

Stack Emissions Monitoring Report

Job Reference: JOB-1466

Commissioned by BAE Systems (Operations) Ltd

Operator Name

BAE Systems (Operations) Ltd | Warton

Operator Address

Warton Aerodrome, Warton Preston, Lancashire PR4 1AX EPR Permit

Release Point

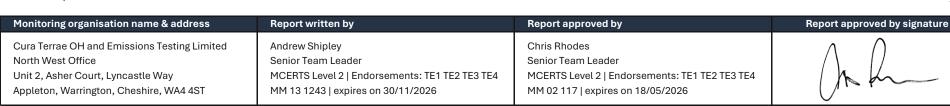
Boiler 1

Dates of the Monitoring Campaign

03/04/2025

Report Date | Version Number

07/04/2025 | Version 1





Cura Terrae Primary Contact

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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 Cura Terrae'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
Oxides of Nitrogen (as NO ₂)	178	6.9	200	mg/m³	939	51.5		g/hr	STP, dry, 3% O ₂	MCERTS
Carbon Monoxide	4.3	0.18		mg/m³	22.5	1.3		g/hr	STP, dry, 3% O ₂	MCERTS
Oxygen	2.7	0.082		% v/v					dry	MCERTS
Stack Gas Temperature	182			°C					actual	MCERTS
Stack Gas Velocity	9.5	0.14		m/s					actual	MCERTS
Stack Gas Flow Rate (ACTUAL)	9011	428		m³/hr					actual	MCERTS
Stack Gas Flow Rate (REF)	5263	250		m³/hr					STP, dry, 3% O ₂	MCERTS

The stack 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.





Part 1: Executive Summary - Monitoring Results Further Details

Monitoring Results - Further Details

		EXPRESS	ED AS A CONCE	NTRATION		EXPRES	SED AS A MASS E	MISSION					
test parameter	run	result	uncertainty in result +/-	limit (ELV)	units	result	uncertainty in result +/-	limit (ELV)	units	sampling date times	run time (mins)	H ₂ O (% v/v)	reference conditions
Oxides of Nitrogen (as NO ₂)	R1	178	6.9	200	mg/m³	939	51.5		g/hr	03/04/2025 10:46 - 11:16	30		STP, dry, 3% O ₂
Carbon Monoxide	R1	4.3	0.18		mg/m³	22.5	1.3		g/hr	03/04/2025 10:46 - 11:16	30		STP, dry, 3% O ₂
Oxygen		2.7	0.082		% v/v					N/A - Concurrent Testing			dry
Velocity & Flow Rate Traverse	R1	9.5	0.14		m/s	9011	428		m³/hr	03/04/2025 10:40 - 10:45			actual
Stack Gas Temperature		182			°C								actual
Stack Gas Velocity		9.5	0.14		m/s								actual
Stack Gas Flow Rate (ACTUAL)		9011	428		m³/hr								actual
Stack Gas Flow Rate (REF)		5263	250		m³/hr								STP, dry, 3% O ₂

The stack 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.





Part 1: Executive Summary - Monitoring and Analytical Methods

Monitoring and Analytical Methods

where analysis not required			MONITORIN	IG			
test parameter	laboratory	accreditation number	technical procedure	reference method	monitoring status	measurement technique & equipment	accreditation status
Oxides of Nitrogen (as NO ₂)	CTA	2522	ETC-SE-10b	EN 14792	MCERTS	Chemiluminescence using Horiba PG-350E	MCERTS
Carbon Monoxide	CTA	2522	ETC-SE-10b	EN 15058	MCERTS	NDIR using Horiba PG-350E	MCERTS
Oxygen	CTA	2522	ETC-SE-10b	EN 14789	MCERTS	Paramagnetism using Horiba PG-350E	MCERTS
Velocity & Flow Rate Traverse	CTA	2522	ETC-SE-24	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.



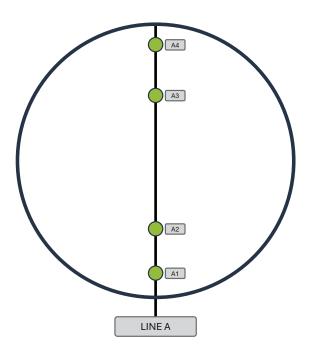


Part 1: Executive Summary - Monitoring Location

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 = 0.58m
area	m²	0.26
orientation	-	Horizontal

parameter	value
primary sample port size	0.5" BSP
primary sample port depth cm	10
primary sample ports number of sampling lines available	1

summary of all sample ports available	
0.5" BSP	

Sampling Location General Information

general information	details
type location access	On the Ground Outside with shelter available in nearby building 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	29.2	> 5 Pa	Yes
lowest traverse velocity	m/s	7.1	-	-
highest traverse velocity	m/s	11.6	-	-
mean traverse velocity	m/s	9.5	-	-
ratio traverse velocities	:1	1.63	<3:1	Yes
angle of swirl compliance	0	< 15	< 15°	Yes
no local negative flow	-	Yes	-	Yes

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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	Combustion
batch or continuous process	On Demand
fuel type	Natural Gas
feedstock	N/A
typical load / throughput of plant	100 % Load
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	
Andrew Shipley	Senior Team Leader	MCERTS Level 2 MM 13 1243 30/11/2026	TE1 TE2 TE3 TE4	
Mike Gormley	Technician	MCERTS Level 1 MM 23 1823 22/01/2029	-	

Analysis Laboratories

	laboratory	ISO 17025 accreditation number	laboratory short name	laboratory phone number
ĺ	Cura Terrae OH and Emissions Testing Limited North West	2522	CTA	0800 970 8945

Test Equipment Used

equipment type	A-EQ ID
Source sampling console	
Low flow sampling MFCs	
ThermoFID / iFID mobile	
Horiba PG-350E multigas analyser	69
Gasmet DX4000 FTIR	
Gasmet PSS	
Protea AtmosFIR	
Protea PIB Pump	
Gasmet syringe calibrator	
M&C PSS5-C conditioning unit	61
Digital thermomanometer	116
Top pan balance kit	

equipment type	A-EQ ID
Pitot	153
Calipers	
Barometer	21
Timer	19
Tape measure	480
Heated head filter	63
Heated tee	
10m heated line	28 30
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	
Stack thermocouple	164
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: Oxides of Nitrogen (as NO₂) | Run 1

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Results

reference conditions are: STP, dry, 3% O₂

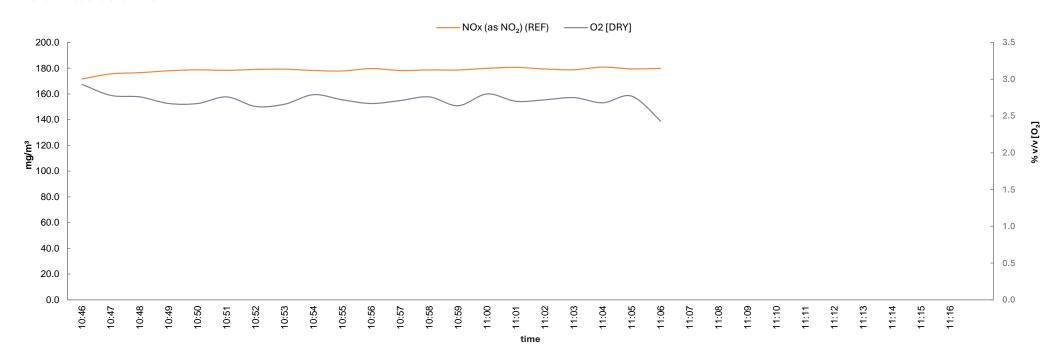
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Oxides of Nitrogen (as NO ₂)	mg/m³	178 ± 6.9	g/hr	939 ± 51.5

General Information

parameter	details
sampling start date & time	03/04/2025 10:46
sampling end date & time	03/04/2025 11:16
test time mins	30
testing team	AS MG
standard technical procedure	EN 14792 ETC-SE-10b
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 NO₂) | Run 1

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Analyser Calibration Information with QA checks

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

	pre-test calibration events								post-tes	t calibration eve	nts			quality	y assı	ırance	
CAL	date & time	zero [A]	span [A]	zero [L]	span [L]	T ₉₀	leak		date & time	zero [A]	span [A]	zero dri	ft	span dri	ft	allowable	temp
ID		[ppm]	[ppm]	[ppm]	[ppm]	[s]	[%]			[ppm]	[ppm]	[%]		[%]		[%]	[°C]
1	03/04/25 10:16	0.00	206.27	0.00	206.27	63	0.0	P	03/04/25 12:05	0.00	212.90	0.0	P	3.2	Р	±5	13.0

Analyser Calibration Extended Information

CAL	performed	drift corr.	log period	CYLID	CYL conc.	CYL expiry	CYL MU	zero gas type	span [CYL] gas type	span target	range	LOD
ID	by	applied	[s]		[ppm]		[%]			[ppm]	[ppm]	[ppm]
1	AS	Yes	60	A-CYL-141	206.27	21/08/2027	1.2	Nitrogen 5.2	5l 200ppm NO 160ppm CO 16% CO2 in Nitrogen	206.27	500	0.09





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Part 2: Supporting Information - Appendix 2: Oxides of Nitrogen (as NO₂) | Run 1

Measurement Uncertainty (MU) Calculations

general information	units	value
emission limit value (ELV) (REF)	mg/m³	200
measured concentration (REF)	mg/m³	178

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

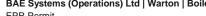
overall MU for O ₂ correction	
2.7%	

MU factor O₂ correction
0.03

			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	0.18
lack of fit	lof	% of value	2	maximum allowable	U_{lof}	mg/m³	2.1
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	mg/m³	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U _{ds}	mg/m³	0
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U _f	mg/m³	0.1
influence of sample gas pressure	р	% 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
influence of supply voltage (/ 60V)	V	% of value	0.4	MCERTS certificate MC130223	U_v	mg/m³	0.27
cross sensitivity at zero	iz	% of value	0.63	MCERTS certificate MC130223	U _{iz}	mg/m³	0.65
cross sensitivity at span	is	% of value	-0.52	MCERTS certificate MC130223	U _{is}	mg/m³	-0.54
maximum leak	L	% of value	0	day of testing	U _L	mg/m³	0
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	mg/m³	1
	-	combined MU	J with O ₂ correc	ction		mg/m³	3.5
		expanded MU	J with O₂ correc	ction (k = 1.96)		mg/m³	6.9
		expanded MU	J 95% CI with C	θ_2 correction (k = 1.96) as percentage of measure	ed value	%	3.9
		expanded MU 95% CI (k = 1.96) as percentage of measured value for mass emission					5.5
		expanded MU with O ₂ correction (k = 1.96) as percentage of ELV [allowable 10.4%]					3.4

method and sampling deviations

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







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

Results

reference conditions are: STP, dry, 3% O₂

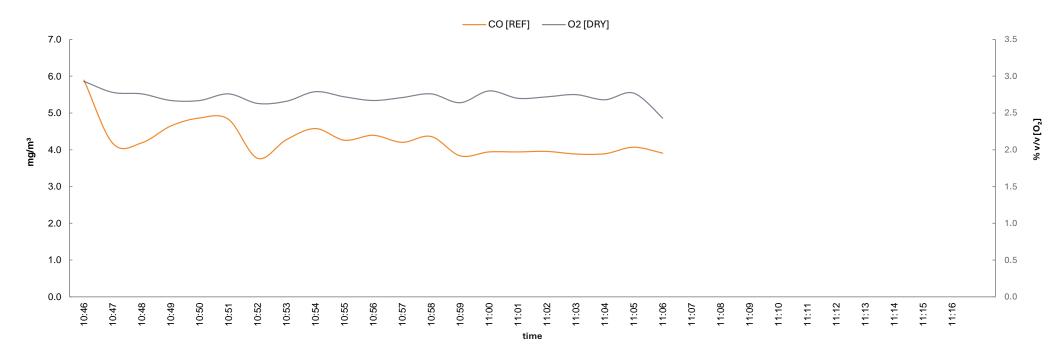
parameter	units	result ± MU (95% CI)	units	result ± MU (95% CI)
Carbon Monoxide	mg/m³	4.3 ± 0.18	g/hr	22.5 ± 1.3

General Information

parameter	details
sampling start date & time	03/04/2025 10:46
sampling end date & time	03/04/2025 11:16
test time mins	30
testing team	AS MG
standard technical procedure	EN 15058 ETC-SE-10b
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

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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	date & time	zero [A]	span [A]	zero [L]	span [L]	T ₉₀	leak		date & time	zero [A]	span [A]	zero drif	ft	span drift	allowable	temp
ID		[ppm]	[ppm]	[ppm]	[ppm]	[s]	[%]			[ppm]	[ppm]	[%]		[%]	[%]	[°C]
1	03/04/25 10:16	0.00	168.98	0.40	166.60	63	1.4	Р	03/04/25 12:05	1.10	164.50	0.7	Р	-3.3 P	±5	13.0

Analyser Calibration Extended Information

CAL	performed	drift corr.	log period	CYLID	CYL conc.	CYL expiry	CYL MU	zero gas type	span [CYL] gas type	span target	range	LOD
ID	by	applied	[s]		[ppm]		[%]			[ppm]	[ppm]	[ppm]
1	AS	Yes	60	A-CYL-141	168.98	21/08/2027	1.0	Nitrogen 5.2	5l 200ppm NO 160ppm CO 16% CO2 in Nitrogen	168.98	500	0.32





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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	N/A
measured concentration (REF)	mg/m³	4.3

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

overall MU for O₂ correction	
2.7%	

MU factor O₂ correction
0.03

			MU budget i	nput 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	0.0043
repeatability at span	rs	% of value	0.2	MCERTS certificate MC130223	U _{rs}	mg/m³	0.0086
lack of fit	lof	% of value	2	maximum allowable	U _{lof}	mg/m³	0.049
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0	day of testing	U_{dz}	mg/m³	0
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0	day of testing	U _{ds}	mg/m³	0
influence of sample gas flow	f	% of value	0.1	MCERTS certificate MC130223	U _f	mg/m³	0.0025
influence of sample gas pressure	р	% of value	0	MCERTS certificate MC130223	Up	mg/m³	0
influence of ambient temperature zero point (/ 35k)	tz	% of value	-0.2	MCERTS certificate MC130223	U _{tz}	mg/m³	0
influence of ambient temperature span point (/ 35k)	ts	% of value	2	MCERTS certificate MC130223	U _{ts}	mg/m³	0
influence of supply voltage (/ 60V)	V	% of value	0.5	MCERTS certificate MC130223	U_{v}	mg/m³	0.0082
cross sensitivity at zero	iz	% of value	-0.48	MCERTS certificate MC130223	U _{iz}	mg/m³	-0.012
cross sensitivity at span	is	% of value	-0.87	MCERTS certificate MC130223	U _{is}	mg/m³	-0.021
maximum leak	L	% of value	1.4	day of testing	U_L	mg/m³	0.035
uncertainty associated with calibration gas	adj	% of value	0.97	span gas calibration certificate	U_{adj}	mg/m³	0.021
		combined MU	J with O₂ correc	tion		mg/m³	0.092
		expanded MU	J with O₂ correc	tion (k = 1.96)		mg/m³	0.18
		expanded MU	J 95% CI with O	correction (k = 1.96) as percentage of measure	d value	%	4.2
		expanded MU	J 95% CI (k = 1.9	96) as percentage of measured value for mass er	mission	%	5.7

method and sampling deviations

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

EPR Permit





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

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Results

parameter	units	result ± MU (95% CI)
Oxygen	% v/v	2.7 ± 0.082

General Information

parameter	details
sampling start date & time	N/A - Concurrent Testing
sampling end date & time	N/A - Concurrent Testing
testing team	AS MG

parameter	details
standard technical procedure	EN 14789 ETC-SE-10b
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	date & time	zero [A]	span [A]	zero [L]	span [L]	T ₉₀	leak		date & time	zero [A]	span [A]	zero dri	ft	span dr	ift	allowable	temp
ID		[% v/v]	[% v/v]	[% v/v]	[% v/v]	[s]	[%]			[% v/v]	[% v/v]	[%]		[%]		[%]	[°C]
1	03/04/25 10:16	0.00	21.14	0.28	20.86	83	1.3	P	03/04/25 12:05	0.11	21.09	0.3	Р	-0.5	Р	±5	13.0

Analyser Calibration Extended Information

CAL	performed	drift corr.	log period	CYLID	CYL conc.	CYL expiry	CYL MU	zero gas type	span [CYL] gas type	span target	range	LOD
ID	by	applied	[s]		[% v/v]		[%]			[% v/v]	[% v/v]	[% v/v]
1	AS	No	60	A-CYL-137	21.14	15/08/2029	1.2	Nitrogen 5.2	5l Synthetic Air	21.14	25	0.03

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

Measurement Uncertainty (MU) Calculations

general information	units	value
measured concentration (dry)	% v/v	2.7

MU budget					
parameter	units	min	max		
ambient temp	°C	13.0	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	0.00054
repeatability at span	rs	% of value	0.02	MCERTS certificate MC130223	U _{rs}	% v/v	0.00054
lack of fit	lof	% of value	2	maximum allowable	U _{lof}	% v/v	0.031
maximum short term zero drift (ABS) [after drift correction]	dz	% of value	0.29	day of testing	U _{dz}	% v/v	0.0045
maximum short term span drift (ABS) [after drift correction]	ds	% of value	0.52	day of testing	U _{ds}	% v/v	0.0082
influence of sample gas flow	f	% of value	-0.01	MCERTS certificate MC130223	U _f	% v/v	-0.00016
influence of sample gas pressure	р	% 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
influence of ambient temperature span point (/ 35k)	ts	% of value	-0.15	MCERTS certificate MC130223	U _{ts}	% v/v	0
influence of supply voltage (/ 60V)	V	% of value	0.02	MCERTS certificate MC130223	U_v	% v/v	0.00021
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	1.3	day of testing	U _L	% v/v	0.021
uncertainty associated with calibration gas	adj	% of value	1.2	span gas calibration certificate	U_{adj}	% v/v	0.016
		combined MU	J			% v/v	0.042
		expanded MU	J 95% CI (k = 1.	96)		% v/v	0.082
		expanded MU	J 95% CI (k = 1.	96) as percentage of measured value		%	3

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

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Supporting Information

parameter	units	value
barometric pressure	kPa	102.3
average wet density	kg/m³	0.786
average stack static pressure	Pa	-87.0
pitot tube coefficient, C _p	-	0.831

ND = N	ot Detected						
NM = N	ot Measured	Line A					
	_	static pressure = -87 Pa					
Pt	Depth m	ΔP Pa	Temp °C	Vel m/s	Swirl °		
1	0.05	41.1	180.5	8.4	< 15		
2	0.15	29.2	182.6	7.1	< 15		
3	0.44	66.4	182.4	10.7	< 15		
4	0.53	77.0	183.5	11.6	< 15		

General Information

parameter	details
traverse date	03/04/2025
traverse times performed by	10:40 - 10:45 performed by: AS MG
standard technical procedure	EN 16911-1 TR 17078 ETC-SE-24
device used	S-type Pitot with KIMO MP 210 (500Pa module)

Limit of Detection (LOD) is 1 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

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

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Measurement Uncertainty (MU) Calculations

ND = Not Detected

parameter	units	value
standard uncertainty on the coefficient of the pitot tube	-	0.0015
standard uncertainty associated with the mean local dynamic pressures	Pa	1.3
standard uncertainty associated with the molar mass of the gas	-	0.000036
standard uncertainty associated with the temperature	K	2.3
standard uncertainty associated with the absolute pressure in the duct	Pa	176
standard uncertainty associated with the density of the gas effluent	kg/m³	0.0043
standard uncertainty associated with the local velocities	m/s	0.13
standard uncertainty associated with the mean velocity	m/s	0.07

ND = Not Detected

parameter	units	value
standard uncertainty associated with the mean velocity (95% CI)	m/s	0.14
standard uncertainty associated with the mean velocity (95% CI), relative	%	1.4
standard uncertainty associated with the volume flow rate @ actual (95% CI)	m³/hr	428
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	250
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.