Faded	%	Yes

Test Conditions	Units	Run 1
Ambient Temperature Recorded?	-	Yes

Blank Runs

Leak Test Results	Units	Blank 1
Expected Sampling Rate	l/min	2.0
Pre-Sampling Leak Rate	l/min	0.00
Post-Sampling Leak Rate	l/min	0.00
Allowable Leak Rate	l/min	0.04
Leak Test Acceptable	-	Yes

Validity of Blank vs ELV	Units	Blank 1
Allowable Blank	mg/m³	35.0
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	
There are no deviations associated with the sampling employed.	wx	

SULPHUR DIOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty		
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**
Sampled Volume (STP)	V_m	0.1192		uV_m	m^3	0.0024
Leak	L	0.00		uL	%	-
Laboratory Result	L_r	2.90		uL_r	%	-

	Uncertainty as a Percentage		
Measured Quantities	**Units**	**Run 1**	**Requirement of Standard**
Sampled Volume (STP)	%	2.00	≤2%
Leak	%	0.00	≤2%
Laboratory Result	%	2.90	No Requirement

	Uncertainty in Measurement Units			Sensitivity Coefficient
Measured Quantities	**Symbol**	**Units**	**Run 1**	**Run 1**
Sampled Volume (STP)	V_m	m^3	0.1192	1868.26
Leak	L	mg/m^3	0.000	1.00
Laboratory Result	L_r	mg/m^3	6.458	1.00

	Uncertainty in Result	
Measured Quantities	**Units**	**Run 1**
Sampled Volume (STP)	mg/m^3	4.454
Leak	mg/m^3	0.0000
Laboratory Result	mg/m^3	6.4583

	Oxygen Correction Part of MU Budget	
Measured Quantities	**Units**	**Run 1**
O_2 Correction Factor	-	1.29
Stack Gas O_2 Content	% v/v	8.58
MU for O_2 Correction	-	0.05
Overall MU For O_2 Measurement	%	4.03

Parameter	**Units**	**Run 1**
Combined uncertainty	mg/m^3	7.85
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	15.38
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	17.80
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	17.80
Reported Uncertainty	mg/m^3	17.80
Expanded uncertainty (95% confidence), without Oxygen Correction	%	6.9
Expanded uncertainty (95% confidence), with Oxygen Correction	%	8.0
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	8.0
Reported Uncertainty	%	8.0

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Vale Bio-Energy, Llancarfan
Engine 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	1109		1109
Uncertainty	±mg/m³	45.8		45.8
Mass Emission	g/hr	1760		1760
Uncertainty	±g/hr	138		138

General Sampling Information

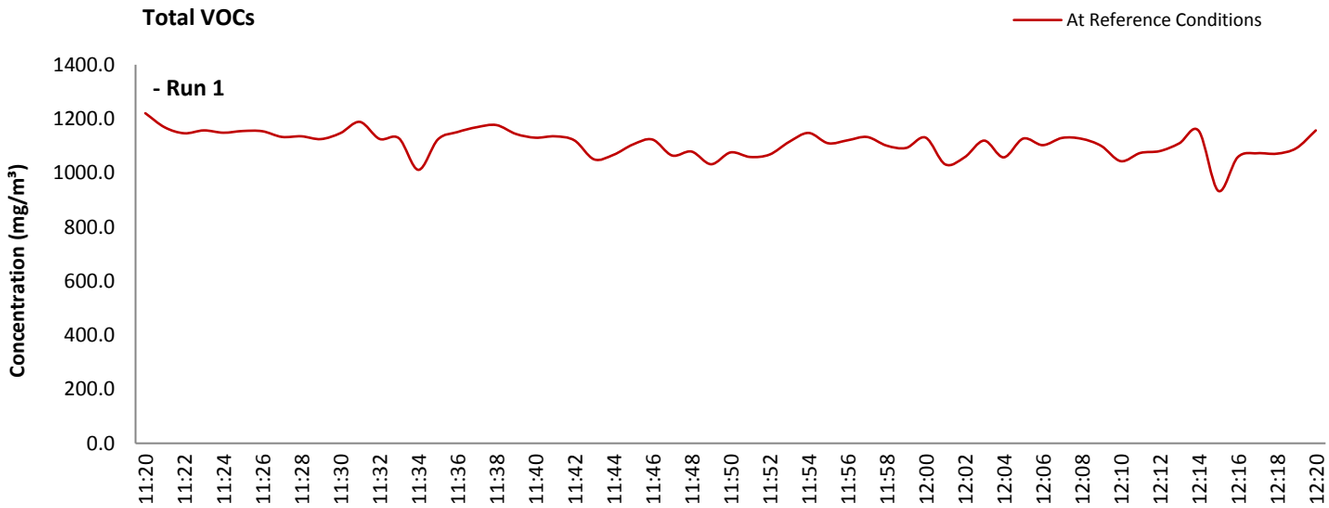
Parameter	Value	
Standard	EN 12619:2013	
Technical Procedure	CAT-TP-20	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Propane in 7% O_2 in N_2 (5 Grade)	
Span Gas Reference Number	12.300 in N_2 | 1.0290a in AIR	
Span Gas Expiry Date	15/05/2022 | 09/09/2021	
Span Gas Start Pressure (bar)	95 | 10	
Gas Cylinder Concentration (ppm)	811.4 | 800	
Span Gas Set Point (ppm)	807.60	This is the blended concentration of both propane cylinders
Span Gas Uncertainty (%)	2 | 2	
Zero Gas Type	7% O_2 in N_2 (5 Grade)	
Number of Sampling Lines Used	1/1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1/1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 5% oxygen.

TOTAL VOCs (as CARBON): DATA TREND

Graphical Trend of Data



TOTAL VOCs (as CARBON): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	11:20 - 12:20
Sampling Dates	-	12/03/2021
Instrument Range	ppm	1000
Span Gas Value	ppm	807.6

Quality Assurance

	Zero Drift	Units	Run 1
CAL 1	Zero Down Sampling Line (Pre)	ppm	2.00
	Zero Down Sampling Line (Post)	ppm	0.00
	Zero Drift	ppm	-2.00
	Allowable Zero Drift	± ppm	40.38
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span Down Sampling Line (Pre)	ppm	805.00
	Span Down Sampling Line (Post)	ppm	813.00
	Span Drift	ppm	8.00
	Allowable Span Drift	± ppm	40.38
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	6 - 8

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	
There are no deviations associated with the sampling employed.	x	

TOTAL VOCs (as CARBON): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	1000.0		mg/m³ (REF)
Allowable MU	15.0		%
Measured concentration	860.49		mg/m³ (STP, dry)
Range Used	1000.0		ppm
Range Used [A]	1606.1		mg/m³
Cal gas conc.	807.6		ppm
Conversion	1.61		ppm to mg/m³
MCERTS Range [B]	15.0		mg/m³
Lower of [A] or [B]	15.0		mg/m³
Cal gas conc.	1297.1		mg/m³

Performance characteristics	RUN 1		Units
Response time	45		seconds
Number of readings in measurement	60		-
Repeatability at zero	2.00		% full scale
Repeatability at span level	0.00		% full scale
Deviation from linearity	0.20		% of value
Zero drift	-0.25		% full scale
Span drift	0.99		% full scale
Volume or pressure flow dependence	1.60		% of full scale
Atmospheric pressure dependence	0.30		% of value/kPa
Ambient temperature dependence	1.40		% full scale/10K
Combined interference	0.45		% range
Dependence on voltage	0.50		% full scale/10V
Losses in the line (leak)	0.74		% of value
Uncertainty of calibration gas	2.83		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m³
Standard deviation of repeatability at span level	0.00		mg/m³
Lack of fit	0.02		mg/m³
Drift	0.00		mg/m³
Volume or pressure flow dependence	0.00		mg/m³
Atmospheric pressure dependence	0.01		mg/m³
Ambient temperature dependence	0.20		mg/m³
Combined interference (from MCERTS Certificate)	0.04		mg/m³
Dependence on voltage	0.06		mg/m³
Losses in the line (leak)	3.69		mg/m³
Uncertainty of calibration gas	14.05		mg/m³

			RUN 1		Units
Measurement uncertainty		**Result**	860.49		mg/m³
Combined uncertainty			14.53		mg/m³
Expanded uncertainty	k =	1.96	28.48		mg/m³
Uncertainty corrected to std conds. (O_2)			36.71		mg/m³ (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	3.31		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	2.85		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	15.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	4.12		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	4.42		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	15.2		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <15% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 15% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

OXIDES OF NITROGEN (as NO_2): RESULTS SUMMARY

Vale Bio-Energy, Llancarfan
Engine 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	409		409
Uncertainty	±mg/m³	15.6		15.6
Mass Emission	g/hr	649		649
Uncertainty	±g/hr	50.0		50.0

General Sampling Information

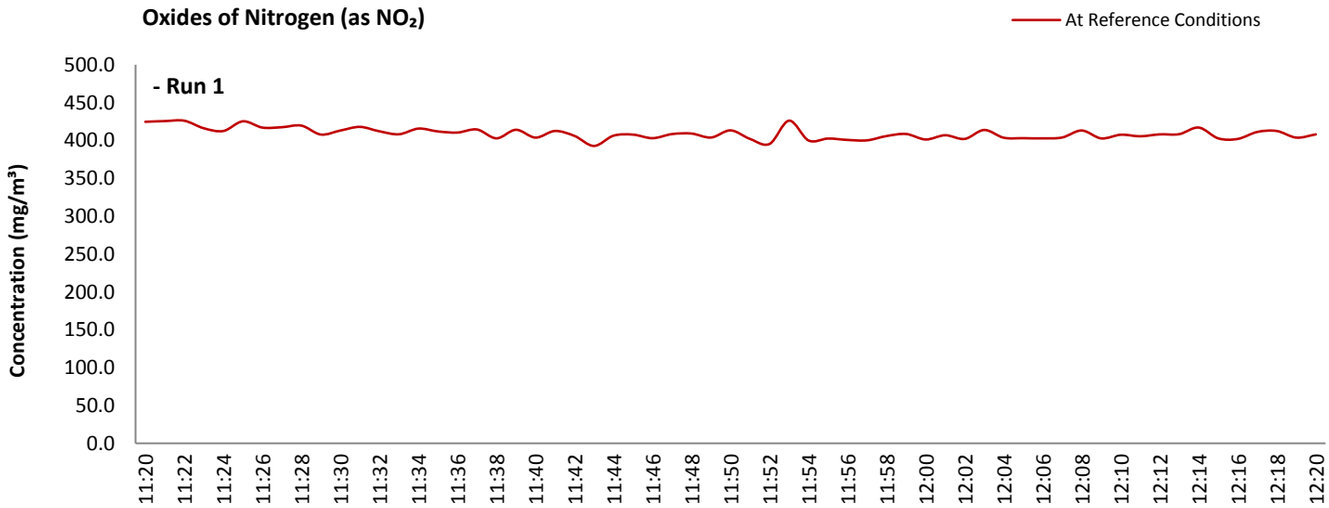
Parameter	Value	
Standard	EN 14792	
Technical Procedure	CAT-TP-39	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Date & Result of Last Converter Check	21/07/2020 - 95.7%	
Span Gas Type	Nitrogen Monoxide	
Span Gas Reference Number	12.0300	
Span Gas Expiry Date	15/05/2022	
Span Gas Start Pressure (bar)	100	
Gas Cylinder Concentration (ppm)	2063	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1/1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1/1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 5% oxygen.

OXIDES OF NITROGEN (as NO_2): DATA TREND

Graphical Trend of Data



OXIDES OF NITROGEN (as NO_2): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	11:20 - 12:20
Sampling Dates	-	12/03/2021
Instrument Range	ppm	500
Span Gas Value	ppm	243.6

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	2.1
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	ppm	0.00
CAL 1	Zero at Analyser (Post)	ppm	2.00
CAL 1	Zero Drift	ppm	2.00
CAL 1	Zero Drift	%	0.82
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	ppm	243.60
CAL 1	Span at Analyser (Post)	ppm	241.20
CAL 1	Span Drift	ppm	-2.40
CAL 1	Zero Adj. Span Drift	%	1.81
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	6 - 8

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	
There are no deviations associated with the sampling employed.	x	

OXIDES OF NITROGEN (as NO_2): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	500.0		mg/m³ (REF)
Allowable MU	10.0		%
Measured concentration	317.66		mg/m³ (STP, dry)
Ratio NO / NO_2	5		%
Range Used	500.0		ppm
Range Used [A]	1026.1		mg/m³
Cal gas conc.	243.6		ppm
Conversion	2.05		ppm to mg/m³
MCERTS Range [B]	205.0		mg/m³
Lower of [A] or [B]	205.0		mg/m³
Cal gas conc.	500.0		mg/m³

Performance characteristics	RUN 1		Units
Response time	31		seconds
Number of readings in measurement	60		-
Repeatability at zero	0.00		% full scale
Repeatability at span level	0.10		% full scale
Deviation from linearity	0.60		% of value
Zero drift	0.82		% full scale
Span drift	-1.81		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.10		% of value/kPa
Ambient temperature dependence	0.04		% full scale/10K
Combined interference	0.63		% range
Dependence on voltage	-0.23		% full scale/10V
Converter efficiency	95.7		%
Losses in the line (leak)	0.45		% of value
Uncertainty of calibration gas blending	1.40		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m³
Standard deviation of repeatability at span level	0.01		mg/m³
Lack of fit	0.71		mg/m³
Drift	0.00		mg/m³
Volume or pressure flow dependence	0.00		mg/m³
Atmospheric pressure dependence	0.06		mg/m³
Ambient temperature dependence	0.01		mg/m³
Combined interference (from MCERTS Certificate)	0.75		mg/m³
Dependence on voltage	-0.03		mg/m³
Converter efficiency	0.39		mg/m³
Losses in the line (leak)	0.83		mg/m³
Uncertainty of calibration gas blending	2.57		mg/m³
Uncertainty of calibration gas	3.67		mg/m³

			RUN 1		Units
Measurement uncertainty		**Result**	317.66		mg/m³
Combined uncertainty			4.74		mg/m³
Expanded uncertainty	k =	1.96	9.30		mg/m³
Uncertainty corrected to std conds. (O_2)			11.98		mg/m³ (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.93		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	1.86		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	10.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	3.82		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	3.43		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	10.3		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <10% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 10% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

CARBON MONOXIDE: RESULTS SUMMARY

Vale Bio-Energy, Llancarfan
Engine 1

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	902		902
Uncertainty	±mg/m³	33.8		33.8
Mass Emission	g/hr	1431		1431
Uncertainty	±g/hr	110		109.6

General Sampling Information

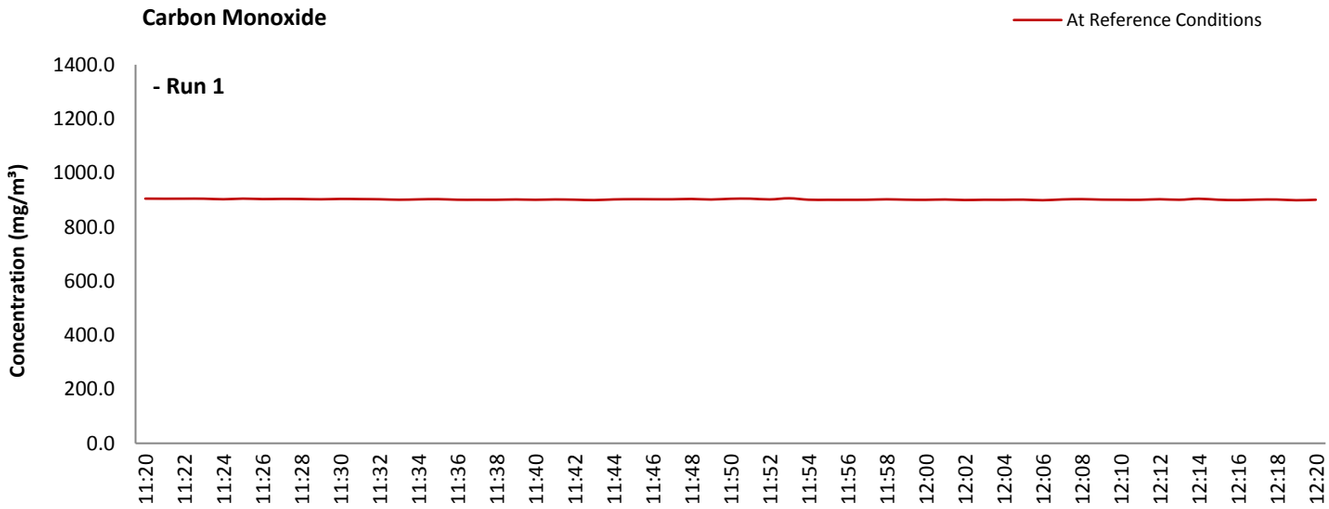
Parameter	Value	
Standard	EN 15058	
Technical Procedure	CAT-TP-39	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Carbon Monoxide	
Span Gas Reference Number	12.300	
Span Gas Expiry Date	15/05/2022	
Span Gas Start Pressure (bar)	100	
Gas Cylinder Concentration (ppm)	4029	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1/1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1/1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 5% oxygen.

CARBON MONOXIDE: DATA TREND

Graphical Trend of Data



CARBON MONOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	11:20 - 12:20
Sampling Dates	-	12/03/2021
Instrument Range	ppm	2000
Span Gas Value	ppm	1120.7

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	2.1
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	ppm	0.00
CAL 1	Zero at Analyser (Post)	ppm	1.00
CAL 1	Zero Drift	ppm	1.00
CAL 1	Zero Drift	%	0.09
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	ppm	1121.00
CAL 1	Span at Analyser (Post)	ppm	1105.00
CAL 1	Span Drift	ppm	-16.00
CAL 1	Zero Adj. Span Drift	%	1.52
CAL 1	Drift Correction Applied	2-5%	No
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	6 - 8

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	
There are no deviations associated with the sampling employed.	x	

CARBON MONOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	1400.0		mg/m³ (REF)
Allowable MU	6.0		%
Measured concentration	700.18		mg/m³ (STP, dry)
Range Used	2000.0		ppm
Range Used [A]	2498.4		mg/m³
Cal gas conc.	1120.7		ppm
Conversion	1.25		ppm to mg/m³
MCERTS Range [B]	75.0		mg/m³
Lower of [A] or [B]	75.0		mg/m³
Cal gas conc.	1400.0		mg/m³

Performance characteristics	RUN 1		Units
Response time	28		seconds
Number of readings in measurement	60		-
Repeatability at zero	0.10		% full scale
Repeatability at span level	0.20		% full scale
Deviation from linearity	0.77		% of value
Zero drift	0.09		% full scale
Span drift	-1.52		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.22		% of value/kPa
Ambient temperature dependence	-0.20		% full scale/10K
Combined interference	-0.48		% range
Dependence on voltage	-0.35		% full scale/10V
Losses in the line (leak)	0.54		% of value
Uncertainty of calibration gas blending	1.40		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		mg/m³
Standard deviation of repeatability at span level	0.03		mg/m³
Lack of fit	0.33		mg/m³
Drift	0.00		mg/m³
Volume or pressure flow dependence	0.00		mg/m³
Atmospheric pressure dependence	0.05		mg/m³
Ambient temperature dependence	-0.03		mg/m³
Combined interference (from MCERTS Certificate)	-0.21		mg/m³
Dependence on voltage	-0.04		mg/m³
Losses in the line (leak)	2.16		mg/m³
Uncertainty of calibration gas blending	5.66		mg/m³
Uncertainty of calibration gas	8.09		mg/m³

			RUN 1		Units
Measurement uncertainty		**Result**	700.18		mg/m³
Combined uncertainty			10.11		mg/m³
Expanded uncertainty	k =	1.96	19.82		mg/m³
Uncertainty corrected to std conds. (O_2)			25.53		mg/m³ (REF)

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.83		% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	1.42		% at ELV
Overall Allowable uncertainty (no O_2) - at 95% Confidence	6.0		% at ELV
Result of Compliance with Uncertainty Requirement	**N/A**		-

	RUN 1		Units
Expanded uncertainty (with O_2) - at 95% Confidence	3.75		% of Value
Expanded uncertainty (with O_2) - at 95% Confidence	3.06		% at ELV
Overall Allowable uncertainty (with O_2) - at 95% Confidence	6.5		% at ELV
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be <6% of the value at the ELV, on a dry gas basis, or if O_2 correction is applied less than 6% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components).

OXYGEN: RESULTS SUMMARY

Vale Bio-Energy, Llancarfan
Engine 1

Sample Runs

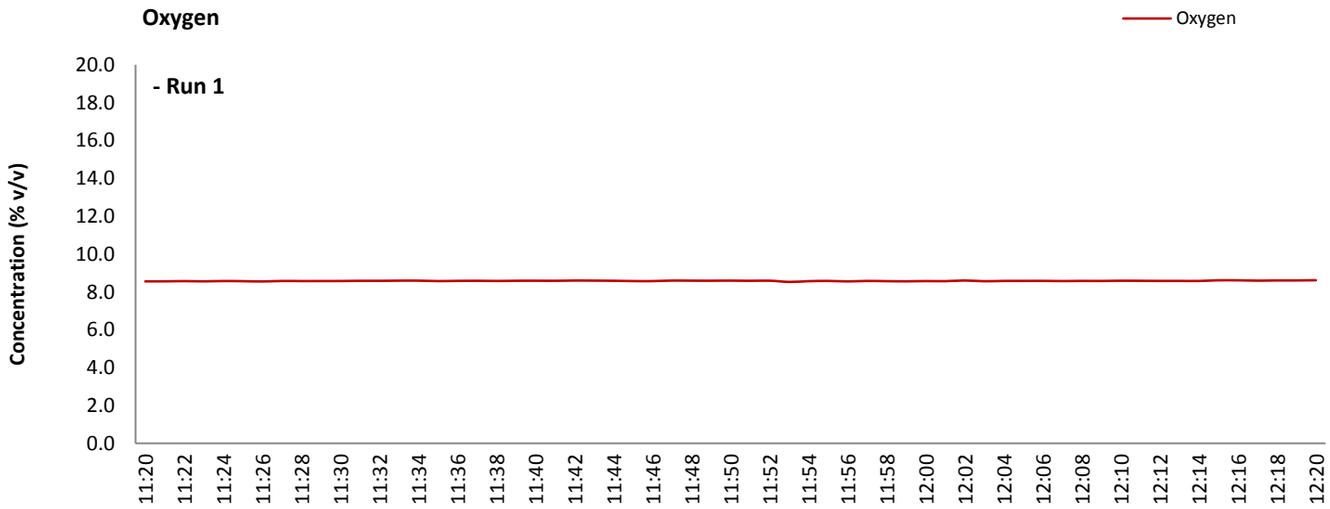
Parameter	Units	Run 1		Mean
Concentration	% v/v	8.6		8.6
Uncertainty	±% v/v	0.21		0.21

General Sampling Information

Parameter	Value	
Standard	EN 14789	
Technical Procedure	CAT-TP-39	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Synthetic Air (5 Grade)	
Span Gas Reference Number	11.0427	
Span Gas Expiry Date	##	
Span Gas Start Pressure (bar)	120	
Gas Cylinder Concentration (% v/v)	21.25	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1/1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1/1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

OXYGEN: DATA TREND

Graphical Trend of Data



OXYGEN: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1
Sampling Times	-	11:20 - 12:20
Sampling Dates	-	12/03/2021
Instrument Range	% v/v	25.0
Span Gas Value	% v/v	5.0

Quality Assurance

Conditioning Unit Temperature	Units	Run 1
Average Temperature	°C	2.1
Allowable Temperature	< °C	4.0
Temperature Acceptable	-	Yes

	Zero Drift	Units	Run 1
CAL 1	Zero at Analyser (Pre)	% v/v	0.00
CAL 1	Zero at Analyser (Post)	% v/v	0.20
CAL 1	Zero Drift	% v/v	0.20
CAL 1	Zero Drift	%	3.98
CAL 1	Drift Correction Applied	2-5%	Yes
	Allowable Zero Drift	± %	5.00
	Zero Drift Acceptable	-	Yes

	Span Drift	Units	Run 1
CAL 1	Span at Analyser (Pre)	% v/v	5.02
CAL 1	Span at Analyser (Post)	% v/v	5.08
CAL 1	Span Drift	% v/v	0.06
CAL 1	Zero Adj. Span Drift	%	2.80
CAL 1	Drift Correction Applied	2-5%	Yes
	Allowable Span Drift	± %	5.00
	Span Drift Acceptable	-	Yes

Test Conditions	Units	Run 1
Run Ambient Temperature Range	°C	6 - 8

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number 1	
There are no deviations associated with the sampling employed.	x	

OXYGEN: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1		Units
Limit value	N/A		%vol
Allowable MU	6.0		%
Measured concentration	8.58		%vol
Range Used	25.0		%vol
Cal gas conc.	21.3		%vol

Performance characteristics	RUN 1		Units
Response time	41		seconds
Number of readings in measurement	60		-
Repeatability at zero	0.02		% full scale
Repeatability at span level	0.02		% full scale
Deviation from linearity	0.18		% of value
Zero drift	0.00		% full scale
Span drift	0.00		% full scale
Volume or pressure flow dependence	0.10		% of full scale
Atmospheric pressure dependence	0.19		% of value/kPa
Ambient temperature dependence	-0.21		% full scale/10K
Combined interference	0.00		% range
Dependence on voltage	0.02		% full scale/10V
Losses in the line (leak)	0.00		% of value
Uncertainty of calibration gas	2.00		% of value

Performance characteristic	RUN 1		Units
Standard deviation of repeatability at zero	use rep at span		%vol
Standard deviation of repeatability at span level	0.00		%vol
Lack of fit	0.03		%vol
Drift	0.00		%vol
Volume or pressure flow dependence	0.00		%vol
Atmospheric pressure dependence	0.01		%vol
Ambient temperature dependence	-0.03		%vol
Combined interference (from MCERTS Certificate)	0.00		%vol
Dependence on voltage	0.00		%vol
Losses in the line (leak)	0.00		%vol
Uncertainty of calibration gas	0.10		%vol

			RUN 1		Units
Measurement uncertainty		**Result**	8.58		%vol
Combined uncertainty			0.11		%vol
Expanded uncertainty	k =	1.96	0.21		%vol

	RUN 1		Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.46		% of Value
Result of Compliance with Uncertainty Requirement	**COMPLIANT**		-

Requirement for SRM is that Uncertainty should be 0.3% vol absolute or 6% relative whichever is the lower, on a dry gas basis. Source, EN 14789.

Version Number	Record of changes made within this version of the document
V1	The original document issued to the client