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Stack Emissions Testing Report Commissioned by
Xaarjet Ltd

Installation Name & Address
Xaarjet Ltd
1 Hurricane Close
Ermine Business Park
Huntingdon
Cambridgeshire
PE29 6XX

PPC Permit: B22/11

Stack Reference
2 - CR1 Room Extract

Dates of the Monitoring Campaign
22nd January 2018

Job Reference Number
CAT-3936

Report Written by
Harpreet Badwal Team Leader MCERTS Level 2 MM 03 149 TE1 TE2 TE3 TE4

Report Approved by
James Eldridge Deputy Regional Manager MCERTS Level 2 MM 05 641 TE1 TE2 TE3 TE4

Report Date
2nd February 2018

Version
Version 1

Signature of Report Approver


CONTENTS

Opinions and interpretations expressed herein are outside the scope of Exova Catalyst's ISO 17025 accreditation.

Executive Summary

MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
2 - CR1 Room Extract
22nd January 2018

Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by Xaarjet Ltd to carry out stack emissions testing on the 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)

Executive Summary

MONITORING RESULTS

Xaarjet Ltd, Huntingdon
2 - CR1 Room Extract
22nd January 2018

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
Total VOCs (as Carbon) [1]	mg/m³	4.4	0.58	75	g/hr	9.4	1.4	-
Stack Gas Temperature	°C	22.2						
Stack Gas Velocity	m/s	8.7	0.29					
Volumetric Flow Rate (ACTUAL)	m³/hr	2351	132					
Volumetric Flow Rate (REF) [1]	m³/hr	2156	121					

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.

MONITORING DATE(S) & TIMES

Xaarjet Ltd, Huntingdon
2 - CR1 Room Extract
22nd January 2018

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total VOCs (as Carbon)	R1	mg/m³	3.4	g/hr	7.4	22/01/2018	11:53 - 12:23	30
Total VOCs (as Carbon)	R2	mg/m³	4.0	g/hr	8.7	22/01/2018	12:23 - 12:53	30
Total VOCs (as Carbon)	R3	mg/m³	5.6	g/hr	12.1	22/01/2018	12:53 - 13:23	30
Velocity Traverse	R1					22/01/2018	10:25 - 10:38	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Xaarjet Ltd, Huntingdon
2 - CR1 Room Extract
22nd January 2018

Standard Operating Conditions

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

Executive Summary

MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
2 - CR1 Room Extract
22nd January 2018

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**ISO 17025 Testing**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**ISO 17025 Analysis**	**Analysis Lab**	**MCERTS Testing**	**LOD (Average)**
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20	Yes	CAT	Flame Ionisation Detection by Sick 3006 FID				Yes	0.32 mg/m³
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	Yes	CAT	Pitot Tube and Thermocouple				Yes	1.2 m/s

ANALYSIS LABORATORIES

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

Exova Catalyst (CAT)	ISO 17025 Accreditation Number: 4279

SUMMARY OF SAMPLING DEVIATIONS

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

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.31
Width	m	-
Area	m²	0.08
Port Depth	cm	0
Orientation of Duct	-	Vertical
Number of Ports	-	2
Sample Port Size	-	2" 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	43.0		> 5 Pa	Yes
Mean Velocity	m/s	8.65		-	-
Lowest Gas Velocity	m/s	7.15		-	-
Highest Gas Velocity	m/s	11.3		-	-
Ratio of Above	: 1	1.58		< 3 : 1	Yes
Maximum Angle of Swirl	°	NM		< 15°	NM
No Local Negative Flow	-	Yes		-	Yes

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

PLANT PHOTOS

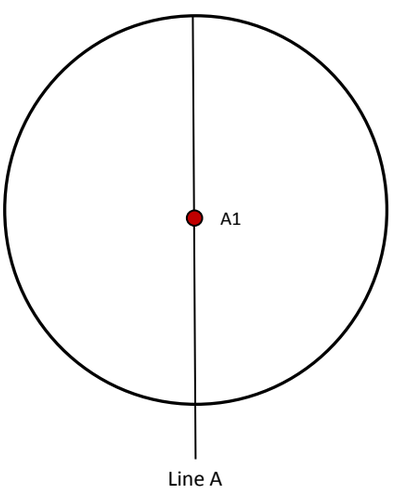
Photo 1

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

APPENDIX CONTENTS

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
Technician	Mathew Miller	MCERTS Level 1	MM 14 1313	None

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	-
Control Box DGM (2)	-
Box Thermocouples (1)	-
Box Thermocouples (2)	-
Umbilical (1)	-
Umbilical (2)	-
Oven Box (1)	-
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	-
Heated Probe (3)	-
S-Pitot (1)	CAT 21S.57
S-Pitot (2)	-
L-Pitot	CAT 21L.44
Site Balance	-
500g / 1Kg Check Weights	-
Last Impinger Arm	-
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-350E	-
Horiba PG-250	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
Ankersmid APS 313	-
ProtIR 204M	-
Gasmet Sampling System	-
Bernath 3006 FID	CAT 8.31
M&C PSS	CAT 12.107
Mass Flow Controller (1)	CAT 6.61
Mass Flow Controller (2)	CAT 6.62
Mass View (1)	-
Mass View (2)	-
Hioki 5043 (V)	CAT 11.69
Easylogger EN-EL-12 Bit	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.142
Digital Manometer (2)	CAT 3.144
Digital Temperature Meter	-
Stopwatch	CAT 14.84
Barometer	CAT 13.40
Stack Thermocouple (1)	CAT 4.874
Stack Thermocouple (2)	CAT 4.870
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	CAT 20.117
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	CAT 20.117
Laboratory Balance	
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	0.31
Stack Width, W	m	-
Stack Area, A	m²	0.08
Average Stack Gas Temperature, T_a	°C	22.2
Average Stack Gas Pressure	Pa	64.5
Average Stack Static Pressure, P_{static}	kPa	0.133
Average Barometric Pressure, P_b	kPa	100.3
Average Pitot Tube Calibration Coefficient, C_p	-	0.84

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m³ p	Conc kg/m³ p_i
CO_2 (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O_2 (Estimated)	-	20.80	20.70	0.2080	32.00	1.4277	0.29696
N_2	-	79.14	78.74	0.7914	28.01	1.2498	0.98913
Moisture (H_2O) (Estimated)	-	-	0.50	0.0050	18.02	0.8037	0.00402

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/m³	1.287
Wet Density (STP), P_{STW}	kg/m³	1.285
Dry Density (Actual), P_{Actual}	kg/m³	1.180
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	1.178

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)

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

$P_{ActualW}$ (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	22.2	0.0
Total Pressure	kPa	100.4	101.3
Moisture	%	1.00	1.00

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	2351
Gas Volumetric Flowrate (STP, Wet)	m³/hr	2156
Gas Volumetric Flowrate (STP, Dry)	m³/hr	2134
Gas Volumetric Flowrate REF [1]	m³/hr	2156

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	22/01/2018
Time of Survey	-	10:25 - 10:38
Atmospheric Pressure	kPa	100.3
Average Stack Static Pressure	Pa	133
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	-	0.84
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)		*131.0*					*134.0*				
Mean		**67.0**	**22.2**	**1.178**	**8.77**		**62.0**	**22.2**	**1.178**	**8.53**	
1	0.02	46.0	22.0	1.179	7.40		83.0	21.9	1.179	9.93	
2	0.08	43.0	22.2	1.178	7.15		68.0	22.1	1.178	9.00	
3	0.23	72.0	22.3	1.178	9.26		52.0	22.3	1.178	7.87	
4	0.29	107.0	22.3	1.178	11.29		45.0	22.4	1.177	7.32	

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(Δpi)	1.271	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	0.433	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	0.098	
- Overall corrections to dynamic measurements	u(Cf)	0.616	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.696	
- $\varphi CO_2,w$	-	0.060	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.026	
- Oxygen, wet	u(ϕO_2,w)	0.634	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.506	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.694	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	0.899	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00635	-
Standard uncertainty associated with the local velocities	u(vi)	0.171	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.148	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.290	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	3.35	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	132.4	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00083	
- $u^2(qV,w)$	-	4562	
- u(qV,w)	-	67.5	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	5.63	%

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Xaarjet Ltd, Huntingdon
2 - CR1 Room Extract

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m³	3.4	4.0	5.6	4.4
Uncertainty	±mg/m³	0.58	0.58	0.59	0.58
Mass Emission	g/hr	7.4	8.7	12.1	9.4
Uncertainty	±g/hr	1.3	1.3	1.5	1.4

General Sampling Information

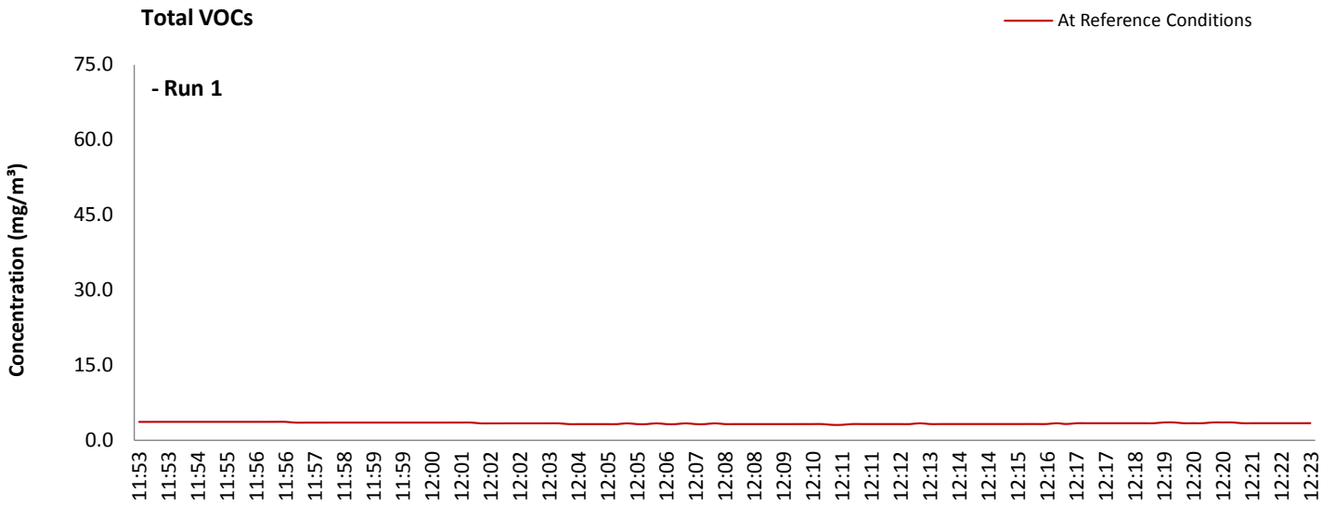
Parameter	Value	
Standard	EN 12619:2013	
Technical Procedure	CAT-TP-20	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Propane In Synthetic Air (5 Grade)	
Span Gas Reference Number	CYL 1.0293a	
Span Gas Expiry Date	12/09/2021	
Span Gas Start Pressure (bar)	80	
Gas Cylinder Concentration (ppm)	79.9	
Span Gas Set Point (ppm)	79.90	
Span Gas Uncertainty (%)	N/A	
Zero Gas Type	Synthetic Air (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

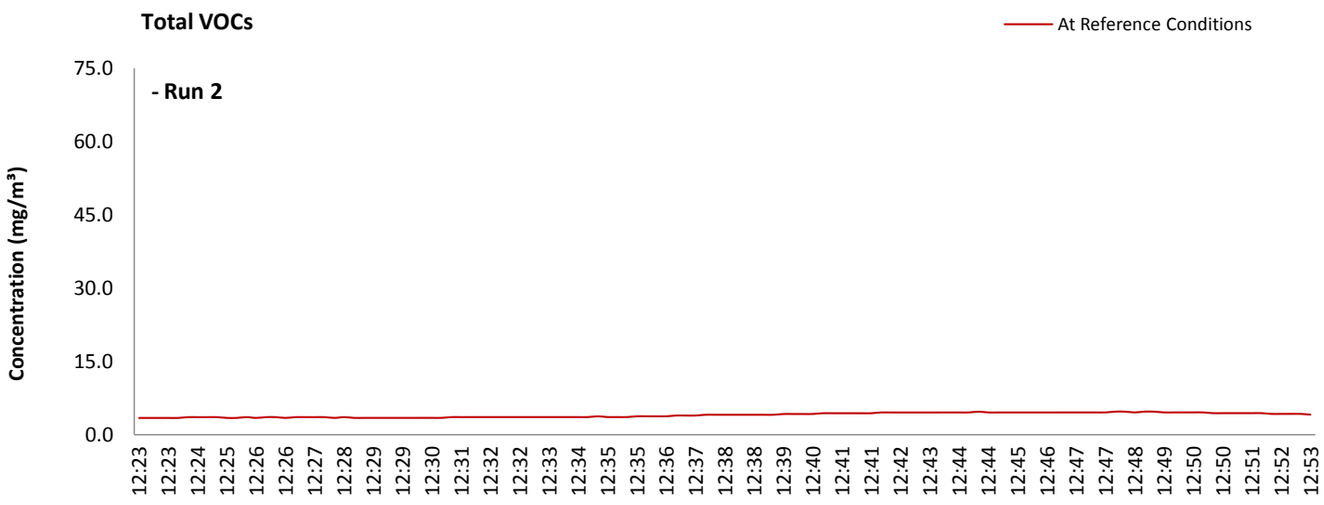
Reference Conditions

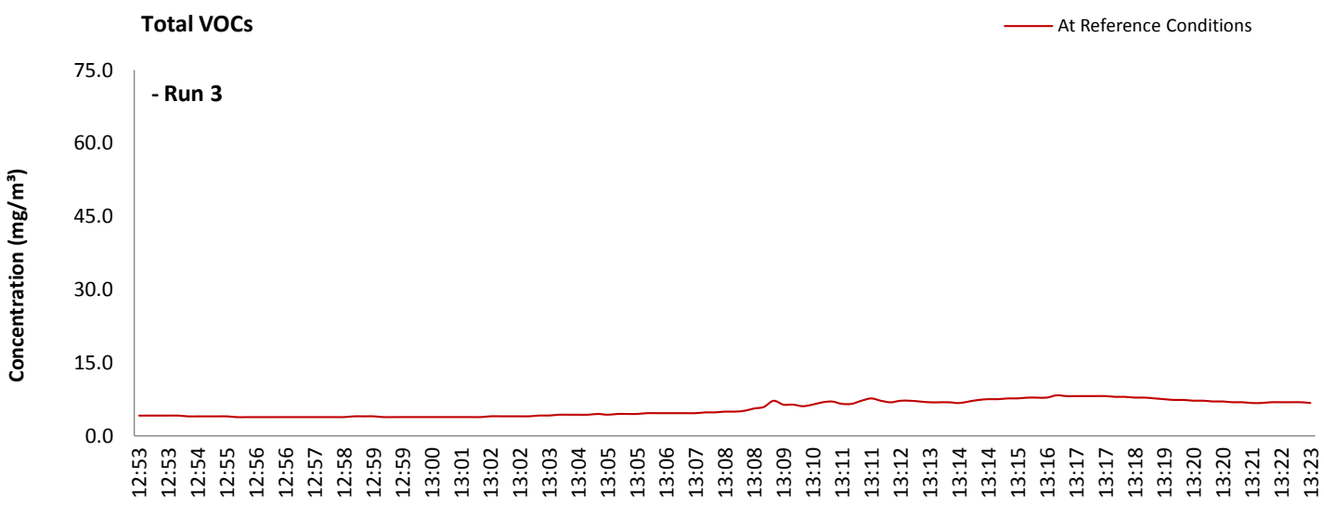
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

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	-	11:53 - 12:23	12:23 - 12:53	12:53 - 13:23
Sampling Dates	-	22/01/2018	22/01/2018	22/01/2018
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	-0.20	-0.20	-0.20
	Zero Drift	ppm	-0.20	-0.20	-0.20
	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	80.00	80.00	80.00
	Span Down Sampling Line (Post)	ppm	79.50	79.50	79.50
	Span Drift	ppm	-0.50	-0.50	-0.50
	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	4 - 9	4 - 9	4 - 9

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/m³ (REF)
TGN M2 Allowable MU	15.0	15.0	15.0	%
Measured concentration	3.45	4.08	5.67	mg/m³ (STP, dry)
Range Used	100.0	100.0	100.0	ppm
Range Used [A]	160.6	160.6	160.6	mg/m³
Cal gas conc.	79.9	79.9	79.9	ppm
Conversion	1.61	1.61	1.61	ppm to mg/m³
MCERTS Range [B]	15.0	15.0	15.0	mg/m³
Lower of [A] or [B]	15.0	15.0	15.0	mg/m³
Cal gas conc.	128.3	128.3	128.3	mg/m³

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	0.00	0.00	0.00	% of value
Zero drift	-0.25	-0.25	-0.25	% full scale
Span drift	-0.63	-0.63	-0.63	% 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/m³
Standard deviation of repeatability at span level	0.00	0.00	0.00	mg/m³
Lack of fit	0.00	0.00	0.00	mg/m³
Drift	-0.20	-0.20	-0.21	mg/m³
Volume or pressure flow dependence	0.00	0.00	0.00	mg/m³
Atmospheric pressure dependence	0.01	0.01	0.01	mg/m³
Ambient temperature dependence	0.20	0.20	0.20	mg/m³
Combined interference (from MCERTS Certificate)	0.04	0.04	0.04	mg/m³
Dependence on voltage	0.06	0.06	0.06	mg/m³
Losses in the line (leak)	0.00	0.00	0.00	mg/m³
Uncertainty of calibration gas	0.04	0.05	0.07	mg/m³

			RUN 1	RUN 2	RUN 3	Units
Measurement uncertainty		**Result**	3.45	4.08	5.67	mg/m³
Combined uncertainty			0.30	0.30	0.31	mg/m³
Expanded uncertainty	k =	1.96	0.58	0.59	0.60	mg/m³
Uncertainty corrected to std conds. (O_2)			0.58	0.59	0.60	mg/m³ (REF)

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O_2) - at 95% Confidence	16.86	14.37	10.60	% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	0.78	0.78	0.80	% 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 O_2 correction is applied less than 15% + the uncertainty associated with the O_2 correction (using sqrt of sum squares to add uncertainty components). Ref EA TGN M2.