

STACK EMISSIONS MONITORING REPORT



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Operator & Address:
Aspoll Cyder Ltd The Cyder House Aspoll House Debenham Stowmarket Suffolk IP14 6PD

Permit Reference:
N/A - Investigative Test

Release Point:
Boiler

Sampling Date(s):
7th March 2019

SOCOTEC UK Job Number:	LSO 190341
Report Date:	19th March 2019
Version:	1
Report By:	Jamie Whiteman
MCERTS Number:	MM 11 1134
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Report Approved By:	Mike Davies
MCERTS Number:	MM 02 087
Business Title:	MCERTS Level 2 - Business Manager
Technical Endorsements:	1, 2, 3 & 4
Signature:	



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EXECUTIVE SUMMARY

MONITORING OBJECTIVES

Aspall Cyder Ltd operates a diesel fired boiler process at Debenham

SOCOTEC UK LTD were commissioned by Michael Close to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under normal operating conditions.

Plant

Boiler

Operator

Aspall Cyder Ltd
The Cyder House
Aspall House
Debenham
Stowmarket
Suffolk
IP14 6PD

No Permit Applicable: Investigative

Stack Emissions Monitoring Test House

SOCOTEC UK - Cirencester Laboratory
Units C & D
Bankside Trade Park
Cirencester
GL7 1YT
UKAS and MCERTS Accreditation Number: 1015

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EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	Units	Result	Calculated Uncertainty +/-	Limit	MCERTS accredited result
Oxides of Nitrogen (as NO ₂)	mg/m ³	119.6	1.89	-	✓
Sulphur Dioxide	mg/m ³	11.2	2.33	-	✓
Carbon Monoxide	mg/m ³	6.91	2.41	-	✓
Carbon Dioxide	% v/v	2.90	0.0	-	✓
Oxygen	% v/v	4.1	0.2	-	✓
Moisture	%	5.4	0.49	-	✓
Stack Gas Temperature	°C	165	-	-	✓

ND = None Detected,

Results at or below the limit of detection are highlighted by bold italic text.

The above volumetric flow rate is calculated using data from the preliminary survey. Mass emissions for non isokinetic tests are calculated using these values. For all isokinetic testing the mass emission is calculated using test specific flow data and not the above values.

Reference conditions are 273K, 101.3kPa, dry gas 3% Oxygen.

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	Sampling Date(s)	Sampling Times	Sampling Duration
Combustion Gases	07 March 2019	09:16 - 10:16	60 minutes

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Diesel fired boiler
Continuous or batch	Continuous
Product Details	Heat & steam
Part of batch to be monitored (if applicable)	N/A
Normal load, throughput or continuous rating	Modulating 10-100% MCR
Fuel used during monitoring	Diesel 35 sec
Abatement	None
Plume Appearance	None visible

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard reference / alternative methods employed by SOCOTEC UK is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency Technical Guidance Note (Monitoring) M2.

MONITORING METHODS						
Species	Method Standard Reference Method / Alternative Method	SOCOTEC UK Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Limit of Detection (LOD)	Calculated MU +/- %
NO _x	SRM - BS EN 14792:2017	AE 102	1015	Yes	0.55 mg/m ³	1.6%
SO ₂	AM - PD CEN/TS 17021:2017	AE 102	1015	Yes	0.86 mg/m ³	20.8%
CO	SRM - BS EN 15058:2017	AE 102	1015	Yes	0.29 mg/m ³	34.9%
CO ₂	SRM - ISO 12039	AE 102	1015	Yes	0.003 %	0.6%
O ₂	AM - BS EN 14789:2017	AE 102	1015	Yes	0.01%	4.1%
H ₂ O	SRM - BS EN 14790	AE 105	1015	Yes	0.21%	8.99%

EXECUTIVE SUMMARY

Analytical Methods

The following tables list the analytical methods employed together with the custody and archiving details:

SAMPLING METHODS WITH SUBSEQUENT ANALYSIS							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	UKAS Accredited Lab Analysis	Analysis Lab	Sample Archive Location	Archive Period
-	-	-	-	-	-	-	-

ON-SITE TESTING							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	MCERTS Accredited Analysis	Laboratory	Data Archive Location	Archive Period
NO _x	Chemiluminescence	AE 102	1015	Yes	SOCOTEC UK - (Cirencester)	SOCOTEC UK - (Cirencester)	5 years
SO ₂	Non Dispersive Infra Red	AE 102	1015	Yes	SOCOTEC UK - (Cirencester)	SOCOTEC UK - (Cirencester)	5 years
CO	Non Dispersive Infra Red	AE 102	1015	Yes	SOCOTEC UK - (Cirencester)	SOCOTEC UK - (Cirencester)	5 years
CO ₂	Non Dispersive Infra Red	AE 102	1015	Yes	SOCOTEC UK - (Cirencester)	SOCOTEC UK - (Cirencester)	5 years
O ₂	Zirconia Cell	AE 102	1015	Yes	SOCOTEC UK - (Cirencester)	SOCOTEC UK - (Cirencester)	5 years
H ₂ O	Gravimetric	AE 105	1015	Yes	SOCOTEC UK - (Cirencester)	-	-

EXECUTIVE SUMMARY

DUCT CHARACTERISTICS		
	Value	Units
Shape	Circular	-
Depth	0.50	m
Width		m
Area	0.20	m ²
Port Depth	10	mm

SAMPLING LINES & POINTS		
	Isokinetic	Non-Iso & Gases
Sample port size	-	3/4" BSP
Number of lines used	-	1
Number of points / line	-	1
Duct orientation	-	Vertical

SAMPLING PLATFORM	
General Platform Information	
Permanent / Temporary Platform / Ground level / Floor Level / Roof	Ground Level
Inside / Outside	Inside

M1 Platform requirements	
Is there a sufficient working area so work can be performed in a compliant manner	Yes
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	N/A
Platform has vertical base boards (approximately 0.25 m high)	N/A
Platform has removable chains / self closing gates at the top of ladders	N/A
Handrail / obstructions do not hamper insertion of sampling equipment	N/A
Depth of Platform = >Stack depth / diameter + wall and port thickness + 1.5m	N/A

Sampling Platform Improvement Recommendations (if applicable)

The sampling location meets all the requirements as specified in EA Guidance Note M1.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

Preliminary traverse

Due to insufficient access and sample port size it was not possible to perform a preliminary traverse therefore mass emissions cannot be reported.

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APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

APPENDIX 3 - Measurement Uncertainty Budget Calculations

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

MONITORING SCHEDULE					
Species	Method Standard Reference Method / Alternative Method	SOCOTEC UK Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Number of Samples
NO _x	SRM - BS EN 14792:2017	AE 102	1015	Yes	1
SO ₂	AM - PD CEN/TS 17021:2017	AE 102	1015	Yes	1
CO	SRM - BS EN 15058:2017	AE 102	1015	Yes	1
CO ₂	SRM - ISO 12039	AE 102	1015	Yes	1
O ₂	AM - BS EN 14789:2017	AE 102	1015	Yes	1
H ₂ O	SRM - BS EN 14790	AE 105	1015	Yes	1

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

CALIBRATEABLE EQUIPMENT CHECKLIST					
Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	Equipment I.D.	Equipment	Equipment I.D.	Equipment	Equipment I.D.
Control Box DGM	-	Horiba PG-250 Analyser	P1985	Laboratory Balance	P66
Box Thermocouples	-	FT-IR Gasmet	-	Tape Measure	P2665
Meter In Thermocouple	-	FT-IR Oven Box	-	Stopwatch	P733
Meter Out Thermocouple	-	Bernath 3006 FID	-	Protractor	-
Control Box Timer	-	Signal 3030 FID	-	Barometer	P153
Oven Box	-	Servomex	-	Digital Micromanometer	P1909
Probe	-	JCT Heated Head Filter	-	Digital Temperature Meter	P1505
Probe Thermocouple	-	Thermo FID	-	Stack Thermocouple	P1239
Probe	-	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	-	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	-	Chiller (JCT/MAK 10)	P2445	1m Heated Line (3)	-
Last Impinger Arm	-	Heated Line Controller (1)	P2780	5m Heated Line (1)	P2490
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	-	Site temperature Logger	-	10m Heated Line (2)	-
Small DGM	-		-	15m Heated Line (1)	-
Heater Controller	-		-	20m Heated Line (1)	-
Inclinometer (Swirl Device)	-		-	20m Heated Line (2)	-

NOTE: If the equipment I.D is represented by a dash (-), then this piece of equipment has not been used for this test.

CALIBRATION GASES					
Gas (traceable to ISO 17025)	Cylinder I.D Number	Supplier	ppm	%	Analytical Tolerance +/- %
Oxygen	CG35	BOC	-	10.3	2.0
Nitric Oxide	SC23	BOC	79.5	-	2.0
Sulphur Dioxide	SC23	BOC	79.7	-	2.0
Carbon Monoxide	CG35	BOC	86.1	-	2.0
Carbon Dioxide	CG35	BOC	-	12	2.0
-	-	-	-	-	-

STACK EMISSIONS MONITORING TEAM

MONITORING TEAM								
Personnel	MCERTS Number	MCERTS		TE / H&S Qualifications and Expiry Date				
		Level	Expiry	TE1	TE2	TE3	TE4	H&S
Jamie Whiteman	MM 11 1134	MCERTS Level 2	May-21	Oct-23	Feb-23	Nov-21	May-21	Oct-21
Warren Clark	MM 02 086	MCERTS Level 1	Sep-22	-	-	-	-	Sep-22

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

COMBUSTION GASES SUMMARY

Test	Sampling Time and Date	Concentration mg/m ³	LOD mg/m ³	Limit mg/m ³	Emission Rate g/hr
NOx	09:16 - 10:16 07 March 2019	119.6	0.55	-	-
SO ₂	09:16 - 10:16 07 March 2019	11.2	0.86	-	-
CO	09:16 - 10:16 07 March 2019	6.91	0.29	-	-

Test	Sampling Time and Date	Concentration %	LOD %
CO ₂	09:16 - 10:16 07 March 2019	12.25	0.003
O ₂	09:16 - 10:16 07 March 2019	4.11	0.01

Reference conditions are 273K, 101.3kPa, dry gas 3% Oxygen.

PRE-SAMPLING CALIBRATION DATA

Date	07 March 2019
Start Time	08:45
End Time	09:00

Chiller Temperature (°C)	2.0
Requirement	< 4°C
Compliant	Yes

Gas	Range (ppm / %)	Zero Reading at analyser	Span Reading at analyser	Zero Check at analyser	Zero Check down line	Span Check down line	Response Time (Secs)	Leak Rate %
NO	250	0.00	79.5	0.00	0.20	79.3	33	0.25
SO ₂	200	0.00	79.7	0.00	0.30	78.9	41	1.00
CO	200	0.00	86.1	0.00	0.20	85.8	28	0.35
CO ₂	25	0.00	12.00	0.00	0.03	11.96	28	0.33
O ₂	25	0.00	10.30	0.00	0.02	10.33	27	-0.29

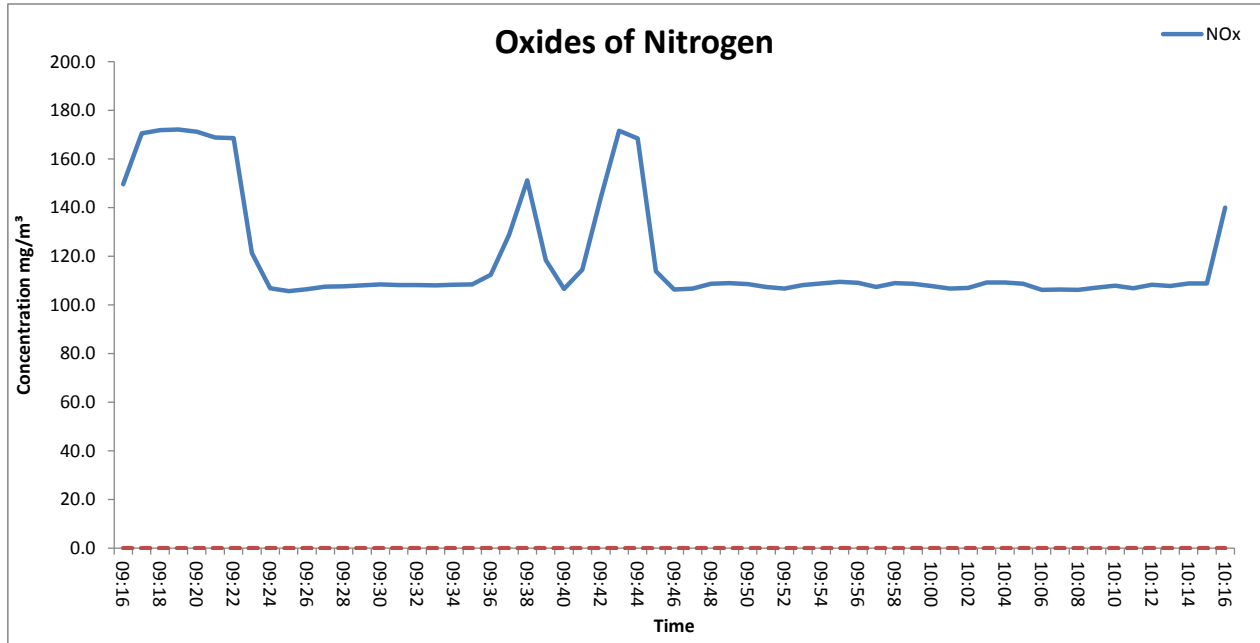
POST-SAMPLING CALIBRATION DATA

Date	07 March 2019
Start Time	11:30
End Time	11:45

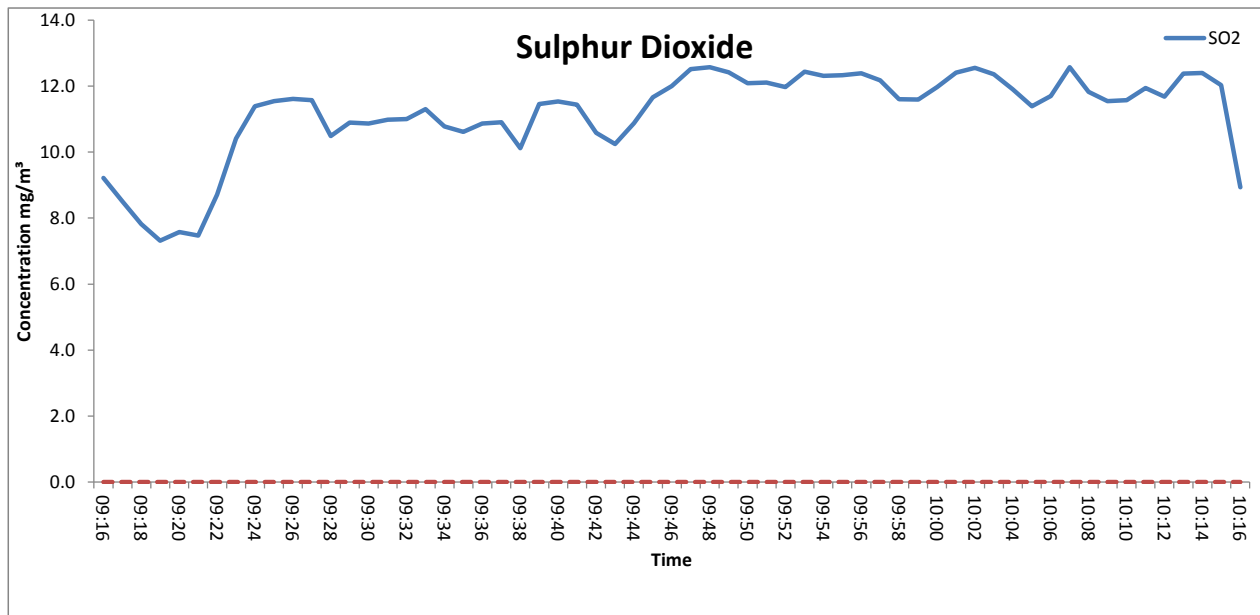
Chiller Temperature (°C)	2.0
Requirement	< 4°C
Compliant	Yes

Gas	Zero Check down line	Span Check down line	Zero Drift (%)	Span Drift (%)
NO	0.40	79.8	0.08	0.12
SO ₂	0.50	78.4	0.10	-0.35
CO	0.60	87.0	0.20	0.40
CO ₂	0.06	12.02	0.12	0.12
O ₂	0.05	10.37	0.12	0.04

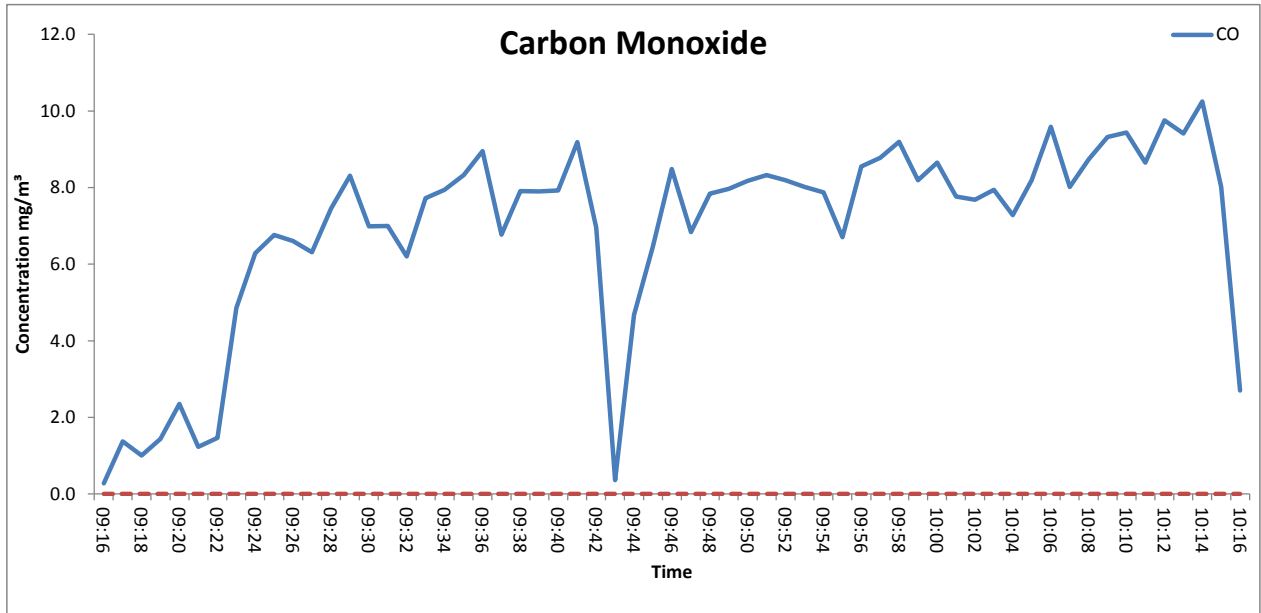
APPENDIX 2 - Summaries, Calculations, Raw Data and Charts
OXIDES OF NITROGEN (as NO₂) EMISSIONS CHART



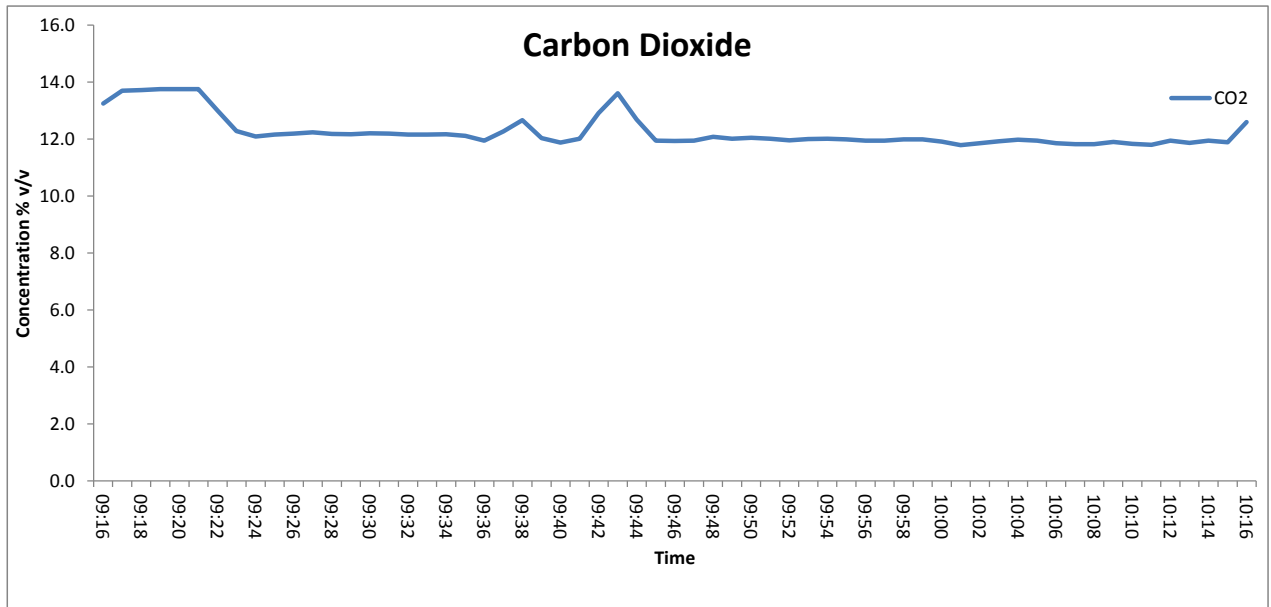
SULPHUR DIOXIDE EMISSIONS CHART



CARBON MONOXIDE EMISSIONS CHART

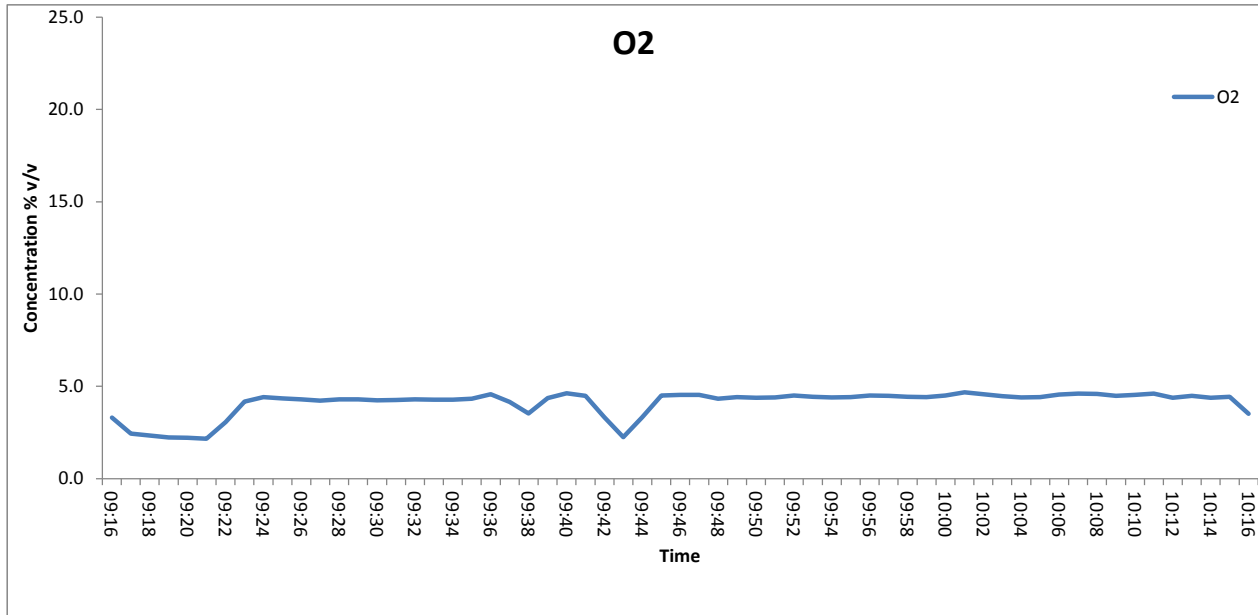


CARBON DIOXIDE EMISSIONS CHART



APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

OXYGEN EMISSIONS CHART



APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

MOISTURE CALCULATIONS

Moisture Determination - Non Isokinetic							
Test Number	Sampling Time and Date	Start Weight	End Weight	Total gain	Concentration	LOD	Uncertainty
		kg	kg	kg	%	%	%
Run 1	09:16-09:46 07 March 2019	3.3241	3.3268	0.0027	5.4	0.21	9.0

Moisture Quality Assurance							
Test Number	Sampling Duration	Total Volume Sampled	Sampling Rate	Start Leak Rate	End Leak Rate	Acceptable Leak Rate	Leak Tests Acceptable?
	mins	l	l/min	l/min	l/min	l/min	
Run 1	30	59	2.0	0.01	0.01	0.04	Yes

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - MOISTURE

Run	Sampled Volume m ³	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Leak %
MU required	≤ 2%	≤ 2%	≤ 1%	≤ 1%	≤ 10%	≤ 2%
Run 1	0.00004	2.0	0.50	1.0	0.1	-
as a %	0.07	0.46	0.49	1.0	2.43	0.51
compliant?	Yes	Yes	Yes	Yes	Yes	Yes

Run	Volume (STP) m ³	Mass Gained mg	O2 Correction -	Leak mg/m ³	Uncollected Mass mg	Combined uncertainty
Run 1	0.04	2700	1.1	134.5	58	-
MU as % v/v	0.07	0.21	0.09	0.02	0.12	0.27
MU as %	1.2	3.7	0.59	0.3	2.1	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	0.54	% v/v	8.99	%
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Reference – SOCOTEC UK Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXIDES OF NITROGEN

Limit value	-	mg/m ³
Concentration @ Ref conditions	119.6	mg/m ³
Cal gas conc	163	mg/m ³
Analyser Full Scale	513	mg/m ³

	Value	Units	specification	MU Met?
Response time	33	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.11	% full scale	<1 % range	Yes
Repeatability at span level	0.1	% full scale	<2 % range	Yes
Deviation from linearity	-0.40	% of value	<2 % range	Yes
Zero drift	0.08	% full scale	<2% range / 24hr	Yes
Span drift	0.12	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	0.25	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.25	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence zero / span	0.25	% full scale/10K	<3% range / 10 K	Yes
Combined interference	3.00	% range	<4% of Range	Yes
dependence on voltage	0.04	% full scale/10V	< 0.1%vol /10 volt	Yes
Influence of Vibration	N/A	% of upper limit of Cal range	<2%	-
losses in the line (leak)	0.04	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.004
lack of fit	U_{lof}	-0.231
short term zero drift	U_{dz}	0.046
short term span drift	U_{ds}	0.069
influence of Ambient Temp at Zero	U_{tz}	0.022
influence of Ambient Temp at Span	U_{ts}	0.390
influence of sample gas pressure	U_p	0.000
influence of sample gas flow	U_{fit}	0.173
influence of supply voltage	U_v	0.122
Combined Interference	U_i	0.004
Uncertainty of Cal gas	U_{adj}	0.795

Measurement uncertainty (Concentration Measured)	119.56	mg/m ³
Combined uncertainty	0.94	mg/m ³
Expanded at a 95% confidence interval	1.89	mg/m ³

Expanded uncertainty expressed with a level of confidence of 95%	-	% ELV
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Expanded uncertainty expressed with a level of confidence of 95%	1.9	mg/m³
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Expanded uncertainty expressed with a level of confidence of 95%	1.6	% value
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Developed for the STA by R Robinson, NPL

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - SULPHUR DIOXIDE

Limit value	-	mg/m ³
Concentration @ Ref conditions	11.2	mg/m ³
Cal gas conc	226.348	mg/m ³
Analyser Full Scale	572	mg/m ³

Performance characteristics	Value	Units	specification	MU Met?
Response time	41	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.70	% of value	<2 % range	Yes
Zero drift	0.10	% full scale	<2% range / 24hr	Yes
Span drift	-0.35	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	0.6	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.00	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence zero / span	0.2	0.48	<3% range / 10 K	Yes
Cross-sensitivity	0.00	% range	<4% of Range	Yes
dependence on voltage	0.27	% full scale/10V	< 0.1%vol /10 volt	Yes
Influence of vibration	N/A	% of upper limit of Cal range	<2%	-

Uncertainty of calibration gas	% of value	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.008
lack of fit	U_{lof}	0.404
short term zero drift	$U_{d,z}$	0.144
short term span drift	$U_{d,s}$	0.087
influence of Ambient Temp at Zero	$U_{t,z}$	-0.030
influence of Ambient Temp at Span	$U_{t,s}$	0.017
influence of sample gas pressure	U_p	0.000
influence of sample gas flow	U_{fit}	0.416
influence of supply voltage	U_v	0.901
Combined Interference	U_i	0.000
Uncertainty of Cal gas	U_{adj}	0.052

Measurement uncertainty (Concentration Measured)	10.4	mg/m ³
Combined uncertainty	1.1	mg/m ³
Expanded uncertainty	2.2	mg/m ³

Expanded uncertainty expressed with a level of confidence of 95%	-	% ELV
Expanded uncertainty expressed with a level of confidence of 95%	2.2	mg/m ³
Expanded uncertainty expressed with a level of confidence of 95%	20.8	% value

Reference – SOCOTEC UK Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - CARBON MONOXIDE

Limit value	-	mg/m ³
Concentration @ Ref conditions	6.9	mg/m ³
Cal gas conc	107.6	mg/m ³
Analyser Full Scale	250	mg/m ³

Performance characteristics	Value	Units	specification	MU Met?
Response time	28	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.1	% full scale	<1 % range	Yes
Repeatability at span level	0.2	% full scale	<2 % range	Yes
Deviation from linearity	0.61	% of value	<2 % range	Yes
Zero drift	0.20	% full scale	<3% range / 24hr	Yes
Span drift	0.40	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	0.2	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.44	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence zero / span	1	0.36	<3% range / 10 K	Yes
Combined interference	0.03	% of Range	<4% of Range	Yes
dependence on voltage	-0.06	% full scale/10V	< 0.1%vol /10 volt	Yes
Influence of Vibration	N/A	% of upper limit of Cal range	<2%	N/A
losses in the line (leak)	0.00	% of value	< 2% of value	Yes
Uncertainty of calibration gas	1.00	% of value	< 2% of value	Yes

N/A - Horiba's are not effected by Vibration

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.003
lack of fit	U_{lof}	0.12
short term zero drift	$U_{d,z}$	0.35
short term span drift	$U_{d,s}$	0.12
influence of Ambient Temp zero	$U_{t,z}$	0.05
influence of Ambient Temp span	$U_{t,s}$	0.03
influence of sample gas pressure	U_p	0.00
influence of sample gas flow	U_{fit}	0.14
influence of supply voltage	U_v	-0.09
Combined Interference	U_i	0.94
Uncertainty of Cal gas	U_{adj}	0.43

Measurement uncertainty (Concentration Measured)	6.4	mg/m ³
Combined uncertainty	1.1	mg/m ³
Expanded uncertainty	2.2	mg/m ³

Expanded uncertainty expressed with a level of confidence of 95%	-	% ELV
Expanded uncertainty expressed with a level of confidence of 95%	2.2	mg/m ³
Expanded uncertainty expressed with a level of confidence of 95%	34.9	% value

Developed for the STA by R Robinson, NPL

Reference – SOCOTEC UK Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - CARBON DIOXIDE

Limit value	-
Measured concentration	12.25
Calibration gas	12
Analyser Full Scale	25

Performance characteristics	Value	Units	specification	MU Met?
Response time	28	seconds	< 200 s	Yes
Logger sampling interval	60	seconds	0	-
Measurement period	60	minutes	0	-
Number of readings in measurement	60	-	0	-
Repeatability at zero	0.015	% by volume	<0.2 % range	Yes
Repeatability at span level	0.014	% by volume	<0.4 % range	Yes
Deviation from linearity	0.13	% vol	<0.3 % volume	Yes
Zero drift (during measurement period)	0.03	% vol at zero level	<2% of volume / 24hr	Yes
Span drift (during measurement period)	0.03	% vol at span level	<2% volume/24hr	Yes
volume or pressure flow dependence	0.02	% of fs / 10l/h	<1% range	Yes
atmospheric pressure dependence	0.8	% of fs/kPa	< 1.5 % range	Yes
ambient temperature dependence	0.01	% by volume /10K	<0.3% volume 10 K	Yes
Combined interference	0.56	% range	<2% range	Yes
Dependence on voltage	0.1	% by volume /10V	< 0.1%vol /10 volt	Yes
Losses in the line (leak)	0.33333333	% of value	< 2% of value	Yes
Uncertainty of calibration gas	1	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	ur0	-
Standard deviation of repeatability at span level	urs	0.001807392
Lack of fit	ufit	0.0751
Drift	u0dr	0.035007933
volume or pressure flow dependence	uspres	2.88675E-05
atmospheric pressure dependence	uapres	0.012220202
ambient temperature dependence	utemp	0.0005
Combined interference (from mcerts)	-	0.080829038
dependence on voltage	uvolt	0.086
losses in the line (leak)	uleak	0.023583234
Uncertainty of calibration gas	ucalib	0.070749701

Measurement uncertainty	12.25	%vol
Combined uncertainty	0.16	%vol
Expanded uncertainty	0.00	%

Expanded uncertainty expressed with a level of confidence of 95%	0.64	% of value
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Expanded uncertainty expressed with a level of confidence of 95%	0.08	% vol
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Reference – SOCOTEC UK Technical Procedure AE150 Estimation of Uncertainty of Measurement

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - OXYGEN

Reference	3	%vol
Reported Concentration	4.11	%vol
Calibration gas	10.3	%vol
Analyser Full Scale	25	%vol

	Value	Units	specification	MU Met?
Response time	27	seconds	180	Yes
Logger sampling interval	60	seconds	-	-
Measurement period	60	minutes	-	-
Number of readings in measurement	60	-	-	-
Repeatability at zero	0.25	% full scale	<1 % range	Yes
Repeatability at span level	0.15	% full scale	<2 % range	Yes
Deviation from linearity	0.13	% of value	<2 % range	Yes
Zero drift	0.12	% full scale	<2% range / 24hr	Yes
Span drift	0.04	% full scale	<2% range/24hr	Yes
volume or pressure flow dependence	0.03	% of full scale/3 kPa	<2 % / 3 kPa	Yes
atmospheric pressure dependence	0.05	% of full scale/2 kPa	<3% / 2 kPa	Yes
ambient temperature dependence	-0.08	0.45	<3% range / 10 K	Yes
Combined interference	0.14	% range	<4% of Range	Yes
dependence on voltage	0.00	% full scale/10V	< 0.1%vol /10 volt	Yes
losses in the line (leak)	0.14	% of value	< 2% of value	Yes
Uncertainty of calibration gas	0.1	% of value	< 2% of value	Yes

Performance characteristic	Uncertainty	Value of uncertainty quantity
repeatability	$U_r = S_r$	0.0083
lack of fit	U_{lof}	0.0751
short term zero drift	$U_{d,z}$	0.0693
short term span drift	$U_{d,s}$	0.0231
influence of Ambient Temp at Zero	$U_{t,z}$	0.0002
influence of Ambient Temp at Span	$U_{t,s}$	-0.0016
influence of sample gas pressure	U_p	0.0000
influence of sample gas flow	U_{fit}	0.0173
influence of supply voltage	U_v	0.0001
Combined Interference	U_i	0.0485
Uncertainty of Cal gas	U_{adj}	0.0515

Measurement uncertainty (Concentration Measured)	4.11	%
Combined uncertainty	0.13	%
Expanded uncertainty	0.25	%

Expanded uncertainty expressed with a level of confidence of 95%	0.3	%
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Expanded uncertainty expressed with a level of confidence of 95%	0.01	% vol
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Developed for the STA by R Robinson, NPL

APPENDIX 3 - Measurement Uncertainty Budget Calculations

END OF REPORT

Thank you for choosing SOCOTEC UK for your environmental monitoring needs. We hope our services have met your requirements and that you are fully satisfied with your experience of working with us, we really do value your custom and would welcome your feedback. We would appreciate it if you could take a moment to complete a short online questionnaire so that we can improve our operations and address any areas that have not met with your expectations, by clicking on the following

https://www.surveymonkey.co.uk/r/CAE_customer_feedback_weblink