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Visit No: 4  
Year: 2023  
Office: Trim

EPA Licence No.: W0004-04  
Licence Holder: SDCC AR07  
Facility Location: Arthurstown Landfill  
Rev.No: 1



<b>Report Title</b>	Air Emissions Compliance Monitoring Emissions Report
<b>Company address</b>	Air Scientific Ltd., 32 DeGranville Court, Dublin road, Trim, Co. Meath
<b>Stack Emissions Testing Report Commissioned by</b>	South Dublin County Council
<b>Facility Name</b>	Arthurstown Landfill
<b>Contact Person</b>	Mr. John Smith
<b>EPA Licence Number</b>	W0004-04
<b>Licence Holder</b>	SDCC AR07
<b>Stack Reference Number</b>	AR07
<b>Dates of the Monitoring Campaign</b>	07/12/2023
<b>Job Reference Number</b>	ARLATL1071223 / 20232015
<b>Report Written By</b>	Amanda Sheridan
<b>Report Approved by</b>	Dr. Brian Sheridan
<b>Stack Testing Team</b>	Dr. John Casey
<b>Report Date</b>	26/01/2024
<b>Report Type</b>	Test Report Compliance Monitoring
<b>Version</b>	1
<b>Signature of Approver</b>	 Brian Sheridan Technical Manager

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## 1. Executive Summary

### I. Monitoring Objectives

#### Overall Aim of the monitoring Campaign

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values as specified in the site licence.

#### Special Requirements

There were no special requirements.

#### Target Parameters

Oxides of Nitrogen (NOx) as NO <sub>2</sub>
Stack Gas Temperature
Volume (m <sup>3</sup> .h <sup>-1</sup> )
Oxygen (O <sub>2</sub> )
Carbon Dioxide (CO <sub>2</sub> )

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### Emission Limit Values

Emission Limit Values / Mass Emissions Limit Values	mg.m <sup>-3</sup>	kg.h <sup>-1</sup>
NOx as NO <sub>2</sub>	500	-
Stack Gas Temperature	-	-
Volume (m <sup>3</sup> .h <sup>-1</sup> )	3,000	-

### Reference Conditions

Reference Condition	Value
Oxygen Reference %	5
Temperature K	273.15
Total Pressure kPa	101.3
Moisture Correction	Yes

**Executive Summary**

**Overall Results**

Parameter	Concentration	Result	MU +/-	Blanks	Limit	Compliant	Mass Emission	Result	Run 1	Dates	Time on	Time off	O2 Ref. (%)	Accreditation	LOD
	Units						Units		Limit						
NOx EN14792:2017	mg.m <sup>-3</sup>	349.03	54.4	-	500	N/A	kg.h <sup>-1</sup>	-	-	07/12/2023	09:45:00	10:17:00	5	Yes	<1.8
Oxygen (%) EN14789:2017	% v/v	6.77	0.27	-	-	N/A	-	-	-	07/12/2023	09:45:00	10:17:00	5	Yes	-
CO <sub>2</sub> ISO12039:2001	% v/v	11.66	0.35	-	-	N/A	-	-	-	07/12/2023	09:45:00	10:17:00	5	Yes	-
Stack Gas Temperature	K	747.15	-	-	-	N/A	-	-	-	07/12/2023	-	00:00:00	5	Yes	-
Stack Gas Velocity EN16911:2013	m.s <sup>-1</sup>	-	-	-	-	N/A	-	-	-	07/12/2023	-	00:00:00	5	N/A	-
Volumetric Flow Rate	m <sup>3</sup> .h <sup>-1</sup>	-	-	-	3,000	N/A	-	-	-	-	-	-	5	N/A	-
Volumetric Flow Rate (Ref)	m <sup>3</sup> .h <sup>-1</sup>	-	-	-	3,000	N/A	-	-	-	-	-	-	5	N/A	-

**Accreditation details**

Air Scientific Limited	INAB319T
External Analytical Laboratory	-
Other	-



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**Executive Summary**

**Monitoring Dates & Times**

Parameter	Run	Location ID	Sampling Dates	Sampling Time On	Sampling Time Off	Duration (mins.)
Oxides of Nitrogen (NOx) as NO <sub>2</sub>	Run 1	AR07	07/12/2023	09:45:00	10:17:00	00:32:00
	Run 2	-	-	-	-	-
	Run 3	-	-	-	-	-
Oxygen (%)	Run 1	AR07	07/12/2023	09:45:00	10:17:00	00:32:00
	Run 2	-	-	-	-	-
	Run 3	-	-	-	-	-
Stack Gas Temperature		AR07	07/12/2023	-	00:00:00	-
Stack Gas Velocity		AR07	07/12/2023	-	00:00:00	-
Carbon Dioxide (%)	Run 1	AR07	07/12/2023	09:45:00	10:17:00	00:32:00
	Run 2	-	-	-	-	-
	Run 3	-	-	-	-	-

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### Monitoring, Equipment & Analytical Methods

Parameter	Monitoring				Analysis	
	Standard	Technical Procedure	Accredited Testing	Testing Lab	Analytical Technique	INAB Analysis
Oxides of Nitrogen (NOx)	EN14792:2017	SOP 2002	Yes	AirSci	Chemiluminescence	-
Oxygen (%)	EN14789:2017	SOP 2008	Yes	AirSci	Paramagnetic	-
Carbon Dioxide	ISO12039:2001	SOP 2045	Yes	AirSci	NDIR	-
Stack Gas Temperature	EN16911:2013	SOP 2005	Yes	AirSci	Thermocouple	-
Stack Gas Velocity	EN16911:2013	SOP 2005	N/A	AirSci	Pitot tubes	-

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### List of Equipment

ID	Item of Equipment	Manufacturer	Serial No.
ASLTM12EQ512	Horiba PG2500 Portable Gas Analyzer	Horiba	41343020031
ASLTM13EQ509	10 metre industrial heated sample line	Neptech	13B088
ASLTM14EQ511	Buhler Sample Gas Cooler	Buhler Technologies	100094941
ASLTM20EQ505	K type thermocouple	TC Direct	109710/1C
ASLTM19EQ509	Kimo Manometer	Kimo	N/A



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### Sampling Deviations

Parameter	Deviation
Standard ID	-
Standard ID	-
Standard ID	-
Standard ID	-

### Reference Documents

Risk Assessment (RA)	SOP1011
Site Review (SR)	SOP1015
Site Specific Protocol (SSP)	SOP1015

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**Suitability of sampling location**

General Information	Value
Permanent/Temporary	Permanent
Inside/ Outside	Outside

Platform Details		
Irish EPA Technical Guidance Note AG1 / BS EN 15259 Platform Requirements	Value	Comment
Sufficient Working area to manipulate probe and measuring instruments	Yes	-
Platform has 2 handrails (approx. 0.5m & 1.0 m high)	Yes	-
Platform has vertical base boards (approx. 0.25 m high)	Yes	-
Platform has chains / self closing gates at top of ladders	Yes	-
There are no obstructions present which hamper insertion of sampling equipment	No	-
Safe Access Available	Yes	-
Easy Access Available	Yes	-

Sampling Location / Platform Improvement Recommendations
None

BSEN 15259 Homogeneity Test Requirements
1: There is no requirement to perform a BSEN15259 Homogeneity Test on this stack

**Process details**

Parameter	
Process status	Normal
Capacity (per/hour) (if applicable)	990KW
Continuous or Batch Process	Continuous
Feedstock	Process Air
Abatement System	No
Abatement Systems Running Status	Normal
Fuel	LFG
Plume Appearance	No
Other information	None

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The process information below has been supplied by the client and as such ASL assume no responsibility or liability for any errors or omissions in the content of this Process Detail Form. The information provided in this form is provided on an 'as is' basis with no guarantees of completeness, accuracy or reliability.

Licensee			
Reg. number	W0004-04	Contractor	Air Scientific Ltd.
Site Contact	Mr. John Smith	Contractor's contact	Amanda Sheridan
Role		Role	-
Signature		Signature	-

Emissions point		-				
Type of process		Load of process	Abatement system		List of Solvents used per process	
Rotogravure Printing	-	as normal	Bag filter	-	-	-
Cement Plant	-		Electrostatic precipitator	-	-	-
Electrical generation	-		Cyclone	-	-	-
Steam boiler	-		Thermal oxidiser	-	-	-
Other	Yes		Active carbon bed	-	-	-
			NSCR	-	-	-
			SCR	-	-	-
			Dry scrubber	-	-	-
			Wet scrubber	-	-	-
			Lime injection	-	-	-
			Biofilter	-	-	-
			None	-	-	-
			Other:	-	-	-

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**Executive Summary**

**Stack diagram**



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**2. APPENDICES**

**II. Appendix I - Monitoring Personnel & Equipment**

**Stack Emissions Monitoring Personnel**

<b>Team Leader</b>	<b>Name</b>	Dr. John Casey
	<b>Qualifications</b>	PhD. (Eng.), MSc. (Agr.), B. Agr. Sc.
	<b>System approval</b>	Air Scientific Limited Approved
		-
<b>Team Leader</b>	<b>Name</b>	-
	<b>Qualifications</b>	-
	<b>System approval</b>	-
		-

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**III. Appendix II - Stack Details & flow characteristics**

**Preliminary stack survey calculations**

<b>General Stack Details</b>		
<b>Stack details</b>	<b>Units</b>	<b>Value</b>
Date of survey		07/12/2023
Time of survey		-
Type		Circular
Stack Diameter / Depth, D	m	-
Stack Width, W	m	-
Average Stack Gas Temp., Ta	C	474
Average Static Pressure, P static	kPa	0.1
Average Barometric Pressure, Pb	kPa	101.9
Type of Pitot		-
Are Water Droplets Present?		-
Average Pitot Tube Calibration Coeff, Cp		-
Negative flow		-
Highly homogeneous flow stream/gas velocity		Yes

Sample Port Size	mm	-
Initial Pitot Leak Check	Pa	-
Final Pitot Leak Check	Pa	-
Orientation of Duct		Vertical
Pitot Tube Cp		0.998
Number of Lines Available		1
Number of Lines Used		1

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Sampling Line A						
Point	Distance to duct (m)	Pa	Temp °C	Velocity (m/s)	Oxygen (%)	Angle of Swirl
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
Average	-	-	-	-	-	-
Min	-	-	-	-	-	-
Max	-	-	-	-	-	-

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Sampling Line B						
Point	Distance to duct (m)	Pa	Temp °C	Velocity (m/s)	Oxygen (%)	Angle of Swirl
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	-	-	-	-
10	-	-	-	-	-	-
Average	-	-	-	-	-	-
Min	-	-	-	-	-	-
Max	-	-	-	-	-	-



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<b>Component</b>	<b>Conc. ppm</b>	<b>Conc. Dry % v/v</b>	<b>Conc. Wet % v/v</b>	<b>Molar Mass</b>
Carbon Dioxide CO <sub>2</sub>	-	11.6	-	44.01
Oxygen O <sub>2</sub>	-	6.77	-	32
Nitrogen N <sub>2</sub>	-	81.63	-	28.1
Moisture (H <sub>2</sub> O)	-	-	-	18.02
<b>Reference Conditions</b>				
<b>Reference Conditions</b>	<b>Units</b>	<b>Numbers</b>		
Temperature	°C	273.15		
Total Pressure	kPa	101.3		
Moisture	%	-		
Oxygen (Dry)	%	5		

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Stack Gas Composition & Molecular Weights								
Component	Molar Mass M	Density Kg/m <sup>3</sup> p	Conc. Dry % v/v	Dry Volume Fraction r	Dry Conc. kg/m <sup>3</sup> pi	Conc. wet % v/v	Wet Volume Fraction r	Wet Conc. kg/m <sup>3</sup> pi
Carbon Dioxide CO <sub>2</sub>	44.01	1.96	11.6	0.116	0.23	11.6	0.12	0.23
Oxygen O <sub>2</sub>	32	1.43	6.77	0.0677	0.1	6.77	0.07	0.1
Nitrogen N <sub>2</sub>	28.1	1.25	81.63	0.8163	1.02	81.63	0.82	1.02
Moisture (H <sub>2</sub> O)	18.02	0.8	-	-	-	0	0	0
where $p = M/22.41$								
$\pi = r \times p$								

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Calculation of Stack Gas Densities		
Determinant	Units	Result
Dry Density (STP), P STD	kg.m <sup>-3</sup>	1.348
Wet Density (STP), P STW	kg.m <sup>-3</sup>	1.348
Dry Density (Actual), P Actual	kg.m <sup>-3</sup>	0.496
Average wet Density (Actual), P Actual W	kg.m <sup>-3</sup>	0.496
<b>Where</b>		
P STD = sum of component concentrations, kg/m <sup>3</sup> (excluding water vapour)		
$P_{STW} = (P_{STD} + p_{i \text{ of } H_2O}) / (1 + (p_{i \text{ of } H_2O} / 0.8036))$		
$P_{actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times (P_a / T_a)$		
$P_{actual \ W} \text{ (at each sampling point)} = P_{STW} \times (T_s / P_s) \times (P_a / T_a)$		

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Sampling Plane Validation Criteria	Value	Units	Requirement	Compliance	Method
Lowest Differential Pressure	-	Pa	>5 Pa	N/A	EN16911:2013
Lowest Gas Velocity	-	m/s	-	N/A	-
Highest Gas Velocity	-	m/s	-	N/A	-
Ratio of Above	-	:1	<3:1	N/A	EN16911:2013
Mean Velocity	-	m/s	-	N/A	-
Angle of flow with regard to duct axis	-	degrees	< 15	N/A	EN16911:2013
No local negative flow	-	-	-	N/A	-
Homogeneous flow stream/gas velocity	-	-	-	N/A	-

Calculation of stack Gas Velocity, V	
Velocity at Traverse Point, $V = K_{cp} * \text{Sqrt}((2 * DP) / \text{Density})$	-
<b>Where</b>	
$K_{pt}$ = Pitot tube calibration coefficient	-
Compressibility correction factor, assumed at a constant 0.998	0.998

Gas Volumetric Flowrate	Units	Result
Gas Volumetric Flow Rate (Actual)	$m^3.h^{-1}$	-
Gas Volumetric Flow Rate (STP, Wet)	$m^3.h^{-1}$	-
Gas Volumetric Flowrate (STP, Dry)	$m^3.h^{-1}$	-
Gas Volumetric Flowrate REF to Oxygen	$m^3.h^{-1}$	-

Standard uncertainty of velocity (m/s)	-	Expanded uncertainty of velocity (m/s)	-	Volume flow rate expanded uncertainty ( $m^3/hr$ )	-
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### Oxides of Nitrogen Quality Assurance

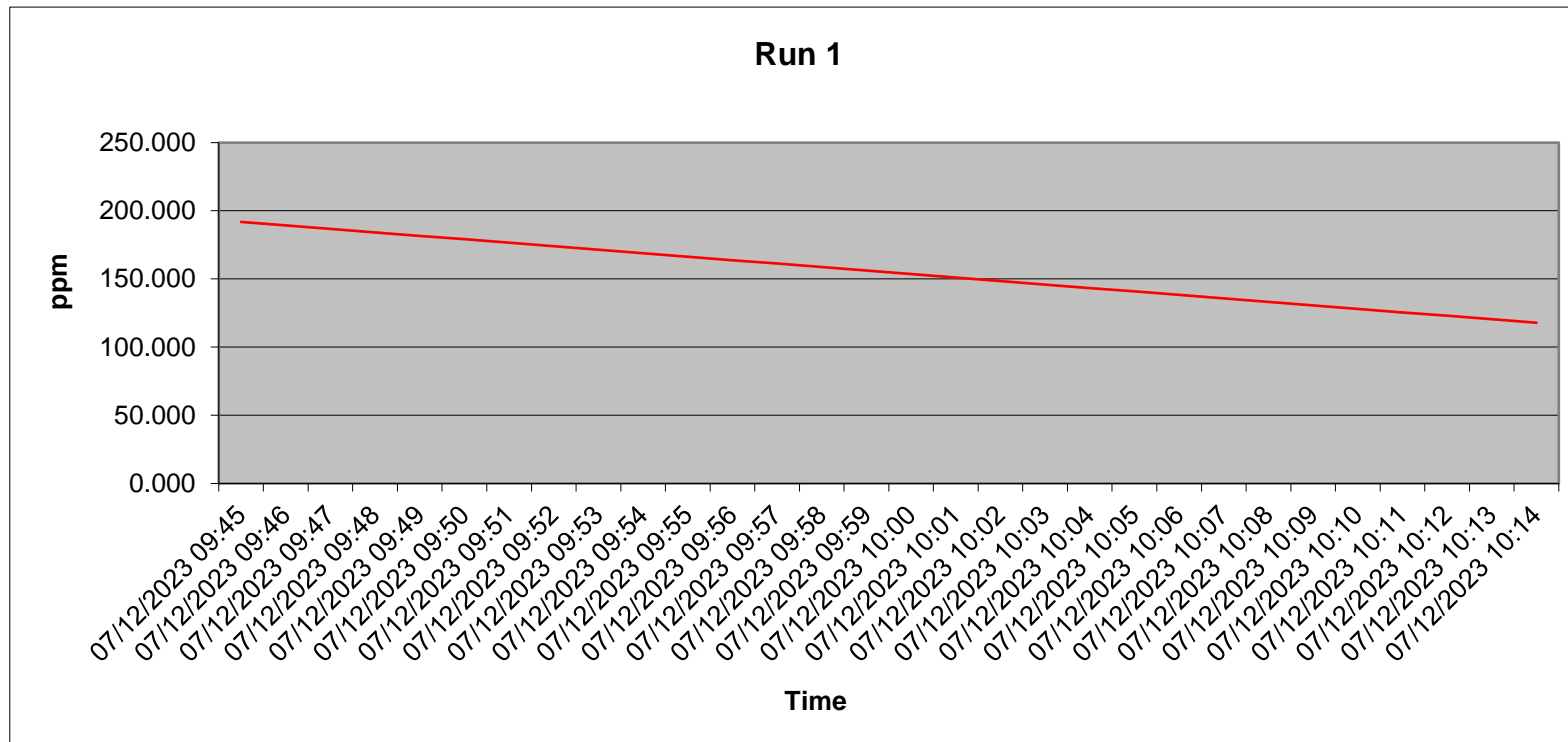
Sampling Details				
Stack ID	AR07			
<b>Parameter</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Sampling Times	-	09:44	-	-
Sampling Dates	-	07/12/2023	-	-
Instrument Range	ppm	250	-	-
Span Gas Value	ppm	161.5	-	-
Acceptable Gas Range	-	Yes	-	-
<b>Quality Assurance</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Conditioning Unit Temperature	°C	2	-	-
Average Temperature	< °C	2	-	-
Allowable Temperature	-	4	-	-
Temperature Acceptable	-	Y	-	-
Pump flow rate	l/min	0.5	-	-
<b>Zero Drift</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Zero Down Sampling Line (Pre)	ppm	0.1	-	-
Zero Down Sampling Line (Post)	ppm	0	-	-
Zero Drift	ppm	0.1	-	-
Allowable Zero Drift (5%)	ppm	8.08	-	-
Zero Drift Acceptable	Y <2%/Y 2-5%/N>5%	Y <2%	-	-
Zero Drift	%	0.06	-	-
<b>Span Drift</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Span Down Sampling Line (Pre)	ppm	161.5	-	-
Span Down Sampling Line (Post)	ppm	160.8	-	-
Span Drift	ppm	0.7	-	-
Allowable Span Drift (5%)	ppm	8.08	-	-
Span Drift Acceptable (Y/N)	Y <2%/Y 2-5%/N>5%	Y <2%	-	-
Span Drift	%	0.43	-	-
<b>Leak Check</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Span Gas Conc.	ppm	161.5	-	-
Recorded Conc. down Line	ppm	161.5	-	-
Leak check acceptable (< 2%)	(Y/N)	Y <2%	-	-
<b>Test Conditions</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Run Ambient Temperature Range	°C	8	-	-

**Oxides of Nitrogen Results & Sampling Details**

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg.m <sup>-3</sup>	310.11	-	-	-
Uncertainty	mg.m <sup>-3</sup>	54.4	-	-	-
Mass Emission	kg.h <sup>-1</sup>	#DIV/0!	-	-	-

General Sampling Information	
Parameter	Value
Standard	EN14792
Technical Procedure	SOP2002
Probe material	SS
Filtration Type/Size	PTFE
Heated Head Filter Used	Yes
Heated Line Temperature	180
Date & Result of last converter check	95.5 07/10/2023
Span Gas Reference Number	ASLTM22ING503
Span Gas Expiry Date	23-Dec
Span Gas Start Pressure (bar)	40
Gas Cylinder Concentration (ppm)	161.5
Span Gas Uncertainty (%)	<2
Zero Gas Type	N
Number of Sampling Lines Used	1
Number of Sampling Points Used	1
Sample Point I.D's	AR07
Reference Conditions	
Temperature (K)	273.15
Pressure (kPa)	101.3
Gas (Wet or Dry)	Dry
Oxygen	5

### Oxides of Nitrogen Trend





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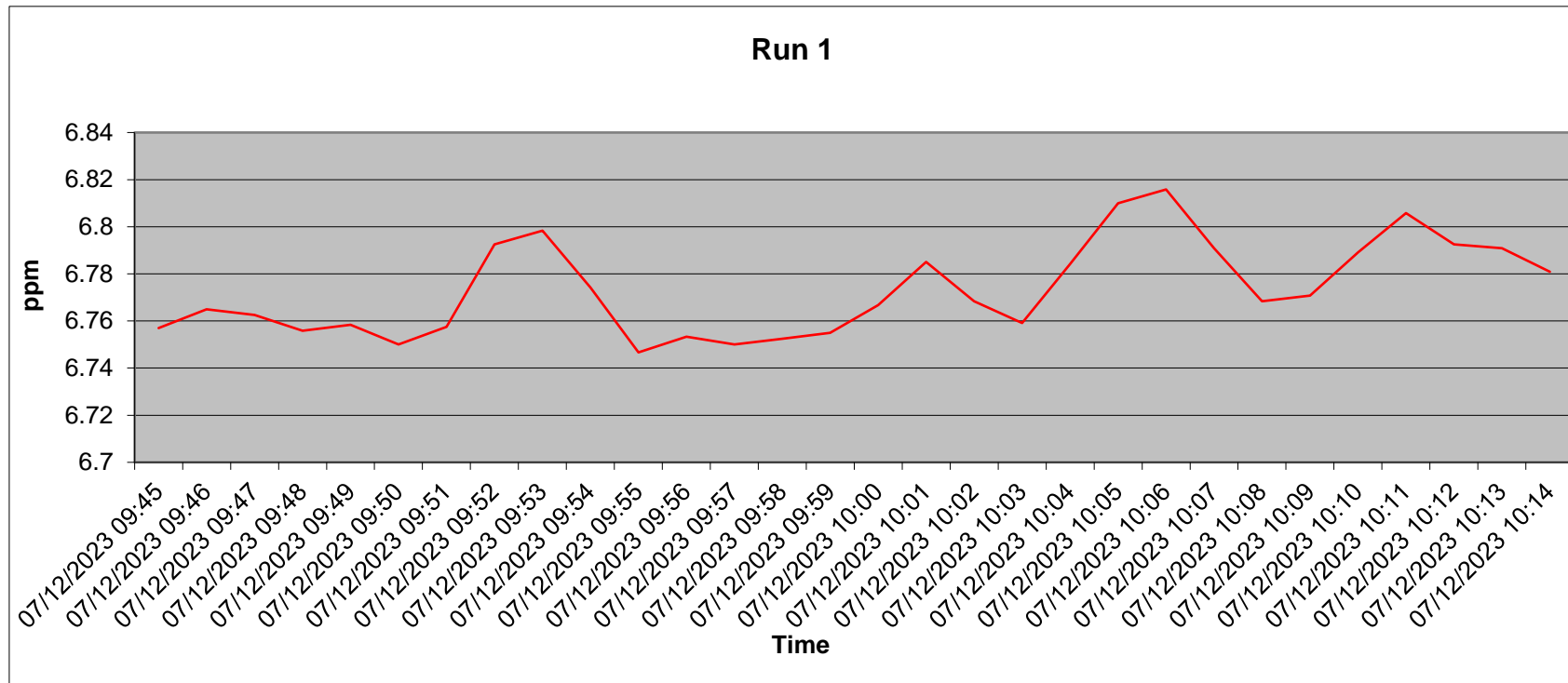
**Oxides of Nitrogen Measurement Uncertainty**

Measured Quantities	Units	Run 1	Run 2	Run 3
Certified Range of Analyser	ppm	0.87-1000	-	-
Operational Range of Analyser	ppm	250	-	-
Measured Reading	ppm	151.05	-	-
<b>Measured Quantities</b>				
Measured Quantities	Units	Run 1	Run 2	Run 3
Nonlinearity	%	1.4	-	-
Temperature Dependent Zero drift	%	-0.04	-	-
Temperature Dependent Span drift	%	-0.25	-	-
Cross-sensitivity	%	0.5	-	-
Leak	%	0	-	-
Calibration Gas Uncertainty	%	<2	-	-
Mass Flow Controllers (Dilution) Uncertainty	%	<1	-	-
NOx Converter Efficiency	%	95.5	-	-
<b>Parameter</b>				
Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg.m <sup>-3</sup>	8.89	-	-
Expanded uncertainty	mg.m <sup>-3</sup>	17.78	-	-
<b>Uncertainty corrected to std conds.</b>	mg.m <sup>-3</sup>	54.4	-	-
<b>Expanded uncertainty expressed with a level of confidence of 95%</b>	% of ELV	10.88	-	-
<b>Expanded uncertainty expressed with a level of confidence of 95%</b>	mg.m <sup>-3</sup>	54.4	-	-
<b>Expanded uncertainty expressed with a level of confidence of 95%</b>	% of value	15.59	-	-
<b>Requirement in standard is for uncertainty to be &lt; 10% at ELV at standard conditions</b>				

**Oxygen Quality Assurance**

Sampling Details				
Stack ID	AR07			
<b>Parameter</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Sampling Times	-	09:44	-	-
Sampling Dates	-	07/12/2023	-	-
Instrument Range	ppm	25	-	-
Span Gas Value	ppm	20.9	-	-
Acceptable Gas Range	-	Y	-	-
<b>Quality Assurance</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Conditioning Unit Temperature	°C	2	-	-
Average Temperature	< °C	2	-	-
Allowable Temperature	-	4	-	-
Temperature Acceptable	-	Y	-	-
Pump flow rate	l/min	0.5	-	-
<b>Zero Drift</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Zero Down Sampling Line (Pre)	%	0.1	-	-
Zero Down Sampling Line (Post)	%	0.1	-	-
Zero Drift	%	0	-	-
Allowable Zero Drift (5%)	%	1.05	-	-
Zero Drift Acceptable (Y/N)	Y <2%/Y 2-5%/N>5%	Y <2%	-	-
<b>Span Drift</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Span Down Sampling Line (Pre)	%	20.9	-	-
Span Down Sampling Line (Post)	%	20.9	-	-
Span Drift	%	0	-	-
Allowable Span Drift (5%)	%	1.05	-	-
Span Drift Acceptable (Y/N)	Y <2%/Y 2-5%/N>5%	Y <2%	-	-
<b>Leak Check</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Span Gas Conc.	%	20.9	-	-
Recorded Conc. down Line	%	20.9	-	-
Leak check acceptable (< 2%)	(Y/N)	Y <2%	-	-
<b>Test Conditions</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Run Ambient Temperature Range	°C	8	-	-
Combined uncertainty	% vol	0.14	-	-
% of value	%	2.03	-	-
Expanded uncertainty	% of value	4.05	-	-
Expanded uncertainty	% vol	0.27	-	-

### Oxygen trend



**Carbon Dioxide Quality Assurance**

Sampling Details				
Stack ID	AR07			
<b>Parameter</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Sampling Times	-	09:44	-	-
Sampling Dates	-	07/12/2023	-	-
Instrument Range	ppm	20	-	-
Span Gas Value	ppm	15	-	-
Acceptable Gas Range	-	Y	-	-
<b>Quality Assurance</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Conditioning Unit Temperature	°C	2	-	-
Average Temperature	< °C	2	-	-
Allowable Temperature	-	4	-	-
Temperature Acceptable	-	Y	-	-
Pump flow rate	l/min	0.5	-	-
<b>Zero Drift</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Zero Down Sampling Line (Pre)	%	0.1	-	-
Zero Down Sampling Line (Post)	%	0.1	-	-
Zero Drift	%	0	-	-
Allowable Zero Drift (4%)	%	0.6	-	-
Zero Drift Acceptable	Y <2%/Y 2-4%/N>4%	Y <2%	-	-
<b>Span Drift</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Span Down Sampling Line (Pre)	%	15.01	-	-
Span Down Sampling Line (Post)	%	15.01	-	-
Span Drift	%	0	-	-
Allowable Span Drift (4%)	%	0.6	-	-
Span Drift Acceptable	Y <2%/Y 2-4%/N>4%	Y <2%	-	-
<b>Leak Check</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Span Gas Conc.	ppm	15	-	-
Recorded Conc. down Line	ppm	15.01	-	-
Leak check acceptable (< 2%)	(Y/N)	Y <2%	-	-
<b>Test Conditions</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>
Run Ambient Temperature Range	°C	8	-	-
Combined uncertainty	% vol	0.18	-	-
% of value	%	1.51	-	-
Expanded uncertainty	% of value	3.01	-	-
Expanded uncertainty	% vol	0.35	-	-

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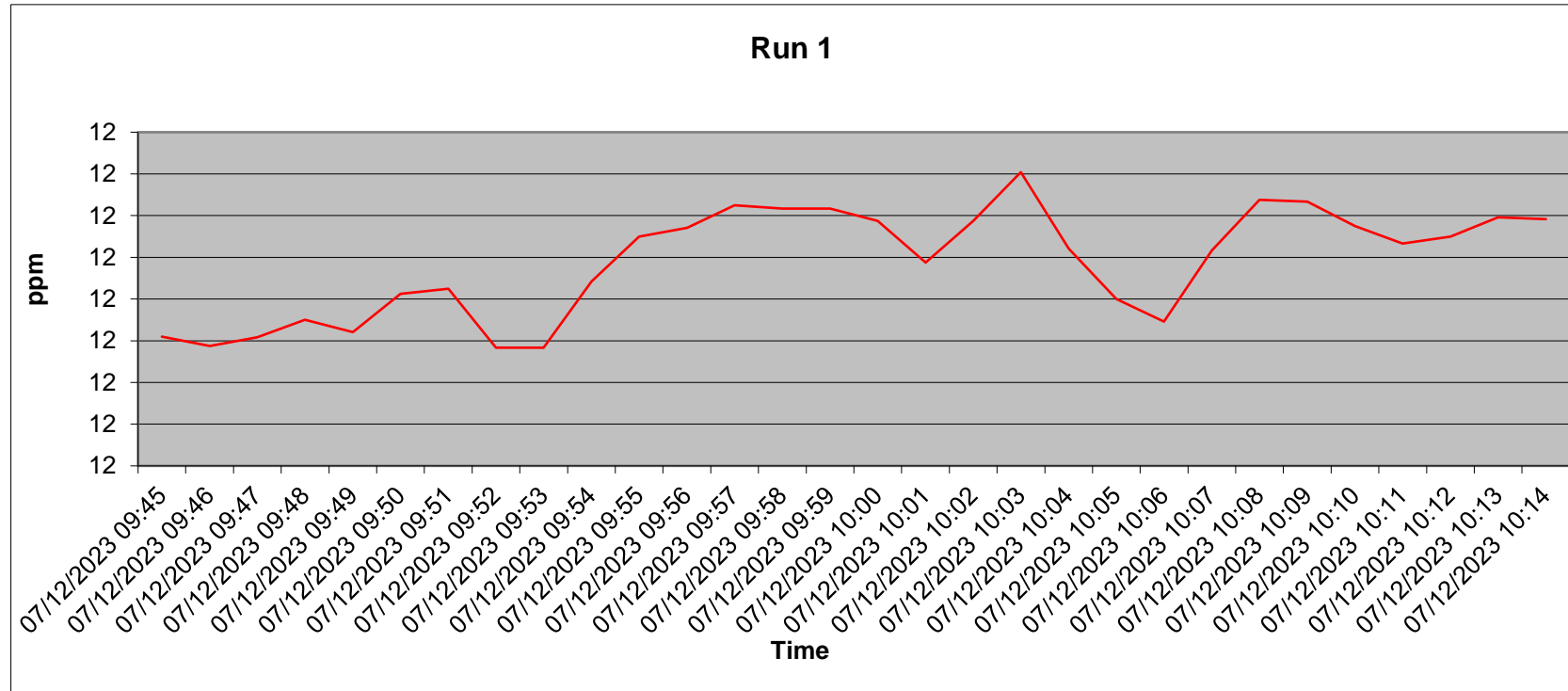
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**Carbon Dioxide Results & Sampling Details**

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	%	11.66	-	-	-
Uncertainty	%	0.35	-	-	-

General Sampling Information	
Parameter	Value
Standard	ISO12039
Technical Procedure	SOP 2045
Probe material	SS
Filtration Type/Size	Ceramic
Heated Head Filter Used	Yes
Heated Line Temperature	180
Span Gas Reference Number	ASLTM23ING505
Span Gas Expiry Date	28-Jun
Span Gas Start Pressure (bar)	60
Gas Cylinder Concentration (ppm)	15.01
Span Gas Uncertainty (%)	<2
Zero Gas Type	N
Number of Sampling Lines Used	1
Number of Sampling Points Used	1
Sample Point I.D's	AR07
Reference Conditions	
Temperature (K)	273.15
Pressure (kPa)	101.3
Gas (Wet or Dry)	Dry
Oxygen	5

### Carbon Dioxide Trend



**Uncert Sheets**

**NOx Uncert**

**Uncertainty calculation for Gaseous Measurement NOx EN14792**

**RUN 1**

Limit value	500	mg/m3 (corre Cal gas conc	331.5595	mg.m-3 (NO2)
Measured concentration	151	ppm		
Measured concentration	310.11	mg/m3 (101.3 Full Scale	513.25	mg/m3 (NO2)
Measured concentration	349.03	mg/m3 (Corrected)		
NO/NO2 ratio	100.00			
Gas		NO		
Full Scale		250	ppm	
Cal gas conc		161.5	ppm	
Conversion		2.053		

Correction for reference conditions					
		O2, %	Moisture,	Pressure, KPa	Temperature, K
	ref	5.00	0.00	101.30	273.00
	measured	6.77	0.00	101.90	747.00
	Uncert	0.35	0.00	0.00	1.00
Factors		1.12	1.00	0.99	2.74
Uncertainty in factor		0.03	0.00	0.00	0.00
Correction Factor		3.06	uf	0.03	

Performance characteristics	Value		specification
Response time	180	seconds	180.000
Logger sampling interval	60	seconds	
Measurement period	33	minutes	
Number of readings in measurement	33		
Repeatability at zero	0.03	% full scale	<1 % range
Repeatability at span level	0.06	% full scale	<2 % range
Deviation from linearity(lack of fit)	0.2	% of value	<2 % range
Zero drift	0.21	mg/m3	<2% range / 24hr
Span drift	1.435	mg/m3	<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
NH3 (mg/m3)	20	0.0	mg/m3
CO2 (% vol)	15	0.2	mg/m3
H2O (% vol)	30	0.0	mg/m3
dependence on voltage	0.1	% full scale/10V	<2% range
losses in the line (leak)	0.00	% of value	< 0.1%vol /10 volt
Converter efficiency	95.5	%	>95%
Uncertainty of calibration gas	2	% of value	< 2% of value

Effect of drift
1.72 mg/m3
0.33 % full scale

	min	max	value at calib	
flow	95.00	105	100	kPa
pressure	101.30	101.3	101.3	kPa
temp	289	289	289	K
NH3 range	0	0	0	mg/m3
CO2 range	0	15	0	%vol
H2O range	0	0	0	%vol
Voltage	93	121	110	V

Performance characteristic	Uncertainty	Value of uncertainty quantity	mg/m3
Standard deviation of repeatability at zero	ur0	for mean	use rep at span
Standard deviation of repeatability at span level	urs	for mean	0.05

**Uncert Sheets**

Lack of fit			ufit				0.36	
Drift			u0dr				0.99	
volume or pressure flow dependence			uspres				0.00	
atmospheric pressure dependence			uapres				0.00	
ambient temperature dependence			utemp				0.00	
NH3			uinterf				0.00	<b>Use largest of sum of all positive or all negative influences</b> Criteria sum <4% range 6.202111663
CO2 (% vol)			uinterf				0.12	
H2O (% vol)			uinterf				0.00	
Dependence on voltage			uvolt				0.44	Value to use for intereference uncertainty uint            0.12
losses in the line (leak)			uleak				0.00	
Uncertainty of calibration gas			ucalib				3.58	
converter efficiency			uceff				8.06	
Uncertainty in factor			uf				8.65	

<b>Measurement uncertainty</b>			349.03	mg/m3
Combined uncertainty			8.89	mg/m3
Expanded uncertainty	k =	2	17.78	mg/m3
<b>Uncertainty corrected to std conds</b>			<b>54.40</b>	<b>mg/m3</b>
<b>Expanded uncertainty</b>	<b>expressed with a level of</b>		<b>10.88 % ELV</b>	
<b>Expanded uncertainty</b>	<b>expressed with a level of</b>		<b>54.40 mg.m-3</b>	
<b>Expanded uncertainty</b>	<b>expressed with a level of</b>		<b>15.59 % value</b>	

Requirement in standard is for uncertainty to be < 10% at ELV at standard conditions

Note: Enter values into green boxes  
 Dark blue boxes indicate information that can be obtained from MCERTS tests

Developed for the STA by R Robinson, NPL

corrected drift to be based on mg/m3 reading and the correction alert to be based on % full scale

**O<sub>2</sub> Uncert**

**Run 1**  
**Uncertainty calculation for Gaseous Measurement Oxygen EN14789**



Uncert Sheets

Limit value	n/a	%vol	Calibration gas	20.9	%vol
Measured concentration	6.77	%vol	Full Scale	25	%vol

Performance characteristics	Value			specification
Response time	180	seconds		< 200 s
Logger sampling interval	60	seconds		
Measurement period	33	minutes		
Number of readings in measurement	33	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)	0.00	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)	0.00	% 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
CO2 (% vol)	15	0.07	% by volume per	15
NO (mg/m3)	300	0.02	% by volume per	300
NO2 (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)	0.00	% of value		< 2% of value
Uncertainty of calibration gas	2	% of value		

Effect of drift
0.00 % vol
0.00 % full scale

	range of variation from conditions at calibration		
	min	max	value at calib
flow	5	15	10 l/h
pressure	99.00	101	100 kPa
temp	280	285	285 K
CO2 range	8	15	0 % vol
NO range	100	150	0 mg/m3
NO2 range	5	7.5	0 mg/m3
Voltage	105	115	110 V

Performance characteristic	Uncertainty	Value of uncertainty quantity	% vol
Standard deviation of repeatability at zero	ur0	for mean	Only use rep at span
Standard deviation of repeatability at span level	urs	for mean	0.00
Lack of fit	ufit		0.08
Drift	u0dr		0.00
volume or pressure flow dependence	uspres		0.00
atmospheric pressure dependence	uapres		0.04
ambient temperature dependence	utemp		-0.02
CO2			0.05
NO			0.01
NO2			0.00
Combined interference (from mcerts)			0.08
dependence on voltage	uvolt		0.03
losses in the line (leak)	uleak		0.00
Uncertainty of calibration gas	ucalib		0.08

Use largest of sum of all positive or all negative influences
0.06 all +ves
0 all -ves
0.06 largest
Value to use for intereference uncertainty
uint 0.06

**Uncert Sheets**

Measurement uncertainty		6.77	%vol
Combined uncertainty		0.14	%vol
% of value		2.03	%
Coverage factor k =	2		
<b>Expanded uncertainty</b>	<b>expressed with a level of confidence</b>	<b>4.05 % of value</b>	
<b>Expanded uncertainty</b>	<b>expressed with a level of confidence</b>	<b>0.27 % vol</b>	

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

Note: Enter values into green boxes  
 Dark blue boxes indicate information that can be obtained from MCERTS tests  
 Purple boxes are from manufacturer specification, or CEN standard as MCERTS data not available

Developed for the STA by R Robinson, NPL

corrected drift alert to be based on % full scale

**CO<sub>2</sub> Uncert**

**Run 1**  
**Uncertainty calculation for Gaseous Measurement Carbon Dioxide**

Limit value	n/a	%vol	Calibration gas	15	%vol
Measured concentration	11.66	%vol	Full Scale	25	%vol

Performance characteristics	Value			specification
Response time	180	seconds		< 200 s
Logger sampling interval	60	seconds		
Measurement period	33	minutes		
Number of readings in measurement	33	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)	0.00	% vol at zero level	+/-	<2% of volume / 24hr
Span drift (during measurement period)	0.00	% 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
CO2 (% vol)	15	0.07	% by volume per	15

Effect of drift
0.00 % vol
0.00 % full scale

	range of variation from conditions at calibration		
	min	max	value at calib
flow	5	15	10 l/h
pressure	99.00	101	100 kPa
temp	280	285	285 K
CO2 range	8	15	0 % vol

**Uncert Sheets**

NO (mg/m3)	300	0.02	% by volume per	300		NO range	100	150	0 mg/m3
NO2 (mg/m3)	30	0	% by volume per	30		NO2 range	5	7.5	0 mg/m3
Combined interference		0.56	% range		<2% range	Voltage	105	115	110 V
Dependence on voltage		0.1	% by volume /10V	+ - 5%	< 0.1%vol /10 volt				
Losses in the line (leak)		-0.01	% of value		< 2% of value				
Uncertainty of calibration gas		2	% of value						

Performance characteristic	Uncertainty	Value of uncertainty quantity	% vol
Standard deviation of repeatability at zero	ur0	for mean	Only use rep at span
Standard deviation of repeatability at span level	urs	for mean	0.00
Lack of fit	ufit		0.08
Drift	u0dr		0.00
volume or pressure flow dependence	uspres		0.00
atmospheric pressure dependence	uapres		0.04
ambient temperature dependence	utemp		-0.02
CO2			0.05
NO			0.01
NO2			0.00
Combined interference (from mcerts)			0.08
dependence on voltage	uvolt		0.03
losses in the line (leak)	uleak		0.00
Uncertainty of calibration gas	ucalib		0.13

**Use largest of sum of all positive or all negative influences**

0.06 all +ves  
 0 all -ves  
 0.06 largest

**Value to use for intereference uncertainty**  
 uint 0.06

<b>Measurement uncertainty</b>		11.66	%vol
Combined uncertainty		0.18	%vol
% of value		1.51	%
Coverage factor k =	2		
<b>Expanded uncertainty</b>	<b>expressed with a level of confidence</b>	<b>3.01 % of value</b>	
<b>Expanded uncertainty</b>	<b>expressed with a level of confidence</b>	<b>0.35 % vol</b>	

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

Note: Enter values into green boxes  
 Dark blue boxes indicate information that can be obtained from MCERTS tests  
 Purple boxes are from manufacturer specification, or CEN standard as MCERTS data not available