

Title: Monitoring of Gaseous Emissions

Permit Number: Not Applicable
Operator: East End Foods plc
Installation: M4P2 Mobile Power Station
from Marshall Energy
Monitoring Dates: 7 September 2016


Reference Number: EI/7129

Client Organisation: East End Foods plc
Address: Upper Thomas Street
Aston
Birmingham
B6 5AD

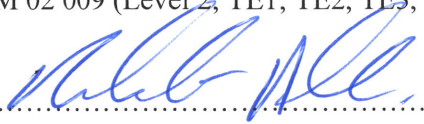
Monitoring Organisation: CES Environmental Instruments Ltd
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Date of Report: 8 September 2016

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Signed: 
.....

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Signed: 
.....

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Part 1: Executive Summary

1.1 Monitoring Objectives

East End Foods plc placed a contract with CES Environmental Instruments Ltd for the monitoring of emissions to air from the Caterpillar C18 Model Generating Set exhaust duct contained within the M4P2 Mobile Power Station .

M4P2 Mobile Power Station from Marshall Energy

The Caterpillar C18 Model Generating Set is run to provide electrical power to a mobile power generating system and method, placed on a mobile carrier. A power supply is coupled to an electric drive motor. Rotational output of the drive motor is guided through a transmission system in order to increase the power and torque, and a rotation-enhanced output is then supplied to a generator, for generating electric power.

Emissions from the Caterpillar C18 Model Generating Set are emitted to atmosphere via an exhaust duct.

The test work was undertaken on 7 September 2016 by CES Environmental Instruments Ltd Engineers and carried out as part of CES Environmental Instruments Ltd job reference EI/7129.

The substances monitored were:-

Oxides of Nitrogen
Carbon Monoxide
Volatile Organic Compound

On the day of testing there were no special requirements for the monitoring.

1.2 Monitoring Results

Emission Point Reference: Caterpillar C18 Model Generating Set Exhaust Duct

Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Uncertainty of Measurement (95% CI)	Blank Result	Units	Reference Conditions	Emission Rate	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method	Operating Status
Oxides of Nitrogen	Not Applicable	392.58	12.68	-	mg/m ³	273K, 101.3kPa	-	7 September 2016	16:05-17:04	BS EN 14792	UKAS & MCERTS	Normal Operation
Carbon Monoxide	Not Applicable	260.41	10.86	-	mg/m ³	273K, 101.3kPa	-	7 September 2016	16:05-17:04	BS EN 15058	UKAS & MCERTS	Normal Operation
Volatile Organic Compound	Not Applicable	31.87	3.26	-	mgC/m ³	273K, 101.3kPa	-	7 September 2016	16:05-17:04	BS EN 12619	UKAS & MCERTS	Normal Operation

1.3 Operating Information

Emission Point Reference: Caterpillar C18 Model Generating Set Exhaust Duct

Process Type	Batch Sample Details	Fuel	Product	Load	Abatement
Continuous	-	Bio Diesel	Electricity	Normal Running	None

Comparison of Operator CEMS and Periodic Monitoring Results								
Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Uncertainty of Measurement (95% CI)	Units	Reference Conditions	Date of Sampling	Start and End Times	CEMS Results
Oxides of Nitrogen	Not Applicable	392.58	12.68	mg/m ³	273K, 101.3kPa	7 September 2016	16:05-17:04	No Data Available
Carbon Monoxide	Not Applicable	260.41	10.86	mg/m ³	273K, 101.3kPa	7 September 2016	16:05-17:04	No Data Available
Volatile Organic Compound	Not Applicable	31.87	3.26	mgC/m ³	273K, 101.3kPa	7 September 2016	16:05-17:04	No Data Available

1.4 Monitoring Deviations

The sample plane does not comply upstream and downstream with the requirements of BS EN 15259. The appropriate sample ports are not fitted as per the requirements of BS EN 15259. The minimum sample platform does not comply with the requirements of BS EN 15259.

Part 2: Supporting Information

Appendix 1 General Information

CES Environmental Instruments Ltd staff details

Name	Role	MCERT Registration Number	Level 1	Level 2	TE1	TE2	TE3	TE4	At site
Robert Allen	Team Leader	MM 02 009		✓	✓	✓	✓	✓	T
				Nov 2017	Nov 2017	Dec 2018	Dec 2018	Nov 2017	
Tom Merry	Technician	Trainee							✓

T = Nominated Team Leader on Site

CES Environmental Instruments Ltd method details

Pollutant	Method	CES Procedure
Oxides of Nitrogen	BS EN 14792	WI 4/39
Carbon Monoxide	BS EN 15058	WI 4/42
Volatile Organic Compound	BS EN 12619	WI 4/44

Monitoring Equipment Used

Horiba PG-250
FID

CES Environmental Instruments Ltd Reference: C153
CES Environmental Instruments Ltd Reference: C232

Appendix 2

Diagrams of Emission Point

Sampling Location

Dimensions	Cross Sectional Area	Orientation	Sample Ports Available/Used	Sampling Positions Per Plane	Standard
Dia=250mm	0.049m ²	Vertical	1/1	1	BS EN 15259
Comments:					
Single Point Sampling					
				Yes	No
Has homogeneity test been carried out?					✓
If Yes - Is stack gas homogenous?				-	-
Any physical or regulatory restrictions regarding usage of equipment? N/A					

Compliance with BS EN 15259 / EA TGN M1	Yes	No
Does the sample plane comply upstream?		✓*
Does the sample plane comply downstream?		✓*
Are the appropriate sample ports fitted?		✓
Do the stack gas velocity / temperature profiles comply?	Not Applicable	
Minimum platform area >5m²		✓

*BS 15259 has a general requirement that the sampling plane shall be in a straight section of duct at least 5 hydraulic diameters downstream and 2 hydraulic diameters upstream of any bend or obstruction which could produce turbulent flow.



Appendix 3
Gas (Instrument Measured Values & Results)

Site	East End Foods
Date	07/09/2016
Plant	East End Foods
File Ref	7129

Date & Time		O2	CO2	CO		SO2		NOx(NO2)		VOC	
Start	End	dry vol%	dry vol%	dry ppm	dry mg/Nm ³	dry ppm	dry mg/Nm ³	dry ppm	dry mg/Nm ³	wet ppm	dry mg/Nm ³
07/09/2016 16:05	07/09/2016 17:04	18.15	2.21	208.33	260.41	5.48	15.64	191.50	392.58	18.84	31.87
Mean		18.15	2.21	208.33	260.41	5.48	15.64	191.50	392.58	18.84	31.87
Max		18.61	4.22	1015.92	1269.90	6.31	18.02	359.43	736.82	40.94	69.26
Min		15.52	1.85	140.17	175.21	4.73	13.50	156.03	319.85	12.97	21.94

Results Correct to

Temperature	Pressure	Oxygen	Gas
*C/K	mbar/kPa	%	Wet/Dry
	0/273	1013/101.3	Dry

Date/Time	O2	CO2	CO	SO2	NOx	CO	SO2	NOx	VOC	VOC
1 min log	dry vol%	dry vol%	dry ppm	dry ppm	dry ppm	dry mg/Nm ³	dry mg/Nm ³	dry mg/Nm ³	Wet ppm	Dry mg/Nm ³
07/09/2016 16:05	18.03	2.26	778.92	6.23	173.12	973.65	17.81	354.89	40.94	69.26
07/09/2016 16:06	18.13	2.21	401.25	6.31	183.30	501.56	18.02	375.76	37.34	63.18
07/09/2016 16:07	18.23	2.13	360.25	6.05	179.25	450.31	17.29	367.46	33.59	56.83
07/09/2016 16:08	18.29	2.09	332.00	5.95	176.21	415.00	17.00	361.23	31.41	53.13
07/09/2016 16:09	18.32	2.06	310.08	5.99	175.67	387.60	17.12	360.12	29.84	50.49
07/09/2016 16:10	18.34	2.05	293.33	5.99	174.67	366.67	17.12	358.07	28.91	48.90
07/09/2016 16:11	18.37	2.03	278.00	5.98	173.61	347.50	17.10	355.90	27.66	46.79
07/09/2016 16:12	18.38	2.02	267.50	5.97	172.35	334.38	17.07	353.32	26.41	44.67
07/09/2016 16:13	18.40	2.00	262.25	6.03	171.30	327.81	17.24	351.16	25.63	43.35
07/09/2016 16:14	18.43	1.98	255.42	5.98	169.13	319.27	17.10	346.71	25.00	42.29
07/09/2016 16:15	18.44	1.98	247.50	5.95	167.91	309.38	17.00	344.21	24.22	40.97
07/09/2016 16:16	18.45	1.97	240.83	5.96	167.00	301.04	17.02	342.35	23.28	39.39
07/09/2016 16:17	18.46	1.97	235.33	5.93	166.75	294.17	16.95	341.84	23.13	39.12
07/09/2016 16:18	18.47	1.96	230.33	6.02	165.78	287.92	17.19	339.86	22.66	38.33
07/09/2016 16:19	18.48	1.95	225.75	5.87	165.03	282.19	16.76	338.32	22.50	38.06
07/09/2016 16:20	18.47	1.95	222.08	5.83	163.78	277.60	16.64	335.76	25.31	42.82
07/09/2016 16:21	18.39	2.02	239.92	5.83	164.31	299.90	16.67	336.83	17.34	29.34
07/09/2016 16:22	15.52	4.22	1015.92	5.47	359.43	1269.90	15.62	736.82	16.09	27.23
07/09/2016 16:23	16.55	3.51	178.83	5.36	325.89	223.54	15.31	668.08	15.78	26.70
07/09/2016 16:24	16.60	3.48	163.67	5.24	320.83	204.58	14.98	657.71	15.00	25.38
07/09/2016 16:25	16.61	3.47	160.33	5.38	317.85	200.42	15.36	651.59	14.53	24.58
07/09/2016 16:26	16.62	3.47	155.67	5.16	316.95	194.58	14.81	649.75	14.69	24.85
07/09/2016 16:27	16.64	3.45	153.58	5.26	314.78	191.98	15.02	645.29	14.38	24.32
07/09/2016 16:28	16.65	3.44	151.17	5.01	313.81	188.96	14.31	643.31	14.06	23.79
07/09/2016 16:29	16.63	3.46	146.92	5.14	315.98	183.65	14.69	647.77	13.44	22.73
07/09/2016 16:30	16.61	3.47	147.00	5.01	318.67	183.75	14.31	653.27	12.97	21.94
07/09/2016 16:31	16.70	3.40	144.25	5.13	310.00	180.31	14.67	635.50	14.53	24.58
07/09/2016 16:32	17.09	3.07	140.17	5.14	285.43	175.21	14.69	585.14	15.47	26.17
07/09/2016 16:33	18.51	1.92	142.92	5.64	169.68	178.65	16.12	347.83	15.63	26.43
07/09/2016 16:34	18.58	1.88	150.50	5.63	162.33	188.13	16.10	332.78	15.78	26.70
07/09/2016 16:35	18.58	1.88	151.75	5.66	161.32	189.69	16.17	330.72	15.78	26.70
07/09/2016 16:36	18.59	1.87	152.50	5.49	161.20	190.63	15.69	330.46	16.09	27.23
07/09/2016 16:37	18.59	1.87	151.17	5.55	160.98	188.96	15.86	330.02	16.25	27.49
07/09/2016 16:38	18.59	1.87	151.83	5.50	160.64	189.79	15.71	329.32	16.09	27.23
07/09/2016 16:39	18.58	1.87	154.33	5.50	160.60	192.92	15.71	329.23	16.25	27.49
07/09/2016 16:40	18.58	1.88	154.17	5.38	160.92	192.71	15.38	329.88	15.78	26.70
07/09/2016 16:41	18.58	1.87	152.25	5.21	159.81	190.31	14.88	327.61	15.78	26.70
07/09/2016 16:42	18.58	1.87	150.08	5.33	159.67	187.60	15.21	327.32	15.63	26.43
07/09/2016 16:43	18.58	1.88	148.25	5.25	160.05	185.31	15.00	328.10	15.94	26.96
07/09/2016 16:44	18.59	1.87	148.83	5.34	159.57	186.04	15.26	327.13	15.78	26.70
07/09/2016 16:45	18.59	1.87	152.33	5.29	158.79	190.42	15.12	325.52	15.63	26.43
07/09/2016 16:46	18.60	1.86	150.17	5.48	157.46	187.71	15.64	322.79	15.94	26.96
07/09/2016 16:47	18.61	1.85	147.17	5.18	157.21	183.96	14.81	322.28	15.78	26.70
07/09/2016 16:48	18.60	1.86	145.75	5.16	158.07	182.19	14.74	324.05	15.78	26.70
07/09/2016 16:49	18.60	1.85	145.08	5.39	157.46	181.35	15.40	322.79	15.63	26.43
07/09/2016 16:50	18.59	1.86	144.75	5.32	157.69	180.94	15.21	323.27	15.78	26.70
07/09/2016 16:51	18.58	1.87	143.42	5.24	158.50	179.27	14.98	324.93	15.63	26.43
07/09/2016 16:52	18.58	1.87	142.92	5.09	158.11	178.65	14.55	324.12	15.78	26.70
07/09/2016 16:53	18.58	1.87	145.33	5.02	157.86	181.67	14.33	323.61	15.78	26.70
07/09/2016 16:54	18.59	1.86	147.17	5.09	156.78	183.96	14.55	321.39	15.47	26.17
07/09/2016 16:55	18.60	1.85	146.42	5.05	156.38	183.02	14.43	320.57	15.63	26.43
07/09/2016 16:56	18.60	1.85	146.08	5.13	156.03	182.60	14.64	319.85	15.63	26.43
07/09/2016 16:57	18.60	1.85	148.17	5.08	155.27	185.21	14.52	320.36	15.78	26.70
07/09/2016 16:58	18.60	1.85	147.25	5.31	156.27	184.06	15.17	320.35	15.78	26.70
07/09/2016 16:59	18.60	1.85	150.33	4.83	156.55	187.92	13.81	320.93	15.63	26.43
07/09/2016 17:00	18.60	1.85	152.33	5.45	156.61	190.42	15.57	321.05	15.63	26.43
07/09/2016 17:01	18.60	1.85	150.00	5.12	156.79	187.50	14.62	321.42	15.63	26.43
07/09/2016 17:02	18.59	1.86	150.00	4.73	157.24	187.50	13.50	322.35	15.31	25.90
07/09/2016 17:03	18.59	1.86	148.58	5.39	157.28	185.73	15.40	322.43	15.63	26.43
07/09/2016 17:04	18.59	1.86	149.75	5.47	157.33	187.19	15.62	322.53	15.63	26.43
Min	15.52	4.22	1015.92	4.73	359.43	1269.90	15.62	736.82	16.09	27.23
Max	18.61	1.85	140.17	5.66	161.32	189.69	16.17	330.72	15.78	26.70
Mean	18.15	2.21	208.33	5.48	191.50	260.41	15.64	392.58	18.84	31.87

Appendix 4
Instrumental Gas Analyser Site Calibration Data

CES Environmental Instruments Ltd
GAS ANALYSER CALIBRATION SHEET

Gas Analyser Calibration		Client	East End Foods	Date	07/09/2016
Instrument Type	PG-250	Job Number	7129	Test	
Quality No.	C153	Site	Aston, Birmingham	Test Period	1hr

Range - Nitrogen (N2)	%
Range - Carbon Dioxide (CO2)	25.00 %
Range - Oxygen (O2)	20.00 %
Range - Carbon Monoxide (CO)	500.00 ppm
Range - Nitric Oxide (NO)	500.00 ppm
Range - Nitrogen Dioxide (NO2)	ppm
Range - Sulphur Dioxide (SO2)	ppm
Range - C ₃ H ₈	100.00 ppm

Zero Gas - Nitrogen (N ₂)	99.999 %	Certificate Number:	40-55145
Span Gas 1 - Carbon Dioxide (CO ₂)	18.15 %	Certificate Number:	40-46689
Span Gas 1 - Oxygen (O ₂)	19.98 %	Certificate Number:	40-46689
Span Gas 1 - Carbon Monoxide (CO)	449.8 ppm	Certificate Number:	40-43837
Span Gas 1 - Nitric Oxide (NO)	450 ppm	Certificate Number:	40-43837
Span Gas 1 - Nitrogen Dioxide (NO ₂)	ppm	Certificate Number:	
Span Gas 1 - Sulphur Dioxide (SO ₂)	ppm	Certificate Number:	
Span Gas 1 - C ₃ H ₈	80 ppm	Certificate Number:	40-47249

Span Gas 2 - Carbon Dioxide (CO ₂)	%	Certificate Number:	
Span Gas 2 - Oxygen (O ₂)	%	Certificate Number:	
Span Gas 2 - Carbon Monoxide (CO)	ppm	Certificate Number:	
Span Gas 2 - Nitric Oxide (NO)	ppm	Certificate Number:	
Span Gas 2 - Nitrogen Dioxide (NO ₂)	ppm	Certificate Number:	
Span Gas 2 - Sulphur Dioxide (SO ₂)	ppm	Certificate Number:	
Span Gas 2 - C ₃ H ₈	ppm	Certificate Number:	

Date	07/09/2016	Time	12:30:00	Amb Press (mbar)	1012	Amb Temp. (°C)	21
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Calibration Check - Pre-Sampling	CO ₂	O ₂	CO	NO	NO ₂	SO ₂	C3H8
Test Gas Entered - Instrument							
Zero Reading	0.00	0.00	0.00	0.00			0.00
Span Gas 1 Reading	18.13	19.95	450.30	449.90			80.30
Zero Reading	0.03	-0.04	0.09	0.70			0.04
Ambient Air		20.86					
Analyser T ₉₀ Response (sec)				40.00			
<2x Repeatability @ zero	0.03	0.04	0.09	0.70	0.00	0.00	0.04

Calibration Check - Pre-Sampling	CO ₂	O ₂	CO	NO	NO ₂	SO ₂	C3H8
Test Gas Entered - Probe							
Zero Reading	0.02	0.01	0.30	0.20			0.00
Span Gas 1 Reading	18.14	19.98	451.20	449.70			79.80
Span Gas 2 Reading							
Ambient Air							
Zero Drift (%)	0.08	0.05	0.06	0.04			0.00
Span Drift (%)	0.04	0.15	0.18	0.04			0.50

Date	07/09/2016	Time	17:15:00
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Calibration Check - Mid / Post Sampling	CO ₂	O ₂	CO	NO	NO ₂	SO ₂	C3H8
Test Gas Entered - Probe							
Zero Reading	0.06	-0.10	3.20	0.70			1.00
Span Gas 1 Reading	18.09	19.94	449.20	448.60			78.90
Span Gas 2 Reading							
Ambient Air							
Zero Drift (%)	0.24	0.50	0.64	0.14			1.00
Span Drift (%)	0.16	0.05	0.22	0.26			1.40

Checks completed by: Robert Allen Page 1 of 1

Appendix 5

Uncertainty Calculations

Uncertainty calculation for Gaseous Measurement NOx EN14792

v3.2 Jul-09

Limit value		mg/m ³ (corrected) NOx	Cal gas conc	923.86	mg.m ⁻³ (NO ₂)
Measured concentration	191.50	ppm			
Measured concentration	393.16	mg/m ³ (101.3kPa, 273K)	Full Scale	1026.5	mg/m ³ (NO ₂)
Measured concentration	396.33	mg/m ³ (Corrected)			
NO/NO ₂ ratio	100.00		Gas	NO	
			Full Scale	500	ppm
			Cal gas conc	450	ppm
			Conversion	2.053	

Correction for reference conditions				
	O ₂ , %	Moisture, %	Pressure, KPa	Temperature, K
ref	0.00	0.00	101.30	273.00
measured	0.00	0.80	101.30	273.00
Uncert			0.00	1.00
Factors	1.00	1.01	1.00	1.00
Uncertainty in factor	0.00	0.00	0.00	0.00
Correction Factor	1.01	uf	0.00	

Effect of drift
0.25 mg/m ³
0.02 % full scale

Performance characteristics	Value		specification
Response time	15	seconds	180.000
Logger sampling interval	60	seconds	
Measurement period	60	minutes	
Number of readings in measurement	60		
Repeatability at zero	0.05	% full scale	<1 % range
Repeatability at span level	0.0623	% full scale	<2 % range
Deviation from linearity(lack of fit)	0.7	% of value	<2 % range
Zero drift	0.14	mg/m ³	<2% range / 24hr
Span drift	0.26	mg/m ³	<2% range/24hr
volume or pressure flow dependence	0	%of full scale/kPa	<2 % / kPa
atmospheric pressure dependence	0	% of value /kPa	<3% / kPa
ambient temperature dependence	0.3	% full scale/10K	<3% range / 10 K
NH ₃ (mg/m ³)	20	0.0	mg/m ³
CO ₂ (% vol)	15	0.2	mg/m ³
H ₂ O (% vol)	30	0.0	mg/m ³
dependence on voltage	0.1	% full scale/10V	<2% range
losses in the line (leak)	1	% of value	< 0.1%vol /10 volt
Converter efficiency	98.72	%	>95%
Uncertainty of calibration gas	2	% of value	< 2% of value

	ranges		
	min	max	value at calib
flow	18	30	24 l/hr
pressure	101.20	101.2	101.2 kPa
temp	294	294	294 K
NH ₃ range	0	0	0 mg/m ³
CO ₂ range	1.8	4.2	0 %vol
H ₂ O range	0	0	0 %vol
Voltage	93	121	110 V

Performance characteristic	Uncertainty	Value of uncertainty quantity	mg/m ³
Standard deviation of repeatability at zero	U ₀	for mean	use rep at span
Standard deviation of repeatability at span level	U _s	for mean	0.08
Lack of fit	U _{fit}		1.59
Drift	U _{odr}		0.15
volume or pressure flow dependence	U _{spres}		0.00
atmospheric pressure dependence	U _{spres}		0.00
ambient temperature dependence	U _{temp}		0.00
NH ₃	U _{interf}		0.00
CO ₂ (% vol)	U _{interf}		0.04
H ₂ O (% vol)	U _{interf}		0.00
Dependence on voltage	U _{volt}		0.89
losses in the line (leak)	U _{leak}		2.27
Uncertainty of calibration gas	U _{calib}		4.54
converter efficiency	U _{ceff}		2.91
Uncertainty in factor	uf		1.44

Use largest of sum of all positive or all negative influences		
0.04 all +ves	Criteria sum <4% range 7.863143982	
0 all -ves		
0.04 largest		
Value to use for interreference uncertainty		U _{int} 0.04

Measurement uncertainty			
Combined uncertainty		6.13	mg/m ³
Expanded uncertainty	k = 2	12.25	mg/m ³
Uncertainty corrected to std conds		12.68	mg/m ³
Expanded uncertainty	expressed with a level of confidence of 95%	#DIV/0!	% ELV
Expanded uncertainty	expressed with a level of confidence of 95%	12.68	mg.m ⁻³
Expanded uncertainty	expressed with a level of confidence of 95%	3.20	% value

Verified

Uncertainty calculation for Gaseous Measurement BS EN 15058 Carbon Monoxide

Limit value		mg.m ⁻³ (corrected) CO	Gas	CO
Measured concentration	208.33	ppm	Full Scale	500 ppm
Measured concentration	260.41	mg.m ⁻³ (273K, 101.3kPa)	Cal gas conc	449.8 ppm
			Conversion	1.25
			Full Scale	625 mg.m ⁻³
			Cal gas conc	562.25 mg.m ⁻³

Correction for reference conditions				
	O2, %	Moisture, %	Pressure, KPa	Temperature, K
ref	0.00	0.00	101.30	273.00
measured	0.00	0.80	101.30	273.00
Factors	1.00	1.01	1.00	1.00
Correction Factor	1.01			

Performance characteristics	Value		specification
Response time	60	seconds	180.000
Number of readings in measurement	60		
Repeatability at zero	0.15	% full scale	0.200
Repeatability at span level	0.8	% full scale	2.000
Deviation from linearity	0.4	% of value	2.000
Zero drift	0.64	% full scale	2.000
Span drift	0.22	% full scale	2.000
volume or pressure flow dependence	0.02	% of full scale/kPa	0.033
atmospheric pressure dependence	0.8	% of value/kPa	0.750
ambient temperature dependence	0.01	% full scale/10K	0.300
N2O (20 mg/m3)	1.2	mg/m3	
CH4 (50 mg/m3)	1.2	mg/m3	
CO2 (15%)	1.2	% by vol	
H2O (30%)	1.2	% by vol	4.000
dependence on voltage	0.1	% full scale/10V	2%fs/10V
losses in the line (leak)	2	% of value	2% of value
Uncertainty of calibration gas	2	% of value	

Effect of drift
4.57 mg/m3
0.73 % value

	ranges		value at calib
	min	max	
flow	18	30	24 l/hr
pressure	101.20	101.20	101.20 kPa
temp	294	294	294 K
NH3 range	0	0	0 mg/m3
N2O range	0	20	0 mg/m3
CH4 range	0	50	0 mg/m3
CO2 range	1.8	4.2	0 %vol
H2O range	0	0.8	0 %vol
Instrument Voltage Rating			110 V
Voltage	104.5	115.5	110 V

Measurement performance related to stationary conditions

Performance characteristic	Uncertainty	Value of uncertainty quantity	
		for mean	use rep at span
Standard deviation of repeatability at zero	u _{r0}		
Standard deviation of repeatability at span level	u _{rs}		0.10
Lack of fit	u _{fit}		1.44
Drift	u _{odr}		2.64
volume or pressure flow dependence	u _{spres}		0.04
atmospheric pressure dependence	u _{apres}		0.00
ambient temperature dependence	u _{temp}		0.00
CO2 (15%)	u _{interf}		0.25
H2O (30%)	u _{interf}		0.02
N2O (20 mg/m3)	u _{interf}		0.35
CH4 (50 mg/m3)	u _{interf}		0.61
Dependence on voltage	u _{volt}		0.03
losses in the line (leak)	u _{leak}		3.01
Uncertainty of calibration gas	u _{calib}		3.01

Use largest negative or positive interferent effect		
CO2	0	0.25
H2O	0	0.02
N2O	0	0.35
CH4	0	0.61
	0	1.22
Interference uncertainty	1.22	

Measurement uncertainty	Result		
Combined uncertainty		260.41	mg/m ³
Expanded uncertainty	k = 2	5.39	mg/m ³
		10.77	mg/m ³
Uncertainty corrected to std conds		10.86	mg.m-3 (corrected)
Expanded uncertainty	expressed with a level of confidence of 95%	#DIV/0! % ELV	
Expanded uncertainty	expressed with a level of confidence of 95%	10.86 mg.m ⁻³ at ELV	

Verified

Uncertainty calculation for Gaseous Measurement Volatile Organic Compounds

BS EN 12619:1999 (0-20mg/m³)
BS EN 13526:2002 (20-500mg/m³)

Limit value		mg.m ⁻³ (corrected)	Gas	C3H8
Measured concentration	18.84	ppm	Full Scale	100 ppm
	30.14	mg.m ⁻³ (273K, 101.3kPa)	Cal gas conc	80 ppm
Measured concentration			Conversion	1.6
			Full Scale	160 mg.m ⁻³
			Cal gas conc	128 mg.m ⁻³

Correction for reference conditions				
	O2, %	Moisture, %	Pressure, KPa	Temperature, K
ref	0.00	0.00	101.30	273.00
measured	0.00	5.00	101.30	273.00
Factors	1.00	1.05	1.00	1.00
Correction Factor	1.05			

Performance characteristics	Value		specification
Response time	60	seconds	180.000
Number of readings in measurement	60		
Repeatability at zero	0.15	% full scale	0.200
Repeatability at span level	0.8	% full scale	2.000
Deviation from linearity	0.4	% of value	2.000
Zero drift	1	% full scale	2.000
Span drift	1.4	% full scale	2.000
volume or pressure flow dependence	0.02	% of full scale/kPa	0.033
atmospheric pressure dependence	0.5	% of value/kPa	0.750
ambient temperature dependence	0.01	% full scale/10K	0.300
N2O (40 mg/m3)	0.3	mg/m3	
CH4 (57 mg/m3)	0.3	mg/m3	
NH3 (20 mg/m3)	0.3	mg/m3	
CO2 (15%)	0.3	% by vol	
H2O (30%)	0.5	% by vol	4.000
dependence on voltage	0.1	% full scale/10V	2%/s/10V
losses in the line (leak)	2	% of value	2% of value
Uncertainty of calibration gas	2	% of value	

Effect of drift
2.02 mg/m3 1.26 % value

	ranges		value at calib
	min	max	
flow	18	30	24 l/hr
pressure	101.20	101.20	101.20 kPa
temp	294	294	294 K
NH3 range	0	20	0 mg/m3
N2O range	0	40	0 mg/m3
CH4 range	0	57	0 mg/m3
CO2 range	8	10	0 %vol
H2O range	5.00	5.00	0 %vol
Instrument Voltage Rating	110 V		
Voltage	104.5	115.5	110 V

Measurement performance related to stationary conditions				
Performance characteristic	Uncertainty		Value of uncertainty quantity	
Standard deviation of repeatability at zero	U _{r0}		for mean	use rep at span
Standard deviation of repeatability at span level	U _{rs}		for mean	0.10
Lack of fit	U _{fit}			0.37
Drift	U _{odr}			1.17
volume or pressure flow dependence	U _{spres}			0.01
atmospheric pressure dependence	U _{apres}			0.00
ambient temperature dependence	U _{temp}			0.00
NH3 (20 mg/m3)	U _{interf}			0.17
CO2 (15%)	U _{interf}			0.18
H2O (30%)	U _{interf}			0.08
N2O (40 mg/m3)	U _{interf}			0.17
CH4 (57 mg/m3)	U _{interf}			0.17
Dependence on voltage	U _{volt}			0.03
losses in the line (leak)	U _{leak}			0.35
Uncertainty of calibration gas	U _{calib}			0.35

Use largest negative or positive interferent effect		
NH3	0	0.17
CO2	0	0.18
H2O	0	0.08
N2O	0	0.17
CH4	0	0.17
	0	0.78
Interference uncertainty	0.78	

Measurement uncertainty	Result	30.14	mg/m ³
Combined uncertainty		1.55	mg/m ³
Expanded uncertainty	k =	2	3.10 mg/m ³
Uncertainty corrected to std conds		3.26	mg.m-3 (corrected)
Expanded uncertainty	expressed with a level of confidence of 95%	#DIV/0! % ELV	
Expanded uncertainty	expressed with a level of confidence of 95%	3.26 mg.m ⁻³ at ELV	

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Uncertainty calculation for Gaseous Measurement Oxygen EN14789

V2.2 Jul-08

Limit value	n/a	%vol	Calibration gas	19.98	%vol
Measured concentration	18.15	%vol	Full Scale	25	%vol

Performance characteristics	Value			specification
Response time	60	seconds		< 200 s
Logger sampling interval	60	seconds		
Measurement period	60	minutes		
Number of readings in measurement	60	Assuming 1 minute collected over 1 hour		
Repeatability at zero	0.015	% by volume	stdev	<0.2 % range
Repeatability at span level	0.014	% by volume	stdev	<0.4 % range
Deviation from linearity	0.13	% vol	+/-	<0.3 % volume
Zero drift (during measurement period)	0.5	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)	0.05	% vol at span level	+/-	<2% volume/24hr
volume or pressure flow dependence	0	% of fs / 10l/h	+ - 5 l/h	<1% range
atmospheric pressure dependence	0.3	% of fs/kPa	+ - 2kPa	< 1.5 % range
ambient temperature dependence	-0.07	% by volume /10K	+ - 15K	<0.3% volume /10 K
CO ₂ (% vol)	15	0.07	% by volume per	15
NO (mg/m3)	300	0.02	% by volume per	300
NO ₂ (mg/m3)	30	0	% by volume per	30
Combined interference	0.56	% range		<2% range
Dependence on voltage	0.1	% by volume /10V	+ - 5%	< 0.1%vol /10 volt
Losses in the line (leak)	2	% of value		< 2% of value
Uncertainty of calibration gas	0.5	% of value		

Effect of drift
0.13 % vol
0.54 % value

range of variation from conditions at calibration			
	min	max	value at calib
flow	18	30	24 l/h
pressure	101.20	101.2	101.2 kPa
temp	294	294	294 K
CO ₂ range	1.8	4.2	0 % vol
NO range	209.1	481.6	0 mg/m3
NO ₂ range	10.5	24.1	0 mg/m3
Voltage	104.5	115.5	110 V

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Performance characteristic	Uncertainty	Value of uncertainty quantity	% vol
Standard deviation of repeatability at zero	u _{r0}	for mean	Only use rep at span
Standard deviation of repeatability at span level	u _{rs}	for mean	0.00
Lack of fit	u _{fit}		0.08
Drift	u _{odr}		0.08
volume or pressure flow dependence	u _{spres}		0.00
atmospheric pressure dependence	u _{apres}		0.00
ambient temperature dependence	u _{temp}		0.00
CO ₂			0.01
NO			0.02
NO ₂			0.00
Combined interference (from mcerts)			0.08
dependence on voltage	u _{volt}		0.03
losses in the line (leak)	u _{leak}		0.21
Uncertainty of calibration gas	u _{calib}		0.05

Use largest of sum of all positive or all negative influences		
0.04 all +ves	0 all -ves	0.04 largest
Criteria sum <2% value 0.363038334		
Value to use for interference uncertainty u _{int} 0.04		

Measurement uncertainty	18.15	%vol
Combined uncertainty	0.25	%vol
% of value	1.36	%
Coverage factor k =	2	
Expanded uncertainty expressed with a level of confidence of 95%	2.72 % of value	
Expanded uncertainty expressed with a level of confidence of 95%	0.49 % vol	

Requirement for SRM is that Uncertainty should be < 6% of value, on a dry gas basis

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