

**Report for the Periodic Monitoring of Emissions to Air from Two Landfill
Gas Engine Stacks Located at Withyhedge Landfill Site**

Part 1: Executive Summary

Permit Number: GP3630HT/V003

Operator: Potter Group

Installation: Withyhedge Landfill Site (Engines 1514 & 1510)



4251

Monitoring dates: 25th August 2020

Job Number: **R20408**

Version: 1

Address: **Potter Group**
Potter House
Henfaes Lane
Welshpool
Powys, SY21 7BE

Monitoring Organisation: **EnviroDat Ltd**

Address: Cutbush Commercial
Cutbush Lane East
Reading, RG2 9AF

Date of Report: 16th September 2020

Report Approved By: Yu Shen

MCERTS Registration Number: MM 06 727 (Level II, TE1, 2, 3 & 4)

Function: Senior Project Manager (Team Leader)

Signed:



Air quality & environmental consultants



0118 466 4000



info@envirodat.org.uk



envirodat.org.uk

Registered Number: 4801798

CONTENTS

	Page No.
Part 1: Executive Summary	
1.1 Monitoring Objectives	3
1.2 Monitoring Results	4
1.3 Operating Information	6
1.4 Monitoring Deviations	6
 Part 2: Supporting Information	
2.1 Appendix I: General Information	7
2.2 Appendix II: Emission Point Reference Data & Results	9
2.3 Appendix III: Uncertainty Calculations	17
2.4 Appendix IV: Moisture Calculations	20

Notes to Report.

- a). EnviroDat Ltd, Report Template V12.
- b). This report should not be reproduced except in full, without written approval of Envirodat Ltd.
- c). Opinions and Interpretations herein are outside the scope of UKAS/MCerts Accreditation.

PART 1: EXECUTIVE SUMMARY

1.1 Monitoring Objectives

Potter Group operates spark ignition engines at Withyhedge Landfill Site. This combustion plant has the potential to pollute the atmosphere. Consequently, these processes are subject to regulation and periodic environmental monitoring is necessary under this regulation.

Methane is produced as a by-product of the decomposition of organic waste that is buried within the site (methanogenesis). This methane is extracted and pumped through inert piping to the engines or flare for combustion, the scale of which is dictated according to local engineering, operational requirements and methanogenic rate. A flare is designed to operate when excess gas is produced or for periods of engine maintenance.

EnviroDat Ltd. was commissioned to monitor the pollutants within the engine emissions - as prescribed in the operational permit - in order to establish the sites environmental compliance.

The pollutants monitored, as required under GP3630HT/V003, are summarised below:

Substances to be monitored	Emission Point Identification	
	Engine 1514	Engine 1510
Oxides of Nitrogen (NO _x as NO ₂)	✓	✓
Carbon Monoxide (CO)	✓	✓
Total Volatile Organic Compounds (VOCs)	✓	✓
Oxygen (for correction)	✓	✓
Moisture (for correction)	✓	✓
Special requirements	None requested	

1.2 Monitoring Results

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Estimate of Uncertainty (2σ at 95% confidence)	Units	Reference Conditions	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method (see note below)	Operating Status
Engine 1514	Oxides of Nitrogen (as NO ₂)	500	478	±23	mg(N)m ⁻³	101.3kPa, 273K, dry gas, 5% Oxygen	25/08/2020	12:07-13:07	BS EN 14792	A	At 97% MCR
	Carbon Monoxide	1400	1000	±51	mg(N)m ⁻³				BS EN 15058	A	
	Volatile Organic Compounds (VOCs as carbon)	1000	1169	±43	mg(N)m ⁻³				BS EN 12619	A	
	Moisture	-	11.1	n/a	%	101.3kPa, 273K, dry gas			BS EN 14790	A	
	Oxygen	-	6.62	±0.39	%	BS EN 14789			A		

NOTE:

- A. EnviroDat Ltd MCerts/UKAS Accredited for sampling and analysis.
- B. EnviroDat Ltd MCerts/UKAS Accredited for sampling only, UKAS Accredited analysis conducted by sub-contract laboratory.
- C. EnviroDat Ltd UKAS Accredited for sampling only (further clarification is given in section 1.4). Analysis of this component is not UKAS Accredited.
- D. The method for sampling and analysis is not UKAS or MCerts Accredited, method follows documented in-house procedure (further clarification is given in section 1.4).
- E. The method for sampling is not UKAS or MCerts Accredited, UKAS Accredited analysis conducted by sub-contract laboratory.

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Estimate of Uncertainty (2σ at 95% confidence)	Units	Reference Conditions	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Operating Status
										(see note below)	
Engine 1510	Oxides of Nitrogen (as NO ₂)	500	473	±24	mg(N)m ⁻³	101.3kPa, 273K, dry gas, 5% Oxygen	25/08/2020	13:36-14:36	BS EN 14792	A	At 95% MCR
	Carbon Monoxide	1400	589	±43	mg(N)m ⁻³				BS EN 15058	A	
	Volatile Organic Compounds (VOCs as carbon)	1000	1197	±47	mg(N)m ⁻³				BS EN 12619	A	
	Moisture	-	11.2	n/a	%	101.3kPa, 273K, dry gas			BS EN 14790	A	
	Oxygen	-	5.16	±0.34	%				BS EN 14789	A	

NOTE:

- A. EnviroDat Ltd MCerts/UKAS Accredited for sampling and analysis.
- B. EnviroDat Ltd MCerts/UKAS Accredited for sampling only, UKAS Accredited analysis conducted by sub-contract laboratory.
- C. EnviroDat Ltd UKAS Accredited for sampling only (further clarification is given in section 1.4). Analysis of this component is not UKAS Accredited.
- D. The method for sampling and analysis is not UKAS or MCerts Accredited, method follows documented in-house procedure (further clarification is given in section 1.4).
- E. The method for sampling is not UKAS or MCerts Accredited, UKAS Accredited analysis conducted by sub-contract laboratory.

1.3 Operating Information

Emission Point Reference	Date	Process Type	Process Duration	Fuel	Feedstock	Abatement	Load	Comparison of Operator CEMS and Periodic Monitoring Results			
								Substance	CEMS Results	Periodic Monitoring Results	Units
Engine 1514	25/08/2020	Combustion	Continuous	Landfill Gas	N/A	None	Producing 1100kWe (97% MCR)	N/A	N/A	N/A	N/A
Engine 1510	25/08/2020	Combustion	Continuous	Landfill Gas	N/A	None	Producing 380kWe (95% MCR)	N/A	N/A	N/A	N/A

1.4 Monitoring Deviations

Emission Point Reference	Substance Deviations	Monitoring Deviations	Other Relevant Issues
Engine 1514	None	None	None
Engine 1510	None	None	None

PART 2: SUPPORTING INFORMATION

2.1 Appendix I: General Information

2.1.1 Monitoring organisation staff details

Monitoring at Withyhedge Landfill Site was conducted by the following EnviroDat Engineer:

Team Leader, Yu Shen - MCERTs Level II (TE1, 2, 3 & 4)

MM06 727

2.1.2 Monitoring method details

Parameter	Standard Reference Method/Alternative	EnviroDat Procedure	MCerts Accreditation
Oxides of Nitrogen (as NO ₂)	BS EN 14792	SP14792	MCerts
Carbon Monoxide (CO)	BS EN 15058	SP15058	MCerts
Volatile Organic Compounds (VOCs)	BS EN 12619	SP12619	MCerts
Moisture (H ₂ O)	BS EN 14790	SP14790	MCerts
Oxygen (O ₂)	BS EN 14789	SP14789	MCerts

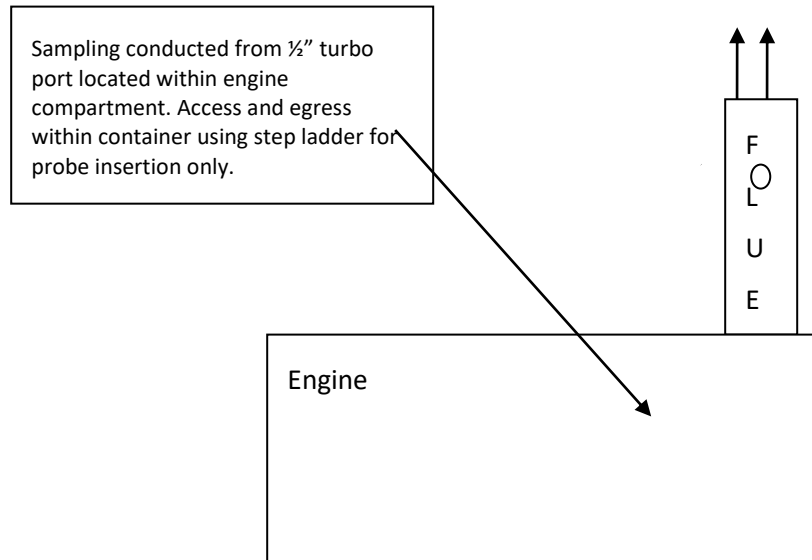
2.1.3 Monitoring organisation equipment and gas check list references

EQUIPMENT – LR68HDA			
Item	Reference	Calibration Due	PAT Due
Portable Gas Analyser	PGA#02	09-Jun-21	Oct-20
Flame Ionisation Detector Analyser	FID#01	20-May-21	Oct-20
Gas Conditioner	COND#01	08-Sep-20	Oct-20
NOx Converter	CONV#02	10-Nov-20	Oct-20
Data Logger	DL#03	08-Oct-20	-

Digital Barometer	DB#27	05-Jan-21	-
Balance	BAL#06	30-Mar-21	-
Heated Filter Head	HFH#01	05-Jan-21	Oct-20
Heated Line	HL#13	08-Oct-20	-
Heated Line Controller	HLC#13	08-Oct-20	Oct-20
'Apex' Kit	APEX#06	See each item	Oct-20
Dry Gas Meter ('Apex')	DGM#02	05-Apr-21	-
Timepiece ('Apex')	TP#20	05-Apr-21	-
Thermocouple ('Apex')	TC#46	05-Apr-21	-
Thermocouple Reader ('Apex')	TCR#24	05-Apr-21	-
Thermocouple Reader ('Apex')	TCR#25	05-Apr-21	-
Thermocouple Reader ('Apex')	TCR#26	05-Apr-21	-
Manometer ('Apex' Orange)	MAN#12	05-Apr-21	-
Manometer ('Apex' Red)	MAN#13	05-Apr-21	-
Thermocouple ('Apex' Dogleg Exit)	TC#08	23-Oct-20	-
Tape Measure	TM#05	02-Oct-20	-
Thermocouple (Stack Temperature Temperature)	TC#38	13-Apr-21	-
Timepiece	TP#24	05-Sep-20	-
GAS CYLINDERS – LR68HDA			
	Certificate No.	Level (ppm)	Validity
'Zero' Gas (%)	VC2920016	99.999%	n/a
Carbon Monoxide Span Gas	VC0130	1209	15-Apr-21
Nitric Oxide Span Gas	VC0130	257.1	15-Apr-21
VOC Span Gas	VC2788921	595	30-Jan-21
Oxygen Span Gas (%)	VC2788921	8.02	30-Jan-21

2.2 Appendix II: Emission Point Reference Data & Results

2.2.1 Diagram of Sampling Location on Engines 1514 & 1510



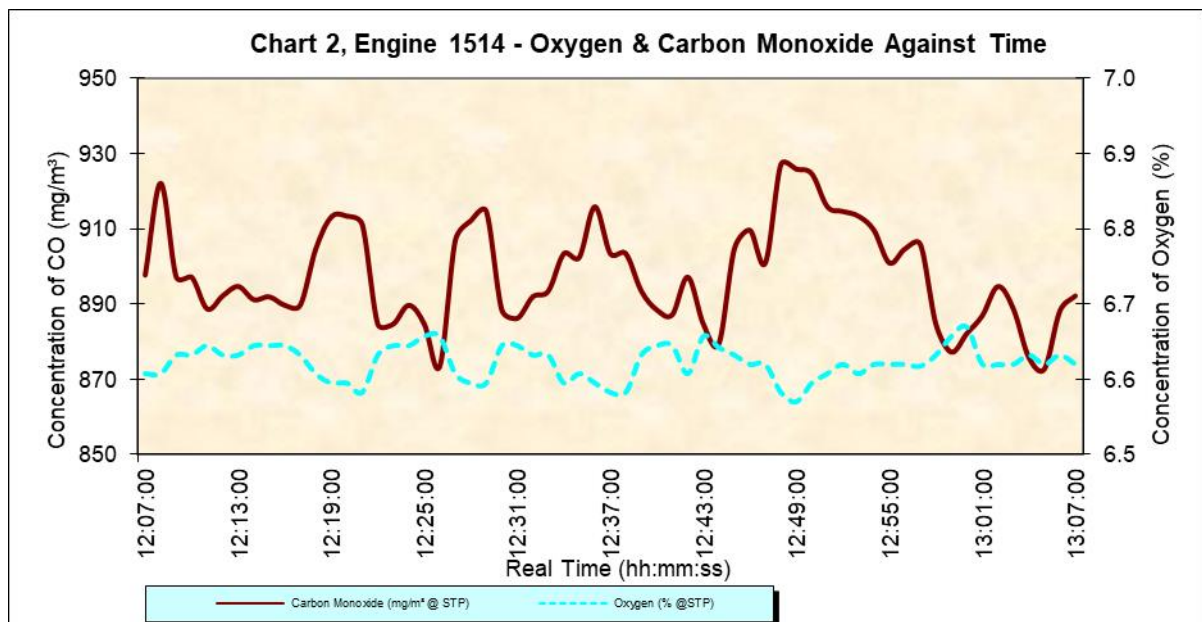
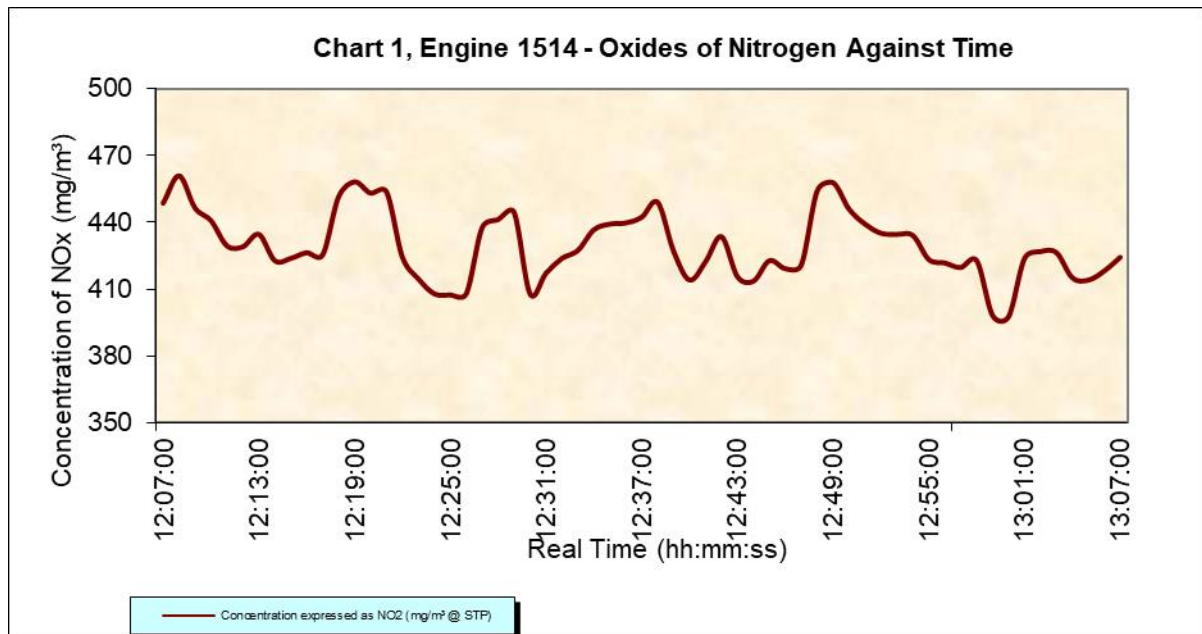
2.2.2 Homogeneity testing

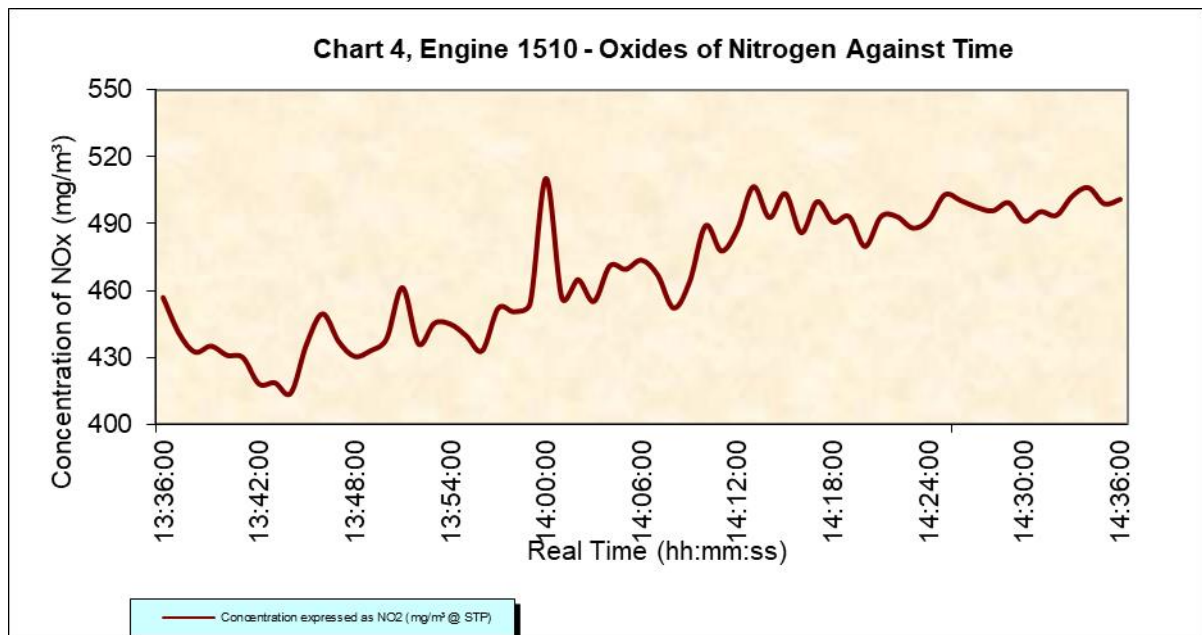
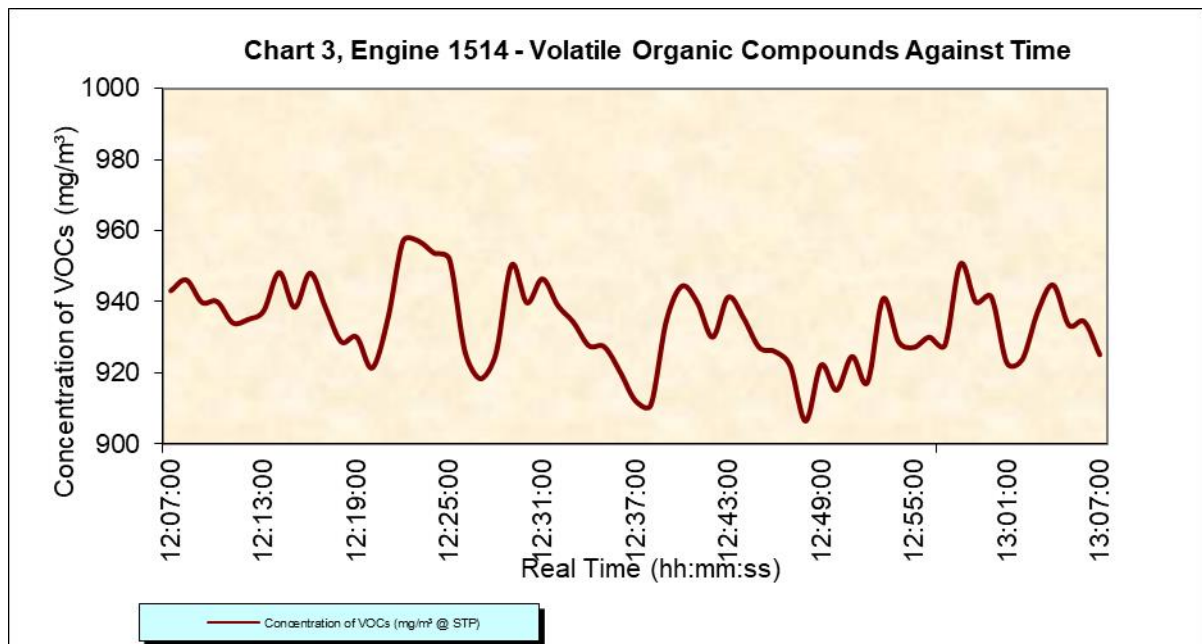
BS EN 15259 stipulates that the exhaust gases emitted from combustion processes are tested to ensure homogeneity and that a representative sample is obtained during the monitoring, subject to a number of caveats as elucidated in Environment Agency guidance MID15259. The details of the testing at each emission point are summarised below:

Stack	Result of Homogeneity Testing
Engines 1514 & 1510	N/A – homogeneity testing only required on stacks exceeding 1.13 m diameter, as specified in MID 15259. Homogeneity assumed & single point sampling acceptable.

2.2.3 Gas analyser site measurements and calibrations

The data in the following Charts 1 - 6 and in Tables 1 – 2 are expressed in mgm^{-3} @ STP and is uncorrected for O_2 . In addition, VOC results are expressed as carbon equivalent. This data was subsequently converted to reference oxygen concentrations (Section 1.2) with the addition of moisture correction for VOCs. Calibration data is shown in Table 3.





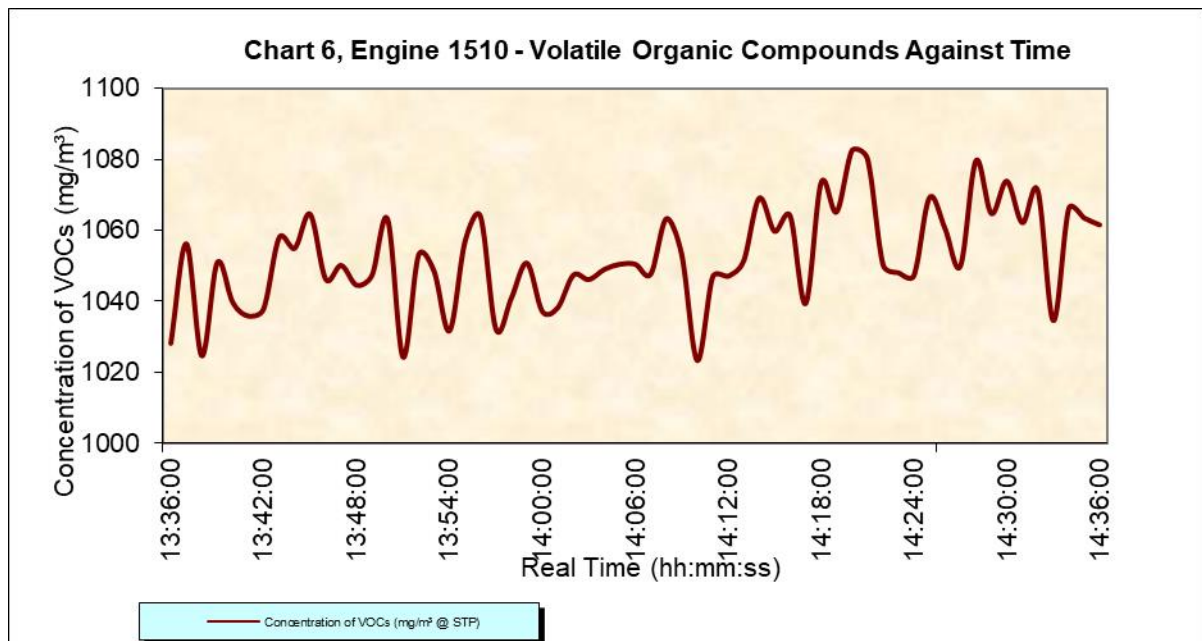
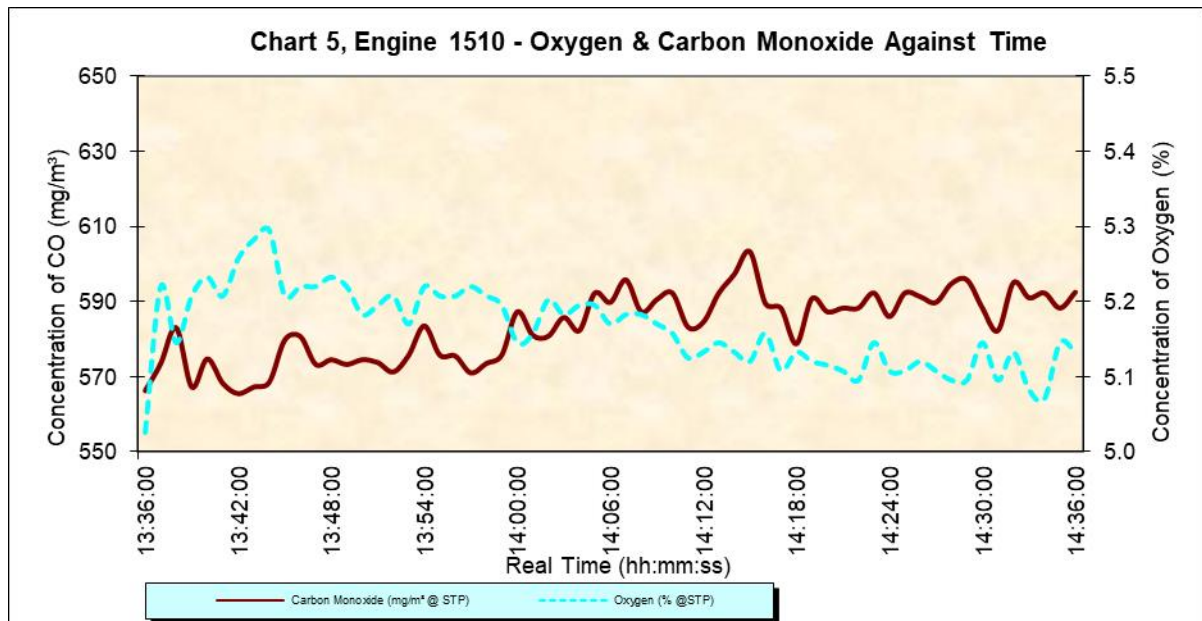


Table 1 – Engine 1514, Raw Data

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	Nox (mg/m ³)	Comment
12:07:00	6.6	943.1	897.8	448.7	
12:08:00	6.6	946.1	922.3	461.0	
12:09:00	6.6	939.9	897.3	446.5	
12:10:00	6.6	940.0	897.3	440.9	
12:11:00	6.6	934.1	888.8	429.6	
12:12:00	6.6	935.0	892.3	429.2	
12:13:00	6.6	937.4	894.8	434.7	
12:14:00	6.6	948.2	891.3	422.9	
12:15:00	6.6	938.4	892.0	424.0	
12:16:00	6.6	948.1	889.8	426.5	
12:17:00	6.6	938.3	889.8	425.5	
12:18:00	6.6	928.8	904.8	451.7	
12:19:00	6.6	930.1	913.3	458.4	
12:20:00	6.6	921.4	913.5	453.2	
12:21:00	6.6	934.9	911.3	453.8	
12:22:00	6.6	957.1	884.8	424.5	
12:23:00	6.6	957.1	884.8	414.7	
12:24:00	6.6	953.7	889.8	408.0	
12:25:00	6.7	951.9	884.8	407.5	
12:26:00	6.7	925.9	873.5	408.0	
12:27:00	6.6	918.3	907.0	437.8	
12:28:00	6.6	925.4	912.3	441.4	
12:29:00	6.6	950.3	914.8	444.6	
12:30:00	6.6	939.7	888.5	408.0	
12:31:00	6.6	946.4	886.3	417.3	
12:32:00	6.6	938.9	892.0	424.0	
12:33:00	6.6	934.2	893.5	427.6	
12:34:00	6.6	927.6	903.5	436.8	
12:35:00	6.6	927.3	902.5	439.4	
12:36:00	6.6	920.4	916.0	439.9	
12:37:00	6.6	912.2	903.5	442.4	
12:38:00	6.6	910.9	903.5	449.1	
12:39:00	6.6	934.6	893.5	427.1	
12:40:00	6.6	944.4	888.5	414.2	
12:41:00	6.6	939.9	887.3	422.4	
12:42:00	6.6	930.1	897.3	433.7	
12:43:00	6.7	941.3	884.8	415.7	
12:44:00	6.6	935.4	879.5	413.7	
12:45:00	6.6	927.2	904.8	422.9	
12:46:00	6.6	926.0	909.8	419.3	
12:47:00	6.6	922.0	901.0	420.9	
12:48:00	6.6	906.4	927.3	454.3	
12:49:00	6.6	922.2	926.0	457.9	
12:50:00	6.6	915.1	924.8	446.0	
12:51:00	6.6	924.6	916.0	439.4	
12:52:00	6.6	917.4	914.8	435.3	

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	Nox (mg/m ³)	Comment
12:53:00	6.6	940.8	913.5	434.7	
12:54:00	6.6	928.8	909.8	434.2	
12:55:00	6.6	927.2	901.0	423.4	
12:56:00	6.6	930.1	904.8	421.9	
12:57:00	6.6	927.8	906.0	419.9	
12:58:00	6.6	950.6	884.8	422.9	
12:59:00	6.7	939.9	877.3	398.3	
13:00:00	6.7	941.3	882.3	397.8	
13:01:00	6.6	922.8	887.0	424.0	
13:02:00	6.6	923.8	894.8	427.0	
13:03:00	6.6	937.3	888.8	426.5	
13:04:00	6.6	944.7	875.8	415.2	
13:05:00	6.6	933.4	872.8	414.2	
13:06:00	6.6	934.4	888.3	418.3	
13:07:00	6.6	925.1	892.3	424.5	

Table 2 – Engine 1510, Raw Data

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	Nox (mg/m ³)	Comment
13:36:00	5.0	1028.1	566.3	457.0	
13:37:00	5.2	1056.2	573.5	440.9	
13:38:00	5.1	1024.6	583.0	432.6	
13:39:00	5.2	1050.9	567.3	435.3	
13:40:00	5.2	1039.7	574.8	431.1	
13:41:00	5.2	1035.8	568.3	430.1	
13:42:00	5.3	1037.9	565.5	418.3	
13:43:00	5.3	1058.0	567.3	418.8	
13:44:00	5.3	1054.9	568.5	414.2	
13:45:00	5.2	1064.6	579.8	436.3	
13:46:00	5.2	1046.3	580.8	449.7	
13:47:00	5.2	1050.1	573.3	437.3	
13:48:00	5.2	1044.5	574.5	430.6	
13:49:00	5.2	1047.4	573.3	433.2	
13:50:00	5.2	1063.1	574.5	438.4	
13:51:00	5.2	1024.2	573.8	461.4	
13:52:00	5.2	1053.0	571.3	436.3	
13:53:00	5.2	1048.5	575.8	445.5	
13:54:00	5.2	1031.6	583.5	445.1	
13:55:00	5.2	1056.9	575.8	439.9	
13:56:00	5.2	1063.9	575.5	433.2	
13:57:00	5.2	1032.1	571.0	452.2	
13:58:00	5.2	1040.9	573.5	450.7	
13:59:00	5.2	1050.8	575.8	454.3	
14:00:00	5.1	1037.1	587.3	510.3	
14:01:00	5.2	1038.2	581.0	456.8	
14:02:00	5.2	1047.4	580.8	465.0	
14:03:00	5.2	1046.1	585.8	455.3	

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	Nox (mg/m ³)	Comment
14:04:00	5.2	1049.0	582.3	471.2	
14:05:00	5.2	1050.4	592.3	469.7	
14:06:00	5.2	1050.4	589.8	473.8	
14:07:00	5.2	1047.7	595.8	467.1	
14:08:00	5.2	1063.3	587.3	452.3	
14:09:00	5.2	1053.2	590.5	464.0	
14:10:00	5.2	1023.3	592.3	489.2	
14:11:00	5.1	1046.9	583.3	477.9	
14:12:00	5.1	1047.1	584.5	487.6	
14:13:00	5.1	1051.4	592.3	506.6	
14:14:00	5.1	1069.1	597.3	492.9	
14:15:00	5.1	1059.8	603.3	503.5	
14:16:00	5.2	1064.1	589.5	486.1	
14:17:00	5.1	1039.3	588.3	499.9	
14:18:00	5.1	1073.4	578.8	490.8	
14:19:00	5.1	1065.2	590.8	493.3	
14:20:00	5.1	1082.6	587.3	479.9	
14:21:00	5.1	1080.2	588.3	493.3	
14:22:00	5.1	1050.3	588.3	493.3	
14:23:00	5.1	1048.0	592.3	488.1	
14:24:00	5.1	1047.2	586.0	491.7	
14:25:00	5.1	1069.2	592.3	503.0	
14:26:00	5.1	1060.6	591.3	500.5	
14:27:00	5.1	1049.9	589.8	497.5	
14:28:00	5.1	1079.7	594.8	495.8	
14:29:00	5.1	1064.7	595.8	499.4	
14:30:00	5.1	1073.9	588.3	491.2	
14:31:00	5.1	1062.2	582.3	495.4	
14:32:00	5.1	1071.2	595.0	493.9	
14:33:00	5.1	1034.5	591.0	502.5	
14:34:00	5.1	1066.2	592.3	506.2	
14:35:00	5.1	1063.4	588.3	499.0	
14:36:00	5.1	1061.5	592.5	501.0	

Table 3 – Flare Stack, Analyser Calibration Data

ANALYSER CALIBRATION DATA					
Pre Sampling Check					
		NO (ppm)	CO (ppm)	O ₂ (%)	VOC's (ppm)
Range		500	2000	25	1000
Zero Gas	Cylinder No.	VC2920016			AIR
Span Gas	Cylinder No.	VC0130		VC2788921	
	Certified Value	257.1	1209	8.02	595
Zero Check	Value	0.3	3	0.05	2
<2 x repeatability (Yes/No)		YES	YES	YES	YES
Down Line Zero & Span Check					
Zero Gas	Value	0.3	1	0.12	0
	<2% of span	YES	YES	YES	YES
Span Gas	Value	260.2	1200	8.01	593
	Within 2% of span	YES	YES	YES	YES
Post Sampling Drift Check					
Zero Gas	Value	3	1	0.07	-1
	Drift (%)	1.1	0.0	0.6	0.2
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required
Span Gas	Value	259	1205	7.95	600
	Drift (%)	1.5	0.4	0.1	1.3
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required

2.3 Appendix III: Uncertainty Calculations

2.3.1 Engine 1514, Uncertainty Calculations

NOx - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rlt}	2.37
Drift	U_{odr}	8.40
volume or pressure flow dependence	U_{apres}	0.06
atmospheric pressure dependence	U_{apres}	1.78
ambient temperature dependence	U_{temp}	0.35
NH ₃ (20 mg/m ³)	U_{interf}	0.14
CO ₂ (15%)	-	0.02
H ₂ O (30%)	-	0.01
Error in logger voltage	-	0.50
Dependence on voltage	U_{volt}	0.03
Converter efficiency	U_{coeff}	1.98
losses in the line (leak)	U_{leak}	4.96
Uncertainty of calibration gas	U_{calib}	4.96

NOx Measurement uncertainty		Result	429.63	mg/m ³
Combined uncertainty			11.53	mg/m ³
Expanded uncertainty	k = 2		23.05	mg/m ³
Uncertainty corrected to std conds			23.05	mg.m-3 (corrected)
Expanded uncertainty	expressed with a level of confidence of 95%		4.61 % ELV	
Expanded uncertainty	expressed with a level of confidence of 95%		23.05 mg.m⁻³ of result	

CO - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rlt}	5.77
Drift	U_{odr}	19.62
volume or pressure flow dependence	U_{apres}	0.00
atmospheric pressure dependence	U_{apres}	3.46
ambient temperature dependence	U_{temp}	0.00
CO ₂ (15%)	U_{interf}	0.00
N ₂ O (40mgm ³)	-	0.00
CH ₄ (57mgm ³)	-	0.00
H ₂ O (1%)	-	0.00
Dependence on voltage	U_{volt}	0.03
Error in Logger reading	-	2.00
losses in the line (leak)	U_{leak}	10.37
Uncertainty of calibration gas	U_{calib}	10.37

CO Measurement uncertainty		Result	897.95	mg/m ³
Combined uncertainty			25.48	mg/m ³
Expanded uncertainty	k = 2		50.96	mg/m ³
Uncertainty corrected to std conds			50.96	mg.m-3 (corrected)
Expanded uncertainty	expressed with a level of confidence of 95%		3.64 % ELV	
Expanded uncertainty	expressed with a level of confidence of 95%		50.96 mg.m⁻³ of result	

VOC - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{fit}	3.74
Drift	U_{odr}	14.74
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	2.24
ambient temperature dependence	U_{temp}	0.00
NH ₃ (20 mg/m ³)	U_{interf}	0.00
CO ₂ (15%)	-	0.00
H ₂ O (30%)	-	0.00
Error on Logger voltage	-	1.00
Dependence on voltage	U_{volt}	0.03
losses in the line (leak)	U_{leak}	10.78
Uncertainty of calibration gas	U_{calib}	10.78

VOC Measurement uncertainty		Result	
Combined uncertainty		933.85	mg/m ³
Expanded uncertainty		21.68	mg/m ³
Expanded uncertainty	k = 2	43.36	mg/m ³
Uncertainty corrected to std conds		43.36	mg.m ⁻³ (corrected)
Expanded uncertainty expressed with a level of confidence of 95%		4.34 % ELV	
Expanded uncertainty expressed with a level of confidence of 95%		43.36 mg.m ⁻³ of result	

Oxygen - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.20
Standard deviation of repeatability at span level	U_{rs}	0.03
Lack of fit	U_{fit}	0.08
Drift	U_{odr}	0.11
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	0.02
ambient temperature dependence	U_{temp}	0.05
CO ₂ (15%)	-	0.00
NO ₂ (300)	-	0.06
NO ₂ (30)	-	0.00
dependence on voltage	U_{volt}	0.02
losses in the line (leak)	U_{leak}	0.08
Error in Logger voltage	-	0.03
Uncertainty of calibration gas	U_{calib}	0.08

O ₂ Measurement uncertainty		Result	
Combined uncertainty		6.62	%vol
Expanded uncertainty		0.19	%vol
% of value		2.92	%
Expanded uncertainty expressed with a level of confidence of 95%		5.84 % of value	
Expanded uncertainty expressed with a level of confidence of 95%		0.39 % vol	

2.3.2 Engine 1510, Uncertainty Calculations

NOx - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{fit}	2.37
Drift	U_{odr}	8.62
volume or pressure flow dependence	U_{spres}	0.06
atmospheric pressure dependence	U_{apres}	1.78
ambient temperature dependence	U_{temp}	0.35
NH ₃ (20 mg/m ³)	U_{interf}	0.14
CO ₂ (15%)	-	0.02
H ₂ O (30%)	-	0.01
Error in logger voltage	-	0.50
Dependence on voltage	U_{volt}	0.03
Converter efficiency	U_{ceff}	2.16
losses in the line (leak)	U_{leak}	5.40
Uncertainty of calibration gas	U_{calib}	5.40

NOx Measurement uncertainty		Result	
Combined uncertainty		467.70	mg/m ³
Expanded uncertainty		12.10	mg/m ³
Expanded uncertainty	k = 2	24.20	mg/m ³
Uncertainty corrected to std conds		24.20	mg.m ⁻³ (corrected)
Expanded uncertainty expressed with a level of confidence of 95%		4.84 % ELV	
Expanded uncertainty expressed with a level of confidence of 95%		24.20 mg.m ⁻³ of result	

CO - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rl}	5.77
Drift	U_{odr}	17.80
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	3.46
ambient temperature dependence	U_{temp}	0.00
CO ₂ (15%)	U_{interf}	0.00
N ₂ O (40mg/m ³)	-	0.00
CH ₄ (57mg/m ³)	-	0.00
H ₂ O (1%)	-	0.00
Dependence on voltage	U_{volt}	0.03
Error in Logger reading	-	2.00
losses in the line (leak)	U_{leak}	6.73
Uncertainty of calibration gas	U_{calib}	6.73

CO Measurement uncertainty		Result	
Combined uncertainty		583.01	mg/m ³
Expanded uncertainty		21.37	mg/m ³
Expanded uncertainty	k = 2	42.75	mg/m ³
Uncertainty corrected to std conds		42.75	mg.m-3 (corrected)
Expanded uncertainty expressed with a level of confidence of 95%		3.05 % ELV	
Expanded uncertainty expressed with a level of confidence of 95%		42.75 mg.m ⁻³ of result	

VOC - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rl}	3.74
Drift	U_{odr}	15.43
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	2.24
ambient temperature dependence	U_{temp}	0.00
NH ₃ (20 mg/m ³)	U_{interf}	0.00
CO ₂ (15%)	-	0.00
H ₂ O (30%)	-	0.00
Error on Logger voltage	-	1.00
Dependence on voltage	U_{volt}	0.03
losses in the line (leak)	U_{leak}	12.15
Uncertainty of calibration gas	U_{calib}	12.15

VOC Measurement uncertainty		Result	
Combined uncertainty		1052.17	mg/m ³
Expanded uncertainty		23.52	mg/m ³
Expanded uncertainty	k = 2	47.04	mg/m ³
Uncertainty corrected to std conds		47.04	mg.m-3 (corrected)
Expanded uncertainty expressed with a level of confidence of 95%		4.70 % ELV	
Expanded uncertainty expressed with a level of confidence of 95%		47.04 mg.m ⁻³ of result	

Oxygen - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.20
Standard deviation of repeatability at span level	U_{rs}	0.03
Lack of fit	U_{rl}	0.06
Drift	U_{odr}	0.09
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	0.02
ambient temperature dependence	U_{temp}	0.05
CO ₂ (15%)	-	0.00
NO ₂ (300)	-	0.06
NO ₂ (30)	-	0.00
dependence on voltage	U_{volt}	0.02
losses in the line (leak)	U_{leak}	0.06
Error in Logger voltage	-	0.03
Uncertainty of calibration gas	U_{calib}	0.06

O ₂ Measurement uncertainty		Result	
Combined uncertainty		5.16	%vol
Expanded uncertainty		0.17	%vol
% of value		3.26	%
Expanded uncertainty expressed with a level of confidence of 95%		6.52 % of value	
Expanded uncertainty expressed with a level of confidence of 95%		0.34 % vol	

2.4 Appendix IV: Moisture Calculations

2.4.1 Engine 1514, Moisture Calculation

Test No	T1
Date	25-8-20
pbar (mbar)	984
pbar (mmHg)	738
Nozzle Diameter (mm)	n/a
Temp of Meter (in)/(out) °C	22
DH _{ave} (mmH ₂ O)	10.0
DGM Cal Factor (Y)	1.0112

Site	Potter Group Withyhedge
Stack	Engine 1514
Job Number:	R20408
Site Team:	YS
Data Entered By:	YS

Enter Data into coloured cells only

Start Volume Reading	248.6092	m³
End Volume Reading	249.2012	m³
Volume Sampled	0.5986	m³

Start time	12:07	hr:min
End time	13:07	hr:min
Total time	01:00	hr:min

IMPINGER	1	2	3	4	Initials of Analyst
Absorber Solution (Type):	H2O	H2O	KO IMP	SILICA	
Sample No:	n/a	n/a	n/a	n/a	
Analysis Required:	n/a	n/a	n/a	n/a	
Initial Weight of Impingers plus absorber (g)	865.2	824.2	801.2	865.2	YS
Final Weight of Impingers plus absorber (g)	901.2	830.2	806.2	872.1	YS
Weight Gain (g)	36.0	6.0	5.0	6.9	

Total Weight Gain (1+2+3+4) (g)	53.9
---------------------------------	------

Gas Volume of water at 0°C and 101.3kPa (l)	67.11
Gas Meter volume at 0°C and 101.3kPa (l)	538.66

Moisture content of Gases (%)	11.1
-------------------------------	------

2.4.2 Engine 1510, Moisture Calculation

Test No	T2
Date	25-8-20
pbar (mbar)	984
pbar (mmHg)	738
Nozzle Diameter (mm)	n/a
Temp of Meter (in)/(out) °C	20
DH _{ave} (mmH ₂ O)	10.0
DGM Cal Factor (Y)	1.0112

Site	Potter Group Withyhedge
Stack	Engine 1510
Job Number:	R20408
Site Team:	YS
Data Entered By:	YS

Enter Data into coloured cells only

Start Volume Reading	249.2048	m³
End Volume Reading	249.8026	m³
Volume Sampled	0.6045	m³

Start time	13:36	hr:min
End time	14:36	hr:min
Total time	01:00	hr:min

IMPINGER	1	2	3	4	Initials of Analyst
Absorber Solution (Type):	H2O	H2O	KO IMP	SILICA	
Sample No:	n/a	n/a	n/a	n/a	
Analysis Required:	n/a	n/a	n/a	n/a	
Initial Weight of Impingers plus absorber (g)	901.2	830.2	806.2	872.1	YS
Final Weight of Impingers plus absorber (g)	942.3	836.5	807.1	879.2	YS
Weight Gain (g)	41.1	6.3	0.9	7.1	

Total Weight Gain (1+2+3+4) (g)	55.4
---------------------------------	------

Gas Volume of water at 0°C and 101.3kPa (l)	68.97
Gas Meter volume at 0°C and 101.3kPa (l)	548.59

Moisture content of Gases (%)	11.2
-------------------------------	------