Stack Emissions Monitoring Report

commissioned by Mr Edward Vaughan

Job Reference: JOB-1000

Operator Name
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Report Date | Version Number
13/02/2024 | Version 1

Dates of the Monitoring Campaign
06/02/2024

Release Point
AD Plant Engine Exhaust

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10706

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Report Contents and Monitoring Objectives

Report Contents

Monitoring Objective

The monitoring objective was to conduct stack emissions monitoring to demonstrate compliance against a set of emission limit values (ELVs) as specified in the Site's Environmental Permit.

Special Requirements

There were no special requirements for this monitoring campaign.

Opinions and Interpretations

Any opinions or interpretations contained within this test report are outside the scope of Atesta's MCERTS / ISO 17025 accreditation.

Part 1: Executive Summary - Monitoring Results Summary

Monitoring Results - Summary

	EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION					
test parameter	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**reference conditions**	**accreditation status**
Sulphur Dioxide	7.0	0.62	350	mg/m³	5.7	0.54		g/hr	STP, dry, 5% O_2	MCERTS
Total VOCs (as Carbon) †	1055	422	1000	mg/m³	864	346		g/hr	STP, dry, 5% O_2	MCERTS
Oxides of Nitrogen (as NO_2) †	476	143	500	mg/m³	390	117		g/hr	STP, dry, 5% O_2	MCERTS
Carbon Monoxide †	890	178	1400	mg/m³	729	146		g/hr	STP, dry, 5% O_2	MCERTS
Oxygen	7.5	0.19		% v/v					dry	MCERTS
Stack Gas Water Vapour	11.4	0.37		% v/v					actual	MCERTS
Stack Gas Temperature	393			°C					actual	MCERTS
Stack Gas Velocity	38.1	0.63		m/s					actual	MCERTS
Stack Gas Flow Rate (ACTUAL)	2756	133		m³/hr					actual	MCERTS
Stack Gas Flow Rate (REF)	819	39.4		m³/hr					STP, dry, 5% O_2	MCERTS

The stack gas water vapour, temperature, velocity and flow rates in the above table are calculated as an average of all of the results recorded during this monitoring campaign

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

† The uncertainties stated above are those specified in Table 4.7 (in Section 4.6.1) of EA LFTGN08 v2 2010, and are the "Assumed maximum values for total uncertainty to be applied when assessing compliance of emissions from [landfill gas] engines". See Appendix 2 of this report for more information.

Part 1: Executive Summary - Monitoring Results Further Details

Monitoring Results - Further Details

		EXPRESSED AS A CONCENTRATION				EXPRESSED AS A MASS EMISSION							
test parameter	**run**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**result**	**uncertainty in result +/-**	**limit** (ELV)	**units**	**sampling date | times**	**run time** (mins)	**H_2O** (% v/v)	**reference conditions**
Sulphur Dioxide	R1	7.0	0.62	350	mg/m³	5.7	0.54		g/hr	06/02/2024 | 11:11 - 12:11	60	11.4	STP, dry, 5% O_2
Total VOCs (as Carbon) †	R1	1055	422	1000	mg/m³	864	346		g/hr	06/02/2024 | 11:11 - 12:11	60		STP, dry, 5% O_2
Oxides of Nitrogen (as NO_2) †	R1	476	143	500	mg/m³	390	117		g/hr	06/02/2024 | 11:11 - 12:11	60		STP, dry, 5% O_2
Carbon Monoxide †	R1	890	178	1400	mg/m³	729	146		g/hr	06/02/2024 | 11:11 - 12:11	60		STP, dry, 5% O_2
Oxygen		7.5	0.19		% v/v					N/A - Concurrent Testing			dry
Velocity & Flow Rate Traverse	R1	38.1	0.63		m/s	2756	133		m³/hr	06/02/2024 | 10:50 - 10:58			actual

The uncertainty in the result is reported at a 95% Confidence Interval in the same units as the monitoring result. In practice, this means that 95 times out of 100, the true result will lie within the stated range.

† The uncertainties stated above are those specified in Table 4.7 (in Section 4.6.1) of EA LFTGN08 v2 2010, and are the "Assumed maximum values for total uncertainty to be applied when assessing compliance of emissions from [landfill gas] engines". See Appendix 2 of this report for more information.

Part 1: Executive Summary - Monitoring and Analytical Methods

Monitoring and Analytical Methods

where analysis required	MONITORING					ANALYSIS					
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**laboratory**	**accreditation number**	**analytical procedure**	**analytical technique**	**analysis status**	**accreditation status**
Sulphur Dioxide	ATA	10706	TP-10	EN 14791	MCERTS	RPS	0605	C27	IC	MCERTS	MCERTS

where analysis not required	MONITORING						
test parameter	**laboratory**	**accreditation number**	**technical procedure**	**reference method**	**monitoring status**	**measurement technique & equipment**	**accreditation status**
Total VOCs (as Carbon)	ATA	10706	TP-21b	EN 12619	MCERTS	FID using iFID Mobile	MCERTS
Oxides of Nitrogen (as NO_2)	ATA	10706	TP-22a	EN 14792	MCERTS	Chemiluminescence using Horiba PG-350E	MCERTS
Carbon Monoxide	ATA	10706	TP-22b	EN 15058	MCERTS	NDIR using Horiba PG-350E	MCERTS
Oxygen	ATA	10706	TP-22d	EN 14789	MCERTS	Paramagnetism using Horiba PG-350E	MCERTS
Velocity & Flow Rate Traverse	ATA	10706	TP-04a	EN 16911-1 | TR 17078	MCERTS	Pitot Tube, Thermocouple & Thermomanometer	MCERTS

Summary of Monitoring Deviations (from Appendix 2)

test parameter	run	details of monitoring deviation
All	1	There were no deviations associated with the monitoring employed.

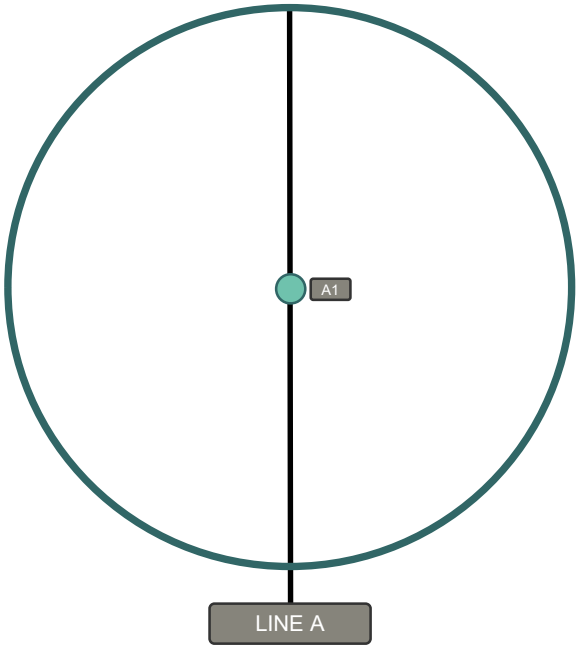
Part 1: Executive Summary - Monitoring Location

Monitoring Location Photos




Identification of Sampling Points on a Duct Diagram

refer to Appendix 2 - Raw Data to see how the points on this diagram relate to the points used for each test



Part 1: Executive Summary - Duct and Sampling Platform Information

Duct Characteristics | Sampling Ports

parameter	units	value
shape	-	Circular
dimensions	-	Diameter = 0.16 m
area	m²	0.02
orientation	-	Horizontal

parameter	value
primary sample port size	1" BSP
primary sample port depth | cm	10
primary sample ports number of sampling lines available	1

summary of all sample ports available
1" BSP

Sampling Location General Information

general information	details
type | location | access	On the Ground | Inside | On Ground Level

CEMS | Abatement Systems

parameter	details
abatement system/s	N/A
CEMS installed on the stack	N/A

Sampling Plane Validation Criteria Summary (EN 15259) from Stack Traverse/s

criteria in EN 15259	units	value	allowed	compliant
lowest differential pressure	Pa	526.7	> 5 Pa	Yes
lowest traverse velocity	m/s	38.1	-	-
highest traverse velocity	m/s	38.1	-	-
mean traverse velocity	m/s	38.1	-	-
ratio traverse velocities	: 1	1.00	< 3 : 1	Yes
angle of swirl compliance	°	< 15	< 15°	Yes
no local negative flow	-	Yes	-	Yes

Part 1: Executive Summary - Sampling Location and Operating Information

Process Details

process detail	details
plume appearance on day of monitoring	No visible plume
type of process	Anaerobic Digester Engine
batch or continuous process	Continuous
fuel type	Biogas
feedstock	N/A
typical load / throughput of plant	Normal Operation - 250kW
details of any unusual process occurrences	None

Part 2: Supporting Information - Appendix 1: Monitoring Personnel, Analysis Laboratories and Test Equipment Used

Monitoring Personnel

name	position	MCERTS level | number | expiry	MCERTS technical endorsements
Matt Miller	Senior Team Leader	MCERTS Level 2 | MM 14 1313 | 31/10/2025	TE1 TE2 TE3 TE4
James Miles	Trainee	MCERTS Trainee | MM 23 1793 | 31/07/2028	-

Analysis Laboratories

laboratory	ISO 17025 accreditation number	laboratory short name	laboratory phone number
Atesta | North West	10706	ATA	0800 970 8945
RPS Laboratories | Salford	0605	RPS	0161 872 2443

Test Equipment Used

equipment type	A-EQ ID
Source sampling console	208
Low flow sampling MFCs	
ThermoFID / iFID mobile	401
Horiba PG-350E multigas analyser	230
Gasmet DX4000 FTIR	
Gasmet PSS	
Protea AtmosFIR	
Protea PIB Pump	
Gasmet syringe calibrator	
M&C PSS5-C conditioning unit	324
Digital thermomanometer	323
Top pan balance kit	340

equipment type	A-EQ ID
Pitot	373
Calipers	331
Barometer	
Timer	399
Tape measure	325
Heated head filter	65
Heated tee	
10m heated line	376
1.5m heated line	
Odour barrel	
Vacuum chamber	
Dilution probe	

equipment type	A-EQ ID
10m umbilical	
30m umbilical	
Heated probe	
Filter oven	
Ambient thermocouple	383
Stack thermocouple	259
Exit thermocouple	
Condenser thermocouple	
Tubes kit thermocouple	
2-way heater controller	
Air sampling pump	
5-figure analytical balance	1

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Results

reference conditions are: STP, dry, 5% O_2

parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Sulphur Dioxide	mg/m³	7 ± 0.62	g/hr	5.7 ± 0.54

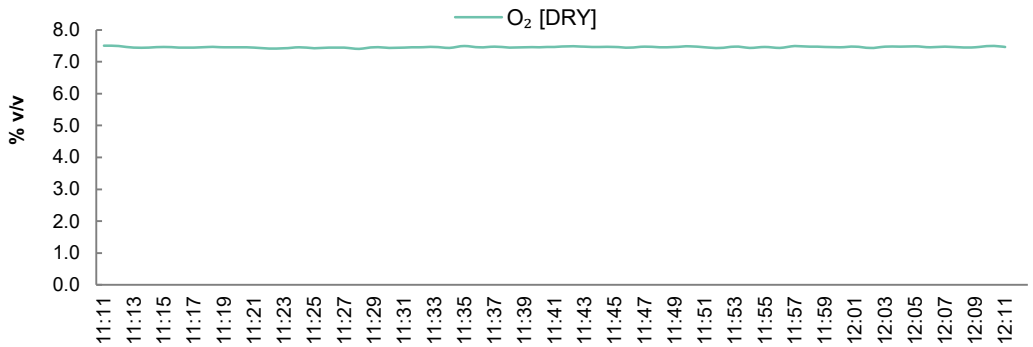
Analytical Laboratory Information

parameter	details
name of analytical lab	RPS
lab analytical procedure	C27
lab analytical technique	IC | Analysis Accreditation: MCERTS
date analysis completed	13/02/2024

General Information

parameter	details
sampling date	06/02/2024
sampling times | testing team	11:11 - 12:11 | 60 minutes | tested by: MM | JM
standard | technical procedure	EN 14791 | TP-10
volume metering device	XD-502 Digital Source Sampling Console
probe material	Titanium
filter housing material	Stainless Steel Heated Head
impinger material | capture media	Borosilicate Glass | 0.3% H_2O_2

Oxygen Data



parameter	details
filter size, material & location	Heated Head Filter Element GF | Within Heated Head | heated to 180°C
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Quality Assurance

² The concentration in the last absorber was less than 5 times the analytical LOD.

		sample run			blank (taken on 06/02/2024)		
QA parameter	units	value	allowable	result	value	allowable	result
maximum allowable blank	mg/m³	-	-	-	0.22	35	Pass
leak test	%	0.00	2.00	Pass	0.00	2.00	Pass
absorption efficiency	%	97.4	N/A²	Pass	-	-	-
silica trap <50% faded	-	Yes	-	Pass	-	-	-
are water droplets present	-	No	-	-	-	-	-
water vapour MU	%	3.2	20.0	Pass	-	-	-

Breakdown of Results

reference conditions are: STP, dry, 5% O_2

parameter	sample volume [m³]	LOD [mg]	impingers [front | back] [mg/l]	impinger volume [front | back] [ml]	mass total [mg]	LOD result [mg/m³]	result [mg/m³]	result reported [mg/m³]	mass emission [g/hr]
sample run	0.1123	0.021	2.27 | 0.24	336 | 86	0.78	0.19	7	**7**	5.7
blank	0.1123	0.016	0.08	315.0	0.025	0.14	0.22	**0.22**	

Part 2: Supporting Information - Appendix 2: Sulphur Dioxide | Run 1

Raw Data | Calculations

data	units	value
P_{bar}	mmHg	735.8
P_g	Pa	-93.0
$\Delta H_@$	mmH_2O	46.2
P_m	mmHg	739.2
P_s	mmHg	735.1
V_m (metered)	m³	0.1432
Y_d	-	1.0026
C_{stp}	-	0.3592

data	units	value
T_m	°C	13.0
ΔH_{av}	Pa	10.0
m_{wts}	g	13.9
M_w	g/mol	18.0
V_{mol}	m³/mol	0.0222
T_s	°C	393.0
R_{wv} (H_2O)	% v/v	11.4

data	units	value
$\%CO_{2d}$	% v/v (est)	4.00
$\%O_{2d}$	% v/v	7.46
$\%O_{2w}$	% v/v	6.61
$\%N_{2d}$	% v/v	88.54
$\%O_{2ref}$	% v/v	5.0
O_{2facd}	-	1.18
O_{2facw}	-	1.11

data	units	value
M_d	g/mol	28.94
M_s	g/mol	27.69
A_s	m²	0.02
θ (sample time)	mins	60

where (est) refers to an estimated value

metered volume calculations	units	value
allow favourable O_2 correction	-	Yes
vol actual stack conditions, $V_{ma} = (V_{mstw})(T_s + 273) / (P_s) / (C_{stp})$	m³	0.3779
vol dry, $V_{mstd} = (V_m)(Y_d)(C_{stp})((P_{bar} + (\Delta H_{av} / 9.80665 / 13.6)) / (T_m + 273))$	m³	0.1327
vol wet, $V_{mstw} = (V_{mstd})(100 / (100 - R_{wv}))$	m³	0.1498
vol dry O_2, $V_{mstdO_2} = (V_{mstd}) / (O_{2facd})$	m³	0.1123
vol wet O_2, $V_{mstwO_2} = (V_{mstw}) / (O_{2facw})$	m³	0.1348

velocity | volume flow rate calculations	units	value
velocity of stack gas, v_s = average of all velocity measurements	m/s	38.1
stack gas flow actual stack conditions, Q_a = average of all flow rate measurements	m³/hr	2756.3

Measurement Uncertainty (MU) Calculations

parameter	units	value	standard MU	MU as %age	required standard	value	sens coeff.	MU | mg/m³
DGM meter volume, V_m	m³	0.1432	0.0007	0.50	≤2%	-	-	-
DGM temperature, T_m	K	286.0	2.0	0.70	≤1%	-	-	-
DGM pressure, P_m	kPa	98.6	0.50	0.51	≤1%	-	-	-
DGM humidity, H_m	% v/v	0	1.0	1.00	≤1%	-	-	-
DGM volume STP, V_{mstd}	m³	-	-	-	-	0.1327	52.57	0.1
leak, L	% [1] | mg/m³ [2]	0 [1]	-	0.00	≤2%	0 [2]	1.00	0
laboratory result, L_r	% [1] | mg/m³ [2]	3.9 [1]	-	3.9	-	0.27 [2]	1.00	0.27
			combined MU with O_2 correction					0.32
			expanded MU 95% CI with O_2 correction (k = 1.96) including method deviations					0.62
			expanded MU 95% CI with O_2 correction (k = 1.96) as percentage of measured value					8.9%
			expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission					9.4%
			expanded MU 95% CI with O_2 correction (k = 1.96) as percentage of ELV [allowable 20.3%]					0.18%

result
Pass

MU factor O_2 correction
0.04

overall MU for O_2 correction
3.7%

method deviation factor
1.00

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Results

reference conditions are: STP, dry, 5% O_2

parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Total VOCs (as Carbon) †	mg/m³	1055 ± 422	g/hr	864 ± 346

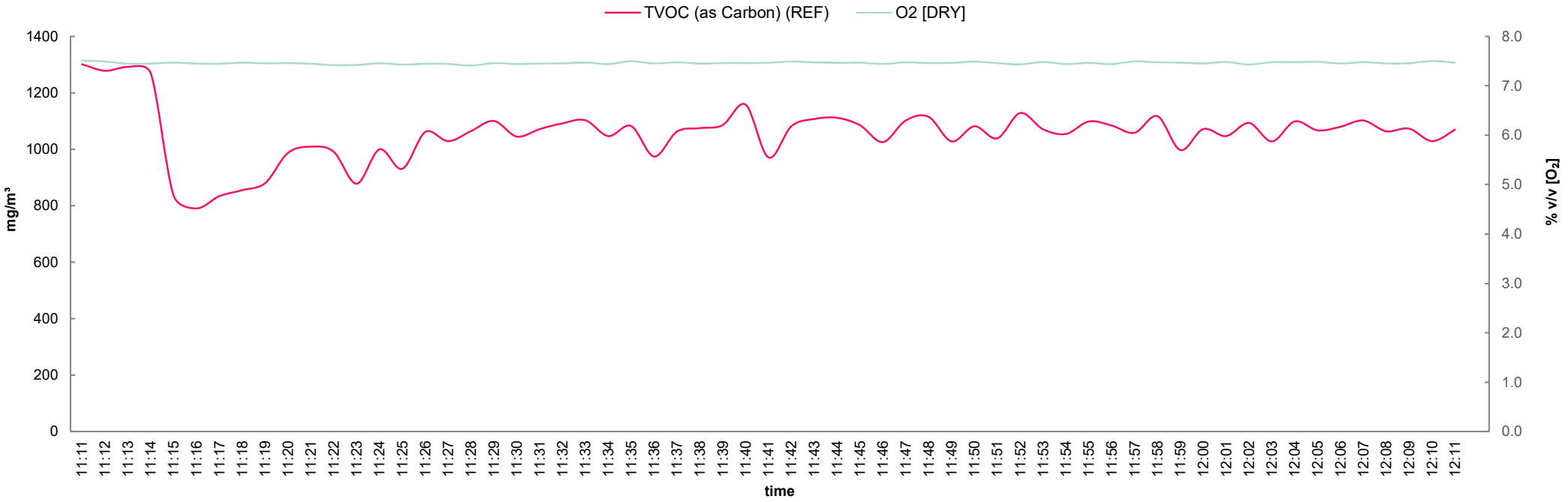
† LFTGN08 maximum value for total uncertainty (40% of measured value) applied to the results

General Information

parameter	details
sampling start date & time	06/02/2024 11:11
sampling end date & time	06/02/2024 12:11
test time | mins	60
testing team	MM | JM
standard | technical procedure	EN 12619 | TP-21b
analyser type	iFID Mobile
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	Filter Element GF | Within Heated Head
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [L] [ppm]	span [L] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	06/02/24 10:39	0.00	8010.80	0.07	7973.00	34	0.5	P	06/02/24 12:23	-0.01	8017.00	0.0	P	0.6	P	±5	11.5

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	MM	No	60	A-CYL-33	8010.82	11/10/2025	1.0	Synthetic Air	10l 8000ppm Propane in Air	8010.82	AUTO	0.03

Part 2: Supporting Information - Appendix 2: Total VOCs (as Carbon) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	1000
measured concentration (REF)	mg/m³	1055

MU budget			
parameter	units	min	max
ambient temp	°C	11.0	12.0
voltage	V	90.0	130.0

overall MU for O_2 correction
3.7%

MU factor O_2 correction
0.04

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.05	MCERTS certificate MC050062	U_{rz}	mg/m³	0.53
repeatability at span	rs	% of value	0.08	MCERTS certificate MC050062	U_{rs}	mg/m³	0.84
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	12.2
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.001	day of testing	U_{dz}	mg/m³	0.0061
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0.55	day of testing	U_{ds}	mg/m³	3.4
influence of sample gas flow	f	% of value	-0.42	MCERTS certificate MC050062	U_f	mg/m³	-2.6
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC050062	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-2.4	MCERTS certificate MC050062	U_{tz}	mg/m³	-0.24
influence of ambient temperature span point (/ 35k)	ts	% of value	-2.7	MCERTS certificate MC050062	U_{ts}	mg/m³	-0.27
influence of supply voltage (/ 60V)	v	% of value	-0.46	MCERTS certificate MC050062	U_v	mg/m³	-1.9
cross sensitivity at zero	iz	% of value	3.8	MCERTS certificate MC050062	U_{iz}	mg/m³	23.1
cross sensitivity at span	is	% of value	3.9	MCERTS certificate MC050062	U_{is}	mg/m³	23.8
maximum leak	L	% of value	0.47	day of testing	U_L	mg/m³	2.9
uncertainty associated with calibration gas	adj	% of value	1	span gas calibration certificate	U_{adj}	mg/m³	5.3
	combined MU with O_2 correction					mg/m³	41.3
	expanded MU with O_2 correction (k = 1.96)					mg/m³	80.9
	expanded MU 95% CI with O_2 correction (k = 1.96) as percentage of measured value					%	7.7
	expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission					%	8.3
	expanded MU with O_2 correction (k = 1.96) as percentage of ELV [allowable 15.4%]					%	8.1

result
N/A [>ELV]

† This MU budget calculates the measurement uncertainty (MU) based upon the equipment used and the Standard followed. The reported MU is that specified in Table 4.7 (in Section 4.6.1) of EA LFTGN08 v2 2010, and is the "Assumed maximum value for total uncertainty to be applied when assessing compliance of emissions from [landfill gas] engines" which is 40% for Total VOCs.

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Results

reference conditions are: STP, dry, 5% O_2

parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Oxides of Nitrogen (as NO_2) †	mg/m³	476 ± 143	g/hr	390 ± 117

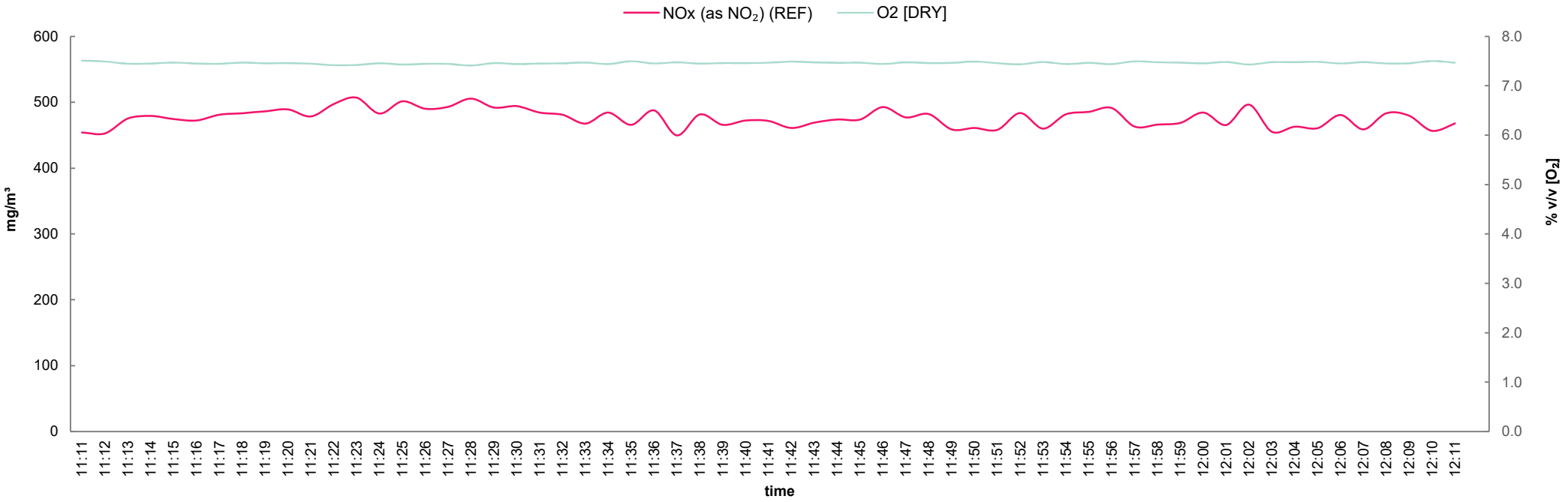
† LFTGN08 maximum value for total uncertainty (30% of measured value) applied to the results

General Information

parameter	details
sampling start date & time	06/02/2024 11:11
sampling end date & time	06/02/2024 12:11
test time | mins	60
testing team	MM | JM
standard | technical procedure	EN 14792 | TP-22a
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	Filter Element GF | Within Heated Head
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	06/02/24 10:49	0.00	431.90	0.00	440.00	34	0.0	P	06/02/24 12:19	3.00	442.00	0.5	P	1.9	P	±5	12.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	MM	No	60	A-CYL-117	431.92	07/09/2026	1.3	Nitrogen 5.2	10l 400ppm NO | 1600ppm CO | 16% CO2 in Nitrogen	431.92	500	0.09

Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO_2) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	500
measured concentration (REF)	mg/m³	476

MU budget			
parameter	units	min	max
ambient temp	°C	11.0	13.0
voltage	V	90.0	130.0

overall MU for O_2 correction
3.7%

MU factor O_2 correction
0.04

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0	MCERTS certificate MC130223	U_{rz}	mg/m³	0
repeatability at span	rs	% of value	0.1	MCERTS certificate MC130223	U_{rs}	mg/m³	0.48
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	5.5
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.45	day of testing	U_{dz}	mg/m³	1.2
maximum short term span drift (ABS) [after drift correction]	ds	% of value	1.9	day of testing	U_{ds}	mg/m³	5.2
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.28
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	0	MCERTS certificate MC130223	U_{tz}	mg/m³	0
influence of ambient temperature span point (/ 35k)	ts	% of value	1.8	MCERTS certificate MC130223	U_{ts}	mg/m³	0.16
influence of supply voltage (/ 60V)	v	% of value	0.4	MCERTS certificate MC130223	U_v	mg/m³	0.73
cross sensitivity at zero	iz	% of value	0.63	MCERTS certificate MC130223	U_{iz}	mg/m³	1.7
cross sensitivity at span	is	% of value	-0.52	MCERTS certificate MC130223	U_{is}	mg/m³	-1.4
maximum leak	L	% of value	0	day of testing	U_L	mg/m³	0
uncertainty associated with calibration gas	adj	% of value	1.3	span gas calibration certificate	U_{adj}	mg/m³	3.1
				combined MU with O_2 correction		mg/m³	12.4
				expanded MU with O_2 correction (k = 1.96)		mg/m³	24.4
				expanded MU 95% CI with O_2 correction (k = 1.96) as percentage of measured value		%	5.1
				expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission		%	6
				expanded MU with O_2 correction (k = 1.96) as percentage of ELV [allowable 10.7%]		%	4.9

result
Pass

† This MU budget calculates the measurement uncertainty (MU) based upon the equipment used and the Standard followed. The reported MU is that specified in Table 4.7 (in Section 4.6.1) of EA LFTGN08 v2 2010, and is the "Assumed maximum value for total uncertainty to be applied when assessing compliance of emissions from [landfill gas] engines" which is 30% for Oxides of Nitrogen (as NO_2).

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Results

reference conditions are: STP, dry, 5% O_2

parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Carbon Monoxide †	mg/m³	890 ± 178	g/hr	729 ± 146

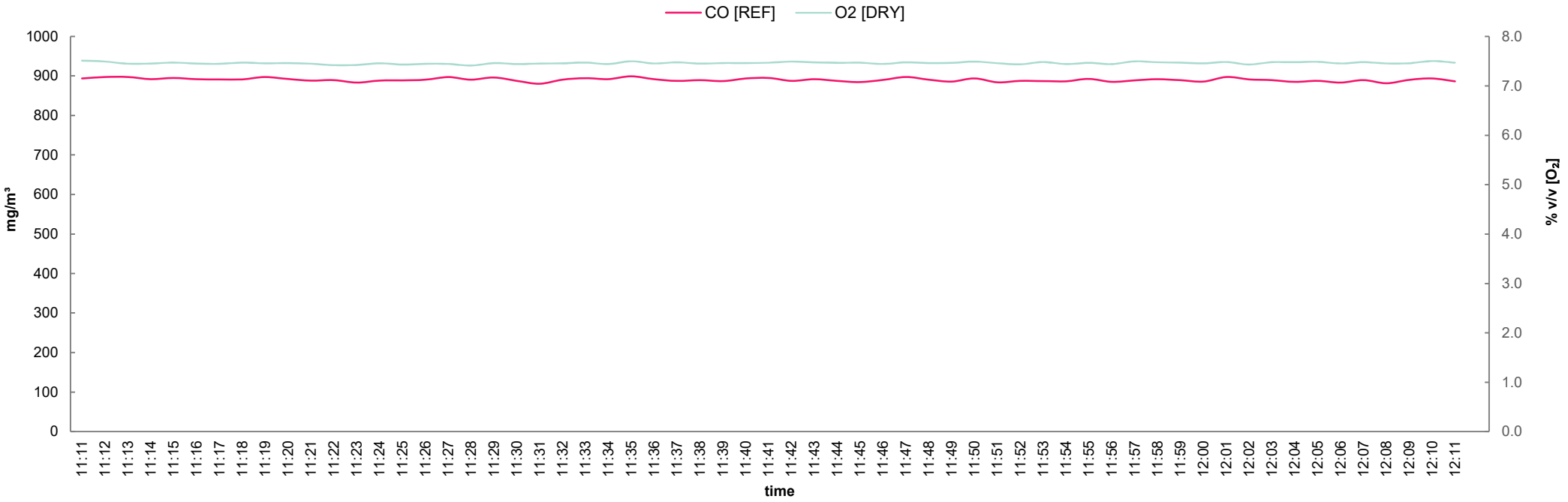
† LFTGN08 maximum value for total uncertainty (20% of measured value) applied to the results

General Information

parameter	details
sampling start date & time	06/02/2024 11:11
sampling end date & time	06/02/2024 12:11
test time | mins	60
testing team	MM | JM
standard | technical procedure	EN 15058 | TP-22b
analyser type	Horiba PG-350E
heated head & line temperature	180°C

parameter	details
probe material	Titanium
filter size, material & location	Filter Element GF | Within Heated Head
number sampling lines available	1
number sampling lines used	1
number sampling points ideal per line	1
number sampling points used per line	1
sampling point IDs	A1

Plot of Emissions Over Time



Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [ppm]	span [A] [ppm]	zero [L] [ppm]	span [L] [ppm]	T_{90} [s]	leak [%]		date & time	zero [A] [ppm]	span [A] [ppm]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	06/02/24 10:49	0.00	1707.80	0.00	1699.00	40	0.5	P	06/02/24 12:19	0.00	1693.00	-0.2	P	-0.7	P	±5	12.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [ppm]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [ppm]	range [ppm]	LOD [ppm]
1	MM	No	60	A-CYL-117	1707.83	07/09/2026	1.1	Nitrogen 5.2	10l 400ppm NO | 1600ppm CO | 16% CO2 in Nitrogen	1707.83	2000	0.32

Part 2: Supporting Information - Appendix 2: Carbon Monoxide | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	1400
measured concentration (REF)	mg/m³	890

MU budget			
parameter	units	min	max
ambient temp	°C	11.0	13.0
voltage	V	90.0	130.0

overall MU for O_2 correction
3.7%

MU factor O_2 correction
0.04

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.1	MCERTS certificate MC130223	U_{rz}	mg/m³	0.89
repeatability at span	rs	% of value	0.2	MCERTS certificate MC130223	U_{rs}	mg/m³	1.8
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	10.3
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.18	day of testing	U_{dz}	mg/m³	0.9
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0.69	day of testing	U_{ds}	mg/m³	3.6
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U_f	mg/m³	0.51
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_p	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.2	MCERTS certificate MC130223	U_{tz}	mg/m³	-0.034
influence of ambient temperature span point (/ 35k)	ts	% of value	2	MCERTS certificate MC130223	U_{ts}	mg/m³	0.34
influence of supply voltage (/ 60V)	v	% of value	0.5	MCERTS certificate MC130223	U_v	mg/m³	1.7
cross sensitivity at zero	iz	% of value	-0.48	MCERTS certificate MC130223	U_{iz}	mg/m³	-2.5
cross sensitivity at span	is	% of value	-0.87	MCERTS certificate MC130223	U_{is}	mg/m³	-4.5
maximum leak	L	% of value	0.52	day of testing	U_L	mg/m³	2.6
uncertainty associated with calibration gas	adj	% of value	1.1	span gas calibration certificate	U_{adj}	mg/m³	4.9
				combined MU with O_2 correction		mg/m³	21.5
				expanded MU with O_2 correction (k = 1.96)		mg/m³	42.2
				expanded MU 95% CI with O_2 correction (k = 1.96) as percentage of measured value		%	4.7
				expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission		%	5.7
				expanded MU with O_2 correction (k = 1.96) as percentage of ELV [allowable 7%]		%	3

result
Pass

† This MU budget calculates the measurement uncertainty (MU) based upon the equipment used and the Standard followed. The reported MU is that specified in Table 4.7 (in Section 4.6.1) of EA LFTGN08 v2 2010, and is the "Assumed maximum value for total uncertainty to be applied when assessing compliance of emissions from [landfill gas] engines" which is 20% for Carbon Monoxide.

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Oxygen | QA Concurrent Testing

Results

parameter	units	result ± MU (95% CI)
Oxygen	% v/v	7.5 ± 0.19

General Information

parameter	details
sampling start date & time	N/A - Concurrent Testing
sampling end date & time	N/A - Concurrent Testing
testing team	MM | JM

parameter	details
standard | technical procedure	EN 14789 | TP-22d
analyser type	Horiba PG-350E

Analyser Calibration Information with QA checks

where [A] = at analyser, [L] = down sampling line

	pre-test calibration events								post-test calibration events			quality assurance					
CAL ID	date & time	zero [A] [% v/v]	span [A] [% v/v]	zero [L] [% v/v]	span [L] [% v/v]	T_{90} [s]	leak [%]		date & time	zero [A] [% v/v]	span [A] [% v/v]	zero drift [%]		span drift [%]		allowable [%]	temp [°C]
1	06/02/24 10:49	0.00	21.43	0.05	21.36	38	0.3	P	06/02/24 12:19	0.04	21.40	0.0	P	-0.1	P	±5	12.0

Analyser Calibration Extended Information

CAL ID	performed by	drift corr. applied	log period [s]	CYL ID	CYL conc. [% v/v]	CYL expiry	CYL MU [%]	zero gas type	span [CYL] gas type	span target [% v/v]	range [% v/v]	LOD [% v/v]
1	MM	No	60	A-CYL-99	21.43	20/03/2028	1.2	Nitrogen 5.2	10l Synthetic Air	21.43	25	0.03

Part 2: Supporting Information - Appendix 2: Oxygen | QA Concurrent Testing

Measurement Uncertainty (MU) Calculations

general information	units	value
measured concentration (dry)	% v/v	7.5

MU budget			
parameter	units	min	max
ambient temp	°C	11.0	13.0
voltage	V	90.0	130.0

	MU budget input parameters				MU budget		
performance characteristics	symbol	units	value	source	symbol	units	value
repeatability at zero	rz	% of value	0.02	MCERTS certificate MC130223	U_{rz}	% v/v	0.0015
repeatability at span	rs	% of value	0.02	MCERTS certificate MC130223	U_{rs}	% v/v	0.0015
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	% v/v	0.086
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.00026	day of testing	U_{dz}	% v/v	0.000011
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0.14	day of testing	U_{ds}	% v/v	0.006
influence of sample gas flow	f	% of value	-0.01	MCERTS certificate MC130223	U_{f}	% v/v	-0.00043
influence of sample gas pressure	p	% of value	0	MCERTS certificate MC130223	U_{p}	% v/v	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.4	MCERTS certificate MC130223	U_{tz}	% v/v	-0.00057
influence of ambient temperature span point (/ 35k)	ts	% of value	-0.15	MCERTS certificate MC130223	U_{ts}	% v/v	-0.00021
influence of supply voltage (/ 60V)	v	% of value	0.02	MCERTS certificate MC130223	U_{v}	% v/v	0.00057
cross sensitivity at zero	iz	% of value	0	MCERTS certificate MC130223	U_{iz}	% v/v	0
cross sensitivity at span	is	% of value	0	MCERTS certificate MC130223	U_{is}	% v/v	0
maximum leak	L	% of value	0.33	day of testing	U_{L}	% v/v	0.014
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	% v/v	0.045
		combined MU				% v/v	0.098
		expanded MU 95% CI (k = 1.96)				% v/v	0.19
		expanded MU 95% CI (k = 1.96) as percentage of measured value				%	2.6

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Supporting Information

parameter	units	value
barometric pressure	kPa	98.1
average wet density	kg/m³	0.489
average stack static pressure	Pa	-93.0
pitot tube coefficient, C_p	-	0.825

General Information

parameter	details
traverse date	06/02/2024
traverse times | performed by	10:50 - 10:58 | performed by: MM | JM
standard | technical procedure	EN 16911-1 | TR 17078 | TP-04a
device used	S-type Pitot with KIMO MP 210 (2500Pa module)

Limit of Detection (LOD) is 2.5 m/s for this device combination

Quality Assurance

parameter	details
result of pitot stagnation test	Pass
result of pitot leak check (pre)	Pass
result of pitot leak check (post)	Pass
water droplets present	No

NM = Not Measured

	Line A				
	static pressure = -93 Pa				
Pt	**Depth | m**	**ΔP | Pa**	**Temp | °C**	**Vel | m/s**	**Swirl | °**
1	0.08	526.7	393.8	38.1	

Part 2: Supporting Information - Appendix 2: Velocity & Flow Rate Traverse | Run 1

Measurement Uncertainty (MU) Calculations

parameter	units	value
standard uncertainty on the coefficient of the pitot tube	-	0.0015
standard uncertainty associated with the mean local dynamic pressures	Pa	8.3
standard uncertainty associated with the molar mass of the gas	-	0.000049
standard uncertainty associated with the temperature	K	3.4
standard uncertainty associated with the absolute pressure in the duct	Pa	176
standard uncertainty associated with the density of the gas effluent	kg/m³	0.0028
standard uncertainty associated with the local velocities	m/s	0.33
standard uncertainty associated with the mean velocity	m/s	0.32

parameter	units	value
standard uncertainty associated with the mean velocity (95% CI)	m/s	0.63
standard uncertainty associated with the mean velocity (95% CI), relative	%	1.7
standard uncertainty associated with the volume flow rate @ actual (95% CI)	m³/hr	133
standard uncertainty associated with the volume flow rate @ actual (95% CI), relative	%	4.8
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI)	m³/hr	39.4
standard uncertainty associated with the volume flow rate @ ref 1 (95% CI), relative	%	4.8

method and sampling deviations
Sampling was performed in full compliance with the Standard, technical procedure and regulatory requirements.