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Stack Emissions Testing Report Commissioned by
Xaarjet Ltd

Installation Name & Address

Xaarjet Ltd
Hurricane Close
Ermine Business Park
Huntingdon
Cambridgeshire
PE29 6XX

PPC Permit: B22/11

Stack Reference

LEV 2 - CR1 Room Extract

Dates of the Monitoring Campaign

28th January 2020

Job Reference Number

EST-5428

Report Written by

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Report Date

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Version

Version 1

Signature of Report Approver



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Executive Summary

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MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
LEV 2 - CR1 Room Extract
28th January 2020

Overall Aim of the Monitoring Campaign

Element were commissioned by Xaarjet Ltd to carry out stack emissions testing on the LEV 2 - CR1 Room Extract at Huntingdon.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Permit.

Special Requirements

There were no special requirements.

Target Parameters

Total VOCs (as Carbon)

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MONITORING RESULTS

Xaarjet Ltd, Huntingdon
LEV 2 - CR1 Room Extract
28th January 2020

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total VOCs (as Carbon)	¹ mg/m ³	3.93	0.43	75	g/hr	13.2	1.61	-
Stack Gas Temperature	°C	18.9						
Stack Gas Velocity	m/s	8.09	0.22					
Volumetric Flow Rate (ACTUAL)	m ³ /hr	3660	194					
Volumetric Flow Rate (REF)	¹ m ³ /hr	3353	178					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

¹ Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

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MONITORING DATE(S) & TIMES

Xaarjet Ltd, Huntingdon
 LEV 2 - CR1 Room Extract
 28th January 2020

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total VOCs (as Carbon)	R1	mg/m³	4.88	g/hr	16.4	28/01/2020	12:12 - 12:42	30
Total VOCs (as Carbon)	R2	mg/m³	3.64	g/hr	12.2	28/01/2020	12:42 - 13:12	30
Total VOCs (as Carbon)	R3	mg/m³	3.27	g/hr	11.0	28/01/2020	13:12 - 13:42	30
Velocity Traverse	R1					28/01/2020	11:40 - 11:51	

All results are expressed at the respective reference conditions.

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PROCESS DETAILS

Xaarjet Ltd, Huntingdon
LEV 2 - CR1 Room Extract
28th January 2020

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	Standard Operating Capacity
Continuous or Batch Process	Continuous
Feedstock (if applicable)	Ink Cartridges
Abatement System	None
Abatement System Running Status	N/A
Fuel	N/A
Plume Appearance	None Visible

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MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
LEV 2 - CR1 Room Extract
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Parameter	Monitoring				Analysis				Overall Accredit ation	LOD (Average)
	Standard	Technical Procedure	Sampling Accredit ation	Testing Lab	Analytical Procedure	Analytical Technique	Analysis Accredit ation	Analysis Lab		
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20	MCERTS	EET	Flame Ionisation Detection by Sick 3006 FID				MCERTS	0.32 mg/m ³
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	MCERTS	EET	Pitot Tube and Thermocouple				MCERTS	1.2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All Parameters	All Runs	There are no deviations associated with the sampling employed.

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SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.40
Width	m	-
Area	m ²	0.13
Port Depth	cm	0
Orientation of Duct	-	Vertical
Number of Ports	-	2
Sample Port Size	-	Hole

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Outside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	Yes
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and EN 15259, and therefore there are no improvement recommendations.

EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1					Required	Compliant
Lowest Differential Pressure	Pa	41.6					> 5 Pa	Yes
Mean Velocity	m/s	8.09					-	-
Lowest Gas Velocity	m/s	6.91					-	-
Highest Gas Velocity	m/s	8.86					-	-
Ratio of Above	: 1	1.28					< 3 : 1	Yes
Maximum Angle of Swirl	°	NM	NM	NM	NM	NM	NM	NM
No Local Negative Flow	-	Yes					-	Yes

Where NM = Not Measured as no Isokinetic sampling was performed.

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PLANT PHOTOS

Photo 1



Photo 2



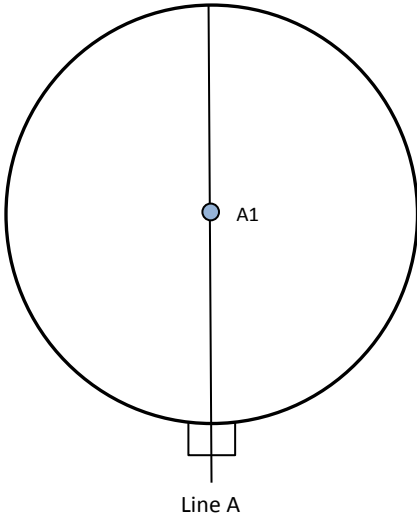
Photo 3



Photo 4



SAMPLE POINTS



- where

○ = isokinetic point sampled at

● = isokinetic point not sampled at

● = combustion gases sample point

○ = non-isokinetic sample point

APPENDICES

APPENDIX CONTENTS

APPENDIX 1 - Stack Emissions Monitoring Personnel, List of Equipment & Methods and Technical Procedures Used

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

APPENDIX 1

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Harpreet Badwal	MCERTS Level 2	MM 03 149	TE1 TE2 TE3 TE4
Team Leader	Lee Heaton	MCERTS Level 2	MM 17 1433	TE1

LIST OF EQUIPMENT

Extractive Sampling		Instrumental Analysers		Miscellaneous Items	
Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.
Control Box DGM (1)	-	Horiba PG-350E	-	Digital Manometer (1)	CAT 3.142
Control Box DGM (2)	-	Horiba PG-250	-	Digital Manometer (2)	CAT 3.144
Box Thermocouples (1)	-	Servomex 5200 MP	-	Digital Temperature Meter	-
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 14.84
Umbilical (1)	-	ABB AO2020-URAS26	-	Barometer	CAT 13.40
Umbilical (2)	-	Testo 350 XL	-	Stack Thermocouple (1)	CAT 4.1281
Oven Box (1)	-	Ankersmid APS 313	-	Stack Thermocouple (2)	CAT 4.870
Oven Box (2)	-	Gasmet DX4000	-	Stack Thermocouple (3)	-
Heated Probe (1)	-	Gasmet Sampling System	-	1m Heated Line (1)	-
Heated Probe (2)	-	Bernath 3006 FID	CAT 8.31	1m Heated Line (2)	-
Heated Probe (3)	-	M&C PSS	CAT 12.107	1m Heated Line (3)	-
S-Pitot (1)	CAT 21S.57	Mass Flow Controller (1)	CAT 6.61	5m Heated Line (1)	-
S-Pitot (2)	-	Mass Flow Controller (2)	CAT 6.62	15m Heated Line (1)	CAT 20.117
L-Pitot	CAT 21L.44	Mass View (1)	-	20m Heated Line (1)	-
Site Balance	CAT 17.33	Mass View (2)	-	20m Heated Line (2)	-
500g / 1Kg Check Weights	CAT 17.33 a & b	Hioki 5043 (V)	CAT 11.69	Dual Channel Heater Controller	-
Last Impinger Arm	-	Easylogger EN-EL-12 Bit	-	Single Channel Heater Controller	CAT 20.117
Callipers	-	Bioaerosols Temperature Logger	-	Laboratory Balance	-
Tubes Kit Thermocouple	-	Electronic Refrigerator	-	Tape Measure	CAT 16.45

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.40
Stack Width, W	m	-
Stack Area, A	m ²	0.13
Average Stack Gas Temperature, T _a	°C	18.9
Average Stack Gas Pressure	Pa	57.5
Average Stack Static Pressure, P _{static}	kPa	0.11
Average Barometric Pressure, P _b	kPa	99.1
Average Pitot Tube Calibration Coefficient, C _p	-	0.82

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m ³ p	Conc kg/m ³ p _i
CO ₂ (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.0012
O ₂ (Estimated)	-	20.80	20.70	0.2080	32.00	1.4277	0.2970
N ₂	-	79.14	78.74	0.7914	28.01	1.2498	0.9891
Moisture (H ₂ O) (Estimated)	-	-	0.50	0.0050	18.02	0.8037	0.0040

NOTE: Moisture has been estimated as no moisture test was performed on the date(s) of testing

Where: $p = M / 22.41$

$p_i = r \times p$

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P _{STD}	kg/m ³	1.2873
Wet Density (STP), P _{STW}	kg/m ³	1.2848
Dry Density (Actual), P _{Actual}	kg/m ³	1.1793
Average Wet Density (Actual), P _{ActualW}	kg/m ³	1.1770

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

P_{STW} = sum of all wet concentrations / 100 x density, kg/m³ (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW} \text{ (at each sampling point)} = P_{STW} \times (T_s / P_s) \times (P_a / T_a)$

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF ¹
Temperature	°C	18.9	0.00
Total Pressure	kPa	99.2	101.3
Moisture	%	1.00	1.00

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m ³ /hr	3660
Gas Volumetric Flowrate (STP, Wet)	m ³ /hr	3353
Gas Volumetric Flowrate (STP, Dry)	m ³ /hr	3319
Gas Volumetric Flowrate REF ¹	m ³ /hr	3353

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID)
(1 of 1)

Parameter	Units	Value
Date of Survey	-	28/01/2020
Time of Survey	-	11:40 - 11:51
Atmospheric Pressure	kPa	99.1
Average Stack Static Pressure	Pa	108
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 210 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C _p	-	0.82
Number of Lines Available	-	2
Number of Lines Used	-	2

Sampling Line A							Sampling Line B					
Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °	
STATIC (Units: Pa)		111.5					104.2					
Mean		54.2	18.8	1.177	7.84		60.8	18.9	1.177	8.34		
1	0.06	41.6	18.7	1.178	6.91		53.2	18.8	1.177	7.82		
2	0.34	66.8	18.9	1.177	8.76		68.3	19.0	1.176	8.86		

APPENDIX 2

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE TO EN 16911-1 (MID) - MEASUREMENT UNCERTAINTY

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	$u(k)$	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	$u(\Delta p_i)$	1.227	Pa
- Resolution	$u(res)$	0.00087	
- Calibration	$u(cal)$	0.344	
- Drift	$u(drift)$	0.083	
- Lack of Fit	$u(fit)$	0.078	
- Overall corrections to dynamic measurements	$u(Cf)$	0.506	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00003	-
- $\phi O_2, w$	-	20.696	
- $\phi CO_2, w$	-	0.060	
- Oxygen, dry	$u(\phi O_2, d)$	0.637	
- Carbon Dioxide, dry	$u(\phi CO_2, d)$	0.002	
- Water Vapour	$u(\phi H_2O)$	0.026	
- Oxygen, wet	$u(\phi O_2, w)$	0.634	
- Carbon Dioxide, wet	$u(\phi CO_2, w)$	0.002	
Standard uncertainty associated with the stack temperature	$u(T_c)$	1.489	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.694	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	0.868	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00636	-
Standard uncertainty associated with the local velocities	$u(v_i)$	0.138	Pa
Standard uncertainty associated with the mean velocity	$u(\bar{v})$	0.114	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	0.224	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	2.77	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV, w)$	194.2	m ³ /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV, w)/q^2V, w$	-	0.00073	
- $u^2(qV, w)$	-	9820	
- $u(qV, w)$	-	99.1	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV, w)$	5.31	%

APPENDIX 2

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Xaarjet Ltd, Huntingdon
LEV 2 - CR1 Room Extract

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m ³	4.88	3.64	3.27	3.93
Uncertainty	±mg/m ³	0.44	0.43	0.43	0.43
Mass Emission	g/hr	16.4	12.2	11.0	13.2
Uncertainty	±g/hr	1.70	1.58	1.55	1.61

General Sampling Information

Parameter	Value
Standard	EN 12619:2013
Technical Procedure	CAT-TP-20
Probe Material	Stainless Steel
Filtration Type / Size	0.1µm Glass Fibre
Heated Head Filter Used	Yes
Heated Line Temperature	180°C
Span Gas Type	Propane In Synthetic Air (5 Grade)
Span Gas Reference Number	CYL 1.0335a
Span Gas Expiry Date	21/08/2023
Span Gas Start Pressure (bar)	135
Gas Cylinder Concentration (ppm)	79.9
Span Gas Set Point (ppm)	79.9
Span Gas Uncertainty (%)	N/A
Zero Gas Type	Synthetic Air (5 Grade)
Number of Sampling Lines Used	1 / 1
Number of Sampling Points Used	1 / 1
Sample Point I.D.'s	A1

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TOTAL VOCs (as CARBON): DATA TREND

Graphical Trend of Data



TOTAL VOCs (as CARBON): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	12:12 - 12:42	12:42 - 13:12	13:12 - 13:42
Sampling Dates	-	28/01/2020	28/01/2020	28/01/2020
Instrument Range	ppm	100	100	100
Span Gas Value	ppm	79.9	79.9	79.9

Quality Assurance

	Zero Drift	Units	Run 1	Run 2	Run 3
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.00	0.00	0.00
	Zero Down Sampling Line (Post)	ppm	0.30	0.30	0.30
	Zero Drift	ppm	0.30	0.30	0.30
	Allowable Zero Drift	± ppm	4.00	4.00	4.00
	Zero Drift Acceptable	-	Yes	Yes	Yes

	Span Drift	Units	Run 1	Run 2	Run 3
CAL 1	Span Down Sampling Line (Pre)	ppm	79.9	79.9	79.9
	Span Down Sampling Line (Post)	ppm	78.9	78.9	78.9
	Span Drift	ppm	-1.00	-1.00	-1.00
	Allowable Span Drift	± ppm	4.00	4.00	4.00
	Span Drift Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Run Ambient Temperature Range	°C	5 - 10	5 - 10	5 - 10

Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number		
	1	2	3
There are no deviations associated with the sampling employed.	x	x	x

TOTAL VOCs (as CARBON): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Limit value	75.0	75.0	75.0	mg/m ³ (REF)
TGN M2 Allowable MU	15.0	15.0	15.0	%
Measured concentration	4.93	3.68	3.30	mg/m ³ (STP, dry)
Range Used	100.0	100.0	100.0	ppm
Range Used [A]	160.6	160.6	160.6	mg/m ³
Cal gas conc.	79.9	79.9	79.9	ppm
Conversion	1.61	1.61	1.61	ppm to mg/m ³
MCERTS Range [B]	15.0	15.0	15.0	mg/m ³
Lower of [A] or [B]	15.0	15.0	15.0	mg/m ³
Cal gas conc.	128.3	128.3	128.3	mg/m ³

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Response time	45	45	45	seconds
Number of readings in measurement	30	30	30	-
Repeatability at zero	2.00	2.00	2.00	% full scale
Repeatability at span level	0.00	0.00	0.00	% full scale
Deviation from linearity	0.11	0.11	0.11	% of value
Zero drift	0.38	0.38	0.38	% full scale
Span drift	-1.25	-1.25	-1.25	% full scale
Volume or pressure flow dependence	1.60	1.60	1.60	% of full scale
Atmospheric pressure dependence	0.30	0.30	0.30	% of value/kPa
Ambient temperature dependence	1.40	1.40	1.40	% full scale/10K
Combined interference	0.45	0.45	0.45	% range
Dependence on voltage	0.50	0.50	0.50	% full scale/10V
Losses in the line (leak)	0.00	0.00	0.00	% of value
Uncertainty of calibration gas	2.00	2.00	2.00	% of value

Performance characteristic	RUN 1	RUN 2	RUN 3	Units
Standard deviation of repeatability at zero	use rep at span	use rep at span	use rep at span	mg/m ³
Standard deviation of repeatability at span level	0.00	0.00	0.00	mg/m ³
Lack of fit	0.01	0.01	0.01	mg/m ³
Drift	0.00	0.00	0.00	mg/m ³
Volume or pressure flow dependence	0.00	0.00	0.00	mg/m ³
Atmospheric pressure dependence	0.01	0.01	0.01	mg/m ³
Ambient temperature dependence	0.20	0.20	0.20	mg/m ³
Combined interference (from MCERTS Certificate)	0.04	0.04	0.04	mg/m ³
Dependence on voltage	0.06	0.06	0.06	mg/m ³
Losses in the line (leak)	0.00	0.00	0.00	mg/m ³
Uncertainty of calibration gas	0.06	0.04	0.04	mg/m ³

Measurement uncertainty	Result	RUN 1	RUN 2	RUN 3	Units
Combined uncertainty		4.93	3.68	3.30	mg/m ³
Expanded uncertainty	k = 1.96	0.23	0.22	0.22	mg/m ³
Uncertainty corrected to std conds. (O ₂)		0.44	0.44	0.43	mg/m ³ (REF)

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O ₂) - at 95% Confidence	8.96	11.83	13.12	% of Value
Expanded uncertainty (no O ₂) - at 95% Confidence	0.59	0.58	0.58	% at ELV
Overall Allowable uncertainty (no O ₂) - at 95% Confidence	15.0	15.0	15.0	% at ELV
Result of Compliance with Uncertainty Requirement in M2	COMPLIANT	COMPLIANT	COMPLIANT	-

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (with O ₂) - at 95% Confidence	N/A	N/A	N/A	% of Value
Expanded uncertainty (with O ₂) - at 95% Confidence	N/A	N/A	N/A	% at ELV
Overall Allowable uncertainty (with O ₂) - at 95% Confidence	N/A	N/A	N/A	% at ELV
Result of Compliance with Uncertainty Requirement in M2	N/A	N/A	N/A	-

Requirement for SRM is that Uncertainty should be <15% of the value at the ELV, on a dry gas basis, or if O₂ correction is applied less than 15% + the uncertainty associated with the O₂ correction (using sqrt of sum squares to add uncertainty components). Ref EA TGN M2.