Exova Catalyst, Unit C6, Emery Court, The Embankment Business Park, Heaton Mersey, Stockport, SK4 3GL
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: toby.campbell@exova.com
Your Exova Catalyst Contact: Toby Campbell (07825 130 074)

**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**
1 - CR1 Room Extract

**Dates of the Monitoring Campaign**
25th January 2017

**Job Reference Number**
CAT-3175

| Report Written by |
| --- |
| Harpreet Badwal<br>Team Leader<br>MCERTS Level 2<br>MM 03 149<br>TE1 TE2 TE3 TE4 |

| Report Approved by |
| --- |
| Brian Jacob<br>Team Leader<br>MCERTS Level 2<br>MM 06 693<br>TE1 TE2 TE3 TE4 |

| Report Date |
| --- |
| 23rd February 2017 |

| Version |
| --- |
| Version 1 |

| Signature of Report Approver |
| --- |
|  |

# CONTENTS

TITLE PAGE

CONTENTS

Summary of Sampling Deviations 2

EXECUTIVE SUMMARY

Monitoring Objectives 3

Monitoring Results 4

Monitoring Dates & Times 5

Process Details 6

Monitoring & Analytical Methods 7

Sampling Location 8

Plant Photos / Sample Points 9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts

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

*This test report shall not be reproduced, except in full, without the written approval of Exova Catalyst.*

## MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
1 - CR1 Room Extract
25th January 2017

**Overall Aim of the Monitoring Campaign**

Exova Catalyst were commissioned by Xaarjet Ltd to carry out stack emissions testing on the 1 - 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
1 - CR1 Room Extract
25th January 2017

*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 | 28.2 | 0.83 | 75 | g/hr | 100 | 6.1 | - |
| Stack Gas Temperature | | °C | 18.7 | | | | | | |
| Stack Gas Velocity | | m/s | 8.3 | 0.22 | | | | | |
| Volumetric Flow Rate (ACTUAL) | | m³/hr | 3772 | 198 | | | | | |
| Volumetric Flow Rate (REF) | [1] | m³/hr | 3561 | 187 | | | | | |

*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

1 - CR1 Room Extract

25th January 2017

| Parameter | | Units | Concentration | Units | Mass Emission | Sampling Date(s) | Sampling Times | Duration mins |
|---|---|---|---|---|---|---|---|---|
| Total VOCs (as Carbon) | R1 | mg/m³ | 38.9 | g/hr | 138 | 25/01/2017 | 11:47 - 12:17 | 30 |
| Total VOCs (as Carbon) | R2 | mg/m³ | 35.6 | g/hr | 127 | 25/01/2017 | 12:17 - 12:47 | 30 |
| Total VOCs (as Carbon) | R3 | mg/m³ | 10.0 | g/hr | 35.5 | 25/01/2017 | 12:47 - 13:17 | 30 |
| Velocity & Volumetric Flow Rate | R1 | | | | | 25/01/2017 | 10:43 - 10:55 | |

All results are expressed at the respective reference conditions.

## PROCESS DETAILS

Xaarjet Ltd, Huntingdon
1 - CR1 Room Extract
25th January 2017

### 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 | N/A |
| Abatement System Running Status | N/A |
| Fuel | N/A |
| Plume Appearance | None Visible |

## MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
1 - CR1 Room Extract
25th January 2017

| | 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 |
|---|---|---|
| Total VOC's | All | There are no deviations associated with the sampling employed. |

## SUITABILITY OF SAMPLING LOCATION

### Duct Characteristics

| Parameter | Units | Value |
|---|---|---|
| Type | - | Circular |
| Depth | m | 0.40 |
| Width | m | - |
| Area | m² | 0.13 |
| Port Depth | cm | 0 |
| Orientation of Duct | - | Vertical |
| 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 | 14.0 | | > 5 Pa | Yes |
| Mean Velocity | m/s | 8.34 | | - | - |
| Lowest Gas Velocity | m/s | 4.02 | | - | - |
| Highest Gas Velocity | m/s | 11.38 | | - | - |
| Ratio of Above | : 1 | 2.83 | | < 3 : 1 | Yes |
| Maximum Angle of Swirl | ° | 3 | | < 15° | Yes |
| No Local Negative Flow | - | Yes | | - | Yes |

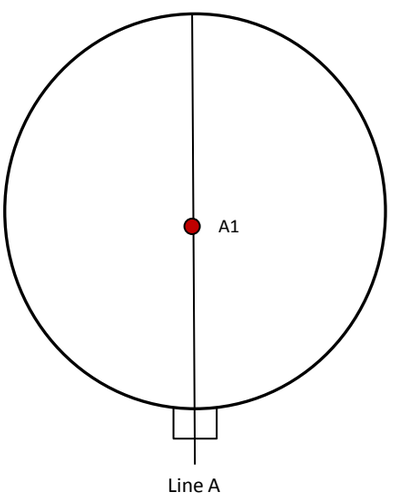
## PLANT PHOTOS

Photo 1

Photo 2

Photo 3

## SAMPLE POINTS




**where**
○ = isokinetic point sampled at
● = isokinetic point not sampled at
● = combustion gases sample point
● = non-isokinetic sample point

## APPENDIX CONTENTS

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## 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 | Aaron Nagha | MCERTS Trainee | MM 16 1392 | 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 | - |
| Servomex 5200MP | - |
| 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 4.874 |
| 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) | CAT 20.117 |
| 15m Heated Line (1) | - |
| 20m Heated Line (1) | CAT 20.116 |
| 20m Heated Line (2) | - |
| Dual Channel Heater Controller | - |
| Single Channel Heater Controller | CAT 20.116 |
| 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 | 0.40 |
| Stack Width, W | m | - |
| Stack Area, A | m² | 0.13 |
| Average Stack Gas Temperature, $T_a$ | °C | 18.7 |
| Average Stack Gas Pressure | Pa | 64.5 |
| Average Stack Static Pressure, $P_{static}$ | kPa | 0.076 |
| Average Barometric Pressure, $P_b$ | kPa | 102.1 |
| 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 | 1.215 |
| Average Wet Density (Actual), $P_{ActualW}$ | kg/m³ | 1.213 |

**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 | 18.7 | 0.0 |
| Total Pressure | kPa | 102.2 | 101.3 |
| Moisture | % | 0.50 | 0.50 |

| Gas Volumetric Flowrate (from Traverse) | Units | Result |
|---|---|---|
| Gas Volumetric Flowrate (Actual) | m³/hr | 3772 |
| Gas Volumetric Flowrate (STP, Wet) | m³/hr | 3561 |
| Gas Volumetric Flowrate (STP, Dry) | m³/hr | 3543 |
| Gas Volumetric Flowrate REF [1] | m³/hr | 3561 |

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

(1 of 1)

| Parameter | Units | Value |
|---|---|---|
| Date of Survey | - | 25/01/2017 |
| Time of Survey | - | 10:43 - 10:55 |
| Atmospheric Pressure | kPa | 102.1 |
| Average Stack Static Pressure | Pa | 76 |
| 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 | - | 1 |
| Number of Lines Used | - | 1 |

**Sampling Line A**

| Traverse Point | Depth m | ΔP Pa | Temp °C | Wet Density kg/m³ | Velocity m/s | Swirl ° |
|---|---|---|---|---|---|---|
| *STATIC (Units: Pa)* | | *76.0* | | | | |
| **Mean** | | **64.5** | **18.7** | **1.213** | **8.34** | |
| 1 | 0.01 | 14.0 | 18.7 | 1.213 | 4.02 | 2.0 |
| 2 | 0.03 | 26.0 | 18.7 | 1.213 | 5.48 | 3.0 |
| 3 | 0.06 | 35.0 | 18.7 | 1.213 | 6.36 | 2.0 |
| 4 | 0.09 | 57.0 | 18.7 | 1.213 | 8.12 | 2.0 |
| 5 | 0.14 | 68.0 | 18.7 | 1.213 | 8.87 | 1.0 |
| 6 | 0.26 | 73.0 | 18.7 | 1.213 | 9.19 | 2.0 |
| 7 | 0.31 | 72.0 | 18.7 | 1.213 | 9.12 | 2.0 |
| 8 | 0.34 | 86.0 | 18.7 | 1.213 | 9.97 | 1.0 |
| 9 | 0.37 | 112.0 | 18.7 | 1.213 | 11.38 | 1.0 |
| 10 | 0.39 | 102.0 | 18.7 | 1.213 | 10.86 | 1.0 |

## 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($\phi O_2$,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(Tc) | 1.488 | K |
| Standard uncertainty associated with the absolute pressure in the duct | u(pc) | 175.697 | Pa |
| *- Atmospheric Pressure* | u(patm) | 175.692 | |
| *- Static Pressure* | u(pstat) | 1.271 | |
| Standard uncertainty associated with the density in the duct | u(ρ) | 0.00653 | - |
| Standard uncertainty associated with the local velocities | u(vi) | 0.152 | Pa |
| Standard uncertainty associated with the mean velocity | u(v) | 0.113 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence) | Uc(v) | 0.222 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence), relative | Uc,rel(v) | 2.67 | % |
| Standard uncertainty associated with the volume flow rate (95% Confidence) | Uc(qV,w) | 198.2 | $m^3$/hr |
| *- $u^2(a)/a^2$* | - | 0.00053 | |
| *- $u^2(qV,w)/q^2V,w$* | - | 0.00072 | |
| *- $u^2(qV,w)$* | - | 10225 | |
| *- u(qV,w)* | - | 101.1 | |
| Standard uncertainty associated with the volume flow rate (95% Confidence), relative | Uc,rel(qV,w) | 5.25 | % |

# TOTAL VOCs (as CARBON): RESULTS SUMMARY

Xaarjet Ltd, Huntingdon
1 - CR1 Room Extract

## Sample Runs

| Parameter | Units | Run 1 | Run 2 | Run 3 | Mean |
|---|---|---|---|---|---|
| Concentration | mg/m³ | 38.9 | 35.6 | 10.0 | 28.2 |
| Uncertainty | ±mg/m³ | 0.99 | 0.92 | 0.57 | 0.83 |
| Mass Emission | g/hr | 138 | 127 | 35.5 | 100 |
| Uncertainty | ±g/hr | 8.1 | 7.4 | 2.8 | 6.1 |

## General Sampling Information

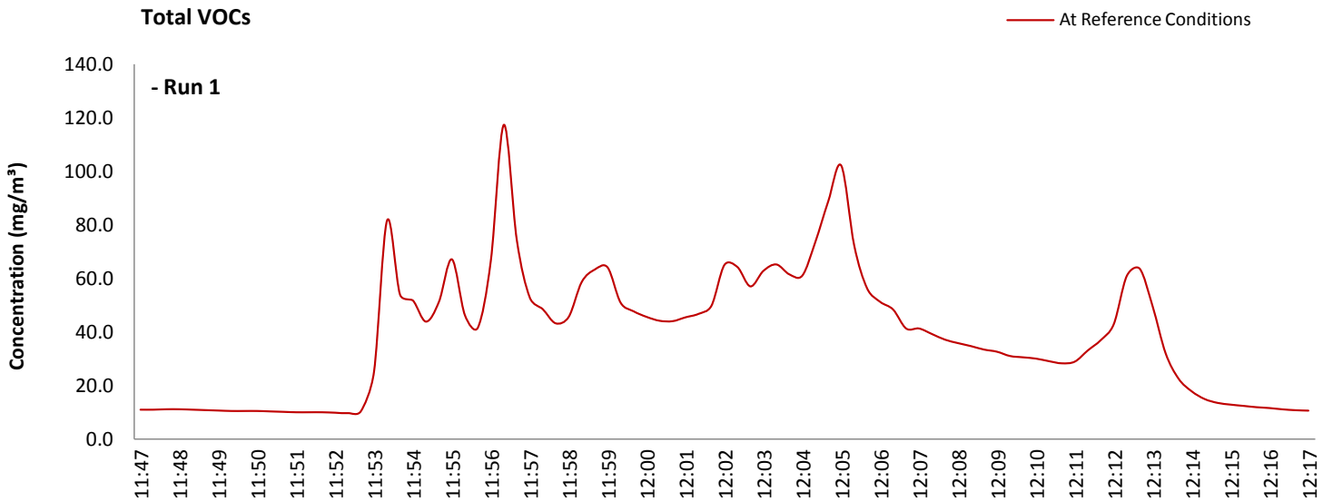
| Parameter | Value | |
|---|---|---|
| Standard | EN 12619:2013 | |
| Technical Procedure | CAT-TP-20 | |
| Probe Material | Stainless Steel | |
| Filtration Type / Size | 0.1µm Glass Fibre | |
| Heated Head Filter Used | Yes | |
| Heated Line Temperature | 180°C | |
| Span Gas Type | Propane In Synthetic Air (5 Grade) | |
| Span Gas Reference Number | CYL 1.0245a | |
| Span Gas Expiry Date | 10/09/2021 | |
| Span Gas Start Pressure (bar) | 85 | |
| Gas Cylinder Concentration (ppm) | 80.1 | |
| Span Gas Set Point (ppm) | 80.10 | |
| 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 | |

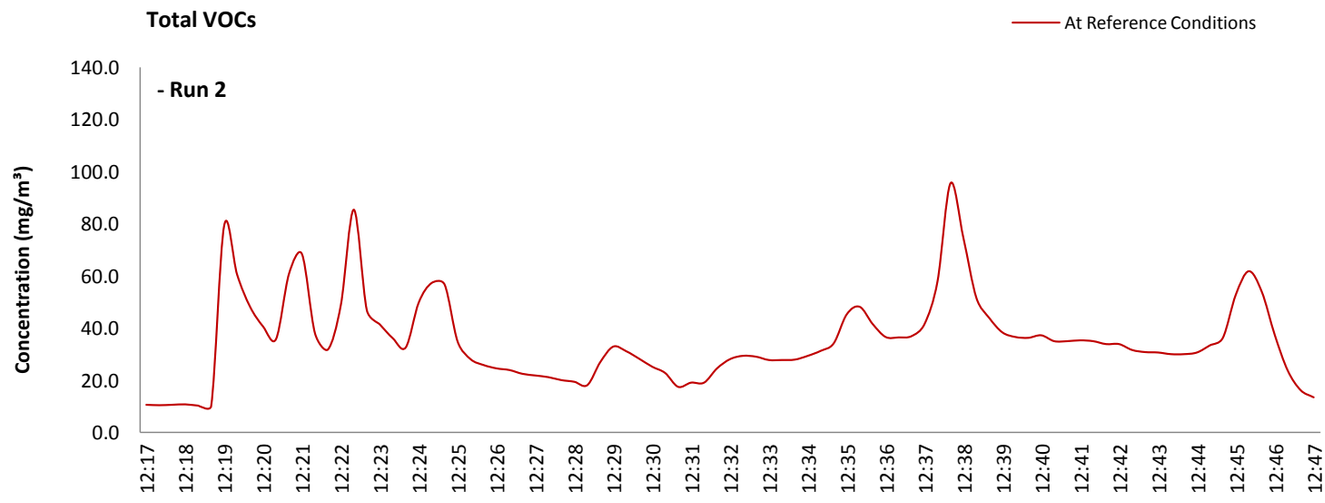
## Reference Conditions

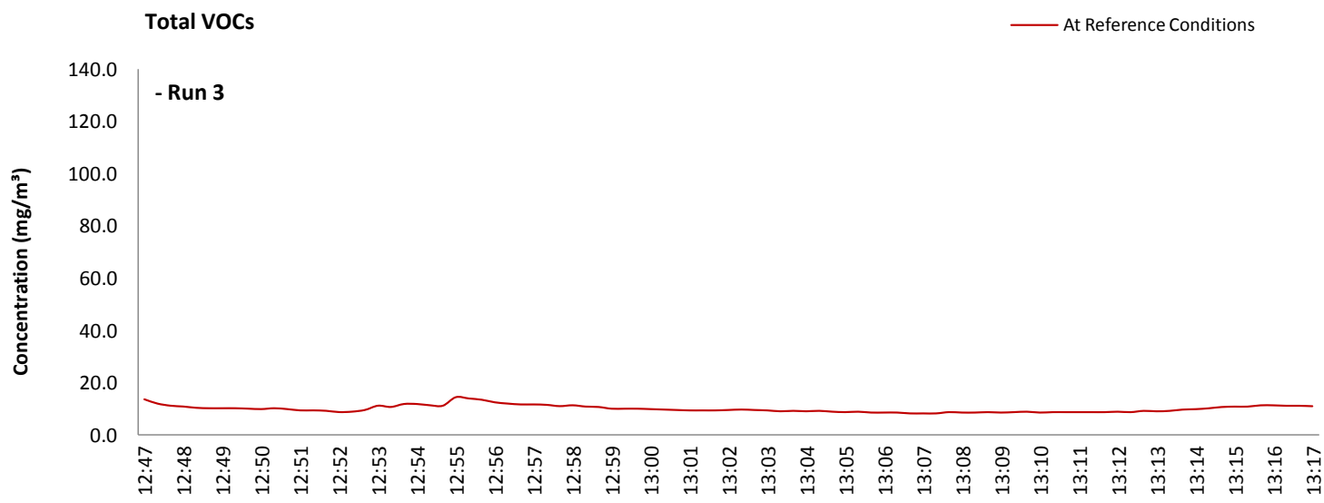
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

## 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 | - | 11:47 - 12:17 | 12:17 - 12:47 | 12:47 - 13:17 |
| Sampling Dates | - | 25/01/2017 | 25/01/2017 | 25/01/2017 |
| Instrument Range | ppm | 100 | 100 | 100 |
| Span Gas Value | ppm | 80.1 | 80.1 | 80.1 |

## 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 | 4.01 | 4.01 | 4.01 |
| | Zero Drift Acceptable | - | Yes | Yes | Yes |

| | Span Drift | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|---|
| CAL 1 | Span Down Sampling Line (Pre) | ppm | 80.30 | 80.30 | 80.30 |
| | Span Down Sampling Line (Post) | ppm | 79.90 | 79.90 | 79.90 |
| | Span Drift | ppm | -0.40 | -0.40 | -0.40 |
| | Allowable Span Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Span Drift Acceptable | - | Yes | Yes | Yes |

| Test Conditions | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|
| Run Ambient Temperature Range | °C | 7 - 14 | 7 - 14 | 7 - 14 |

## 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 | 39.05 | 35.79 | 10.03 | 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. | 80.1 | 80.1 | 80.1 | 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. | 128.7 | 128.7 | 128.7 | 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 | 0.07 | 0.07 | 0.07 | % of value |
| Zero drift | 0.25 | 0.25 | 0.25 | % full scale |
| Span drift | -0.50 | -0.50 | -0.50 | % 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 | 0.07 | 0.08 | 0.16 | 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 | 0.45 | 0.41 | 0.12 | mg/m³ |

| Measurement uncertainty | | Result | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|---|---|
| Combined uncertainty | | | 39.05 | 35.79 | 10.03 | mg/m³ |
| Expanded uncertainty | k = | 1.96 | 0.51 | 0.47 | 0.29 | mg/m³ |
| Uncertainty corrected to std conds. ($O_2$) | | | 0.99 | 0.93 | 0.57 | mg/m³ |
| | | | 0.99 | 0.93 | 0.57 | mg/m³ (REF) |

| | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 2.54 | 2.60 | 5.70 | % of Value |
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 1.32 | 1.24 | 0.76 | % 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.*

Exova Catalyst, Unit C6, Emery Court, The Embankment Business Park, Heaton Mersey, Stockport, SK4 3GL
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: toby.campbell@exova.com
Your Exova Catalyst Contact: Toby Campbell (07825 130 074)

**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**
25th January 2017

**Job Reference Number**
CAT-3175

| Report Written by |
| --- |
| Harpreet Badwal<br>Team Leader<br>MCERTS Level 2<br>MM 03 149<br>TE1 TE2 TE3 TE4 |

| Report Approved by |
| --- |
| Brian Jacob<br>Team Leader<br>MCERTS Level 2<br>MM 06 693<br>TE1 TE2 TE3 TE4 |

| Report Date |
| --- |
| 23rd February 2017 |

| Version |
| --- |
| Version 1 |

| Signature of Report Approver |
| --- |
|  |

# CONTENTS

TITLE PAGE

CONTENTS

Summary of Sampling Deviations 2

EXECUTIVE SUMMARY

Monitoring Objectives 3

Monitoring Results 4

Monitoring Dates & Times 5

Process Details 6

Monitoring & Analytical Methods 7

Sampling Location 8

Plant Photos / Sample Points 9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts

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

*This test report shall not be reproduced, except in full, without the written approval of Exova Catalyst.*

## MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
2 - CR1 Room Extract
25th January 2017

**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
25th January 2017

*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 | 2.6 | 0.55 | 75 | g/hr | 5.8 | 1.3 | - |
| Stack Gas Temperature | °C | 20.8 | | | | | | |
| Stack Gas Velocity | m/s | 8.7 | 0.29 | | | | | |
| Volumetric Flow Rate (ACTUAL) | m³/hr | 2365 | 133 | | | | | |
| Volumetric Flow Rate (REF) [1] | m³/hr | 2215 | 125 | | | | | |

*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
2 - CR1 Room Extract
25th January 2017

| Parameter | | Units | Concentration | Units | Mass Emission | Sampling Date(s) | Sampling Times | Duration mins |
|---|---|---|---|---|---|---|---|---|
| Total VOCs (as Carbon) | R1 | mg/m³ | 4.8 | g/hr | 10.6 | 25/01/2017 | 13:20 - 13:50 | 30 |
| Total VOCs (as Carbon) | R2 | mg/m³ | 2.6 | g/hr | 5.8 | 25/01/2017 | 13:50 - 14:20 | 30 |
| Total VOCs (as Carbon) | R3 | mg/m³ | 0.44 | g/hr | 1.0 | 25/01/2017 | 14:20 - 14:50 | 30 |
| Velocity & Volumetric Flow Rate | R1 | | | | | 25/01/2017 | 10:58 - 11:10 | |

All results are expressed at the respective reference conditions.

## PROCESS DETAILS

Xaarjet Ltd, Huntingdon
2 - CR1 Room Extract
25th January 2017

### 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 | N/A |
| 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
25th January 2017

| | 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 |
|---|---|---|
| Total VOC's | 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 |
| 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 | 40.0 | | > 5 Pa | Yes |
| Mean Velocity | m/s | 8.70 | | - | - |
| Lowest Gas Velocity | m/s | 6.83 | | - | - |
| Highest Gas Velocity | m/s | 11.37 | | - | - |
| Ratio of Above | : 1 | 1.67 | | < 3 : 1 | Yes |
| Maximum Angle of Swirl | ° | 2 | | < 15° | Yes |
| No Local Negative Flow | - | Yes | | - | Yes |

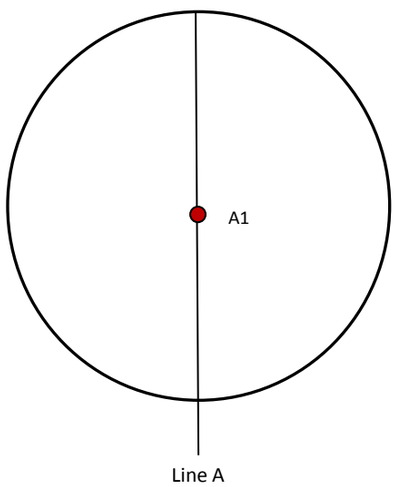
## PLANT PHOTOS

Photo 1

Photo 2

Photo 3

## SAMPLE POINTS




**where** ○ = isokinetic point sampled at
● = isokinetic point not sampled at
● = combustion gases sample point
● = non-isokinetic sample point

## APPENDIX CONTENTS

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## 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 | Aaron Nagha | MCERTS Trainee | MM 16 1392 | 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 | - |
| Servomex 5200MP | - |
| 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 4.874 |
| 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) | CAT 20.117 |
| 15m Heated Line (1) | - |
| 20m Heated Line (1) | CAT 20.116 |
| 20m Heated Line (2) | - |
| Dual Channel Heater Controller | - |
| Single Channel Heater Controller | CAT 20.116 |
| 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 | 20.8 |
| Average Stack Gas Pressure | Pa | 67.4 |
| Average Stack Static Pressure, $P_{static}$ | kPa | 0.123 |
| Average Barometric Pressure, $P_b$ | kPa | 102.0 |
| 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 | 1.206 |
| Average Wet Density (Actual), $P_{ActualW}$ | kg/m³ | 1.204 |

**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 | 20.8 | 0.0 |
| Total Pressure | kPa | 102.1 | 101.3 |
| Moisture | % | 0.50 | 0.50 |

| Gas Volumetric Flowrate (from Traverse) | Units | Result |
|---|---|---|
| Gas Volumetric Flowrate (Actual) | m³/hr | 2365 |
| Gas Volumetric Flowrate (STP, Wet) | m³/hr | 2215 |
| Gas Volumetric Flowrate (STP, Dry) | m³/hr | 2204 |
| Gas Volumetric Flowrate REF [1] | m³/hr | 2215 |

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

(1 of 1)

| Parameter | Units | Value |
|---|---|---|
| Date of Survey | - | 25/01/2017 |
| Time of Survey | - | 10:58 - 11:10 |
| Atmospheric Pressure | kPa | 102.0 |
| Average Stack Static Pressure | Pa | 123 |
| 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 | - | 1 |
| Number of Lines Used | - | 1 |

**Sampling Line A**

| Traverse Point | Depth m | ΔP Pa | Temp °C | Wet Density kg/m³ | Velocity m/s | Swirl ° |
|---|---|---|---|---|---|---|
| *STATIC (Units: Pa)* | | *123.0* | | | | |
| **Mean** | | **67.4** | **20.8** | **1.204** | **8.70** | |
| 1 | 0.01 | 48.0 | 20.8 | 1.204 | 7.48 | 1.0 |
| 2 | 0.03 | 42.0 | 20.8 | 1.204 | 7.00 | 2.0 |
| 3 | 0.05 | 40.0 | 20.8 | 1.204 | 6.83 | 2.0 |
| 4 | 0.07 | 44.0 | 20.8 | 1.204 | 7.16 | 1.0 |
| 5 | 0.11 | 47.0 | 20.8 | 1.204 | 7.40 | 2.0 |
| 6 | 0.20 | 75.0 | 20.8 | 1.204 | 9.35 | 2.0 |
| 7 | 0.24 | 70.0 | 20.8 | 1.204 | 9.03 | 2.0 |
| 8 | 0.26 | 102.0 | 20.8 | 1.204 | 10.90 | 1.0 |
| 9 | 0.28 | 95.0 | 20.8 | 1.204 | 10.52 | 1.0 |
| 10 | 0.30 | 111.0 | 20.8 | 1.204 | 11.37 | 1.0 |

## 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) | 1.290 | Pa |
| *- Resolution* | u(res) | 0.00087 | |
| *- Calibration* | u(cal) | 0.473 | |
| *- Drift* | u(drift) | 0.083 | |
| *- Lack of Fit* | u(fit) | 0.107 | |
| *- Overall corrections to dynamic measurements* | u(Cf) | 0.664 | |
| 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($\phi O_2$,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(Tc) | 1.499 | K |
| Standard uncertainty associated with the absolute pressure in the duct | u(pc) | 175.697 | Pa |
| *- Atmospheric Pressure* | u(patm) | 175.692 | |
| *- Static Pressure* | u(pstat) | 1.290 | |
| Standard uncertainty associated with the density in the duct | u(ρ) | 0.00648 | - |
| Standard uncertainty associated with the local velocities | u(vi) | 0.173 | 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) | 3.33 | % |
| Standard uncertainty associated with the volume flow rate (95% Confidence) | Uc(qV,w) | 132.9 | $m^3$/hr |
| *- $u^2(a)/a^2$* | - | 0.00053 | |
| *- $u^2(qV,w)/q^2V,w$* | - | 0.00082 | |
| *- $u^2(qV,w)$* | - | 4600 | |
| *- u(qV,w)* | - | 67.8 | |
| Standard uncertainty associated with the volume flow rate (95% Confidence), relative | Uc,rel(qV,w) | 5.62 | % |

# 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 | 4.8 | 2.6 | 0.44 | 2.6 |
| Uncertainty | ±mg/m³ | 0.55 | 0.55 | 0.56 | 0.55 |
| Mass Emission | g/hr | 10.6 | 5.8 | 1.0 | 5.8 |
| Uncertainty | ±g/hr | 1.4 | 1.3 | 1.2 | 1.3 |

## General Sampling Information

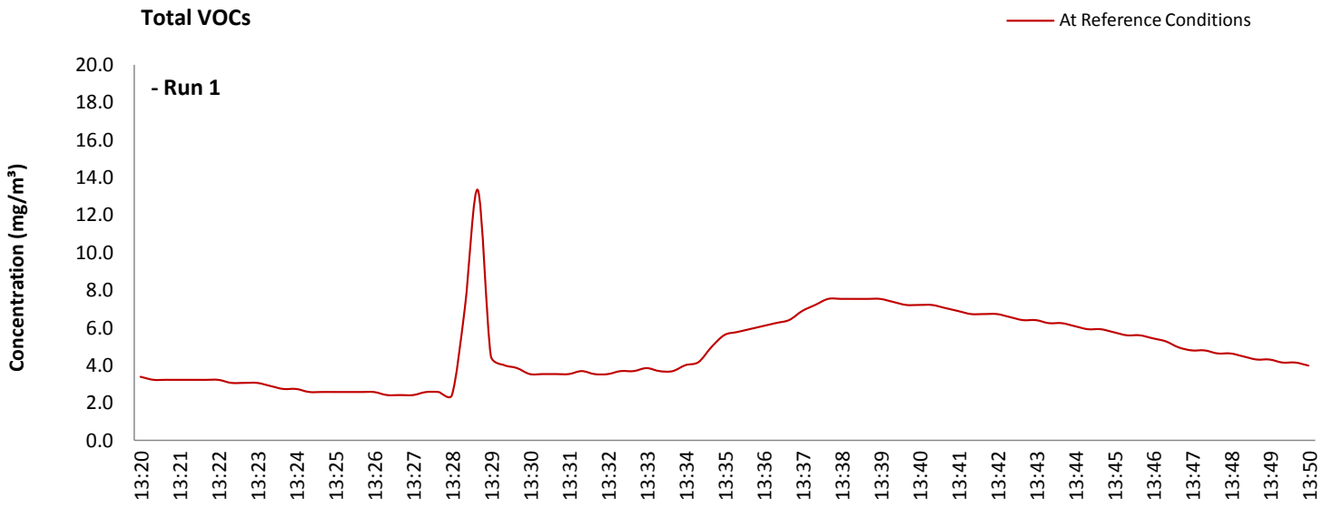
| Parameter | Value | |
|---|---|---|
| Standard | EN 12619:2013 | |
| Technical Procedure | CAT-TP-20 | |
| Probe Material | Stainless Steel | |
| Filtration Type / Size | 0.1µm Glass Fibre | |
| Heated Head Filter Used | Yes | |
| Heated Line Temperature | 180°C | |
| Span Gas Type | Propane In Synthetic Air (5 Grade) | |
| Span Gas Reference Number | CYL 1.0245a | |
| Span Gas Expiry Date | 10/09/2021 | |
| Span Gas Start Pressure (bar) | 85 | |
| Gas Cylinder Concentration (ppm) | 80.1 | |
| Span Gas Set Point (ppm) | 80.10 | |
| 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 | |

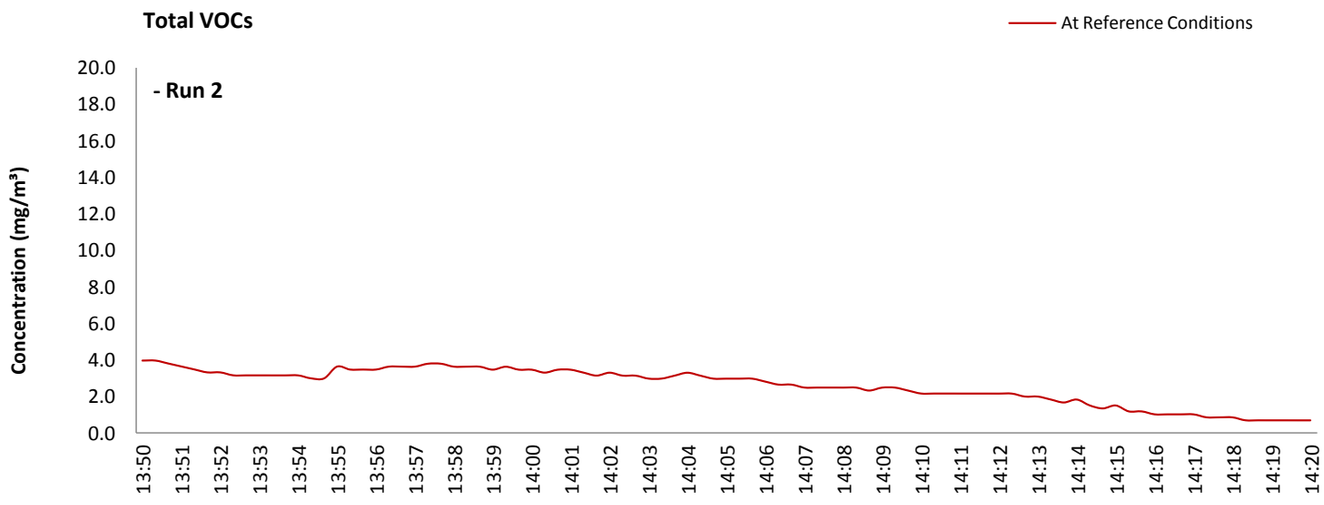
## Reference Conditions

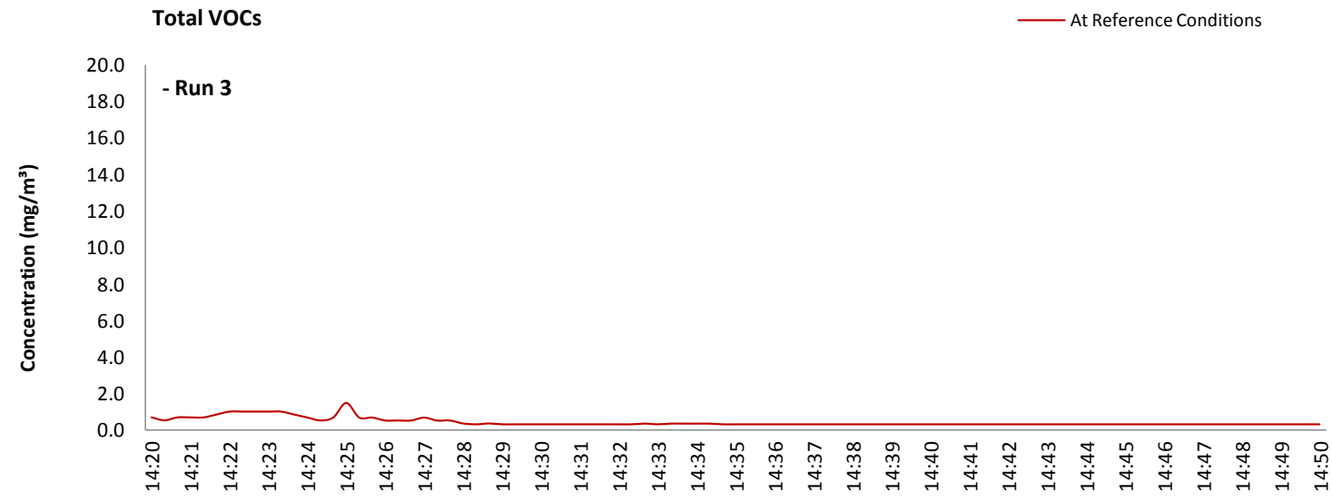
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

## 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 | - | 13:20 - 13:50 | 13:50 - 14:20 | 14:20 - 14:50 |
| Sampling Dates | - | 25/01/2017 | 25/01/2017 | 25/01/2017 |
| Instrument Range | ppm | 100 | 100 | 100 |
| Span Gas Value | ppm | 80.1 | 80.1 | 80.1 |

## 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 | 4.01 | 4.01 | 4.01 |
| | Zero Drift Acceptable | - | Yes | Yes | Yes |

| | Span Drift | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|---|
| CAL 1 | Span Down Sampling Line (Pre) | ppm | 80.30 | 80.30 | 80.30 |
| | Span Down Sampling Line (Post) | ppm | 79.90 | 79.90 | 79.90 |
| | Span Drift | ppm | -0.40 | -0.40 | -0.40 |
| | Allowable Span Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Span Drift Acceptable | - | Yes | Yes | Yes |

| Test Conditions | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|
| Run Ambient Temperature Range | °C | 7 - 14 | 7 - 14 | 7 - 14 |

## 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 | 4.82 | 2.62 | 0.44 | 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. | 80.1 | 80.1 | 80.1 | 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. | 128.7 | 128.7 | 128.7 | 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 | 0.07 | 0.07 | 0.07 | % of value |
| Zero drift | 0.25 | 0.25 | 0.25 | % full scale |
| Span drift | -0.50 | -0.50 | -0.50 | % 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 | 0.17 | 0.18 | 0.18 | 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 | 0.06 | 0.03 | 0.01 | mg/m³ |

| Measurement uncertainty | | Result | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|---|---|
| Combined uncertainty | | | 4.82 | 2.62 | 0.44 | mg/m³ |
| Expanded uncertainty | k = | 1.96 | 0.28 | 0.28 | 0.28 | mg/m³ |
| Uncertainty corrected to std conds. ($O_2$) | | | 0.55 | 0.55 | 0.56 | mg/m³ |
| | | | 0.55 | 0.55 | 0.56 | mg/m³ (REF) |

| | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 11.48 | 21.17 | 125.78 | % of Value |
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 0.74 | 0.74 | 0.74 | % 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.*

Exova Catalyst, Unit 19, Bordesley Green Trading Estate, Bordesley Green Road, Birmingham, B8 1BZ
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: toby.campbell@exova.com
Your Exova Catalyst Contact: Toby Campbell (07825 130 074)

**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**
9 - CR2 Room Extract

**Dates of the Monitoring Campaign**
26th January 2017

**Job Reference Number**
CAT-3175

| Report Written by |
| --- |
| Harpreet Badwal<br>Team Leader<br>MCERTS Level 2<br>MM 03 149<br>TE1 TE2 TE3 TE4 |

| Report Approved by |
| --- |
| Brian Jacob<br>Team Leader<br>MCERTS Level 2<br>MM 06 693<br>TE1 TE2 TE3 TE4 |

| Report Date |
| --- |
| 23rd February 2017 |

| Version |
| --- |
| Version 1 |

| Signature of Report Approver |
| --- |
|  |

# CONTENTS

TITLE PAGE

CONTENTS

Summary of Sampling Deviations 2

EXECUTIVE SUMMARY

Monitoring Objectives 3

Monitoring Results 4

Monitoring Dates & Times 5

Process Details 6

Monitoring & Analytical Methods 7

Sampling Location 8

Plant Photos / Sample Points 9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts

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

*This test report shall not be reproduced, except in full, without the written approval of Exova Catalyst.*

## MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
9 - CR2 Room Extract
26th January 2017

**Overall Aim of the Monitoring Campaign**

Exova Catalyst were commissioned by Xaarjet Ltd to carry out stack emissions testing on the 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
9 - CR2 Room Extract
26th January 2017

*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 | 31.4 | 0.96 | 75 | g/hr | 93.6 | 6.0 | - |
| Stack Gas Temperature | °C | 17.9 | | | | | | |
| Stack Gas Velocity | m/s | 12.3 | 0.42 | | | | | |
| Volumetric Flow Rate (ACTUAL) | m³/hr | 3136 | 178 | | | | | |
| Volumetric Flow Rate (REF) [1] | m³/hr | 2977 | 169 | | | | | |

*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
9 - CR2 Room Extract
26th January 2017

| Parameter | | Units | Concentration | Units | Mass Emission | Sampling Date(s) | Sampling Times | Duration mins |
|---|---|---|---|---|---|---|---|---|
| Total VOCs (as Carbon) | R1 | mg/m³ | 24.8 | g/hr | 73.7 | 26/01/2017 | 09:28 - 09:58 | 30 |
| Total VOCs (as Carbon) | R2 | mg/m³ | 29.5 | g/hr | 88.0 | 26/01/2017 | 09:58 - 10:28 | 30 |
| Total VOCs (as Carbon) | R3 | mg/m³ | 40.0 | g/hr | 119 | 26/01/2017 | 10:28 - 10:58 | 30 |
| Velocity & Volumetric Flow Rate | R1 | | | | | 26/01/2017 | 08:43 - 08:55 | |

All results are expressed at the respective reference conditions.

## PROCESS DETAILS

Xaarjet Ltd, Huntingdon
9 - CR2 Room Extract
26th January 2017

### 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 | N/A |
| Abatement System Running Status | N/A |
| Fuel | N/A |
| Plume Appearance | None Visible |

# Executive Summary



## MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
9 - CR2 Room Extract
26th January 2017

| | 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 |
|---|---|---|
| Total VOC's | All | 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 | - | Vertical |
| 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 | 81.0 | | > 5 Pa | Yes |
| Mean Velocity | m/s | 12.32 | | - | - |
| Lowest Gas Velocity | m/s | 11.42 | | - | - |
| Highest Gas Velocity | m/s | 13.43 | | - | - |
| Ratio of Above | : 1 | 1.18 | | < 3 : 1 | Yes |
| Maximum Angle of Swirl | ° | 0 | | < 15° | Yes |
| No Local Negative Flow | - | Yes | | - | Yes |

## PLANT PHOTOS

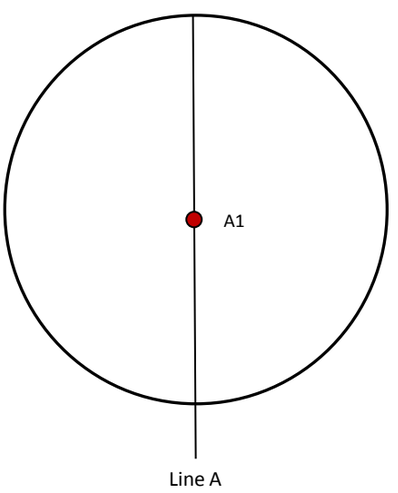
Photo 1


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

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## 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 | Aaron Nagha | MCERTS Trainee | MM 16 1392 | 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 | - |
| Servomex 5200MP | - |
| 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 4.874 |
| 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) | CAT 20.117 |
| 15m Heated Line (1) | - |
| 20m Heated Line (1) | CAT 20.116 |
| 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 | 17.9 |
| Average Stack Gas Pressure | Pa | 94.5 |
| Average Stack Static Pressure, $P_{static}$ | kPa | 0.568 |
| Average Barometric Pressure, $P_b$ | kPa | 101.9 |
| Average Pitot Tube Calibration Coefficient, $C_p$ | - | 0.99 |

## 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 | 1.222 |
| Average Wet Density (Actual), $P_{ActualW}$ | kg/m³ | 1.220 |

**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 | 17.9 | 0.0 |
| Total Pressure | kPa | 102.5 | 101.3 |
| Moisture | % | 0.50 | 0.50 |

| Gas Volumetric Flowrate (from Traverse) | Units | Result |
|---|---|---|
| Gas Volumetric Flowrate (Actual) | m³/hr | 3136 |
| Gas Volumetric Flowrate (STP, Wet) | m³/hr | 2977 |
| Gas Volumetric Flowrate (STP, Dry) | m³/hr | 2962 |
| Gas Volumetric Flowrate REF [1] | m³/hr | 2977 |

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

(1 of 1)

| Parameter | Units | Value |
|---|---|---|
| Date of Survey | - | 26/01/2017 |
| Time of Survey | - | 08:43 - 08:55 |
| Atmospheric Pressure | kPa | 101.9 |
| Average Stack Static Pressure | Pa | 568 |
| 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, $C_p$ | - | 0.99 |
| Number of Lines Available | - | 1 |
| Number of Lines Used | - | 1 |

**Sampling Line A**

| Traverse Point | Depth m | ΔP Pa | Temp °C | Wet Density kg/m³ | Velocity m/s | Swirl ° |
|---|---|---|---|---|---|---|
| *STATIC (Units: Pa)* | | *568.0* | | | | |
| **Mean** | | **94.5** | **17.9** | **1.220** | **12.32** | |
| 1 | 0.01 | 87.0 | 17.7 | 1.221 | 11.83 | 0.0 |
| 2 | 0.02 | 91.0 | 17.7 | 1.221 | 12.10 | 0.0 |
| 3 | 0.04 | 90.0 | 17.8 | 1.220 | 12.04 | 0.0 |
| 4 | 0.07 | 99.0 | 17.8 | 1.220 | 12.62 | 0.0 |
| 5 | 0.10 | 81.0 | 17.8 | 1.220 | 11.42 | 0.0 |
| 6 | 0.20 | 86.0 | 17.9 | 1.220 | 11.77 | 0.0 |
| 7 | 0.23 | 95.0 | 17.9 | 1.220 | 12.37 | 0.0 |
| 8 | 0.26 | 107.0 | 18.0 | 1.219 | 13.13 | 0.0 |
| 9 | 0.28 | 112.0 | 18.0 | 1.219 | 13.43 | 0.0 |
| 10 | 0.29 | 97.0 | 18.1 | 1.219 | 12.50 | 0.0 |

## 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) | 1.881 | Pa |
| *- Resolution* | u(res) | 0.00087 | |
| *- Calibration* | u(cal) | 0.930 | |
| *- Drift* | u(drift) | 0.083 | |
| *- Lack of Fit* | u(fit) | 1.523 | |
| *- Overall corrections to dynamic measurements* | u(Cf) | 2.537 | |
| 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($\phi O_2$,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(Tc) | 1.484 | K |
| Standard uncertainty associated with the absolute pressure in the duct | u(pc) | 175.702 | Pa |
| *- Atmospheric Pressure* | u(patm) | 175.692 | |
| *- Static Pressure* | u(pstat) | 1.881 | |
| Standard uncertainty associated with the density in the duct | u(ρ) | 0.00657 | - |
| Standard uncertainty associated with the local velocities | u(vi) | 0.246 | Pa |
| Standard uncertainty associated with the mean velocity | u(v) | 0.216 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence) | Uc(v) | 0.423 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence), relative | Uc,rel(v) | 3.43 | % |
| Standard uncertainty associated with the volume flow rate (95% Confidence) | Uc(qV,w) | 178.1 | $m^3$/hr |
| *- $u^2(a)/a^2$* | - | 0.00053 | |
| *- $u^2(qV,w)/q^2V,w$* | - | 0.00084 | |
| *- $u^2(qV,w)$* | - | 8259 | |
| *- u(qV,w)* | - | 90.9 | |
| Standard uncertainty associated with the volume flow rate (95% Confidence), relative | Uc,rel(qV,w) | 5.68 | % |

# TOTAL VOCs (as CARBON): RESULTS SUMMARY

Xaarjet Ltd, Huntingdon
9 - CR2 Room Extract

## Sample Runs

| Parameter | Units | Run 1 | Run 2 | Run 3 | Mean |
|---|---|---|---|---|---|
| Concentration | mg/m³ | 24.8 | 29.5 | 40.0 | 31.4 |
| Uncertainty | ±mg/m³ | 0.87 | 0.92 | 1.07 | 0.96 |
| Mass Emission | g/hr | 73.7 | 88.0 | 119 | 93.6 |
| Uncertainty | ±g/hr | 4.9 | 5.7 | 7.5 | 6.0 |

## General Sampling Information

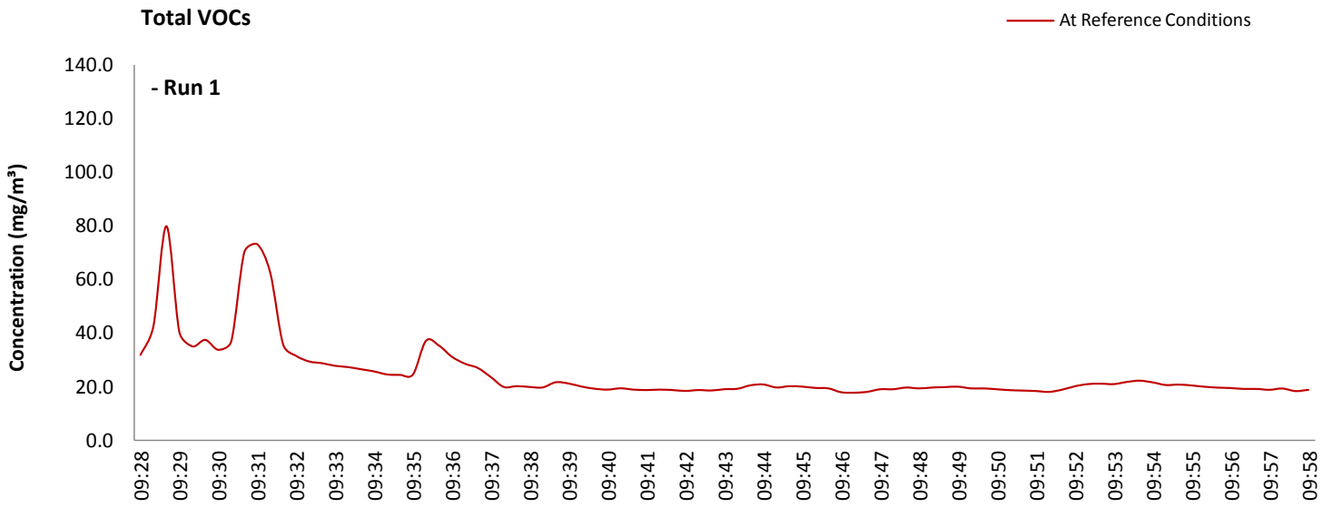
| Parameter | Value | |
|---|---|---|
| Standard | EN 12619:2013 | |
| Technical Procedure | CAT-TP-20 | |
| Probe Material | Stainless Steel | |
| Filtration Type / Size | 0.1µm Glass Fibre | |
| Heated Head Filter Used | Yes | |
| Heated Line Temperature | 180°C | |
| Span Gas Type | Propane In Synthetic Air (5 Grade) | |
| Span Gas Reference Number | CYL 1.0245a | |
| Span Gas Expiry Date | 10/09/2021 | |
| Span Gas Start Pressure (bar) | 75 | |
| Gas Cylinder Concentration (ppm) | 80.1 | |
| Span Gas Set Point (ppm) | 80.10 | |
| 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 | |

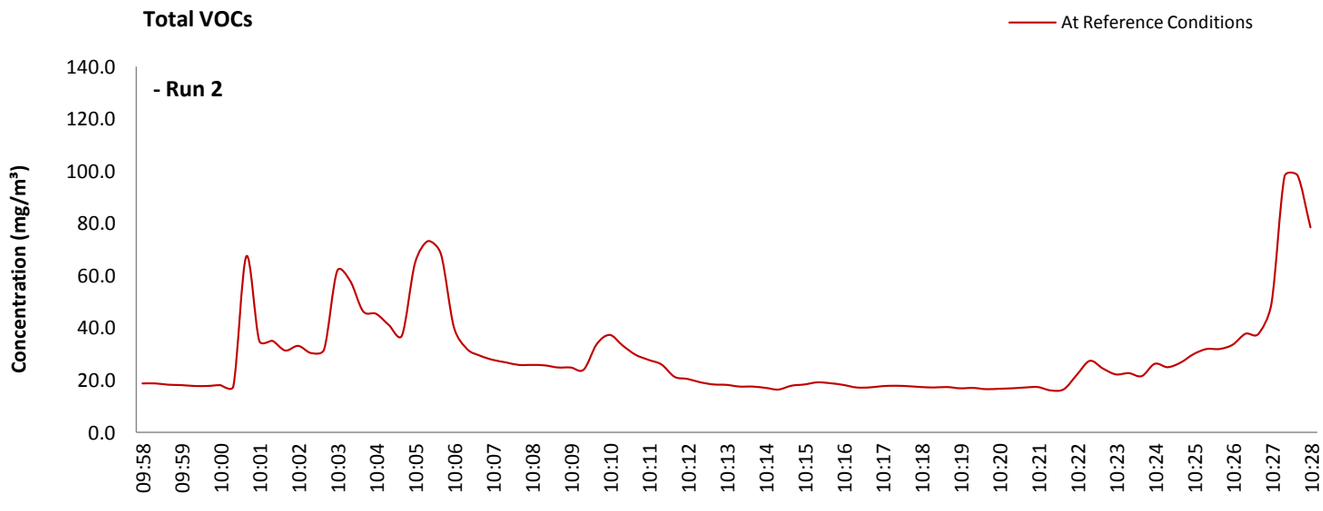
## Reference Conditions

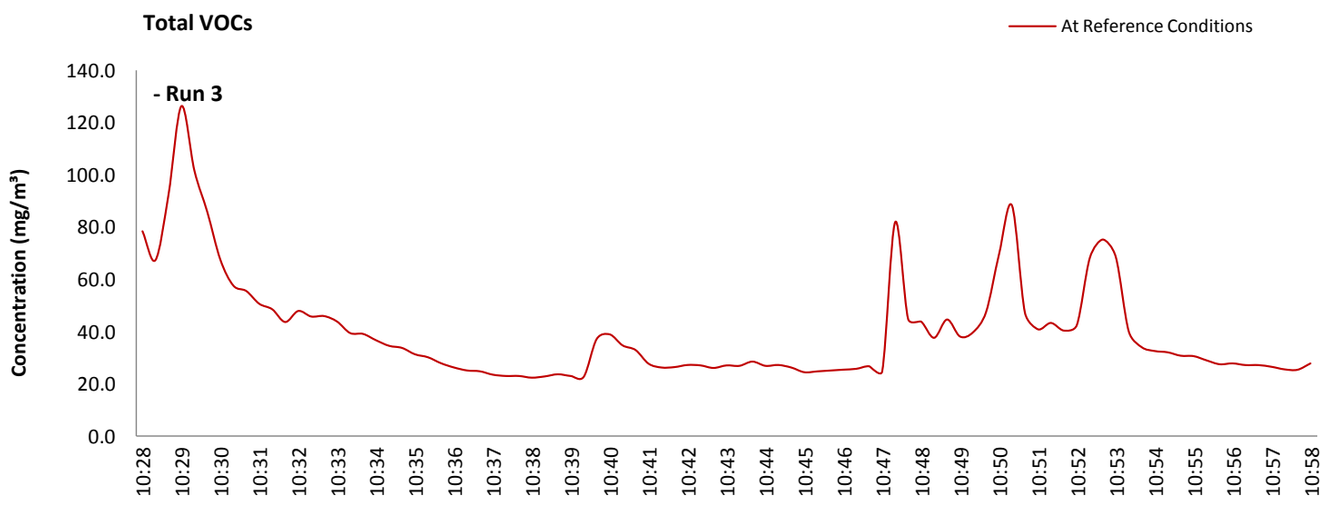
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

# 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 | - | 09:28 - 09:58 | 09:58 - 10:28 | 10:28 - 10:58 |
| Sampling Dates | - | 26/01/2017 | 26/01/2017 | 26/01/2017 |
| Instrument Range | ppm | 100 | 100 | 100 |
| Span Gas Value | ppm | 80.1 | 80.1 | 80.1 |

## 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 | 0.40 | 0.40 | 0.40 |
| | Zero Drift | ppm | 0.40 | 0.40 | 0.40 |
| | Allowable Zero Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | 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 | 79.40 | 79.40 | 79.40 |
| | Span Drift | ppm | -0.60 | -0.60 | -0.60 |
| | Allowable Span Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Span Drift Acceptable | - | Yes | Yes | Yes |

| Test Conditions | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|
| Run Ambient Temperature Range | °C | 7 - 14 | 7 - 14 | 7 - 14 |

## 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 | 24.88 | 29.69 | 40.25 | 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. | 80.1 | 80.1 | 80.1 | 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. | 128.7 | 128.7 | 128.7 | 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 | 0.07 | 0.07 | 0.07 | % of value |
| Zero drift | 0.50 | 0.50 | 0.50 | % full scale |
| Span drift | -0.75 | -0.75 | -0.75 | % 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) | 0.12 | 0.12 | 0.12 | % 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 | 0.26 | 0.24 | 0.20 | 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) | 0.02 | 0.02 | 0.03 | mg/m³ |
| Uncertainty of calibration gas | 0.29 | 0.34 | 0.46 | mg/m³ |

| Measurement uncertainty | | Result | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|---|---|
| | | | 24.88 | 29.69 | 40.25 | mg/m³ |
| Combined uncertainty | | | 0.45 | 0.47 | 0.55 | mg/m³ |
| Expanded uncertainty | k = | 1.96 | 0.88 | 0.93 | 1.08 | mg/m³ |
| Uncertainty corrected to std conds. ($O_2$) | | | 0.88 | 0.93 | 1.08 | mg/m³ (REF) |

| | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 3.52 | 3.13 | 2.68 | % of Value |
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 1.17 | 1.24 | 1.44 | % 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.*

Exova Catalyst, Unit 19, Bordesley Green Trading Estate, Bordesley Green Road, Birmingham, B8 1BZ
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: toby.campbell@exova.com
Your Exova Catalyst Contact: Toby Campbell (07825 130 074)

**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**
13 - CR3 Room Extract

**Dates of the Monitoring Campaign**
26th January 2017

**Job Reference Number**
CAT-3175

| Report Written by |
| --- |
| Harpreet Badwal<br>Team Leader<br>MCERTS Level 2<br>MM 03 149<br>TE1 TE2 TE3 TE4 |

| Report Approved by |
| --- |
| Brian Jacob<br>Team Leader<br>MCERTS Level 2<br>MM 06 693<br>TE1 TE2 TE3 TE4 |

| Report Date |
| --- |
| 23rd February 2017 |

| Version |
| --- |
| Version 1 |

| Signature of Report Approver |
| --- |
|  |

# CONTENTS

TITLE PAGE

CONTENTS

Summary of Sampling Deviations 2

EXECUTIVE SUMMARY

Monitoring Objectives 3

Monitoring Results 4

Monitoring Dates & Times 5

Process Details 6

Monitoring & Analytical Methods 7

Sampling Location 8

Plant Photos / Sample Points 9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts

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

*This test report shall not be reproduced, except in full, without the written approval of Exova Catalyst.*

## MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
13 - CR3 Room Extract
26th January 2017

**Overall Aim of the Monitoring Campaign**

Exova Catalyst were commissioned by Xaarjet Ltd to carry out stack emissions testing on the 13 - CR3 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
13 - CR3 Room Extract
26th January 2017

*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 | 5.0 | 0.60 | 75 | g/hr | 40.7 | 5.3 | - |
| Stack Gas Temperature | °C | 23.3 | | | | | | |
| Stack Gas Velocity | m/s | 8.7 | 0.16 | | | | | |
| Volumetric Flow Rate (ACTUAL) | m³/hr | 8815 | 431 | | | | | |
| Volumetric Flow Rate (REF) [1] | m³/hr | 8189 | 401 | | | | | |

*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
13 - CR3 Room Extract
26th January 2017

| Parameter | | Units | Concentration | Units | Mass Emission | Sampling Date(s) | Sampling Times | Duration mins |
|---|---|---|---|---|---|---|---|---|
| Total VOCs (as Carbon) | R1 | mg/m³ | 4.3 | g/hr | 35.3 | 26/01/2017 | 12:06 - 12:36 | 30 |
| Total VOCs (as Carbon) | R2 | mg/m³ | 5.0 | g/hr | 40.6 | 26/01/2017 | 12:36 - 13:06 | 30 |
| Total VOCs (as Carbon) | R3 | mg/m³ | 5.6 | g/hr | 46.1 | 26/01/2017 | 13:06 - 13:36 | 30 |
| Velocity & Volumetric Flow Rate | R1 | | | | | 26/01/2017 | 11:23 - 11:35 | |

All results are expressed at the respective reference conditions.

## PROCESS DETAILS

Xaarjet Ltd, Huntingdon
13 - CR3 Room Extract
26th January 2017

### 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 | N/A |
| Abatement System Running Status | N/A |
| Fuel | N/A |
| Plume Appearance | None Visible |

## MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
13 - CR3 Room Extract
26th January 2017

| | 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 |
|---|---|---|
| Total VOC's | All | There are no deviations associated with the sampling employed. |

## SUITABILITY OF SAMPLING LOCATION

### Duct Characteristics

| Parameter | Units | Value |
|---|---|---|
| Type | - | Circular |
| Depth | m | 0.60 |
| Width | m | - |
| Area | m² | 0.28 |
| Port Depth | cm | 0 |
| Orientation of Duct | - | Horizontal |
| Sample Port Size | - | Hole |

### Location of Sampling Platform

| General Platform Information | Value |
|---|---|
| Permanent / Temporary Platform | Temporary |
| 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 | 47.0 | | > 5 Pa | Yes |
| Mean Velocity | m/s | 8.66 | | - | - |
| Lowest Gas Velocity | m/s | 7.43 | | - | - |
| Highest Gas Velocity | m/s | 10.17 | | - | - |
| Ratio of Above | : 1 | 1.37 | | < 3 : 1 | Yes |
| Maximum Angle of Swirl | ° | 2 | | < 15° | Yes |
| No Local Negative Flow | - | Yes | | - | Yes |

## PLANT PHOTOS

Photo 1

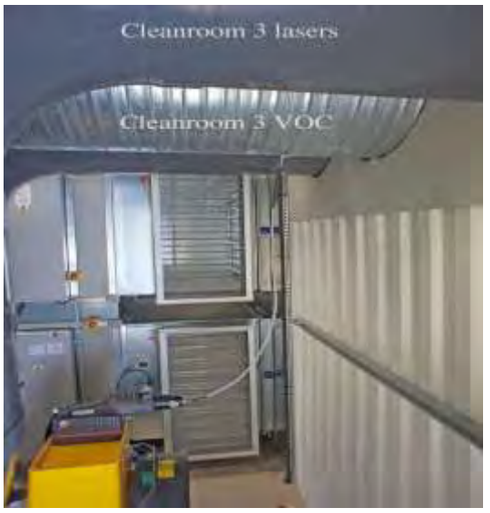
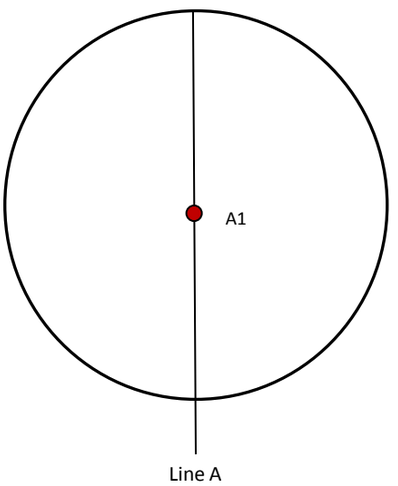



Photo 2

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

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## 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 | Aaron Nagha | MCERTS Trainee | MM 16 1392 | 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 | - |
| Servomex 5200MP | - |
| 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 4.874 |
| 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) | CAT 20.117 |
| 15m Heated Line (1) | - |
| 20m Heated Line (1) | CAT 20.116 |
| 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 | 0.60 |
| Stack Width, W | m | - |
| Stack Area, A | m² | 0.28 |
| Average Stack Gas Temperature, $T_a$ | °C | 23.3 |
| Average Stack Gas Pressure | Pa | 64.3 |
| Average Stack Static Pressure, $P_{static}$ | kPa | 0.218 |
| Average Barometric Pressure, $P_b$ | kPa | 101.9 |
| 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 | 1.196 |
| Average Wet Density (Actual), $P_{ActualW}$ | kg/m³ | 1.194 |

**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 | 23.3 | 0.0 |
| Total Pressure | kPa | 102.1 | 101.3 |
| Moisture | % | 0.50 | 0.50 |

| Gas Volumetric Flowrate (from Traverse) | Units | Result |
|---|---|---|
| Gas Volumetric Flowrate (Actual) | m³/hr | 8815 |
| Gas Volumetric Flowrate (STP, Wet) | m³/hr | 8189 |
| Gas Volumetric Flowrate (STP, Dry) | m³/hr | 8148 |
| Gas Volumetric Flowrate REF [1] | m³/hr | 8189 |

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

(1 of 1)

| Parameter | Units | Value |
|---|---|---|
| Date of Survey | - | 26/01/2017 |
| Time of Survey | - | 11:23 - 11:35 |
| Atmospheric Pressure | kPa | 101.9 |
| Average Stack Static Pressure | Pa | 218 |
| 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, $C_p$ | - | 0.84 |
| Number of Lines Available | - | 1 |
| Number of Lines Used | - | 1 |

**Sampling Line A**

| Traverse Point | Depth m | ΔP Pa | Temp °C | Wet Density kg/m³ | Velocity m/s | Swirl ° |
|---|---|---|---|---|---|---|
| *STATIC (Units: Pa)* | | *218.0* | | | | |
| **Mean** | | **64.3** | **23.3** | **1.194** | **8.66** | |
| 1 | 0.02 | 63.0 | 23.1 | 1.194 | 8.60 | 0.0 |
| 2 | 0.05 | 52.0 | 23.1 | 1.194 | 7.81 | 1.0 |
| 3 | 0.09 | 66.0 | 23.2 | 1.194 | 8.80 | 1.0 |
| 4 | 0.14 | 64.0 | 23.2 | 1.194 | 8.67 | 2.0 |
| 5 | 0.21 | 62.0 | 23.2 | 1.194 | 8.53 | 1.0 |
| 6 | 0.39 | 78.0 | 23.3 | 1.193 | 9.57 | 2.0 |
| 7 | 0.46 | 88.0 | 23.3 | 1.193 | 10.17 | 2.0 |
| 8 | 0.51 | 65.0 | 23.3 | 1.193 | 8.74 | 1.0 |
| 9 | 0.55 | 58.0 | 23.4 | 1.193 | 8.26 | 2.0 |
| 10 | 0.58 | 47.0 | 23.4 | 1.193 | 7.43 | 2.0 |

## 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) | 1.270 | Pa |
| *- Resolution* | u(res) | 0.00087 | |
| *- Calibration* | u(cal) | 0.430 | |
| *- Drift* | u(drift) | 0.083 | |
| *- Lack of Fit* | u(fit) | 0.098 | |
| *- Overall corrections to dynamic measurements* | u(Cf) | 0.612 | |
| 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($\phi O_2$,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(Tc) | 1.511 | K |
| Standard uncertainty associated with the absolute pressure in the duct | u(pc) | 175.697 | Pa |
| *- Atmospheric Pressure* | u(patm) | 175.692 | |
| *- Static Pressure* | u(pstat) | 1.270 | |
| Standard uncertainty associated with the density in the duct | u(ρ) | 0.00643 | - |
| Standard uncertainty associated with the local velocities | u(vi) | 0.117 | Pa |
| Standard uncertainty associated with the mean velocity | u(v) | 0.082 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence) | Uc(v) | 0.161 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence), relative | Uc,rel(v) | 1.86 | % |
| Standard uncertainty associated with the volume flow rate (95% Confidence) | Uc(qV,w) | 431.3 | $m^3$/hr |
| *- $u^2(a)/a^2$* | - | 0.00053 | |
| *- $u^2(qV,w)/q^2V,w$* | - | 0.00062 | |
| *- $u^2(qV,w)$* | - | 48414 | |
| *- u(qV,w)* | - | 220.0 | |
| Standard uncertainty associated with the volume flow rate (95% Confidence), relative | Uc,rel(qV,w) | 4.89 | % |

# TOTAL VOCs (as CARBON): RESULTS SUMMARY

Xaarjet Ltd, Huntingdon
13 - CR3 Room Extract

## Sample Runs

| Parameter | Units | Run 1 | Run 2 | Run 3 | Mean |
|---|---|---|---|---|---|
| Concentration | mg/m³ | 4.3 | 5.0 | 5.6 | 5.0 |
| Uncertainty | ±mg/m³ | 0.59 | 0.60 | 0.61 | 0.60 |
| Mass Emission | g/hr | 35.3 | 40.6 | 46.1 | 40.7 |
| Uncertainty | ±g/hr | 5.2 | 5.3 | 5.5 | 5.3 |

## General Sampling Information

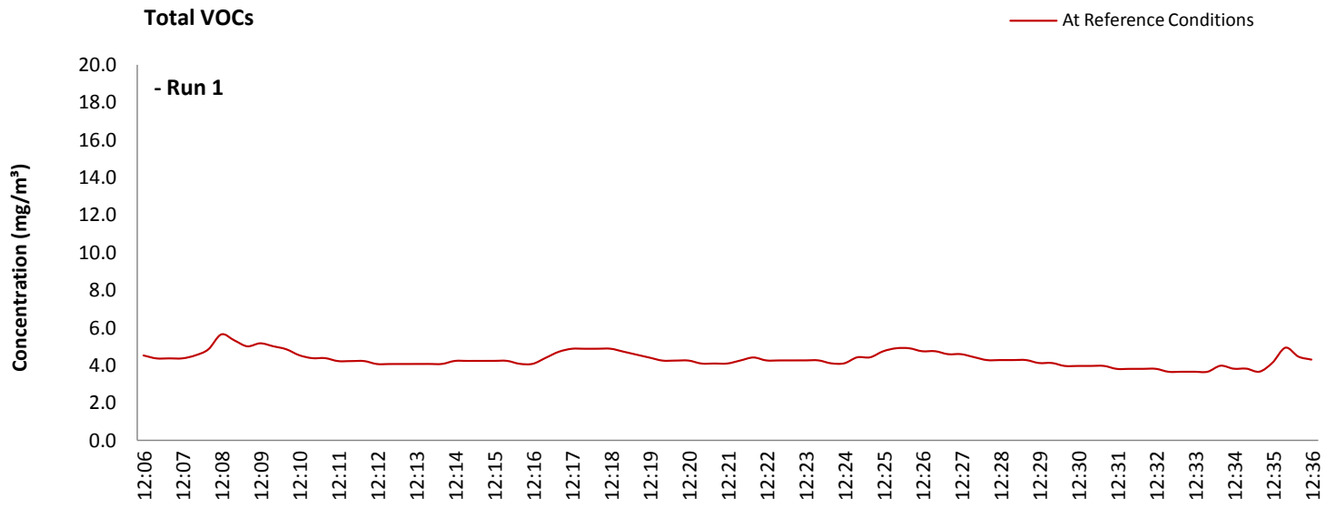
| Parameter | Value | |
|---|---|---|
| Standard | EN 12619:2013 | |
| Technical Procedure | CAT-TP-20 | |
| Probe Material | Stainless Steel | |
| Filtration Type / Size | 0.1µm Glass Fibre | |
| Heated Head Filter Used | Yes | |
| Heated Line Temperature | 180°C | |
| Span Gas Type | Propane In Synthetic Air (5 Grade) | |
| Span Gas Reference Number | CYL 1.0245a | |
| Span Gas Expiry Date | 10/09/2021 | |
| Span Gas Start Pressure (bar) | 70 | |
| Gas Cylinder Concentration (ppm) | 80.1 | |
| Span Gas Set Point (ppm) | 80.10 | |
| 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 | |

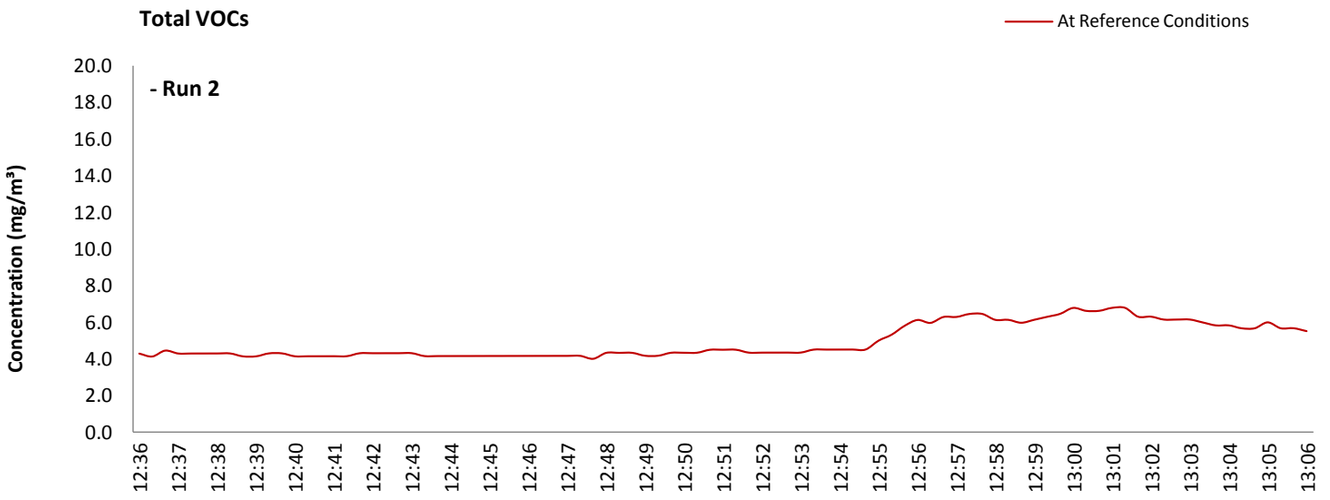
## Reference Conditions

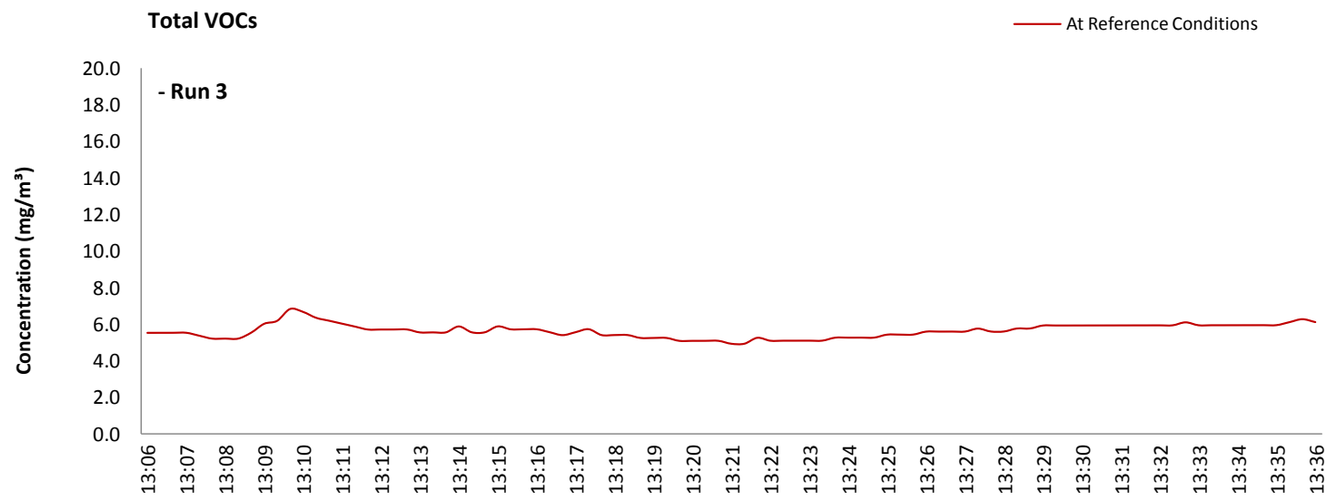
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

# 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 | - | 12:06 - 12:36 | 12:36 - 13:06 | 13:06 - 13:36 |
| Sampling Dates | - | 26/01/2017 | 26/01/2017 | 26/01/2017 |
| Instrument Range | ppm | 100 | 100 | 100 |
| Span Gas Value | ppm | 80.1 | 80.1 | 80.1 |

## Quality Assurance

| | Zero Drift | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|---|
| CAL 1 | Zero Down Sampling Line (Pre) | ppm | 0.10 | 0.10 | 0.10 |
| | Zero Down Sampling Line (Post) | ppm | -0.10 | -0.10 | -0.10 |
| | Zero Drift | ppm | -0.20 | -0.20 | -0.20 |
| | Allowable Zero Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Zero Drift Acceptable | - | Yes | Yes | Yes |

| | Span Drift | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|---|
| CAL 1 | Span Down Sampling Line (Pre) | ppm | 80.30 | 80.30 | 80.30 |
| | Span Down Sampling Line (Post) | ppm | 79.60 | 79.60 | 79.60 |
| | Span Drift | ppm | -0.70 | -0.70 | -0.70 |
| | Allowable Span Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Span Drift Acceptable | - | Yes | Yes | Yes |

| Test Conditions | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|
| Run Ambient Temperature Range | °C | 7 - 14 | 7 - 14 | 7 - 14 |

## 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 | 4.34 | 4.98 | 5.65 | 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. | 80.1 | 80.1 | 80.1 | 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. | 128.7 | 128.7 | 128.7 | 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 | 0.07 | 0.07 | 0.07 | % of value |
| Zero drift | -0.25 | -0.25 | -0.25 | % full scale |
| Span drift | -0.87 | -0.87 | -0.87 | % 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 | -0.21 | -0.21 | -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 | 0.05 | 0.06 | 0.07 | mg/m³ |

| Measurement uncertainty | | Result | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|---|---|
| Combined uncertainty | | | 4.34 | 4.98 | 5.65 | mg/m³ |
| Expanded uncertainty | k = | 1.96 | 0.30 | 0.31 | 0.31 | mg/m³ |
| Uncertainty corrected to std conds. ($O_2$) | | | 0.60 | 0.60 | 0.61 | mg/m³ |
| | | | 0.60 | 0.60 | 0.61 | mg/m³ (REF) |

| | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 13.76 | 12.12 | 10.81 | % of Value |
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 0.80 | 0.80 | 0.81 | % 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.*

Exova Catalyst, Unit 19, Bordesley Green Trading Estate, Bordesley Green Road, Birmingham, B8 1BZ
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: toby.campbell@exova.com
Your Exova Catalyst Contact: Toby Campbell (07825 130 074)

**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**
14 - Validation Lab

**Dates of the Monitoring Campaign**
26th January 2017

**Job Reference Number**
CAT-3175

| Report Written by |
| --- |
| Harpreet Badwal<br>Team Leader<br>MCERTS Level 2<br>MM 03 149<br>TE1 TE2 TE3 TE4 |

| Report Approved by |
| --- |
| Brian Jacob<br>Team Leader<br>MCERTS Level 2<br>MM 06 693<br>TE1 TE2 TE3 TE4 |

| Report Date |
| --- |
| 23rd February 2017 |

| Version |
| --- |
| Version 1 |

| Signature of Report Approver |
| --- |
|  |

# CONTENTS

TITLE PAGE

CONTENTS

Summary of Sampling Deviations 2

EXECUTIVE SUMMARY

Monitoring Objectives 3

Monitoring Results 4

Monitoring Dates & Times 5

Process Details 6

Monitoring & Analytical Methods 7

Sampling Location 8

Plant Photos / Sample Points 9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts

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

*This test report shall not be reproduced, except in full, without the written approval of Exova Catalyst.*

## MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
14 - Validation Lab
26th January 2017

**Overall Aim of the Monitoring Campaign**

Exova Catalyst were commissioned by Xaarjet Ltd to carry out stack emissions testing on the 14 - Validation Lab 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
14 - Validation Lab
26th January 2017

*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 | 19.1 | 0.63 | 75 | g/hr | 53.3 | 3.4 | - |
| Stack Gas Temperature | °C | 20.8 | | | | | | |
| Stack Gas Velocity | m/s | 5.2 | 0.14 | | | | | |
| Volumetric Flow Rate (ACTUAL) | m³/hr | 2981 | 158 | | | | | |
| Volumetric Flow Rate (REF) [1] | m³/hr | 2784 | 148 | | | | | |

*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
14 - Validation Lab
26th January 2017

| Parameter | | Units | Concentration | Units | Mass Emission | Sampling Date(s) | Sampling Times | Duration mins |
|---|---|---|---|---|---|---|---|---|
| Total VOCs (as Carbon) | R1 | mg/m³ | 7.5 | g/hr | 20.9 | 26/01/2017 | 14:35 - 15:05 | 30 |
| Total VOCs (as Carbon) | R2 | mg/m³ | 28.7 | g/hr | 79.9 | 26/01/2017 | 15:05 - 15:35 | 30 |
| Total VOCs (as Carbon) | R3 | mg/m³ | 21.2 | g/hr | 59.0 | 26/01/2017 | 15:35 - 16:05 | 30 |
| Velocity & Volumetric Flow Rate | R1 | | | | | 26/01/2017 | 14:05 - 14:17 | |

All results are expressed at the respective reference conditions.

## PROCESS DETAILS

Xaarjet Ltd, Huntingdon
14 - Validation Lab
26th January 2017

### 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 | N/A |
| Abatement System Running Status | N/A |
| Fuel | N/A |
| Plume Appearance | None Visible |

## MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
14 - Validation Lab
26th January 2017

| | 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 |
|---|---|---|
| Total VOC's | All | There are no deviations associated with the sampling employed. |

## SUITABILITY OF SAMPLING LOCATION

### Duct Characteristics

| Parameter | Units | Value |
|---|---|---|
| Type | - | Circular |
| Depth | m | 0.45 |
| Width | m | - |
| Area | m² | 0.16 |
| Port Depth | cm | 0 |
| Orientation of Duct | - | Vertical |
| 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 | 11.0 | | > 5 Pa | Yes |
| Mean Velocity | m/s | 5.21 | | - | - |
| Lowest Gas Velocity | m/s | 3.59 | | - | - |
| Highest Gas Velocity | m/s | 7.41 | | - | - |
| Ratio of Above | : 1 | 2.07 | | < 3 : 1 | Yes |
| Maximum Angle of Swirl | ° | 3 | | < 15° | Yes |
| No Local Negative Flow | - | Yes | | - | Yes |

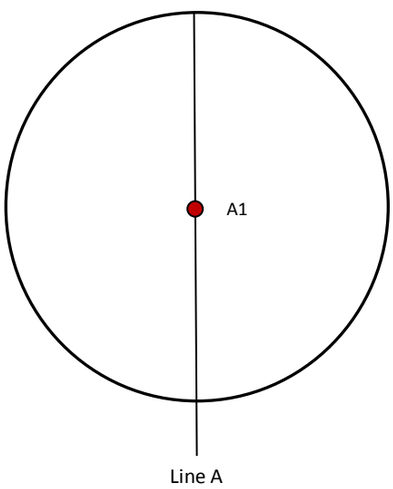
## PLANT PHOTOS

Photo 1


Photo 2

Photo 3


## SAMPLE POINTS




**where**
- ○ = isokinetic point sampled at
- ● = isokinetic point not sampled at
- ● = combustion gases sample point
- ● = non-isokinetic sample point

## APPENDIX CONTENTS

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## 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 | Aaron Nagha | MCERTS Trainee | MM 16 1392 | 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 | - |
| Servomex 5200MP | - |
| 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 4.874 |
| 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) | CAT 20.117 |
| 15m Heated Line (1) | - |
| 20m Heated Line (1) | CAT 20.116 |
| 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 | 0.45 |
| Stack Width, W | m | - |
| Stack Area, A | m² | 0.16 |
| Average Stack Gas Temperature, $T_a$ | °C | 20.8 |
| Average Stack Gas Pressure | Pa | 24.7 |
| Average Stack Static Pressure, $P_{static}$ | kPa | 0.015 |
| Average Barometric Pressure, $P_b$ | kPa | 101.8 |
| 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 | 1.202 |
| Average Wet Density (Actual), $P_{ActualW}$ | kg/m³ | 1.200 |

**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 | 20.8 | 0.0 |
| Total Pressure | kPa | 101.8 | 101.3 |
| Moisture | % | 0.50 | 0.50 |

| Gas Volumetric Flowrate (from Traverse) | Units | Result |
|---|---|---|
| Gas Volumetric Flowrate (Actual) | m³/hr | 2981 |
| Gas Volumetric Flowrate (STP, Wet) | m³/hr | 2784 |
| Gas Volumetric Flowrate (STP, Dry) | m³/hr | 2771 |
| Gas Volumetric Flowrate REF [1] | m³/hr | 2784 |

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

(1 of 1)

| Parameter | Units | Value |
|---|---|---|
| Date of Survey | - | 26/01/2017 |
| Time of Survey | - | 14:05 - 14:17 |
| Atmospheric Pressure | kPa | 101.8 |
| Average Stack Static Pressure | Pa | 15 |
| 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 | - | 1 |
| Number of Lines Used | - | 1 |

**Sampling Line A**

| Traverse Point | Depth m | ΔP Pa | Temp °C | Wet Density kg/m³ | Velocity m/s | Swirl ° |
|---|---|---|---|---|---|---|
| *STATIC (Units: Pa)* | | *15.0* | | | | |
| **Mean** | | **24.7** | **20.8** | **1.200** | **5.21** | |
| 1 | 0.01 | 35.0 | 20.8 | 1.200 | 6.40 | 2.0 |
| 2 | 0.04 | 23.0 | 20.8 | 1.200 | 5.18 | 2.0 |
| 3 | 0.07 | 12.0 | 20.8 | 1.200 | 3.74 | 3.0 |
| 4 | 0.10 | 22.0 | 20.8 | 1.200 | 5.07 | 2.0 |
| 5 | 0.15 | 11.0 | 20.8 | 1.200 | 3.59 | 2.0 |
| 6 | 0.30 | 12.0 | 20.8 | 1.200 | 3.74 | 1.0 |
| 7 | 0.35 | 15.0 | 20.8 | 1.200 | 4.19 | 1.0 |
| 8 | 0.38 | 29.0 | 20.8 | 1.200 | 5.82 | 2.0 |
| 9 | 0.41 | 47.0 | 20.8 | 1.200 | 7.41 | 2.0 |
| 10 | 0.44 | 41.0 | 20.8 | 1.200 | 6.92 | 2.0 |

## 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) | 1.078 | Pa |
| *- Resolution* | u(res) | 0.00087 | |
| *- Calibration* | u(cal) | 0.064 | |
| *- Drift* | u(drift) | 0.083 | |
| *- Lack of Fit* | u(fit) | 0.014 | |
| *- Overall corrections to dynamic measurements* | u(Cf) | 0.162 | |
| 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($\phi O_2$,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(Tc) | 1.499 | K |
| Standard uncertainty associated with the absolute pressure in the duct | u(pc) | 175.695 | Pa |
| *- Atmospheric Pressure* | u(patm) | 175.692 | |
| *- Static Pressure* | u(pstat) | 1.078 | |
| Standard uncertainty associated with the density in the duct | u(ρ) | 0.00646 | - |
| Standard uncertainty associated with the local velocities | u(vi) | 0.145 | Pa |
| Standard uncertainty associated with the mean velocity | u(v) | 0.074 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence) | Uc(v) | 0.145 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence), relative | Uc,rel(v) | 2.78 | % |
| Standard uncertainty associated with the volume flow rate (95% Confidence) | Uc(qV,w) | 158.4 | $m^3/hr$ |
| *- $u^2(a)/a^2$* | - | 0.00053 | |
| *- $u^2(qV,w)/q^2V,w$* | - | 0.00073 | |
| *- $u^2(qV,w)$* | - | 6529 | |
| *- u(qV,w)* | - | 80.8 | |
| Standard uncertainty associated with the volume flow rate (95% Confidence), relative | Uc,rel(qV,w) | 5.31 | % |

# TOTAL VOCs (as CARBON): RESULTS SUMMARY

Xaarjet Ltd, Huntingdon
14 - Validation Lab

## Sample Runs

| Parameter | Units | Run 1 | Run 2 | Run 3 | Mean |
|---|---|---|---|---|---|
| Concentration | mg/m³ | 7.5 | 28.7 | 21.2 | 19.1 |
| Uncertainty | ±mg/m³ | 0.47 | 0.78 | 0.64 | 0.63 |
| Mass Emission | g/hr | 20.9 | 79.9 | 59.0 | 53.3 |
| Uncertainty | ±g/hr | 1.7 | 4.8 | 3.6 | 3.4 |

## General Sampling Information

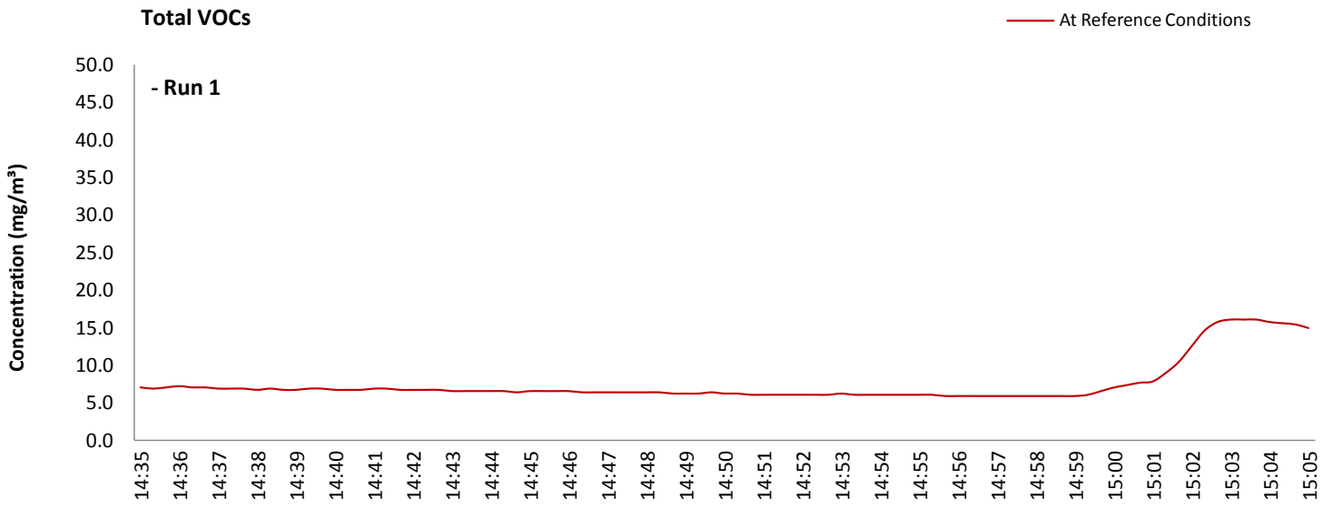
| Parameter | Value | |
|---|---|---|
| Standard | EN 12619:2013 | |
| Technical Procedure | CAT-TP-20 | |
| Probe Material | Stainless Steel | |
| Filtration Type / Size | 0.1µm Glass Fibre | |
| Heated Head Filter Used | Yes | |
| Heated Line Temperature | 180°C | |
| Span Gas Type | Propane In Synthetic Air (5 Grade) | |
| Span Gas Reference Number | CYL 1.0245a | |
| Span Gas Expiry Date | 10/09/2021 | |
| Span Gas Start Pressure (bar) | 70 | |
| Gas Cylinder Concentration (ppm) | 80.1 | |
| Span Gas Set Point (ppm) | 80.10 | |
| 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 | |

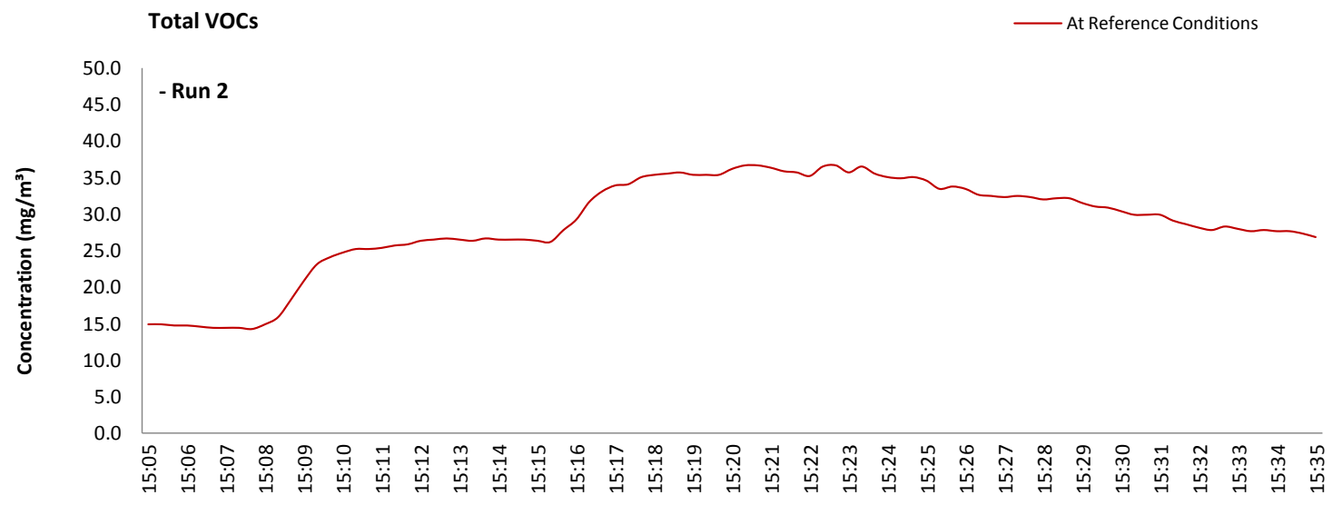
## Reference Conditions

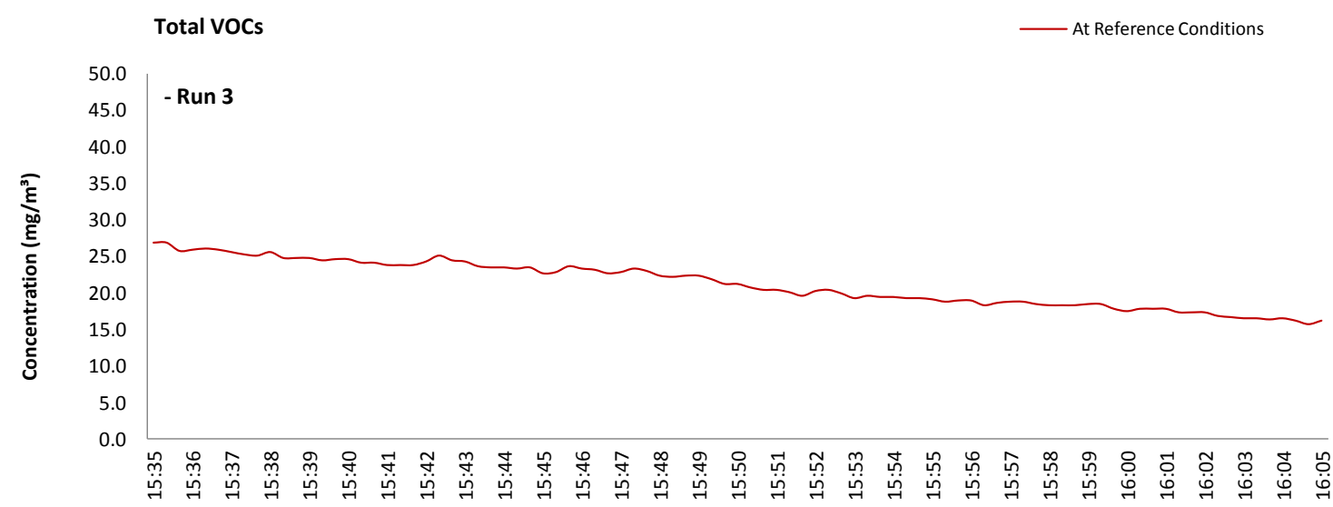
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

# 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 | - | 14:35 - 15:05 | 15:05 - 15:35 | 15:35 - 16:05 |
| Sampling Dates | - | 26/01/2017 | 26/01/2017 | 26/01/2017 |
| Instrument Range | ppm | 100 | 100 | 100 |
| Span Gas Value | ppm | 80.1 | 80.1 | 80.1 |

## Quality Assurance

| | Zero Drift | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|---|
| CAL 1 | Zero Down Sampling Line (Pre) | ppm | 0.10 | 0.10 | 0.10 |
| CAL 1 | Zero Down Sampling Line (Post) | ppm | 0.20 | 0.20 | 0.20 |
| CAL 1 | Zero Drift | ppm | 0.10 | 0.10 | 0.10 |
| | Allowable Zero Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Zero Drift Acceptable | - | Yes | Yes | Yes |

| | Span Drift | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|---|
| CAL 1 | Span Down Sampling Line (Pre) | ppm | 80.30 | 80.30 | 80.30 |
| CAL 1 | Span Down Sampling Line (Post) | ppm | 79.60 | 79.60 | 79.60 |
| CAL 1 | Span Drift | ppm | -0.70 | -0.70 | -0.70 |
| | Allowable Span Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Span Drift Acceptable | - | Yes | Yes | Yes |

| Test Conditions | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|
| Run Ambient Temperature Range | °C | 7 - 14 | 7 - 14 | 7 - 14 |

## 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 | 7.55 | 28.84 | 21.31 | 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. | 80.1 | 80.1 | 80.1 | 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. | 128.7 | 128.7 | 128.7 | 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 | 0.07 | 0.07 | 0.07 | % of value |
| Zero drift | 0.12 | 0.12 | 0.12 | % full scale |
| Span drift | -0.87 | -0.87 | -0.87 | % 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 | 0.05 | -0.05 | -0.01 | 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 | 0.09 | 0.33 | 0.25 | mg/m³ |

| Measurement uncertainty | | Result | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|---|---|
| | | | 7.55 | 28.84 | 21.31 | mg/m³ |
| Combined uncertainty | | | 0.24 | 0.40 | 0.33 | mg/m³ |
| Expanded uncertainty | k = | 1.96 | 0.47 | 0.79 | 0.64 | mg/m³ |
| Uncertainty corrected to std conds. ($O_2$) | | | 0.47 | 0.79 | 0.64 | mg/m³ (REF) |

| | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 6.25 | 2.73 | 3.02 | % of Value |
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 0.63 | 1.05 | 0.86 | % 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.*

Exova Catalyst, Unit 19, Bordesley Green Trading Estate, Bordesley Green Road, Birmingham, B8 1BZ
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: toby.campbell@exova.com
Your Exova Catalyst Contact: Toby Campbell (07825 130 074)

**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**
17 - Bay 1 Rear Wall

**Dates of the Monitoring Campaign**
25th January 2017

**Job Reference Number**
CAT-3175

| Report Written by |
| --- |
| Harpreet Badwal<br>Team Leader<br>MCERTS Level 2<br>MM 03 149<br>TE1 TE2 TE3 TE4 |

| Report Approved by |
| --- |
| Brian Jacob<br>Team Leader<br>MCERTS Level 2<br>MM 06 693<br>TE1 TE2 TE3 TE4 |

| Report Date |
| --- |
| 23rd February 2017 |

| Version |
| --- |
| Version 1 |

| Signature of Report Approver |
| --- |
|  |

# CONTENTS


TITLE PAGE

CONTENTS

Summary of Sampling Deviations 2

EXECUTIVE SUMMARY

Monitoring Objectives 3

Monitoring Results 4

Monitoring Dates & Times 5

Process Details 6

Monitoring & Analytical Methods 7

Sampling Location 8

Plant Photos / Sample Points 9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts


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


*This test report shall not be reproduced, except in full, without the written approval of Exova Catalyst.*

## MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
17 - Bay 1 Rear Wall
25th January 2017

**Overall Aim of the Monitoring Campaign**

Exova Catalyst were commissioned by Xaarjet Ltd to carry out stack emissions testing on the 17 - Bay 1 Rear Wall 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
17 - Bay 1 Rear Wall
25th January 2017

*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 | 3.6 | 0.57 | 75 | g/hr | 2.5 | 0.42 | - |
| Stack Gas Temperature | °C | 12.8 | | | | | | |
| Stack Gas Velocity | m/s | 4.0 | 0.19 | | | | | |
| Volumetric Flow Rate (ACTUAL) | m³/hr | 708 | 46.0 | | | | | |
| Volumetric Flow Rate (REF) [1] | m³/hr | 682 | 44.3 | | | | | |

*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
17 - Bay 1 Rear Wall
25th January 2017

| Parameter | | Units | Concentration | Units | Mass Emission | Sampling Date(s) | Sampling Times | Duration mins |
|---|---|---|---|---|---|---|---|---|
| Total VOCs (as Carbon) | R1 | mg/m³ | 5.0 | g/hr | 3.4 | 25/01/2017 | 16:19 - 16:49 | 30 |
| Total VOCs (as Carbon) | R2 | mg/m³ | 2.9 | g/hr | 2.0 | 25/01/2017 | 16:49 - 17:19 | 30 |
| Total VOCs (as Carbon) | R3 | mg/m³ | 2.9 | g/hr | 2.0 | 25/01/2017 | 17:19 - 17:49 | 30 |
| Velocity & Volumetric Flow Rate | R1 | | | | | 25/01/2017 | 15:53 - 16:05 | |

All results are expressed at the respective reference conditions.

## PROCESS DETAILS

Xaarjet Ltd, Huntingdon
17 - Bay 1 Rear Wall
25th January 2017

### 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 | N/A |
| Abatement System Running Status | N/A |
| Fuel | N/A |
| Plume Appearance | None Visible |

## MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
17 - Bay 1 Rear Wall
25th January 2017

| | 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 |
|---|---|---|
| Total VOC's | All | There are no deviations associated with the sampling employed. |

## SUITABILITY OF SAMPLING LOCATION

### Duct Characteristics

| Parameter | Units | Value |
|---|---|---|
| Type | - | Circular |
| Depth | m | 0.25 |
| Width | m | - |
| Area | m² | 0.05 |
| Port Depth | cm | 0 |
| Orientation of Duct | - | Horizontal |
| Sample Port Size | - | Hole |

### Location of Sampling Platform

| General Platform Information | Value |
|---|---|
| Permanent / Temporary Platform | Temporary |
| 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 | 11.0 | | > 5 Pa | Yes |
| Mean Velocity | m/s | 4.00 | | - | - |
| Lowest Gas Velocity | m/s | 3.53 | | - | - |
| Highest Gas Velocity | m/s | 4.88 | | - | - |
| Ratio of Above | : 1 | 1.38 | | < 3 : 1 | Yes |
| Maximum Angle of Swirl | ° | 4 | | < 15° | Yes |
| No Local Negative Flow | - | Yes | | - | Yes |

## PLANT PHOTOS

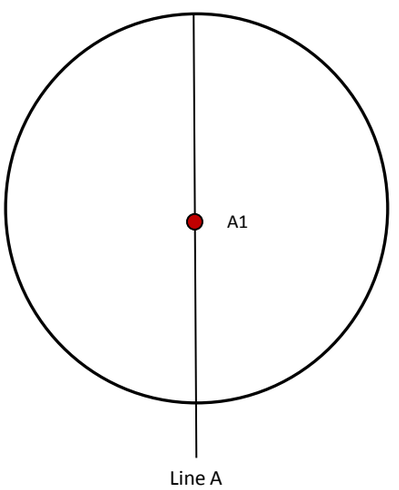
Photo 1

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

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## 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 | Aaron Nagha | MCERTS Trainee | MM 16 1392 | 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 | - |
| Servomex 5200MP | - |
| 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 4.874 |
| 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) | CAT 20.117 |
| 15m Heated Line (1) | - |
| 20m Heated Line (1) | CAT 20.116 |
| 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 | 0.25 |
| Stack Width, W | m | - |
| Stack Area, A | m² | 0.05 |
| Average Stack Gas Temperature, $T_a$ | °C | 12.8 |
| Average Stack Gas Pressure | Pa | 14.3 |
| Average Stack Static Pressure, $P_{static}$ | kPa | 0.143 |
| Average Barometric Pressure, $P_b$ | kPa | 102.0 |
| 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 | 1.240 |
| Average Wet Density (Actual), $P_{ActualW}$ | kg/m³ | 1.238 |

**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 | 12.8 | 0.0 |
| Total Pressure | kPa | 102.1 | 101.3 |
| Moisture | % | 0.50 | 0.50 |

| Gas Volumetric Flowrate (from Traverse) | Units | Result |
|---|---|---|
| Gas Volumetric Flowrate (Actual) | m³/hr | 708 |
| Gas Volumetric Flowrate (STP, Wet) | m³/hr | 682 |
| Gas Volumetric Flowrate (STP, Dry) | m³/hr | 678 |
| Gas Volumetric Flowrate REF [1] | m³/hr | 682 |

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

(1 of 1)

| Parameter | Units | Value |
|---|---|---|
| Date of Survey | - | 25/01/2017 |
| Time of Survey | - | 15:53 - 16:05 |
| Atmospheric Pressure | kPa | 102.0 |
| Average Stack Static Pressure | Pa | 143 |
| 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, $C_p$ | - | 0.84 |
| Number of Lines Available | - | 1 |
| Number of Lines Used | - | 1 |

**Sampling Line A**

| Traverse Point | Depth m | ΔP Pa | Temp °C | Wet Density kg/m³ | Velocity m/s | Swirl ° |
|---|---|---|---|---|---|---|
| *STATIC (Units: Pa)* | | *143.0* | | | | |
| **Mean** | | **14.3** | **12.8** | **1.238** | **4.00** | |
| 1 | 0.01 | 11.0 | 12.8 | 1.238 | 3.53 | 2.0 |
| 2 | 0.02 | 11.0 | 12.8 | 1.238 | 3.53 | 3.0 |
| 3 | 0.04 | 13.0 | 12.8 | 1.238 | 3.84 | 3.0 |
| 4 | 0.06 | 13.0 | 12.8 | 1.238 | 3.84 | 3.0 |
| 5 | 0.09 | 13.0 | 12.8 | 1.238 | 3.84 | 2.0 |
| 6 | 0.16 | 14.0 | 12.8 | 1.238 | 3.98 | 3.0 |
| 7 | 0.19 | 13.0 | 12.8 | 1.238 | 3.84 | 4.0 |
| 8 | 0.21 | 16.0 | 12.8 | 1.238 | 4.26 | 4.0 |
| 9 | 0.23 | 18.0 | 12.8 | 1.238 | 4.52 | 3.0 |
| 10 | 0.24 | 21.0 | 12.8 | 1.238 | 4.88 | 3.0 |

## 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) | 1.051 | Pa |
| *- Resolution* | u(res) | 0.00087 | |
| *- Calibration* | u(cal) | 0.021 | |
| *- Drift* | u(drift) | 0.083 | |
| *- Lack of Fit* | u(fit) | 0.000 | |
| *- Overall corrections to dynamic measurements* | u(Cf) | 0.106 | |
| 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($\phi O_2$,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(Tc) | 1.458 | K |
| Standard uncertainty associated with the absolute pressure in the duct | u(pc) | 175.695 | Pa |
| *- Atmospheric Pressure* | u(patm) | 175.692 | |
| *- Static Pressure* | u(pstat) | 1.051 | |
| Standard uncertainty associated with the density in the duct | u(ρ) | 0.00666 | - |
| Standard uncertainty associated with the local velocities | u(vi) | 0.172 | Pa |
| Standard uncertainty associated with the mean velocity | u(v) | 0.095 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence) | Uc(v) | 0.187 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence), relative | Uc,rel(v) | 4.66 | % |
| Standard uncertainty associated with the volume flow rate (95% Confidence) | Uc(qV,w) | 46.0 | $m^3/hr$ |
| *- $u^2(a)/a^2$* | - | 0.00053 | |
| *- $u^2(qV,w)/q^2V,w$* | - | 0.00110 | |
| *- $u^2(qV,w)$* | - | 551 | |
| *- u(qV,w)* | - | 23.5 | |
| Standard uncertainty associated with the volume flow rate (95% Confidence), relative | Uc,rel(qV,w) | 6.50 | % |

# TOTAL VOCs (as CARBON): RESULTS SUMMARY

Xaarjet Ltd, Huntingdon
17 - Bay 1 Rear Wall

## Sample Runs

| Parameter | Units | Run 1 | Run 2 | Run 3 | Mean |
|---|---|---|---|---|---|
| Concentration | mg/m³ | 5.0 | 2.9 | 2.9 | 3.6 |
| Uncertainty | ±mg/m³ | 0.58 | 0.57 | 0.57 | 0.57 |
| Mass Emission | g/hr | 3.4 | 2.0 | 2.0 | 2.5 |
| Uncertainty | ±g/hr | 0.45 | 0.41 | 0.41 | 0.42 |

## General Sampling Information

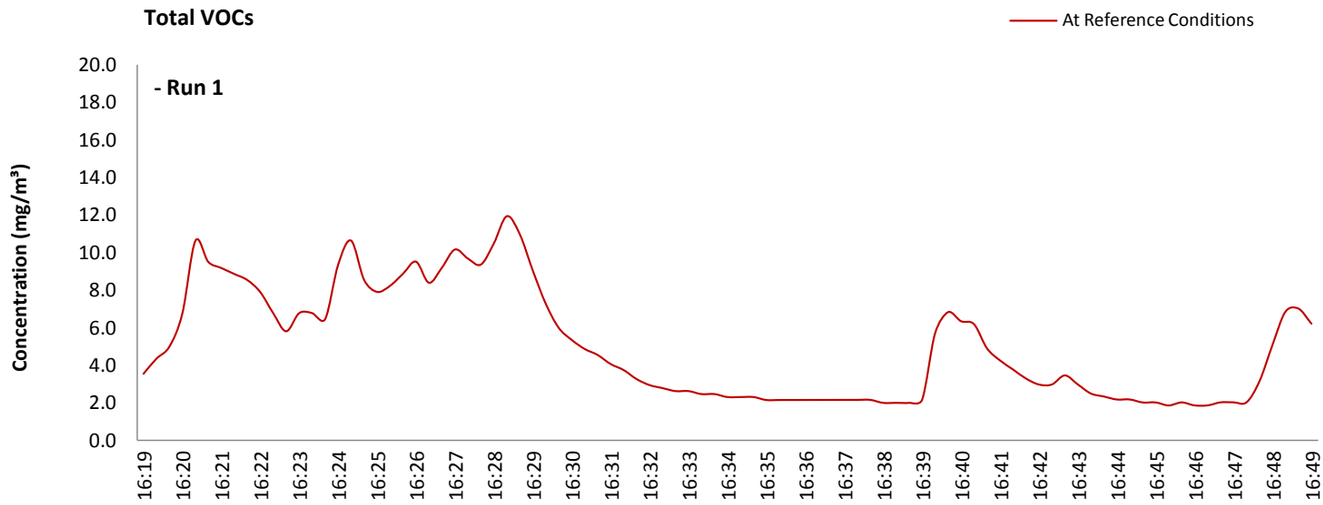
| Parameter | Value | |
|---|---|---|
| Standard | EN 12619:2013 | |
| Technical Procedure | CAT-TP-20 | |
| Probe Material | Stainless Steel | |
| Filtration Type / Size | 0.1µm Glass Fibre | |
| Heated Head Filter Used | Yes | |
| Heated Line Temperature | 180°C | |
| Span Gas Type | Propane In Synthetic Air (5 Grade) | |
| Span Gas Reference Number | CYL 1.0245a | |
| Span Gas Expiry Date | 10/09/2021 | |
| Span Gas Start Pressure (bar) | 85 | |
| Gas Cylinder Concentration (ppm) | 80.1 | |
| Span Gas Set Point (ppm) | 80.10 | |
| 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 | |

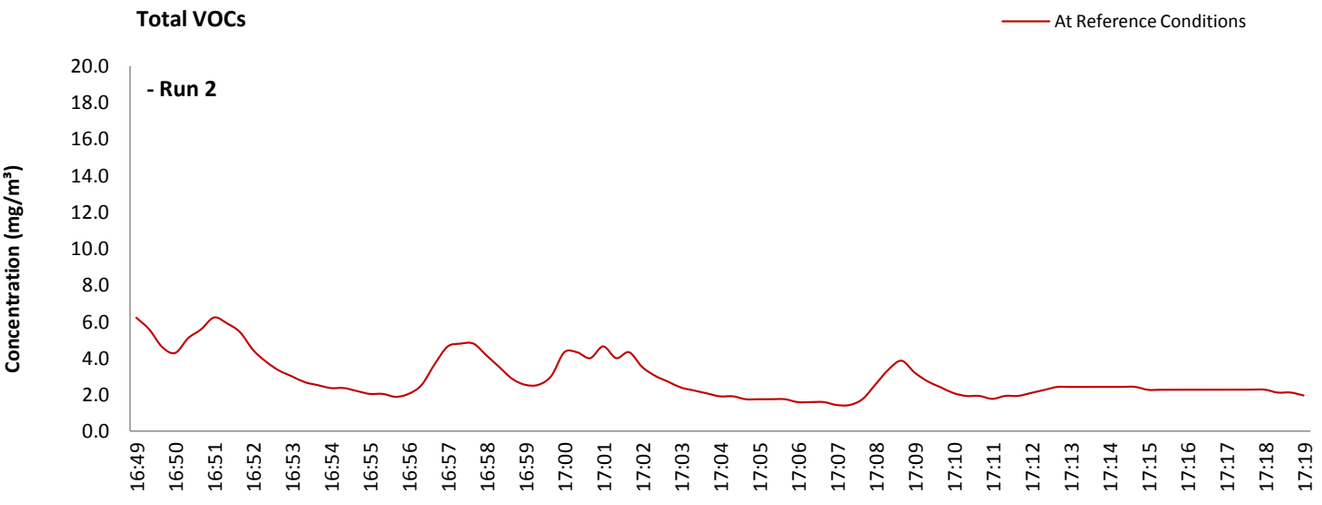
## Reference Conditions

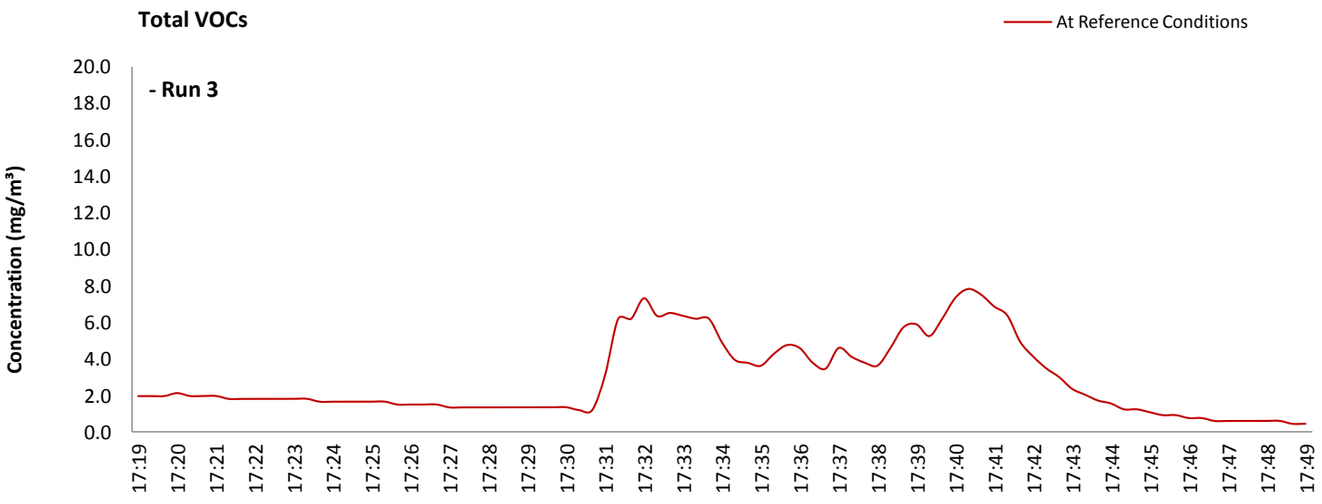
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

## 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 | - | 16:19 - 16:49 | 16:49 - 17:19 | 17:19 - 17:49 |
| Sampling Dates | - | 25/01/2017 | 25/01/2017 | 25/01/2017 |
| Instrument Range | ppm | 100 | 100 | 100 |
| Span Gas Value | ppm | 80.1 | 80.1 | 80.1 |

## 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 | 4.01 | 4.01 | 4.01 |
| | Zero Drift Acceptable | - | Yes | Yes | Yes |

| | Span Drift | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|---|
| CAL 1 | Span Down Sampling Line (Pre) | ppm | 80.10 | 80.10 | 80.10 |
| | Span Down Sampling Line (Post) | ppm | 79.90 | 79.90 | 79.90 |
| | Span Drift | ppm | -0.20 | -0.20 | -0.20 |
| | Allowable Span Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Span Drift Acceptable | - | Yes | Yes | Yes |

| Test Conditions | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|
| Run Ambient Temperature Range | °C | 7 - 14 | 7 - 14 | 7 - 14 |

## 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 | 5.05 | 2.93 | 2.93 | 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. | 80.1 | 80.1 | 80.1 | 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. | 128.7 | 128.7 | 128.7 | 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 | 0.07 | 0.07 | 0.07 | % of value |
| Zero drift | -0.25 | -0.25 | -0.25 | % full scale |
| Span drift | -0.25 | -0.25 | -0.25 | % 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/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 | -0.19 | -0.19 | -0.19 | 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 | 0.06 | 0.03 | 0.03 | mg/m³ |

| | | | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|---|---|
| **Measurement uncertainty** | | **Result** | 5.05 | 2.93 | 2.93 | mg/m³ |
| Combined uncertainty | | | 0.30 | 0.29 | 0.29 | mg/m³ |
| Expanded uncertainty | k = | 1.96 | 0.58 | 0.57 | 0.57 | mg/m³ |
| Uncertainty corrected to std conds. ($O_2$) | | | 0.58 | 0.57 | 0.57 | mg/m³ (REF) |

| | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 11.51 | 19.46 | 19.48 | % of Value |
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 0.78 | 0.76 | 0.76 | % 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.*

Exova Catalyst, Unit 19, Bordesley Green Trading Estate, Bordesley Green Road, Birmingham, B8 1BZ
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: toby.campbell@exova.com
Your Exova Catalyst Contact: Toby Campbell (07825 130 074)

**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**
20 - CR4 Room Extract

**Dates of the Monitoring Campaign**
27th January 2017

**Job Reference Number**
CAT-3175

| Report Written by |
| --- |
| Harpreet Badwal<br>Team Leader<br>MCERTS Level 2<br>MM 03 149<br>TE1 TE2 TE3 TE4 |

| Report Approved by |
| --- |
| Brian Jacob<br>Team Leader<br>MCERTS Level 2<br>MM 06 693<br>TE1 TE2 TE3 TE4 |

| Report Date |
| --- |
| 23rd February 2017 |

| Version |
| --- |
| Version 1 |

| Signature of Report Approver |
| --- |
|  |

# CONTENTS

TITLE PAGE

CONTENTS

Summary of Sampling Deviations 2

EXECUTIVE SUMMARY

Monitoring Objectives 3

Monitoring Results 4

Monitoring Dates & Times 5

Process Details 6

Monitoring & Analytical Methods 7

Sampling Location 8

Plant Photos / Sample Points 9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts

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

*This test report shall not be reproduced, except in full, without the written approval of Exova Catalyst.*

## MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
20 - CR4 Room Extract
27th January 2017

**Overall Aim of the Monitoring Campaign**

Exova Catalyst were commissioned by Xaarjet Ltd to carry out stack emissions testing on the 20 - CR4 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
20 - CR4 Room Extract
27th January 2017

*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 | 18.6 | 0.81 | 75 | g/hr | 21.3 | 1.6 | - |
| Stack Gas Temperature | °C | 12.7 | | | | | | |
| Stack Gas Velocity | m/s | 4.8 | 0.18 | | | | | |
| Volumetric Flow Rate (ACTUAL) | m³/hr | 1209 | 71.4 | | | | | |
| Volumetric Flow Rate (REF) [1] | m³/hr | 1145 | 67.6 | | | | | |

*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
20 - CR4 Room Extract
27th January 2017

| Parameter | | Units | Concentration | Units | Mass Emission | Sampling Date(s) | Sampling Times | Duration mins |
|---|---|---|---|---|---|---|---|---|
| Total VOCs (as Carbon) | R1 | mg/m³ | 22.7 | g/hr | 26.0 | 27/01/2017 | 10:10 - 10:40 | 30 |
| Total VOCs (as Carbon) | R2 | mg/m³ | 16.9 | g/hr | 19.3 | 27/01/2017 | 10:40 - 11:10 | 30 |
| Total VOCs (as Carbon) | R3 | mg/m³ | 16.2 | g/hr | 18.5 | 27/01/2017 | 11:10 - 11:40 | 30 |
| Velocity & Volumetric Flow Rate | R1 | | | | | 27/01/2017 | 09:10 - 09:22 | |

All results are expressed at the respective reference conditions.

## PROCESS DETAILS

Xaarjet Ltd, Huntingdon
20 - CR4 Room Extract
27th January 2017

### 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 | N/A |
| Abatement System Running Status | N/A |
| Fuel | N/A |
| Plume Appearance | None Visible |

## MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
20 - CR4 Room Extract
27th January 2017

| | 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)

## SUMMARY OF SAMPLING DEVIATIONS

| Parameter | Run | Deviation |
|---|---|---|
| Total VOC's | All | 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 | - | Vertical |
| Sample Port Size | - | Hole |

### Location of Sampling Platform

| General Platform Information | Value |
|---|---|
| Permanent / Temporary Platform | Temporary |
| 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) | 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 | 11.0 | | > 5 Pa | Yes |
| Mean Velocity | m/s | 4.75 | | - | - |
| Lowest Gas Velocity | m/s | 3.56 | | - | - |
| Highest Gas Velocity | m/s | 5.58 | | - | - |
| Ratio of Above | : 1 | 1.57 | | < 3 : 1 | Yes |
| Maximum Angle of Swirl | ° | 2 | | < 15° | Yes |
| No Local Negative Flow | - | Yes | | - | Yes |

## PLANT PHOTOS

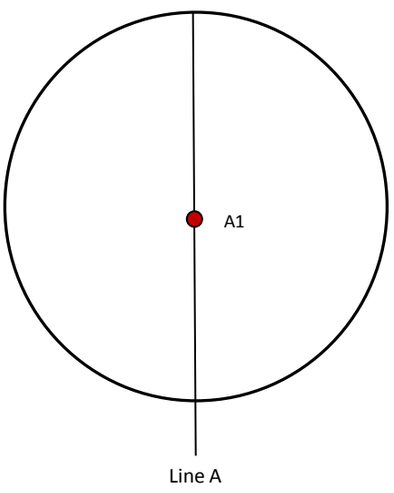
Photo 1

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

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## 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 | Aaron Nagha | MCERTS Trainee | MM 16 1392 | 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 | - |
| Servomex 5200MP | - |
| 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 4.874 |
| 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) | CAT 20.117 |
| 15m Heated Line (1) | - |
| 20m Heated Line (1) | CAT 20.116 |
| 20m Heated Line (2) | - |
| Dual Channel Heater Controller | - |
| Single Channel Heater Controller | CAT 20.116 |
| 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 | 12.7 |
| Average Stack Gas Pressure | Pa | 19.9 |
| Average Stack Static Pressure, $P_{static}$ | kPa | 0.005 |
| 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 | 1.218 |
| Average Wet Density (Actual), $P_{ActualW}$ | kg/m³ | 1.216 |

**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 | 12.7 | 0.0 |
| Total Pressure | kPa | 100.3 | 101.3 |
| Moisture | % | 0.50 | 0.50 |

| Gas Volumetric Flowrate (from Traverse) | Units | Result |
|---|---|---|
| Gas Volumetric Flowrate (Actual) | m³/hr | 1209 |
| Gas Volumetric Flowrate (STP, Wet) | m³/hr | 1145 |
| Gas Volumetric Flowrate (STP, Dry) | m³/hr | 1139 |
| Gas Volumetric Flowrate REF [1] | m³/hr | 1145 |

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

(1 of 1)

| Parameter | Units | Value |
|---|---|---|
| Date of Survey | - | 27/01/2017 |
| Time of Survey | - | 09:10 - 09:22 |
| Atmospheric Pressure | kPa | 100.3 |
| Average Stack Static Pressure | Pa | 5 |
| 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 | - | 1 |
| Number of Lines Used | - | 1 |

**Sampling Line A**

| Traverse Point | Depth m | ΔP Pa | Temp °C | Wet Density kg/m³ | Velocity m/s | Swirl ° |
|---|---|---|---|---|---|---|
| *STATIC (Units: Pa)* | | *5.0* | | | | |
| **Mean** | | **19.9** | **12.7** | **1.216** | **4.75** | |
| 1 | 0.01 | 19.0 | 12.6 | 1.216 | 4.68 | 1.0 |
| 2 | 0.02 | 23.0 | 12.6 | 1.216 | 5.15 | 0.0 |
| 3 | 0.04 | 26.0 | 12.6 | 1.216 | 5.48 | 1.0 |
| 4 | 0.07 | 27.0 | 12.6 | 1.216 | 5.58 | 2.0 |
| 5 | 0.10 | 24.0 | 12.6 | 1.216 | 5.26 | 2.0 |
| 6 | 0.20 | 20.0 | 12.7 | 1.216 | 4.80 | 1.0 |
| 7 | 0.23 | 11.0 | 12.7 | 1.216 | 3.56 | 2.0 |
| 8 | 0.26 | 15.0 | 12.7 | 1.216 | 4.16 | 1.0 |
| 9 | 0.28 | 18.0 | 12.7 | 1.216 | 4.56 | 1.0 |
| 10 | 0.29 | 16.0 | 12.7 | 1.216 | 4.30 | 0.0 |

## 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) | 1.061 | Pa |
| *- Resolution* | u(res) | 0.00087 | |
| *- Calibration* | u(cal) | 0.041 | |
| *- Drift* | u(drift) | 0.083 | |
| *- Lack of Fit* | u(fit) | 0.000 | |
| *- Overall corrections to dynamic measurements* | u(Cf) | 0.126 | |
| 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($\phi O_2$,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(Tc) | 1.457 | K |
| Standard uncertainty associated with the absolute pressure in the duct | u(pc) | 175.695 | Pa |
| *- Atmospheric Pressure* | u(patm) | 175.692 | |
| *- Static Pressure* | u(pstat) | 1.061 | |
| Standard uncertainty associated with the density in the duct | u(ρ) | 0.00656 | - |
| Standard uncertainty associated with the local velocities | u(vi) | 0.155 | Pa |
| Standard uncertainty associated with the mean velocity | u(v) | 0.092 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence) | Uc(v) | 0.180 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence), relative | Uc,rel(v) | 3.79 | % |
| Standard uncertainty associated with the volume flow rate (95% Confidence) | Uc(qV,w) | 71.4 | $m^3/hr$ |
| *- $u^2(a)/a^2$* | - | 0.00053 | |
| *- $u^2(qV,w)/q^2V,w$* | - | 0.00091 | |
| *- $u^2(qV,w)$* | - | 1327 | |
| *- u(qV,w)* | - | 36.4 | |
| Standard uncertainty associated with the volume flow rate (95% Confidence), relative | Uc,rel(qV,w) | 5.90 | % |

# TOTAL VOCs (as CARBON): RESULTS SUMMARY

Xaarjet Ltd, Huntingdon
20 - CR4 Room Extract

## Sample Runs

| Parameter | Units | Run 1 | Run 2 | Run 3 | Mean |
|---|---|---|---|---|---|
| Concentration | mg/m³ | 22.7 | 16.9 | 16.2 | 18.6 |
| Uncertainty | ±mg/m³ | 0.83 | 0.80 | 0.80 | 0.81 |
| Mass Emission | g/hr | 26.0 | 19.3 | 18.5 | 21.3 |
| Uncertainty | ±g/hr | 1.8 | 1.5 | 1.4 | 1.6 |

## General Sampling Information

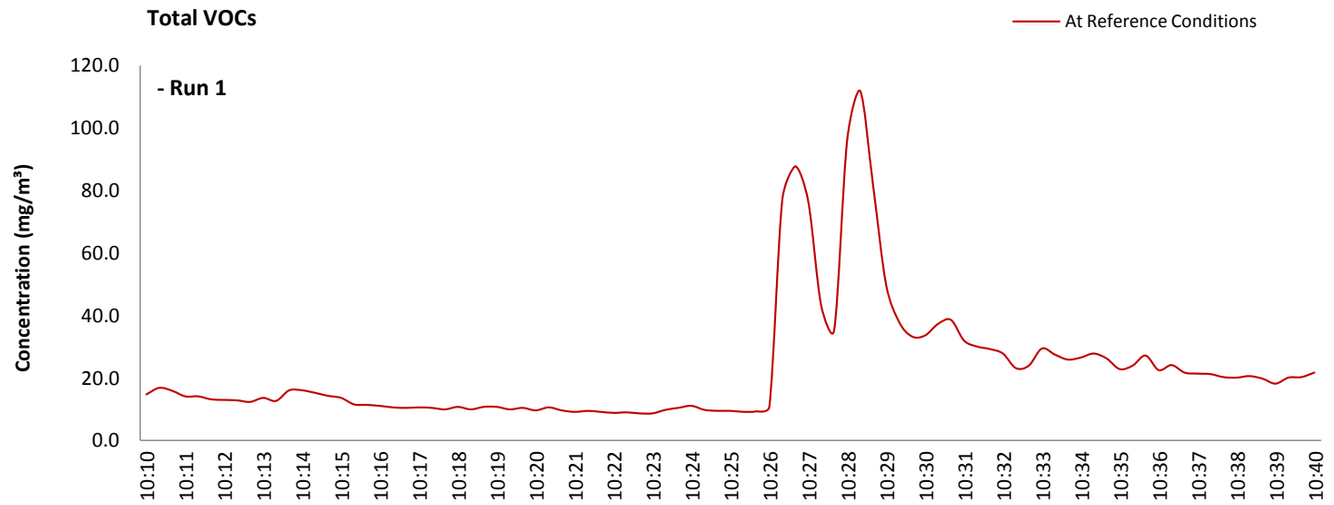
| Parameter | Value | |
|---|---|---|
| Standard | EN 12619:2013 | |
| Technical Procedure | CAT-TP-20 | |
| Probe Material | Stainless Steel | |
| Filtration Type / Size | 0.1µm Glass Fibre | |
| Heated Head Filter Used | Yes | |
| Heated Line Temperature | 180°C | |
| Span Gas Type | Propane In Synthetic Air (5 Grade) | |
| Span Gas Reference Number | CYL 1.0245a | |
| Span Gas Expiry Date | 10/09/2021 | |
| Span Gas Start Pressure (bar) | 55 | |
| Gas Cylinder Concentration (ppm) | 80.1 | |
| Span Gas Set Point (ppm) | 80.10 | |
| 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 | |

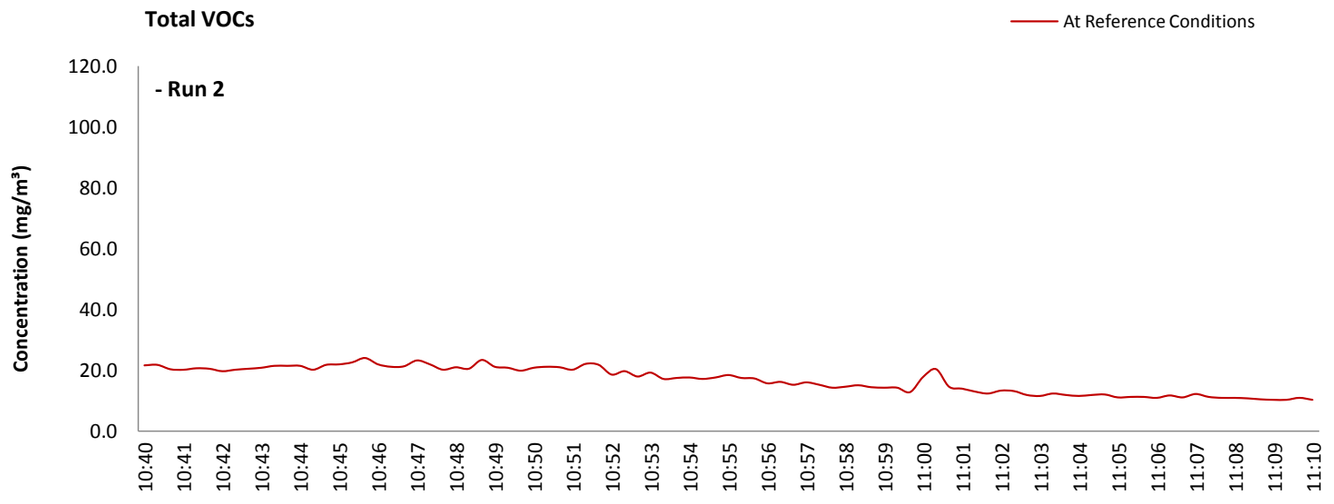
## Reference Conditions

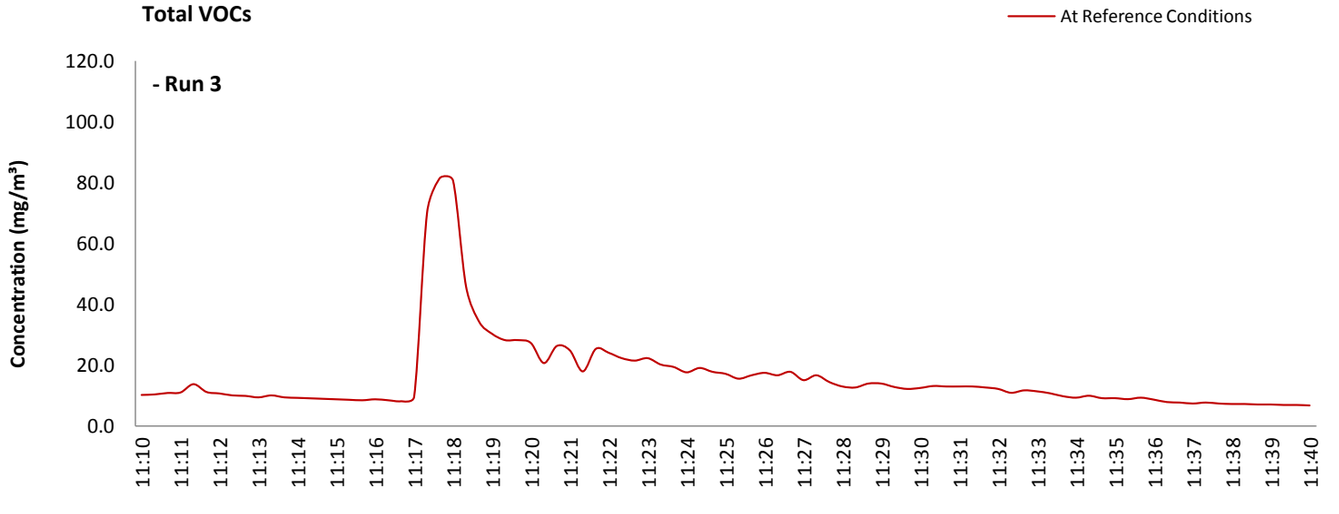
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

# 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 | - | 10:10 - 10:40 | 10:40 - 11:10 | 11:10 - 11:40 |
| Sampling Dates | - | 27/01/2017 | 27/01/2017 | 27/01/2017 |
| Instrument Range | ppm | 100 | 100 | 100 |
| Span Gas Value | ppm | 80.1 | 80.1 | 80.1 |

## Quality Assurance

| | Zero Drift | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|---|
| CAL 1 | Zero Down Sampling Line (Pre) | ppm | 0.10 | 0.10 | 0.10 |
| | Zero Down Sampling Line (Post) | ppm | -0.30 | -0.30 | -0.30 |
| | Zero Drift | ppm | -0.40 | -0.40 | -0.40 |
| | Allowable Zero Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | 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 | 80.70 | 80.70 | 80.70 |
| | Span Drift | ppm | 0.70 | 0.70 | 0.70 |
| | Allowable Span Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Span Drift Acceptable | - | Yes | Yes | Yes |

| Test Conditions | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|
| Run Ambient Temperature Range | °C | 7 - 14 | 7 - 14 | 7 - 14 |

## 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 | 22.83 | 16.98 | 16.23 | 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. | 80.1 | 80.1 | 80.1 | 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. | 128.7 | 128.7 | 128.7 | 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 | 0.07 | 0.07 | 0.07 | % of value |
| Zero drift | -0.50 | -0.50 | -0.50 | % full scale |
| Span drift | 0.88 | 0.88 | 0.88 | % 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) | 0.12 | 0.12 | 0.12 | % 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 | -0.26 | -0.29 | -0.29 | 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) | 0.02 | 0.01 | 0.01 | mg/m³ |
| Uncertainty of calibration gas | 0.26 | 0.20 | 0.19 | mg/m³ |

| | | | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|---|---|
| **Measurement uncertainty** | | **Result** | 22.83 | 16.98 | 16.23 | mg/m³ |
| Combined uncertainty | | | 0.43 | 0.41 | 0.41 | mg/m³ |
| Expanded uncertainty | k = | 1.96 | 0.84 | 0.80 | 0.80 | mg/m³ |
| Uncertainty corrected to std conds. ($O_2$) | | | 0.84 | 0.80 | 0.80 | mg/m³ (REF) |

| | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 3.67 | 4.72 | 4.93 | % of Value |
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 1.12 | 1.07 | 1.07 | % 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.*

Exova Catalyst, Unit 19, Bordesley Green Trading Estate, Bordesley Green Road, Birmingham, B8 1BZ
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: toby.campbell@exova.com
Your Exova Catalyst Contact: Toby Campbell (07825 130 074)

**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**
21 - CR4 Room Extract

**Dates of the Monitoring Campaign**
27th January 2017

**Job Reference Number**
CAT-3175

| Report Written by |
| --- |
| Harpreet Badwal<br>Team Leader<br>MCERTS Level 2<br>MM 03 149<br>TE1 TE2 TE3 TE4 |

| Report Approved by |
| --- |
| Brian Jacob<br>Team Leader<br>MCERTS Level 2<br>MM 06 693<br>TE1 TE2 TE3 TE4 |

| Report Date |
| --- |
| 23rd February 2017 |

| Version |
| --- |
| Version 1 |

| Signature of Report Approver |
| --- |
|  |

# CONTENTS

TITLE PAGE

CONTENTS

Summary of Sampling Deviations 2

EXECUTIVE SUMMARY

Monitoring Objectives 3

Monitoring Results 4

Monitoring Dates & Times 5

Process Details 6

Monitoring & Analytical Methods 7

Sampling Location 8

Plant Photos / Sample Points 9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts

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

*This test report shall not be reproduced, except in full, without the written approval of Exova Catalyst.*

## MONITORING OBJECTIVES

Xaarjet Ltd, Huntingdon
21 - CR4 Room Extract
27th January 2017

**Overall Aim of the Monitoring Campaign**

Exova Catalyst were commissioned by Xaarjet Ltd to carry out stack emissions testing on the 21 - CR4 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
21 - CR4 Room Extract
27th January 2017

*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 | 10.0 | 0.79 | 75 | g/hr | 16.2 | 1.6 | - |
| Stack Gas Temperature | °C | 15.7 | | | | | | |
| Stack Gas Velocity | m/s | 6.8 | 0.24 | | | | | |
| Volumetric Flow Rate (ACTUAL) | m³/hr | 1731 | 99.0 | | | | | |
| Volumetric Flow Rate (REF) [1] | m³/hr | 1623 | 92.8 | | | | | |

*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
21 - CR4 Room Extract
27th January 2017

| Parameter | | Units | Concentration | Units | Mass Emission | Sampling Date(s) | Sampling Times | Duration mins |
|---|---|---|---|---|---|---|---|---|
| Total VOCs (as Carbon) | R1 | mg/m³ | 9.3 | g/hr | 15.1 | 27/01/2017 | 11:50 - 12:20 | 30 |
| Total VOCs (as Carbon) | R2 | mg/m³ | 9.3 | g/hr | 15.0 | 27/01/2017 | 12:20 - 12:50 | 30 |
| Total VOCs (as Carbon) | R3 | mg/m³ | 11.5 | g/hr | 18.6 | 27/01/2017 | 12:50 - 13:20 | 30 |
| Velocity & Volumetric Flow Rate | R1 | | | | | 27/01/2017 | 11:24 - 11:36 | |

All results are expressed at the respective reference conditions.

## PROCESS DETAILS

Xaarjet Ltd, Huntingdon
21 - CR4 Room Extract
27th January 2017

### 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 | N/A |
| Abatement System Running Status | N/A |
| Fuel | N/A |
| Plume Appearance | None Visible |

## MONITORING & ANALYTICAL METHODS

Xaarjet Ltd, Huntingdon
21 - CR4 Room Extract
27th January 2017

| | 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)

## SUMMARY OF SAMPLING DEVIATIONS

| Parameter | Run | Deviation |
|---|---|---|
| Total VOC's | All | 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 | - | Vertical |
| Sample Port Size | - | Hole |

### Location of Sampling Platform

| General Platform Information | Value |
|---|---|
| Permanent / Temporary Platform | On Ground |
| 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) | 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 | 36.0 | | > 5 Pa | Yes |
| Mean Velocity | m/s | 6.80 | | - | - |
| Lowest Gas Velocity | m/s | 6.47 | | - | - |
| Highest Gas Velocity | m/s | 7.24 | | - | - |
| Ratio of Above | : 1 | 1.12 | | < 3 : 1 | Yes |
| Maximum Angle of Swirl | ° | 2 | | < 15° | Yes |
| No Local Negative Flow | - | Yes | | - | Yes |

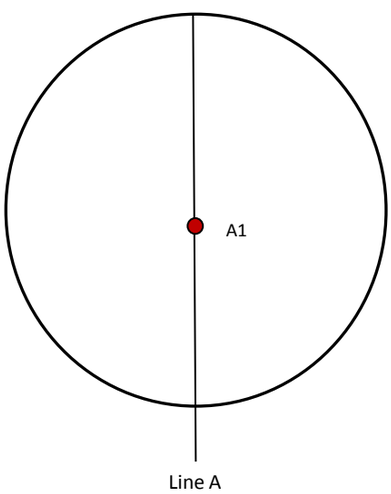
## PLANT PHOTOS

Photo 1

Photo 2

Photo 3

## SAMPLE POINTS




**where**
- ○ = isokinetic point sampled at
- ● = isokinetic point not sampled at
- ● = combustion gases sample point
- ● = non-isokinetic sample point

## APPENDIX CONTENTS

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

## 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 | Aaron Nagha | MCERTS Trainee | MM 16 1392 | 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 | - |
| Servomex 5200MP | - |
| 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 4.874 |
| 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) | CAT 20.117 |
| 15m Heated Line (1) | - |
| 20m Heated Line (1) | CAT 20.116 |
| 20m Heated Line (2) | - |
| Dual Channel Heater Controller | - |
| Single Channel Heater Controller | CAT 20.116 |
| 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 | 15.7 |
| Average Stack Gas Pressure | Pa | 39.8 |
| Average Stack Static Pressure, $P_{static}$ | kPa | 0.025 |
| Average Barometric Pressure, $P_b$ | kPa | 100.4 |
| 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 | 1.207 |
| Average Wet Density (Actual), $P_{ActualW}$ | kg/m³ | 1.204 |

**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 | 15.7 | 0.0 |
| Total Pressure | kPa | 100.4 | 101.3 |
| Moisture | % | 0.50 | 0.50 |

| Gas Volumetric Flowrate (from Traverse) | Units | Result |
|---|---|---|
| Gas Volumetric Flowrate (Actual) | m³/hr | 1731 |
| Gas Volumetric Flowrate (STP, Wet) | m³/hr | 1623 |
| Gas Volumetric Flowrate (STP, Dry) | m³/hr | 1615 |
| Gas Volumetric Flowrate REF [1] | m³/hr | 1623 |

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

(1 of 1)

| Parameter | Units | Value |
|---|---|---|
| Date of Survey | - | 27/01/2017 |
| Time of Survey | - | 11:24 - 11:36 |
| Atmospheric Pressure | kPa | 100.4 |
| Average Stack Static Pressure | Pa | 25 |
| 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 | - | 1 |
| Number of Lines Used | - | 1 |

**Sampling Line A**

| Traverse Point | Depth m | ΔP Pa | Temp °C | Wet Density kg/m³ | Velocity m/s | Swirl ° |
|---|---|---|---|---|---|---|
| *STATIC (Units: Pa)* | | *25.0* | | | | |
| **Mean** | | **39.8** | **15.7** | **1.204** | **6.80** | |
| 1 | 0.01 | 36.0 | 15.4 | 1.206 | 6.47 | 1.0 |
| 2 | 0.02 | 38.0 | 15.4 | 1.206 | 6.65 | 1.0 |
| 3 | 0.04 | 39.0 | 15.6 | 1.205 | 6.74 | 2.0 |
| 4 | 0.07 | 43.0 | 15.6 | 1.205 | 7.07 | 2.0 |
| 5 | 0.10 | 41.0 | 15.7 | 1.204 | 6.91 | 2.0 |
| 6 | 0.20 | 36.0 | 15.8 | 1.204 | 6.47 | 1.0 |
| 7 | 0.23 | 38.0 | 15.8 | 1.204 | 6.65 | 1.0 |
| 8 | 0.26 | 40.0 | 16.0 | 1.203 | 6.83 | 0.0 |
| 9 | 0.28 | 42.0 | 16.0 | 1.203 | 7.00 | 0.0 |
| 10 | 0.29 | 45.0 | 16.1 | 1.203 | 7.24 | 1.0 |

## 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) | 1.134 | Pa |
| *- Resolution* | u(res) | 0.00087 | |
| *- Calibration* | u(cal) | 0.165 | |
| *- Drift* | u(drift) | 0.083 | |
| *- Lack of Fit* | u(fit) | 0.037 | |
| *- Overall corrections to dynamic measurements* | u(Cf) | 0.287 | |
| 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($\phi O_2$,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(Tc) | 1.473 | K |
| Standard uncertainty associated with the absolute pressure in the duct | u(pc) | 175.696 | Pa |
| *- Atmospheric Pressure* | u(patm) | 175.692 | |
| *- Static Pressure* | u(pstat) | 1.134 | |
| Standard uncertainty associated with the density in the duct | u(ρ) | 0.00650 | - |
| Standard uncertainty associated with the local velocities | u(vi) | 0.152 | Pa |
| Standard uncertainty associated with the mean velocity | u(v) | 0.121 | m/s |
| Standard uncertainty associated with the mean velocity (95% Confidence) | Uc(v) | 0.237 | 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) | 99.0 | $m^3/hr$ |
| *- $u^2(a)/a^2$* | - | 0.00053 | |
| *- $u^2(qV,w)/q^2V,w$* | - | 0.00085 | |
| *- $u^2(qV,w)$* | - | 2549 | |
| *- u(qV,w)* | - | 50.5 | |
| 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
21 - CR4 Room Extract

## Sample Runs

| Parameter | Units | Run 1 | Run 2 | Run 3 | Mean |
|---|---|---|---|---|---|
| Concentration | mg/m³ | 9.3 | 9.3 | 11.5 | 10.0 |
| Uncertainty | ±mg/m³ | 0.79 | 0.79 | 0.79 | 0.79 |
| Mass Emission | g/hr | 15.1 | 15.0 | 18.6 | 16.2 |
| Uncertainty | ±g/hr | 1.5 | 1.5 | 1.7 | 1.6 |

## General Sampling Information

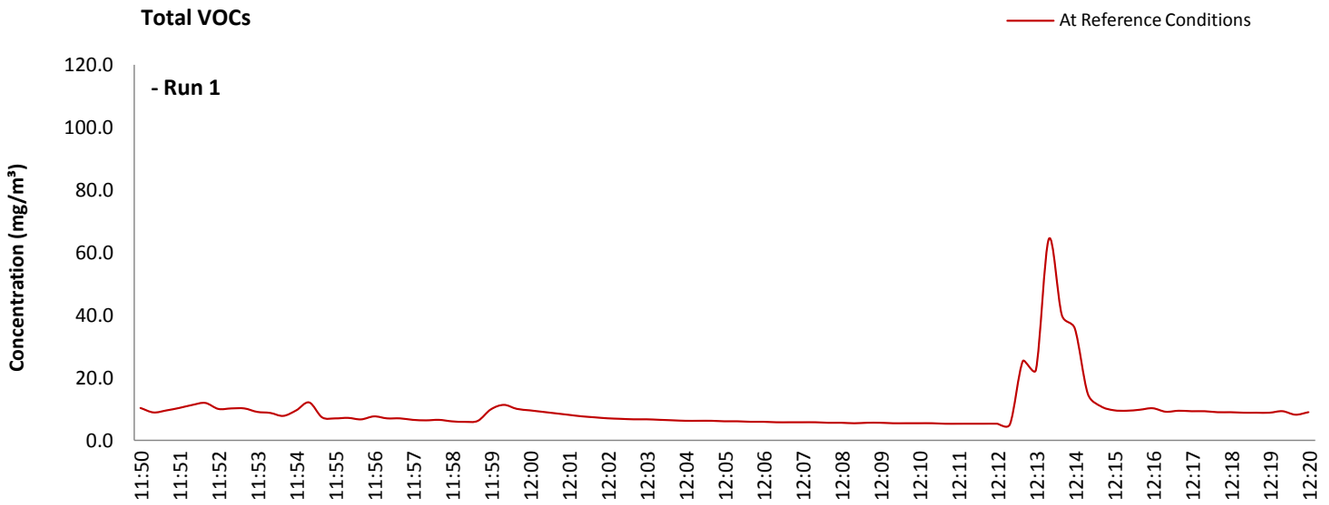
| Parameter | Value | |
|---|---|---|
| Standard | EN 12619:2013 | |
| Technical Procedure | CAT-TP-20 | |
| Probe Material | Stainless Steel | |
| Filtration Type / Size | 0.1µm Glass Fibre | |
| Heated Head Filter Used | Yes | |
| Heated Line Temperature | 180°C | |
| Span Gas Type | Propane In Synthetic Air (5 Grade) | |
| Span Gas Reference Number | CYL 1.0245a | |
| Span Gas Expiry Date | 10/09/2021 | |
| Span Gas Start Pressure (bar) | 55 | |
| Gas Cylinder Concentration (ppm) | 80.1 | |
| Span Gas Set Point (ppm) | 80.10 | |
| 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 | |

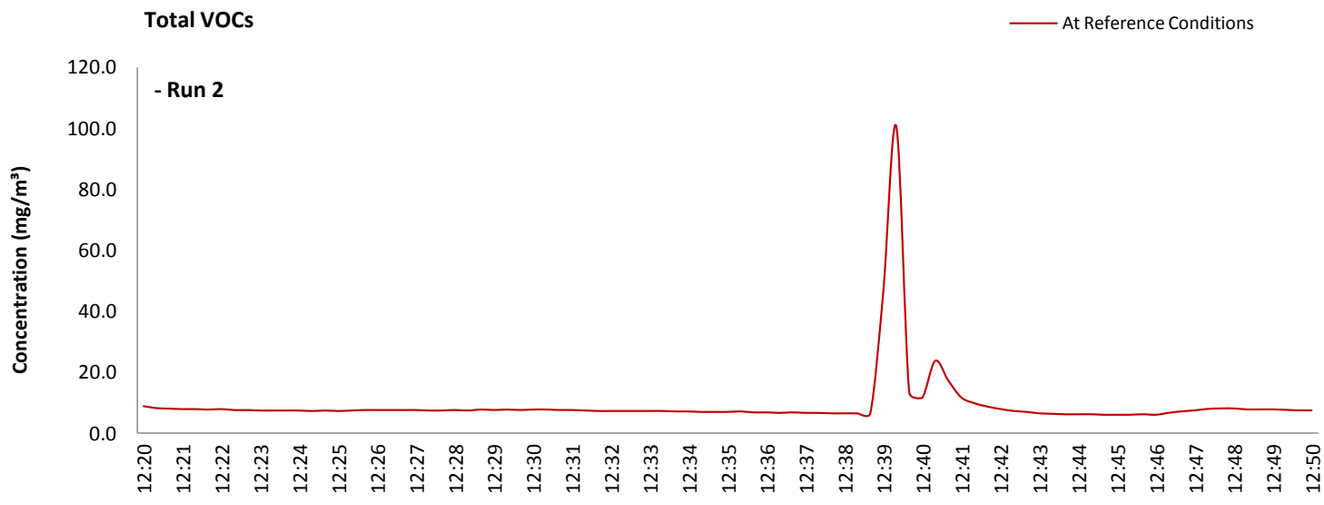
## Reference Conditions

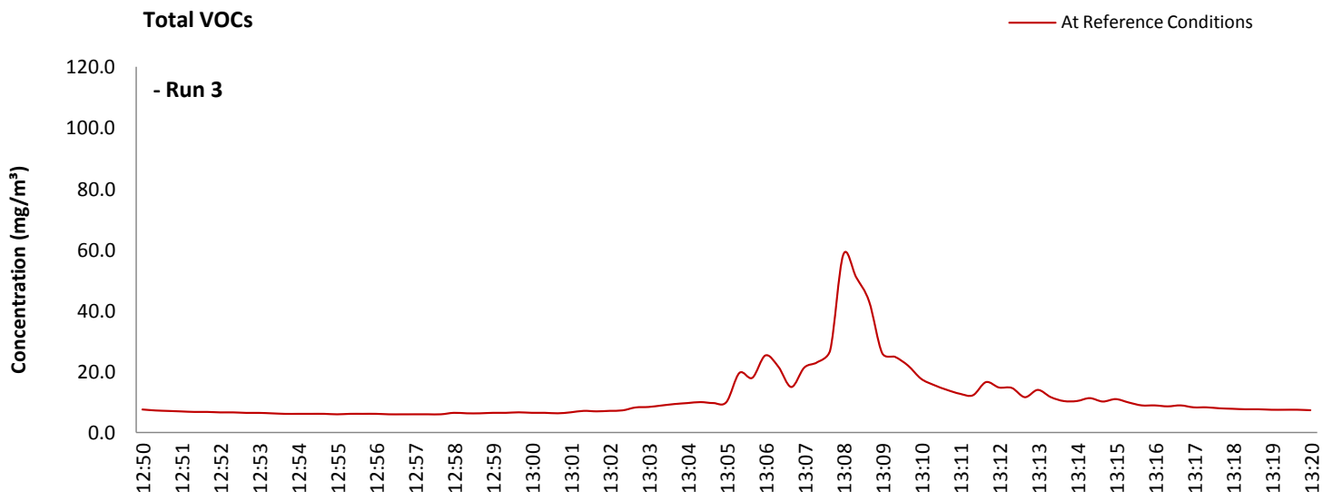
Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

## 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 | - | 11:50 - 12:20 | 12:20 - 12:50 | 12:50 - 13:20 |
| Sampling Dates | - | 27/01/2017 | 27/01/2017 | 27/01/2017 |
| Instrument Range | ppm | 100 | 100 | 100 |
| Span Gas Value | ppm | 80.1 | 80.1 | 80.1 |

## Quality Assurance

| | Zero Drift | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|---|
| CAL 1 | Zero Down Sampling Line (Pre) | ppm | 0.10 | 0.10 | 0.10 |
| | Zero Down Sampling Line (Post) | ppm | -0.30 | -0.30 | -0.30 |
| | Zero Drift | ppm | -0.40 | -0.40 | -0.40 |
| | Allowable Zero Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | 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 | 80.70 | 80.70 | 80.70 |
| | Span Drift | ppm | 0.70 | 0.70 | 0.70 |
| | Allowable Span Drift | ± ppm | 4.01 | 4.01 | 4.01 |
| | Span Drift Acceptable | - | Yes | Yes | Yes |

| Test Conditions | Units | Run 1 | Run 2 | Run 3 |
|---|---|---|---|---|
| Run Ambient Temperature Range | °C | 7 - 14 | 7 - 14 | 7 - 14 |

## 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 | 9.37 | 9.30 | 11.52 | 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. | 80.1 | 80.1 | 80.1 | 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. | 128.7 | 128.7 | 128.7 | 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 | 0.07 | 0.07 | 0.07 | % of value |
| Zero drift | -0.50 | -0.50 | -0.50 | % full scale |
| Span drift | 0.88 | 0.88 | 0.88 | % 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) | 0.12 | 0.12 | 0.12 | % 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 | -0.32 | -0.32 | -0.31 | 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) | 0.01 | 0.01 | 0.01 | mg/m³ |
| Uncertainty of calibration gas | 0.11 | 0.11 | 0.13 | mg/m³ |

| Measurement uncertainty | | Result | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|---|---|
| | | | 9.37 | 9.30 | 11.52 | mg/m³ |
| Combined uncertainty | | | 0.41 | 0.41 | 0.40 | mg/m³ |
| Expanded uncertainty | k = | 1.96 | 0.79 | 0.79 | 0.79 | mg/m³ |
| Uncertainty corrected to std conds. ($O_2$) | | | 0.79 | 0.79 | 0.79 | mg/m³ (REF) |

| | RUN 1 | RUN 2 | RUN 3 | Units |
|---|---|---|---|---|
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 8.48 | 8.54 | 6.87 | % of Value |
| Expanded uncertainty (no $O_2$) - at 95% Confidence | 1.06 | 1.06 | 1.06 | % 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.*