

STACK EMISSIONS MONITORING REPORT



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Permit:
EPR Permit: KP3235SS

Release Point:
Reactor South 1

Sampling Date(s):
21st May 2015

ESG Job Number:	LSO 150512
Report Date:	5th July 2015
Version:	1
Report By:	Catherine Elsey
MCERTS Number:	MM 08 996
MCERTS Level:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
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Technical Endorsements:	1, 2, 3 & 4
Signature:	



1015

CONTENTS

EXECUTIVE SUMMARY

Stack Emissions Monitoring Objectives

- Plant
- Operator
- Stack Emissions Monitoring Test House

Emissions Summary

Monitoring Times

Process Details

Monitoring Methods

Analytical Methods

- Sampling Methods with Subsequent Analysis
- On-Site Testing

Sampling Location

- Sampling Plane Validation Criteria
- Duct Characteristics
- Sampling Lines & Sample Points
- Sampling Platform
- Sampling Location / Platform Improvement Recommendations

Sampling and Analytical Method Deviations

APPENDICES

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

APPENDIX 3 - Measurement Uncertainty Budget Calculations

EXECUTIVE SUMMARY

MONITORING OBJECTIVES

IQE Europe Limited operates a epitaxis process at St Mellons which is subject to EPR Permit KP3235SS, under the Environmental Permitting Regulations 2010.

Environmental Scientifics Group Limited were commissioned by ESP Environmental to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under normal operating conditions.

The results of these tests shall be used to demonstrate compliance with a set of emission limit values for prescribed pollutants as specified in the Plant's EPR Permit, KP3235SS.

Plant

Reactor South 1

Operator

IQE Europe Limited
Cypress Driver
St. Mellons
Cardiff
CF3 0EG

EPR Permit: KP3235SS

Stack Emissions Monitoring Test House

Environmental Scientifics Group Limited - Cirencester Laboratory
Units C&D Bankside Trade Park
2 Wilkinson Road
Cirencester
GL7 1YT
UKAS and MCERTS Accreditation Number: 1015

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.

MCERTS accredited results will only be claimed where both the sampling and analytical stages are UKAS accredited.

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EXECUTIVE SUMMARY

EMISSIONS SUMMARY					
Parameter	Units	Result	Calculated Uncertainty +/-	Limit	MCERTS accredited result
Hydrogen Chloride	mg/m ³	0.08	0.01	10	✓
Hydrogen Chloride Emission Rate	g/hr	0.01	0.00	-	
Moisture	%	1.8	0.08	-	✓
Stack Gas Temperature	°C	20	-	-	✓
Stack Gas Velocity	m/s	2.1	0.47	-	
Gas Volumetric Flow Rate (Actual)	m ³ /hr	72.4	3.3	-	
Gas Volumetric Flow Rate (STP, Wet)	m ³ /hr	68.2	3.1	-	
Gas Volumetric Flow Rate (STP, Dry)	m ³ /hr	67.0	3.0	-	
Gas Volumetric Flow Rate at Reference Conditions	m ³ /hr	68.2	3.1	-	

ND = None Detected,

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

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

Reference conditions are 273K, 101.3kPa without correction for water vapour

EXECUTIVE SUMMARY

MONITORING TIMES			
Parameter	Sampling Date(s)	Sampling Times	Sampling Duration
Hydrogen Chloride Run 1	21 May 2015	12:33 - 13:06	33 minutes
Stack Gas Flow Rate & Temperature Run 1	21 May 2015	12:33 - 13:06	-

EXECUTIVE SUMMARY

PROCESS DETAILS

Parameter	Process Details
Description of process	Epitaxis
Continuous or batch	Batch
Product Details	Silicon Wafer
Part of batch to be monitored (if applicable)	3 micron DCS Intrinsic
Normal load, throughput or continuous rating	Normal
Fuel used during monitoring	N/A
Abatement	Wet Scrubber & Dry Bed Scrubber
Plume Appearance	None Visible

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard reference / alternative methods employed by Environmental Scientifics Group Limited is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency Technical Guidance Note (Monitoring) M2. i.e. CEN, ISO, BS, US EPA etc.

MONITORING METHODS						
Species	Method Standard Reference Method / Alternative Method	ESG Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Limit of Detection (LOD)	Calculated MU +/- %
Hydrogen Chloride	SRM - BS EN 1911	AE 111	1015	Yes	0 mg/m ³	12 %
H ₂ O	SRM - BS EN 14790	AE 105	1015	Yes	0.03%	4.34%
Velocity	SRM - BS EN ISO 16911-1	AE 154	1015	Yes	5 Pa	22.4 %
Volumetric Flow Rate	SRM - BS EN ISO 16911-1	AE 154	1015	Yes	-	4.5 %

BS EN 14790 has been validated over a range of 4 - 40%. It is however the preferred method of the Environment Agency for concentrations below 4%

EXECUTIVE SUMMARY

Analytical Methods

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

SAMPLING METHODS WITH SUBSEQUENT ANALYSIS							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	UKAS Accredited Lab Analysis	Analysis Lab (ESG or Subcontract)	Sample Archive Location	Archive Period
Hydrogen Chloride	Ion Chromatography	ASC/SOP/110/10	1015	Yes	ESG Bretby	ESG Bretby	3 months

ON-SITE TESTING							
Species	Analytical Technique	Analytical Procedure	UKAS Lab Number	MCERTS Accredited Analysis	Laboratory	Data Archive Location	Archive Period
H ₂ O	Gravimetric	AE 105	1015	Yes	ESG - Cirencester	-	-

EXECUTIVE SUMMARY

SAMPLING LOCATION					
Sampling Plane Validation Criteria	Value	Units	Requirement	Compliant	Method
Lowest Differential Pressure	3	Pa	≥ 5 Pa	No	BS EN 16911-1
Lowest Gas Velocity	2.11	m/s	-	-	-
Highest Gas Velocity	2.11	m/s	-	-	-
Ratio of Gas Velocities	1.00	: 1	$< 3 : 1$	Yes	BS EN 16911-1
Mean Velocity	2.11	m/s	-	-	-
Maximum angle of flow with regard to duct axis	< 15	$^{\circ}$	$< 15^{\circ}$	Yes	BS EN 16911-1
No local negative flow	Yes	-	-	Yes	BS EN 16911-1
Highly homogeneous flow stream / gas velocity	Yes	-	-	Yes	BS EN 16911-1

DUCT CHARACTERISTICS		
	Value	Units
Shape	Circular	-
Depth	0.11	m
Width	-	m
Area	0.01	m ²
Port Depth	85	mm

SAMPLING LINES & POINTS			
	Isokinetic (CEN Methods)	Isokinetic (ISO Methods)	Non-Iso & Gases
Sample port size	-	48mm	-
Number of lines used	-	1	-
Number of points / line	-	1	-
Duct orientation	-	Horizontal	-

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

M1 Platform requirements	
Is there a sufficient working area so work can be performed in a compliant manner	N/A
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	N/A
Platform has vertical base boards (approximately 0.25 m high)	N/A
Platform has removable chains / self closing gates at the top of ladders	N/A
Handrail / obstructions do not hamper insertion of sampling equipment	N/A
Depth of Platform = $\geq$ Stack depth / diameter + wall and port thickness + 1.5m	No

Sampling Platform Improvement Recommendations (if applicable)

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

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

Flow Traverse

Due to the nature of the process it is not possible to perform a preliminary flow traverse. A single point flow measurement was obtained during the course of the sampling instead

APPENDICES

CONTENTS

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

APPENDIX 3 - Measurement Uncertainty Budget Calculations

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

MONITORING SCHEDULE					
Species	Method Standard Reference Method / Alternative Method	ESG Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Number of Samples
Hydrogen Chloride	SRM - BS EN 1911	AE 111	1015	Yes	1
H ₂ O	SRM - BS EN 14790	AE 105	1015	Yes	1
Velocity	SRM - BS EN ISO 16911-1	AE 154	1015	Yes	1

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

CALIBRATEABLE EQUIPMENT CHECKLIST					
Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	Equipment I.D.	Equipment	Equipment I.D.	Equipment	Equipment I.D.
Control Box DGM	P1298	Horiba PG-250 Analyser	-	Laboratory Balance Mitcheldean	-
Box Thermocouples	P1298	FT-IR	-	Laboratory Balance Stockport	-
Meter In Thermocouple	P1298	FT-IR Oven Box	-	Laboratory Balance Stockport	-
Meter Out Thermocouple	P1298	Bernath 3006 FID	-	Tape Measure	P1300
Control Box Timer	-	Signal 3030 FID	-	Stopwatch	-
Oven Box	-	Servomex	-	Barometer	P1408
Probe	-	JCT Heated Head Filter	-	Digital Temperature Meter	P1272
Probe Thermocouple	-	Thermo FID	-	Stack Thermocouple	P1855
Probe	-	Stackmaster	-	Digital Manometer	P2053
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	-	Anemometer	-	1m Heated Line (1)	-
L-Pitot	P1384	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	P2316	Chiller (JCT/MAK 10)	-	1m Heated Line (3)	-
Last Impinger Arm	P1714	Heated Line Controller (1)	-	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-	Heated Line Controller (2)	-	10m Heated Line (1)	-
Callipers	-	Site temperature Logger	P2210	10m Heated Line (2)	-
Small DGM	-		-	15m Heated Line (1)	-
Heater Controller	-		-	20m Heated Line (1)	-
Inclinometer (Swirl Device)	-		-	20m Heated Line (2)	-

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

CALIBRATION GASES					
Gas (traceable to ISO 17025)	Cylinder I.D Number	Supplier	ppm	%	Analytical Tolerance +/- %
-	-	-	-	-	-

STACK EMISSIONS MONITORING TEAM

MONITORING TEAM							
Personnel	MCERTS Number	MCERTS Qualification	TE / H&S Qualifications and Expiry Date				
			TE1	TE2	TE3	TE4	H&S
Jonathan Ward	MM 02 080	MCERTS Level 2 - Team Leader	Mar-18	Jun-18	Aug-16	Mar-16	Sep-17
Catherine Elsey	MM 08 996	MCERTS Level 2 - Team Leader	Dec-15	Dec-20	Feb-19	Mar-17	Nov-18

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

HYDROGEN CHLORIDE SUMMARY					
Test	Sampling Times	Concentration mg/m ³	LOD mg/m ³	Limit mg/m ³	Emission Rate g/hr
Run 1	12:33 - 13:06 21 May 2015	0.080	0.004	10	0.01
Field Blank	-	0.009	-	-	-

Reference conditions are 273K, 101.3kPa without correction for water vapour

HYDROGEN CHLORIDE QUALITY ASSURANCE CHECKLIST

Leak Test Results	Mean Sampling Rate	Pre sampling leak rate	Post sampling leak rate	Acceptable leak rate	Leak Tests Acceptable?
	l/min	l/min	l/min	l/min	
Run 1	14.4	0.15	0.10	0.29	Yes

	Filter Material	Filter Size mm	Max. Filtration Temp. °C	Max. Storage / Transit Temp. °C	Type of Absorbers	Absorption Solutions
Run 1	QF	7	N/A	15	Glass	HPLC Water

GF = Glass Fibre

QF = Quartz Fibre

HYDROGEN CHLORIDE ABSORPTION EFFICIENCY

Parameter	Total ug	IMP C ug	Absorption Efficiency %	Acceptable Absorption Efficiency %	Absorption Efficiency Acceptable ?
Run 1	38.8	10.8	72	95	N/A- < 1mg/m ³

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

MOISTURE CALCULATIONS

Moisture Determination - Non Isokinetic							
Test Number	Sampling Time and Date	Start Weight	End Weight	Total gain	Concentration	LOD	Uncertainty
		kg	kg	kg	%	%	%
Run 1	12:33 - 13:06 21 May 2015	4.4667	4.4738	0.0071	1.8	0.026	4.3

Moisture Quality Assurance							
Test Number	Sampling Duration	Total Volume Sampled	Sampling Rate	Start Leak Rate	End Leak Rate	Acceptable Leak Rate	Leak Tests Acceptable?
	mins	l	l/min	l/min	l/min	l/min	
Run 1	33	475	14.4	0.1500	0.1000	0.2881	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics		
Stack Diameter / Depth, D	0.11	m
Stack Width, W	-	m
Stack Area, A	0.01	m ²
Average stack gas temperature	20	°C
Stack static pressure	0.005	kPa
Barometric Pressure	102.5	kPa
Pitot tube calibration coefficient, K _{pt}	1.00	-

Stack Gas Composition & Molecular Weights								
Component	Molar Mass M	Density kg/m ³ p	Conc Dry % Vol	Dry Volume Fraction r	Dry Conc kg/m ³ pi	Conc Wet % Vol	Wet Volume Fraction r	Wet Conc kg/m ³ pi
CO ₂	44	1.963059	0.030000	0.000300	0.000589	0.029452	0.000295	0.000578
O ₂	32	1.427679	20.900000	0.209000	0.298385	20.518134	0.205181	0.292933
N ₂	28	1.249219	79.070000	0.790700	0.987758	77.625305	0.776253	0.969710
H ₂ O	18	0.803070	-	-	-	1.827109	0.018271	0.014673

Where: $p = M / 22.41$ $pi = r \times p$

Calculation of Stack Gas Densities		
Determinand	Result	Units
Dry Density (STP), P_{STD}	1.2867	kg/m ³
Wet Density (STP), P_{STW}	1.2779	kg/m ³
Dry Density (Actual), P_{Actual}	1.2132	kg/m ³
Average Wet Density (Actual), $P_{ActualW}$	1.205	kg/m ³

Where:

P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)

$P_{STW} = (P_{STD} + pi \text{ of H}_2\text{O}) / (1 + (pi \text{ of H}_2\text{O} / 0.8036))$

$P_{Actual} = P_{STD} \times (Ts / Ps) \times (Pa / Ta)$

$P_{ActualW} = P_{STW} \times (Ts / Ps) \times (Pa / Ta)$

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY

TRAVERSE 1

Date of Survey	21 May 2015
Time of Survey	12:33 - 13:06
Velocity Measurement Device:	L-Type Pitot

Sampling Line A								
Traverse Point	Distance into duct (m)	ΔP pt mmH ₂ O (average of 3)	ΔP pt Pa (average of 3)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m ³ /s	O ₂ % Vol	Angle of Swirl °
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
1	0.04	0.3	3	20	2.11	0.02	-	<15
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
Mean	-	0.3	3	20	2.11	0.02	-	-

Sampling Line B								
Traverse Point	Distance into duct (m)	ΔP pt mmH ₂ O (average of 3)	ΔP pt Pa (average of 3)	Temp °C	Velocity m/s	Volumetric Flow Rate (actual) m ³ /s	O ₂ % Vol	Angle of Swirl °
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-
Mean	-	-	-	-	-	-	-	-

PRELIMINARY STACK SURVEY QUALITY ASSURANCE CHECKLIST

PITOT LEAK CHECK								
Run	Pre Traverse Leak Rate				Post Traverse Leak Rate			
	Start Value mmH ₂ O	End Value mmH ₂ O	Difference %	Outcome	Start Value mmH ₂ O	End Value mmH ₂ O	Difference %	Outcome
Run 1	83.0	84.0	-1.2	Pass	88.00	86	2.3	Pass

To complete a compliant pitot leak check a pressure of over 80mmH₂O is applied and the pressure drop monitored over 5 mins. A drop of less than 5% must be observed.

L-Type Pitot Blockage Test				
Run	Final Reading (Pa)	Reading After Purge (Pa)	Difference (%)	Outcome
Run 1	42	41	-1	Pass

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY (CONTINUED)

Sampling Plane Validation Criteria				
EA Technical Guidance Note (Monitoring) M1	Result	Units	Requirement	Compliant
Lowest Differential Pressure	2.711333333	Pa	>= 5 Pa	No
Lowest Gas Velocity	2.11	m/s	-	-
Highest Gas Velocity	2.11	m/s	-	-
Ratio of Gas Velocities	1.00	-	< 3 : 1	Yes
Maximum angle of flow with regard to duct axis	0	°	< 15°	Yes
No local negative flow	Yes	-	-	Yes

Calculation of Stack Gas Velocity, V		
Velocity at Traverse Point, $V = K_{pt} \times (1-\epsilon) \times \sqrt{2 \times \Delta P_{pt} / \rho_{ActualW}}$		
Where: K_{pt} = Pitot tube calibration coefficient $(1-\epsilon)$ = Compressibility correction factor, assumed at a constant 0.998		
Average Stack Gas Velocity, V_a	2.11	m/s

Calculation of Stack Gas Volumetric Flowrate, Q			
Duct gas flow conditions	Actual	Reference	Units
Temperature	20	0	°C
Total Pressure	102.505	101.3	kPa
Oxygen	21.0	21	%
Moisture	1.83	1.83	%

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (V_a)	2.11	m/s
Stack Area (A)	0.01	m ²
Gas Volumetric Flowrate (Actual), Q_{Actual}	72	m ³ /hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	68	m ³ /hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	67	m ³ /hr
Gas Volumetric Flowrate (REF), Q_{Ref}	68	m ³ /hr

Where:

$$Q_{Actual} = V_a \times A \times 3600$$

$$Q_{STP} = Q_{Actual} \times (T_s / T_a) \times (P_a / P_s) \times 3600$$

$$Q_{STP,Dry} = Q_{STP} / (100 - (100 / Ma)) \times 3600$$

$$Q_{Ref} = Q_{STP} \times ((100 - Ma) / (100 - Ms)) \times ((20.9 - O_{2a}) / (20.9 - O_{2s}))$$

Nomenclature:

T_s = Absolute Temperature, Standard Conditions, 273 K

P_s = Absolute Pressure, Standard Conditions, 101.3 kPa

T_a = Absolute Temperature, Actual Conditions, K

P_a = Absolute Pressure, Actual Conditions, kPa

Ma = Water vapour, Actual Conditions, % Vol

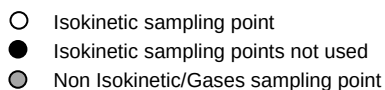
Ms = Water vapour, Reference Conditions, % Vol

O_{2a} = Oxygen, Actual Conditions, % Vol

O_{2s} = Oxygen, Reference Conditions, % Vol

STACK DIAGRAM

Non-Isokinetic/Gases Sampling			
Sampling Point	Distance (% of Depth)	Distance into Stack	Units
A	50	0.06	m

[illegible]

SAMPLING LOCATION



APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - NON-ISOKINETIC HYDROGEN CHLORIDE

Run	Sampled Volume m ³	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Concentration in impinger mg	Limit of Detection % by mass	Leak %
MU required	<=2%	<2.5 k	<=1%	<=1%	<=5%	<5%	≤ 5% of ELV	<=2%
Run 1	0.000	2.000	0.500	1.000	0.100	0.002	0.001	-
as a %	0.059	0.671	0.488	1.000	-	3.000	3.006	0.694
compliant?	Yes	Yes	Yes	Yes	N/A	Yes	Yes	Yes

Run	Volume (STP) m ³	Mass of Hydrogen Chloride mg	O2 Correction -	Leak mg/m ³	Lab Uncertainty mg	Combined uncertainty
Run 1	0.4485	0.0388	-	0.0003	-	-
MU as mg/m ³	0.0010	0.0024	-	0.0003	0.0040	0.0048
MU as %	1.3007	3.0059	-	0.4008	5.0	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	0.01	mg/m³	11.98	%
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(k is a coverage factor which gives a 95% confidence in the quoted figures)

Developed for the STA by R Robinson, NPL

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - MOISTURE

Run	Sampled Volume m ³	Sampled Gas Temp K	Sampled Gas Pressure kPa	Sampled Gas Humidity % by volume	Oxygen Content % by volume	Leak %
MU required	≤ 2%	≤ 2%	≤ 1%	≤ 1%	≤ 10%	≤ 2%
Run 1	0.000	2	0.5	1	N/A	-
as a %	0.06	0.68	0.49	1.00	N/A	1.04
compliant?	Yes	Yes	Yes	Yes	N/A	Yes

Run	Volume (STP) m ³	Mass Gained mg	O2 Correction -	Leak mg/m ³	Uncollected Mass mg	Combined uncertainty
Run 1	0.4	7100.0	1.00	89.8	57.7	-
MU as % v/v	0.02	0.03	-	0.01	0.02	0.04
MU as %	1.3	1.4	-	0.6	0.8	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	0.08	% v/v	4.34	%
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Developed for the STA by R Robinson, NPL

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - VELOCITY & VOLUMETRIC FLOW RATE

Measured Velocity at Actual Conditions	2.1	m/s
Measured Volumetric Flow rate at Actual Conditions	72	m ³ /hr

Performance Characteristics & Source of Value	Units	Values	Requirement	Compliant
Uncertainty of Local Gas Velocity Determination				
Uncertainty of pitot tube coefficient	-	0.010		
Uncertainty of mean local dynamic pressures	-	0.33		
Factor loading, function of the number of measurements.	3 readings	0.591	minimum 3	Yes
Range of measurment device	pa	1000		
Resolution	pa	1.00		
Calibration uncertainty	pa	0.20	<1% of Value or 20 Pa whichever is greater	Yes
Drift	% range	0.10		
Linearity	% range	0.06	<2% of value	Yes
Uncertainty of gas density determination				
Uncertainty of molar mass determination	kg/mol	0.00003		
Uncertainty of temperature measurement	K	1.49	<1% of value	Yes
Uncertainty of absolute pressure in the duct	pa	523		
Uncertainty associated with the estimate of density	-	0.007		
Uncertainty associated with the measurement of local velocity	-	0.0001		
Uncertainty associated with the measurement of mean velocity	-	0.0130		

Measurement Uncertainty - Velocity	m/s
Combined uncertainty	0.24
Expanded uncertainty at a 95% Confidence Interval	0.47

Note - The expanded uncertainty uses a coverage factor of $k = 2$.

Expanded Measurement Uncertainty of Velocity at a 95% Confidence Interval	%
Expressed as a % of the Measured Concentration	11.40
Expanded uncertainty at a 95% Confidence Interval	22.35

Measurement Uncertainty Volumetric Flow Rate	m ³ /hr
Combined uncertainty	1.67
Expanded uncertainty at a 95% Confidence Interval	3.27

Note - The expanded uncertainty uses a coverage factor of $k = 2$.

Expanded Measurement Uncertainty of Volumetric Flow Rate at a 95% Confidence Interval	%
Expressed as a % of the Measured Concentration	2.31
Expanded uncertainty at a 95% Confidence Interval	4.53

END OF REPORT