Element Materials Technology, Unit 3, Wednesbury One, Black Country New Road, Wednesbury, WS10 7NZ
Your Element Contact: James Eldridge (07826 916 684)
E: james.eldridge@element.com

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 9 - CR2 Room Extract

Dates of the Monitoring Campaign
29th January 2020

Job Reference Number
EST-5428

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

Report Approved by
Matthew Pendlebury Team Leader MCERTS Level 2 MM 04 535 TE1 TE2 TE3 TE4

Report Date
13th February 2020

Version
Version 1

Signature of Report Approver


CONTENTS

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

Executive Summary

MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
LEV 9 - CR2 Room Extract
29th January 2020

Overall Aim of the Monitoring Campaign

Element were commissioned by Xaarjet Ltd to carry out stack emissions testing on the LEV 9 - CR2 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
LEV 9 - CR2 Room Extract
29th January 2020

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	28.0	0.77	75	g/hr	79.6	5.06	-
Stack Gas Temperature	°C	20.2						
Stack Gas Velocity	m/s	12.1	0.42					
Volumetric Flow Rate (ACTUAL)	m³/hr	3074	176					
Volumetric Flow Rate (REF) [1]	m³/hr	2840	162					

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.

Executive Summary

MONITORING DATE(S) & TIMES

Xaarjet Ltd, Huntingdon
LEV 9 - CR2 Room Extract
29th January 2020

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total VOCs (as Carbon)	R1	mg/m³	42.8	g/hr	121	29/01/2020	13:00 - 13:30	30
Total VOCs (as Carbon)	R2	mg/m³	16.3	g/hr	46.4	29/01/2020	13:30 - 14:00	30
Total VOCs (as Carbon)	R3	mg/m³	24.9	g/hr	70.8	29/01/2020	14:00 - 14:30	30
Velocity Traverse	R1					29/01/2020	12:42 - 12:53	

All results are expressed at the respective reference conditions.

Executive Summary

(Page 4 of 7)

PROCESS DETAILS

Xaarjet Ltd, Huntingdon
LEV 9 - CR2 Room Extract
29th 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

MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
LEV 9 - CR2 Room Extract
29th January 2020

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**Sampling Accreditation**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**Analysis Accreditation**	**Analysis Lab**	**Overall Accreditation**	**LOD (Average)**
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20	MCERTS	EET	Flame Ionisation Detection by Sick 3006 FID				MCERTS	0.32 mg/m³
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.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.30
Width	m	-
Area	m²	0.07
Port Depth	cm	0
Orientation of Duct	-	Horizontal
Number of Ports	-	2
Sample Port Size	-	Hole

Location of Sampling Platform

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

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)	N/A
Platform has vertical base boards (approx. 0.25m high)	N/A
Platform has chains / self closing gates at top of ladders	N/A
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	113.4					> 5 Pa	Yes
Mean Velocity	m/s	12.08					-	-
Lowest Gas Velocity	m/s	11.37					-	-
Highest Gas Velocity	m/s	12.54					-	-
Ratio of Above	: 1	1.10					< 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.

Executive Summary

(Page 7 of 7)

PLANT PHOTOS

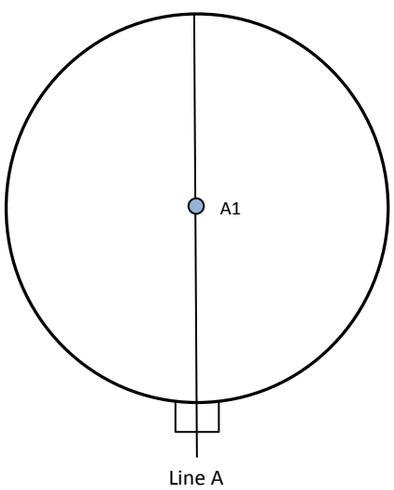
Photo 1

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
Team Leader	Lee Heaton	MCERTS Level 2	MM 17 1433	TE1

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	CAT 17.33
500g / 1Kg Check Weights	CAT 17.33 a & b
Last Impinger Arm	-
Callipers	-
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-350E	-
Horiba PG-250	-
Servomex 5200 MP	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Testo 350 XL	-
Ankersmid APS 313	-
Gasmet DX4000	-
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 4.1281
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	0.30
Stack Width, W	m	-
Stack Area, A	m²	0.07
Average Stack Gas Temperature, T_a	°C	20.2
Average Stack Gas Pressure	Pa	128
Average Stack Static Pressure, P_{static}	kPa	0.20
Average Barometric Pressure, P_b	kPa	100.3
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/m³ p	Conc kg/m³ 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_2O) (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 x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m³	1.2873
Wet Density (STP), P_{STW}	kg/m³	1.2848
Dry Density (Actual), P_{Actual}	kg/m³	1.1893
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	1.1871

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	20.2	0.00
Total Pressure	kPa	100.5	101.3
Moisture	%	1.00	1.00

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	3074
Gas Volumetric Flowrate (STP, Wet)	m³/hr	2840
Gas Volumetric Flowrate (STP, Dry)	m³/hr	2811
Gas Volumetric Flowrate REF [1]	m³/hr	2840

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	29/01/2020
Time of Survey	-	12:42 - 12:53
Atmospheric Pressure	kPa	100.3
Average Stack Static Pressure	Pa	199
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	-	Horizontal
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)		*197.2*					*200.1*				
Mean		**130.8**	**20.0**	**1.188**	**12.20**		**125.6**	**20.3**	**1.186**	**11.95**	
1	0.04	127.3	19.9	1.188	12.04		113.4	20.2	1.187	11.37	
2	0.26	134.2	20.1	1.187	12.36		137.8	20.4	1.186	12.54	

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)	2.366	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	1.711	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	2.802	
- Overall corrections to dynamic measurements	u(Cf)	4.597	
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)	1.496	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.700	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	1.673	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00640	-
Standard uncertainty associated with the local velocities	u(vi)	0.236	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.215	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.422	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	3.49	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	175.8	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00085	
- $u^2(qV,w)$	-	8042	
- u(qV,w)	-	89.7	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	5.72	%

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Xaarjet Ltd, Huntingdon
LEV 9 - CR2 Room Extract

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m³	42.8	16.3	24.9	28.0
Uncertainty	±mg/m³	1.06	0.56	0.71	0.77
Mass Emission	g/hr	121	46.4	70.8	79.6
Uncertainty	±g/hr	7.57	3.09	4.52	5.06

General Sampling Information

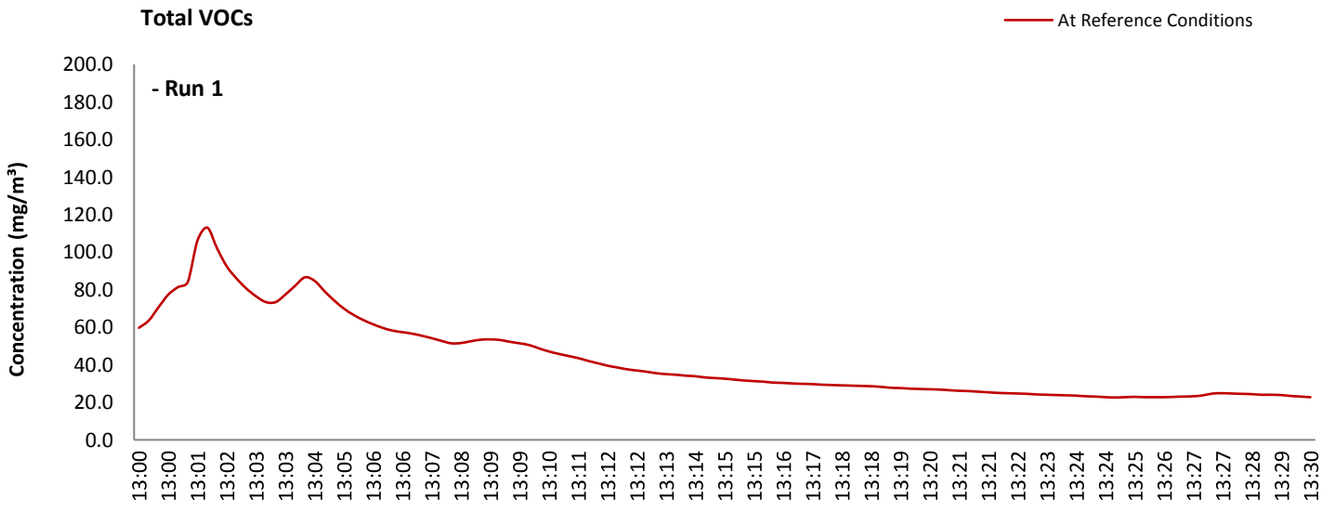
Parameter	Value	
Standard	EN 12619:2013	
Technical Procedure	CAT-TP-20	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Propane In Synthetic Air (5 Grade)	
Span Gas Reference Number	CYL 1.0335a	
Span Gas 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	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

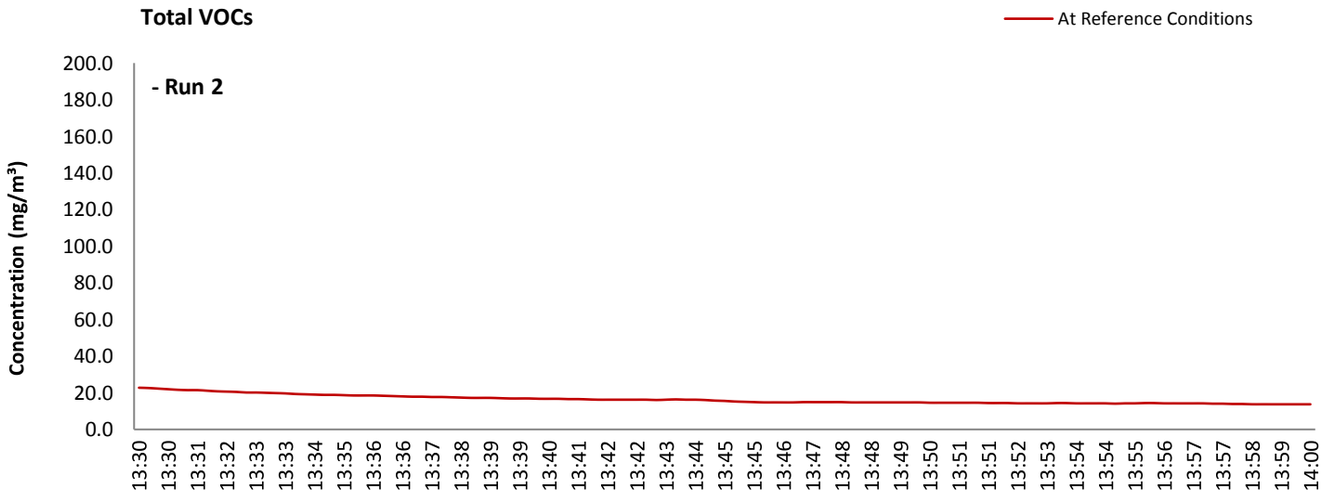
Reference Conditions

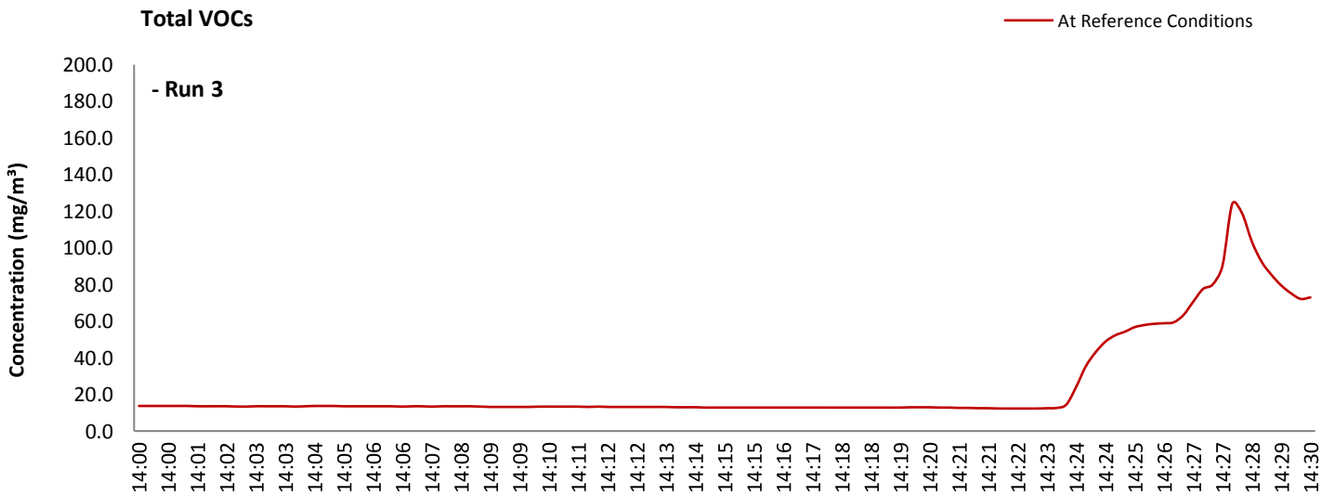
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

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	-	13:00 - 13:30	13:30 - 14:00	14:00 - 14:30
Sampling Dates	-	29/01/2020	29/01/2020	29/01/2020
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	0.50	0.50	0.50
	Zero Drift	ppm	0.50	0.50	0.50
	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	80.0	80.0	80.0
	Span Down Sampling Line (Post)	ppm	78.0	78.0	78.0
	Span Drift	ppm	-2.00	-2.00	-2.00
	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/m³ (REF)
TGN M2 Allowable MU	15.0	15.0	15.0	%
Measured concentration	43.22	16.49	25.19	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	0.11	0.11	0.11	% of value
Zero drift	0.63	0.63	0.63	% full scale
Span drift	0.00	0.00	0.00	% 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	0.01	0.01	0.01	mg/m³
Drift	0.00	0.00	0.00	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	0.50	0.19	0.29	mg/m³

			RUN 1	RUN 2	RUN 3	Units
Measurement uncertainty		**Result**	43.22	16.49	25.19	mg/m³
Combined uncertainty			0.54	0.29	0.36	mg/m³
Expanded uncertainty	k =	1.96	1.07	0.57	0.71	mg/m³
Uncertainty corrected to std conds. (O_2)			1.07	0.57	0.71	mg/m³ (REF)

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O_2) - at 95% Confidence	2.47	3.44	2.83	% of Value
Expanded uncertainty (no O_2) - at 95% Confidence	1.42	0.76	0.95	% 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.