

Client Xaarjet Ltd
1 Hurricane Close
Ermine Business Park
Huntingdon
Cambridgeshire

PE29 6XX

Part 1: Executive Summary

Report for the Periodic Monitoring of Emissions to Air.

Site Huntingdon Plant LEV 1

Sampling Date 28th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd

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Company Registration No SC070429

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Monitoring Objectives

The monitoring was undertaken to check compliance with authorised emission limits.

All monitoring procedures were carried out to the MCERTS requirements under the Exova (UK) Ltd quality system to ISO 17025: 2005.

Monitoring was undertaken for the listed emissions from the following sampling positions:

Sampling Location	Emission
LEV 1	Total volatile organic carbon

Special Monitoring Requirements

There were no special requirements for this monitoring campaign.

Summary of Methods

Method number	Method standard
TPM/01A	BS EN ISO 16911-1:2013
MM0002	BS EN 12619 : 2013
	TPM/01A

Nm³ 273 K, 101.3 kPa

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Summary Of Results

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd** The results were measured from the sample positions downstream of the arrestment plant.

Emission at	Sampling			Emission	Authorised	Uncertainty	Detection	Mass
Huntingdon	Time			Result	Limit	+/-	Limit	Emission
LEV 1	Date	Start	End	mg/m³∗	mg/m³*	mg/m³∗	mg/m³∗	g/h
тос	28/01/16	14:23	15:53	49.7	75	1.5	0.2	171.5

* at reference conditions	Stack Gas Weight	0 °C	Without correcti	on for moisture	
	29.00 Kg/kmol	101.3 kPa	Oxygen	No Correction	%

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above)

** Analysis not required # - UKAS accredited only
ND Non detectable ## - Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



All tests included in this report are accredited under UKAS and MCERTS accreditation schemes unless otherwise stated.

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





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Summary Of Results, Exhaust Gases

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd** The results were measured from the sample positions downstream of the arrestment plant.

	Emission at Sampling Huntingdon Time			Emission Result	Authorised Limit	Uncertainty +/-	Detection Limit	Mass Emission	
	LEV 1	Date	Start	End	mg/m ³ *	mg/m ³ *	mg/m³*	mg/m³*	g/h
TOC	Test 1	28/01/16	14:23	14:53	48.4	75	1.5	0.2	167.1
TOC	Test 2	28/01/16	14:53	15:23	44.9	75	1.5	0.2	154.9
TOC	Test 3	28/01/16	15:23	15:53	55.8	75	1.6	0.2	192.6

I	* at ref	Stack Gas Weight	0 °C	Without correction for moisture
	Conditions	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction %

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above)

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

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a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



Nm³ 273 K, 101.3 kPa



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Operating Information

The table below shows details of the operating information on each sampling date for: LEV 1

Date	Process type	Process duration	Fuel	Feedstock	Abatement	Load
28/01/2016	Production and cleaning of inkjet cartridges	Continuous	N/A	N/A	N/A	Normal

No CEMs installed on the emission point.

Comments & Monitoring Deviations

A waste gas homogeneity test to BS EN 15259:2007 (MID) is not required:-

The homogeneity test is not applicable to non-combustion processes.

The homogeneity test is not applicable to duct areas less than 1m².

The homogeneity test is not usually applicable to pollutant emissions that are less than 30% of the ELV.

All monitoring was performed in accordance with the relevant procedures.



Part 2: Supporting Information

Report for the Periodic Monitoring of Emissions to Air.

Client Xaarjet Ltd Site Huntingdon Plant LEV 1

Sampling Date

28th January 2016 Report Date 25th February 2016

Job Number EM-2708 **Permit Number** B22/11

Report Prepared by: Print **Rob Jones**

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APPENDIX 1

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Emission Monitoring Procedures And Instrumentation

Gas velocity and temperature

Documented in-house procedure TPM01/A to the main procedural requirements of BS EN ISO 16911-1:2013 Velocity and temperature measurements are performed using a calibrated Pitot tube, a calibrated pressure differential reading device and a calibrated thermocouple. Velocity and possible flow deviation measurements are carried out at selected, representative points in the gas stream.

Total organic carbon

Documented in-house procedure MM0002 to the main procedural requirements of BS EN 12619:2013. Continuous analysis using probe, sample line and multi range Flame Ionisation Detector (FID) analyser. The analyser is calibrated before and during the tests using certified gas mixtures of nitrogen, oxygen and propane. Sampling points are selected in accordance with the findings of any BS EN 15259 assessment.

Sampling Project Personnel Competency And Expiry Dates

Report prepared by:	Rob Jones	MCERTS No MM08 984	Level 1	Level 2 31/03/2016	TE1 31/03/2020	TE2 31/03/2016	TE3 30/09/2016	TE4 31/12/2020
Report authorised by:	Derek Myers	MM02 115	-	30/09/2017	31/05/2018	30/11/2018	30/11/2018	30/11/2018
Team leader:	Rob Jones	MM08 984	-	31/03/2016	31/03/2020	31/03/2016	30/09/2016	31/12/2020
Team leader:	Harpreet Badwal	MM03 149	-	30/09/2018	30/09/2018	30/04/2019	31/10/2019	31/10/2019

Equipment References

Equipment	Reference Number
FID	AQ271
Heated Line	HL40
Stack Thermocouple	PTTS97
Timer / Stopwatch	ST41
Barometer	WS03
Pitot	PT97
Thermometer	TK24
Manometer	PI03

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Date	28/01/2016
Time	12:20
Pitot Cp	0.79

Barometric pressure	101.6	kPa
Duct static pressure	0.08	kPa
Stack Area	0.126	m²

Stack Diameter (circular)	0.40	m

Traverse	Traverse	Depth	ΔΡ	T	Angle	velocity	Traverse	Depth	ΔΡ	Т	Angle	velocity
Point	Line	cm	mmH ₂ O	°C	0	m/s	Line	cm	mmH ₂ O	°C	0	m/s
1	Α						В					
2	Α						В					
3	Α	5.0	3.1	22	<15	5.6	В	5.0	9.0	22	<15	9.6
4	Α	7.1	4.0	22	<15	6.4	В	7.1	7.4	22	<15	8.7
5	Α	10.0	4.8	22	<15	7.0	В	10.0	7.0	22	<15	8.5
6	Α	14.2	5.7	22	<15	7.6	В	14.2	6.2	22	<15	8.0
7	Α	25.8	7.4	22	<15	8.7	В	25.8	5.4	22	<15	7.4
8	Α	30.0	8.5	22	<15	9.3	В	30.0	6.0	22	<15	7.8
9	Α	32.9	8.9	22	<15	9.5	В	32.9	7.3	22	<15	8.6
10	Α	35.0	8.5	22	<15	9.3	В	35.0	8.8	22	<15	9.5
11	Α						В					
12	Α						В					

Average Pitot DP	6.62	mmH ₂ O
Average Temperature	295.2	К
Average Velocity	8.2	m/s
Average volumetric flow rate	1.03	m ³ /s at stack conditions
Average volumetric flow rate	0.96	m ³ /s (wet STP)

Sampling plane requirements Re: BS EN 13284-1:2001 5.2

a	a Angel of gas flow less than 15° with regard to duct axis					
b	b No local negative flow					
С	Minimum pitot greater than 5Pa					
d	Ratio of highest to lowest local gas velocity less than 3:1					
	Minimum local gas velocity	5.6				
	Maximum local gas velocity 9.6					
	Ratio of highest to lowest local gas velocity 1.71					

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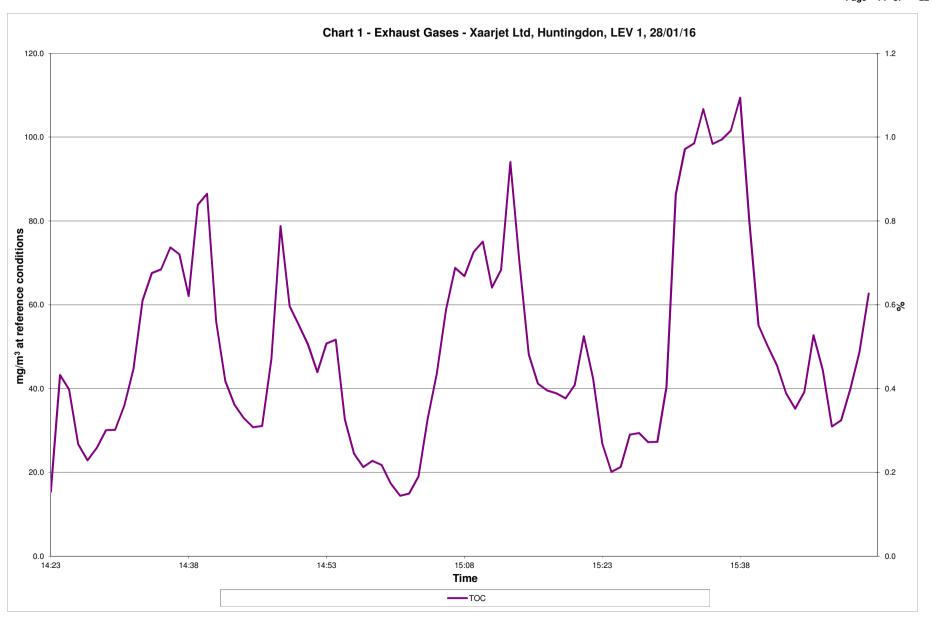
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n .	00/04/0040
Date	28/01/2016

From	14:23	to	14:53	30 minute mean	l		
Volatile orga	nic compounds		vppm, wet	30.13	mg/m³*	48	.42
From	14:53	to	15:23	30 minute mean	1		
Volatile orga	nic compounds		vppm, wet	27.92	mg/m³*	44	.87
From	15:23	to	15:53	30 minute mean			
Volatile orga	nic compounds		vppm, wet	34.72	mg/m³*	55	.80
	etection Limits						
Volatile orga	nic compounds		vppm	0.10	mg/m³*	0.	16
Reference G	as Details						
Species			Units	Value	Cylinder Reference	Analyser Range	Uncertainity $k = 2$
Nitrogen			%	99.999	VCK01959	-	± 2
Volatile orga	nic compounds		vppm	75.50	VCSMG3066	10	± 2
Zero And Sp	an Gas Details						
Species			units	Initial Time	11:30	Final Time	16:00
				Initial Zero	Initial Span	Final Zero	Final Span
Volatile orga	nic compounds		maay	0.00	75.50	-0.04	75.63

Exhaust Gases - Continuous Analysis Data

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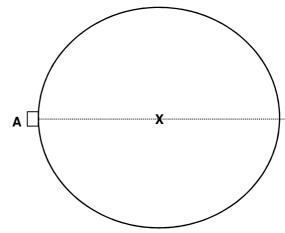
Diagram Of The Sampling Location

Diagram of sampling points across the cross section of the duct (not to scale).

Traverse length =

0.40 m

Point	% of D	Location
		cm
1	50.0	20.0



LEV 1



General Calculations

Stack area:

$$Area of a circle = \frac{\pi . D^2}{4}$$

D = Diameter (m) $\pi = 3.142$

Pressure conversion:

1mmH2O = 0.00980665 kPa 1mmH2O = 9.80665 Pa 1 mar = 0.1 kPa

Water vapour concentration:

From reference calculations (taken from BS EN 14790):

$$V_{WC(\%)} = \frac{\frac{M_{WC}.V_{mol(std)}}{M_W}}{\frac{M_{WC}.V_{mol(std)}}{M_W} + V_{m(std)}} \times 100$$

VWC (%) = Water vapour content on wet basis, in volume % (m³ of water vapour in m³ of wet gas)

Vm(std) = Dry gas volume measured, corrected to standard conditions (m³)

mWC = Mass of water collected in the impingers (g)

Mw = Molecular weight of water, 18.01534 rounded to 18 (g/mol)

Vmol(std) = Molar volume of water at standard conditions = 0.0224 (m3/mol)

Gas meter volume at standard conditions (STP)

From reference calculations (taken from BS EN 14790):

$$V_{m(std)} = y_d \times (V_2 - V_1) \times \frac{T_{std}}{T_m} \times \frac{p_m}{p_{std}}$$

Vm(std) = Dry gas meter volume at standard conditions (m³)

yd = Gas meter calibration coefficient

(V2-V1) = Dry gas meter volume at actual conditions (m³)

Tm = Actual Temperature (K)
Tstd = Standard temperature (273 K)

pm = Absolute pressure at the gas meter (kPa)
pstd = Standard gas pressure (101.3 kPa)

Isokenetic Ratio (%):

From reference calculations (taken from EA TGN M2):

$$IsokineticRatio(\%) = \frac{Velocity\ at\ the\ sampling\ nozzle}{Velocity\ of\ the\ stack\ gas} \times 100$$

Estimating Measurment Uncertainty

Uncertainty estimates are calculated using the general rule of uncertainty propagation. Guidance is taken from publications including UKAS document M3003 and ISO 20988:2007.

Flow Calculations

Velocity:

From reference calculations (taken from ISO 10780):

$$\overline{v} = KC \sqrt{\frac{T_s \Delta \overline{p}}{p_e M_s}}$$

v = Average velocity (m/s)

 \dot{C} = velocity calculation constant = 129

Ts = Average stack temperature (K)

Ms = Molar mass of gas; assume 29 kg/kmol unless the molar mass is < 27 kg/kmol or > 31 g/kmol

K = Pitot calibration coefficientPe = Absolute gas pressure (kPa)

 $\Delta p = \Delta p$ Average pitot tube pressure differencial (kPa)

Volume flow rate

From reference calculations (taken from ISO 10780):

$$q_{va} = vA$$

qva = Average flow rate (m³/s)

v = v Average velocity (m/s)

A =Stack cross-sectional area (m²)

Volume flow rate corrected for moisture

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{(100 - H_a)}{(100 - H_m)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s) Ha = Moisture at actual conditions (%volume)

Hm = Reference moisture (%volume)

Volume flow rate corrected for temperature and pressure

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(T_m p_a\right)}{\left(T_a p_m\right)}$$

qm = Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

Ta = Temperature at actual conditions (K)

Tm = Reference Temperatue (K)

pa = Absolute gas pressure at actual conditions (kPa)

pm =Reference pressure (kPa)

Volume flow rate corrected for oxygen

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(20.9 - O_{2,ref}\right)}{\left(20.9 - O_{2,m}\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

O2,m = Actual oxygen concentration (%)

O2,ref = Reference oxygen concentration (%)

Concentration Calculations

Concentration:

From reference calculations (taken from BS EN 13284-1):

$$c = \frac{m}{V}$$

c = Concentration m = Mass of substane V = Volume sampled

Mass Emission

Mass emission= $c \times q_m$

c = Concentration q = Volume flow rate

Concentration corrected for oxygen:

From reference calculations (taken from BS ISO 9096):

$$c_m = c_a \times \frac{20.9 - O_{2,ref}}{20.9 - O_{2,a}}$$

cm = Concentration at reference conditions

ca = Actual concentration
O2, ref = Reference oxygen (%)
O2, a= Actual Oxygen (%)

Concentration corrected for moisture:

From reference calculations (taken from BS ISO 9096):

Convert wet gas to dry gas

$$c_{dry} = c_{wet} \times \frac{100}{100 - H_a}$$

Convert dry gas to wet gas

$$c_{wet} = c_{dry} \times \frac{100 - H_a}{100}$$

cwet = Concentration wet gascdry = Concentration dry gasHa = Water vapour content (%vol)

Conversion of parts per million (ppm) to mg/m³

From reference calculations (taken from EA TGN M2):

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

molar volume at 273K = 22.4 litres

When Converting TOC

 $Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight of\ carbonin\ span\ gas(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$

Calculation of Uncertainty Estimates - Instrumental Monitoring Techniques

Model equation

 $C_{ppm} = C_{reading} + Corr_{fit} + Corr_{f,dr} + Corr_{s,dr} + Corr_{rep} + Corr_{adj} + \sum_{i=1}^{p} Corr_{inf} + Corr_{inf}$

Corr_{rep} Corr_{adj} Corr_{inf} $C_{,ppm}$ correction of repeatability of measurement concentration in ppm concentration given by analyser C_{NO.reading} correction of adjustment Corr fit correction of lack of fit correction of influence quantities Corr _{0,dr} correction of zero drift

Corr s,dr correction of span drift

Calculation of partial uncertainties

u(Corr_{fit}) $\left(\frac{X_{fit,\max}}{100 \times range}\right)$ Where: $X_{\text{fit,max}}$ is the maximum allowable deviation from linearity

Expressed as % of the range and calculated by applying a rectangular probability distribution

$$\mathsf{u}(\mathsf{Corr}_{0,\mathsf{dr}}) \qquad = \qquad \frac{X_{0,\mathit{dr}}}{\sqrt{3}} \qquad \qquad \mathsf{u}(\mathsf{Corr}_{\mathsf{s},\mathsf{dr}}) \qquad = \qquad \frac{X_{s,\mathit{dr}}}{\sqrt{3}}$$

$$u(Corr_{rep}) \hspace{1.5cm} = \hspace{1.5cm} max \; (S_{0,rep} \; ; S_{srep}) \hspace{1.5cm} = \hspace{1.5cm} S_{rep} \\ \hspace{1.5cm} Where: \hspace{1.5cm} \\$$

is the standard uncertainty at zero level is the standard uncertainty at span level

$$u(Corr_{inf}) = c_{j} \sqrt{\frac{(x_{j,\max} - x_{j,adj})^{2} + (x_{j,\min} - x_{j,adj}) \times (x_{j,\max} - x_{j,adj}) + (x_{j,\min} - x_{j,adj})^{2}}{3}}$$

is the sensitivity coefficient of the influence quantity is the minimum value of the influence quantity during monitoring

is the maximum value of the influence quantity during monitoring is the value of the influence quantity during adjustment

$$u(Corr_{int}) = \frac{c_j}{Int_{j,test}} \sqrt{\frac{Int_{j,max}^2 + Int_{j,min} \times Int_{j,max} + Int_{j,min}^2}{3}}$$

 $= \max \left[S_{Int,p}; S_{Int,n} \right]$

 c_{j} Int_{j,test} is the sensitivity coefficient of the interferent i is the concentration of the interferent j used to determine c

is the minimum value of the interferent j quantity during monitoring is the maximum value of the interferent i quantity during monitoring

 $\mathsf{Int}_{\mathsf{j},\mathsf{adj}}$ is the concentration of the interferent j in the cal gas used to adjust the analyser $S_{int,p}$ is the sum of interferents with positive impact

is the sum of interferents with negative impact

Combined uncertainty

 $u(\Sigma Corr_{int})$

$$u(C, ppm) =$$

$$\sqrt{u^2 (corr_{\mathit{fit}}) + u^2 (corr_{\mathit{o,dr}}) + u^2 (corr_{\mathit{s,dr}}) + u^2 (corr_{\mathit{rep}}) + u^2 (corr_{\mathit{s,yf}}) + u^2 (corr_{\mathit{a,press}}) + u^2 (corr_{\mathit{temp}}) + u^2 (corr_{\mathit{volt}}) + u^2 (corr_{\mathit{adj}}) + S_{\mathit{hit}}^{-2}}$$

Overall expanded uncertainty (k = 2)

$$U(C_m) = u(C_m) \times k$$

Uncertainty of NOx measurements

C_{NOx} is the concentration of NOx measured by the analyser is the ratio of NO:Nox in the stack gas is the NOx converter efficiency

Combined uncertainty NOx measurements

$$u(C_{NOx}, _{stack}) =$$

$$\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{o,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{rep}) + u^{2}(corr_{rep}) + u^{2}(corr_{s,vf}) + u^{2}(corr_{a,press}) + u^{2}(corr_{temp}) + u^{2}(corr_{volt}) + u^{2}(corr_{odj}) + S_{lnt}^{2} + u^{2}(corr_{NOx,comv}) + u^{2}(corr_{temp}) + u^{2}(cor$$

Uncertainty of mass concentration at oxygen reference concentration

$$u(C, O2 ref) =$$

$$\sqrt{u^{2}(corr_{\mathit{fit}}) + u^{2}(corr_{\mathit{o,dr}}) + u^{2}(corr_{\mathit{s,dr}}) + u^{2}(corr_{\mathit{rep}}) + u^{2}(corr_{\mathit{s,vf}}) + u^{2}(corr_{\mathit{s,vf}}) + u^{2}(corr_{\mathit{s,otr}}) + u^{2}(corr_{\mathit{sott}}) + u^{2}(corr_{\mathit{odd}}) + S_{\mathit{Int}}^{2} + \left(\frac{u^{2}(O_{2,\mathit{meas,dry}})}{(21 - O_{2,\mathit{meas,dry}})^{2}}\right)}$$

u(C,O_{2,ref)} uncertainty associated with the mass concentration at O₂ ref. concentration mg/m³ C,O_{2,ref} mg/m³ mass concentration at O₂ reference concentration O2 measured concentration % volume uncertainty associated to the measured O2 concentration % (relative to O_{2 meas})

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APPENDIX 4

Uncertainty Estimate For The Measurement Of Total Organic Carbon

	Jncertainty				
Analyser Type/Model Reference Oxygen %		Maihak 0	(0 = No corre		
		Test 1	Test 2	Test 3	
Limit value	mg/m ³	75	75	75	
Limit value	ppm	46.7	46.7	46.7	
Measured concentration	ppm	30.1	27.9	34.7	
Measured concentration	mg/m ³	48.4	44.9	55.8	
Calibration gas	ppm	75.5	75.5	75.5	
Calibration gas	mg/m ³	121.3	121.3	121.3	
Analyser range	ppm	9.3	9.3	9.3	
Analyser range	mg/m ³	15.0	15.0	15.0	
Correction of Lack of Fit					
ack of fit	% range	2.0	2.0	2.0	
	u(Corr, _{fit})	0.11	0.11	0.11	
Corrections of Zero and Span Drift	(*All drift is c	alculated for ·	the residual is	assumed to be	< 5% µ(m:
Zero Drift	% range	0.00	0.00	0.00	< 070 d(III
	u(Corr, _{0dr})	0.00	0.00	0.00	
Span Drift	% range	0.00	0.00	0.00	
	u(Corr, _{sdr})	0.00	0.00	0.00	
Correction of Repeatability of Measurement					
Repeatability SD at span level	% range	0.0	0.0	0.0	
Not reported)	u(Corr, _{rep})	0.00	0.00	0.00	
Correction of adjustment					
osses in the line	% range	0.13	0.13	0.13	
	u(Corr, _{loss})	0.02	0.02	0.03	
Incertainty of calibration gas	% range	2.0	2.0	2.0	
	u(Corr, _{cal})	0.30	0.28	0.35	
Correction of Influence of Interferents					
I ₂ O	% range				
	u(Corr, _{N2O})	0.00	0.00	0.00	
CO ₂	% range	0.00	0.00	0.00	
CH ₄	u(Corr, _{CO2}) % range	0.00	0.00	0.00	
	u(Corr, _{CH4})	0.00	0.00	0.00	
Total of interferent influences	% range	2.50	2.50	2.50	
$u(\Sigma Corrint) = \max [S_{Int,p}; S_{Int,n}]$	$u(\Sigma Corr_{int})$	0.16	0.16	0.16	
Correction of Influence Quantities					
Sensitivity to sample volume flow	% range	1.60	1.60	1.60	
	u(Corr,flow)	0.09	0.09	0.09	
Sensitivity to atmospheric pressure	% range				
Not reported)	u(Corr, _{press})	0.00	0.00	0.00	
Sensitivity to ambient temperature	% range	-2.40	-2.40	-2.40	
No. 100 Maria and 100 Maria 100 Mari	u(Corr, _{temp})	-0.28	-0.28	-0.28	
Sensitivity to electrical voltage Not reported)	% range u(Corr, _{volt})	0.50 0.10	0.50 0.10	0.50 0.10	
not repende	a(con,vai)	0.10	0.10	0.10	
Maximum standard uncertainty	u(Corr, _{max})	0.30	0.28	0.35	
% of maximum standard uncertainty	u(Corr, _{5%})	0.02	0.01	0.02	
nterferent Concentration Variations	Minimum	Maximum	Value at cal	Performance	Units
CH₄ range	0	10	0	50	mg/m ³
I₂O range	8	0 12	0	20 15	mg/m ³ mg/m ³
:O- range				13	mg/m ² Units
	Minimum		Value at cal	Performance	
Oxygen effect variations		Maximum 20	Value at cal 0	Performance 2	
Oxygen effect variations Oxygen effect	Minimum	Maximum			mg/m ³
Oxygen effect variations Oxygen effect	Minimum 0	Maximum 20	0	2	
Dxygen effect variations Dxygen effect Influence Quantitiy Variations	Minimum	Maximum			mg/m ³
oxygen effect variations oxygen effect Iffluence Quantitiy Variations ensitivity to sample volume flow ensitivity to atmospheric pressure	Minimum 0 Minimum 55 99	Maximum 20 Maximum 65 100	Value at cal	Performance 5 1	Units I/h kPa
oxygen effect variations oxygen effect influence Quantitiy Variations itensitivity to sample volume flow itensitivity to atmospheric pressure itensitivity to ambient temperature	Minimum 0 Minimum 55 99 278	Maximum 20 Maximum 65 100 313	0 Value at cal 60 99 288	Performance 5 1 1 10	mg/m³ Units //h kPa K
oxygen effect variations oxygen effect influence Quantitiy Variations itensitivity to sample volume flow itensitivity to atmospheric pressure itensitivity to ambient temperature	Minimum 0 Minimum 55 99	Maximum 20 Maximum 65 100	Value at cal	Performance 5 1	Units I/h kPa
Oxygen effect variations Oxygen effect Influence Quantitiy Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage	Minimum 0 Minimum 55 99 278	Maximum 20 Maximum 65 100 313 250	0 Value at cal 60 99 288 230	2 Performance 5 1 10 5	mg/m³ Units //h kPa K
Oxygen effect variations Oxygen effect Influence Quantitiy Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty	Minimum 0 Minimum 55 99 278	Maximum 20 Maximum 65 100 313	0 Value at cal 60 99 288	Performance 5 1 1 10	mg/m³ Units //h kPa K
Oxygen effect variations Oxygen effect Influence Quantitiy Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty	Minimum 0 Minimum 55 99 278 187	Maximum 20 Maximum 65 100 313 250 Test 1	0 Value at cal 60 99 288 230 Test 2	2 Performance 5 1 10 5 Test 3	mg/m³ Units //h kPa K
Oxygen effect variations Oxygen effect Influence Quantitiy Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Combined uncertainty	Minimum 0 Minimum 55 99 278 187 ppm mq/m³	Maximum 20 Maximum 65 100 313 250 Test 1 0.47 0.76	0 Value at cal 60 99 288 230 Test 2 0.46	2 Performance 5 1 10 5 Test 3 0.50	mg/m³ Units //h kPa K
Oxygen effect variations Oxygen effect Influence Quantitiy Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of confinence.	Minimum 0 Minimum 55 99 278 187 ppm mq/m³	Maximum 20 Maximum 65 100 313 250 Test 1 0.47 0.76	0 Value at cal 60 99 288 230 Test 2 0.46	2 Performance 5 1 10 5 Test 3 0.50	mg/m³ Units //h kPa K
Oxygen effect variations Oxygen effect Influence Quantitiy Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Expanded uncertainty Expanded uncertainty Diverall uncertainty Diverall uncertainty Diverall uncertainty Diverall uncertainty	Minimum 0 Minimum 55 99 278 187 ppm mg/m³ dence of 95%, k ppm mg/m³	Maximum 20 Maximum 65 100 313 250 Test 1 0.47 0.76 =2 0.9 1.5	Value at cal 60 99 288 230 Test 2 0.46 0.74	2 Performance 5 1 10 5 Test 3 0.50 0.81 1.0 1.6	mg/m³ Units //h kPa K
CO2 range Doxygen effect variations Doxygen effect Influence Quantitiy Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty Diverall uncertainty Diverall uncertainty Diverall uncertainty Diverall uncertainty Diverall uncertainty relative to measured value Diverall uncertainty relative to range	Minimum 0 Minimum 55 99 278 187 ppm ma/m³ dence of 95%, k	Maximum 20 Maximum 65 100 313 250 Test 1 0.47 0.76 =2 0.9	0 Value at cal 60 99 288 230 Test 2 0.46 0.74	2 Performance 5 1 10 5 Test 3 0.50 0.81	mg/m³ Units //h kPa K

The uncertainty evaluation has been carried out in accordance with UKAS requirements.



Client Xaarjet Ltd
1 Hurricane Close
Ermine Business Park
Huntingdon
Cambridgeshire

PE29 6XX

Part 1: Executive Summary

Report for the Periodic Monitoring of Emissions to Air.

Site Huntingdon Plant LEV 2

Sampling Date 28th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd

Unit C5 Emery Court The Embankment Business Park Heaton Mersey Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

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Monitoring Objectives

The monitoring was undertaken to check compliance with authorised emission limits.

All monitoring procedures were carried out to the MCERTS requirements under the Exova (UK) Ltd quality system to ISO 17025: 2005.

Monitoring was undertaken for the listed emissions from the following sampling positions:

Sampling Location	Emission
LEV 2	Total volatile organic carbon

Special Monitoring Requirements

There were no special requirements for this monitoring campaign.

Summary of Methods

Emission	Method number	Method standard
Gas velocity and volume flow	TPM/01A	BS EN ISO 16911-1:2013
тос	MM0002	BS EN 12619 : 2013

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Summary Of Results

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd** The results were measured from the sample positions downstream of the arrestment plant.

Emission at	Sampling			Emission	Authorised	Uncertainty	Detection	Mass
Huntingdon	Time		Result	Limit	+/-	Limit	Emission	
LEV 2	LEV 2 Date Start End		mg/m³*	mg/m³*	mg/m³*	mg/m³*	g/h	
тос	28/01/16	11:45	13:15	3.8	75	1.2	0.2	5.7

* at reference conditions	Stack Gas Weight	0 °C	Without correction for moisture	
	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction	n %

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above) Nm³ 273 K, 101.3 kPa

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



All tests included in this report are accredited under UKAS and MCERTS accreditation schemes unless otherwise stated.

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





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Summary Of Results, Exhaust Gases

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd** The results were measured from the sample positions downstream of the arrestment plant.

	ission at ntingdon	Sampling Time		Emission Result	Authorised Limit	Uncertainty +/-	Detection Limit	Mass Emission	
	LEV 2	Date	Start	End	mg/m³*	mg/m³*	mg/m³*	mg/m³*	g/h
тос	Test 1	28/01/16	11:45	12:15	3.7	75	1.2	0.2	5.6
тос	Test 2	28/01/16	12:15	12:45	3.1	75	1.2	0.2	4.5
тос	Test 3	28/01/16	12:45	13:15	4.7	75	1.2	0.2	6.9

I	* at ref	Stack Gas Weight	0 °C	Without correction for moisture
	Conditions	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction %

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above)

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



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Nm³ 273 K, 101.3 kPa



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Operating Information

The table below shows details of the operating information on each sampling date for: LEV 2

Date	Process type	Process duration	Fuel	Feedstock	Abatement	Load
28/01/2016	Production and cleaning of inkjet cartridges	Continuous	N/A	N/A	N/A	Normal

No CEMs installed on the emission point.

Comments & Monitoring Deviations

A waste gas homogeneity test to BS EN 15259:2007 (MID) is not required:-

The homogeneity test is not applicable to non-combustion processes.

The homogeneity test is not applicable to duct areas less than 1m².

All monitoring was performed in accordance with the relevant procedures.



Part 2: Supporting Information

Report for the Periodic Monitoring of Emissions to Air.

Client Xaarjet Ltd Site Huntingdon Plant LEV 2

Sampling Date 28th January 2016 Report Date 25th February 2016

Job Number EM-2708 **Permit Number** B22/11

Report Prepared by: Print **Rob Jones**

> MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

> Print **Derek Myers**

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd Unit C5 Emery Court

The Embankment Business Park **Heaton Mersey** Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

Xaarjet Ltd, Huntingdon, Permit No: B22/11, R/16-6518, v1

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APPENDIX 1

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Emission Monitoring Procedures And Instrumentation

Gas velocity and temperature

Documented in-house procedure TPM01/A to the main procedural requirements of BS EN ISO 16911-1:2013 Velocity and temperature measurements are performed using a calibrated Pitot tube, a calibrated pressure differential reading device and a calibrated thermocouple. Velocity and possible flow deviation measurements are carried out at selected, representative points in the gas stream.

Total organic carbon

Documented in-house procedure MM0002 to the main procedural requirements of BS EN 12619:2013. Continuous analysis using probe, sample line and multi range Flame Ionisation Detector (FID) analyser. The analyser is calibrated before and during the tests using certified gas mixtures of nitrogen, oxygen and propane. Sampling points are selected in accordance with the findings of any BS EN 15259 assessment.

Sampling Project Personnel Competency And Expiry Dates

Report prepared by:	Rob Jones	MCERTS No MM08 984	Level 1 -	Level 2 31/03/2016	TE1 31/03/2020	TE2 31/03/2016	TE3 30/09/2016	TE4 31/12/2020
Report authorised by:	Derek Myers	MM02 115	-	30/09/2017	31/05/2018	30/11/2018	30/11/2018	30/11/2018
Team leader:	Rob Jones	MM08 984	-	31/03/2016	31/03/2020	31/03/2016	30/09/2016	31/12/2020
Team leader:	Harpreet Badwal	MM03 149	-	30/09/2018	30/09/2018	30/04/2019	31/10/2019	31/10/2019

Equipment References

Equipment	Reference Number
FID	AQ271
Heated Line	HL40
Stack Thermocouple	PTTS97
Timer / Stopwatch	ST41
Barometer	WS03
Pitot	PT97
Thermometer	TK24
Manometer	PI03

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APPENDIX 2

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Date	28/01/2016
Time	11:20
Pitot Cp	0.79

Barometric pressure	101.6	kPa
Duct static pressure	0.14	kPa
Stack Area	0.073	m²

Stack Diameter (circular)	0.31	m

Traverse	Traverse	Depth	ΔΡ	T	Angle	velocity	Traverse	Depth	ΔΡ	Т	Angle	velocity
Point	Line	cm	mmH ₂ O	°C	0	m/s	Line	cm	mmH ₂ O	°C	0	m/s
1	Α						В					
2	Α						В					
3	Α	5.0	1.3	23	<15	3.7	В	5.0	3.5	23	<15	6.0
4	Α	5.4	2.1	23	<15	4.7	В	5.4	3.2	23	<15	5.7
5	Α	7.6	2.9	23	<15	5.4	В	7.6	3.2	23	<15	5.7
6	Α	10.9	3.7	23	<15	6.1	В	10.9	2.8	23	<15	5.3
7	Α	19.6	4.8	23	<15	7.0	В	19.6	3.0	23	<15	5.5
8	Α	22.9	5.4	23	<15	7.4	В	22.9	3.1	23	<15	5.6
9	Α	25.1	6.6	23	<15	8.2	В	25.1	4.0	23	<15	6.4
10	Α	25.5	6.6	23	<15	8.2	В	25.5	4.5	23	<15	6.8
11	Α						В					
12	Α						В					

Average Pitot DP	3.64	mmH ₂ O
Average Temperature	296.2	К
Average Velocity	6.1	m/s
Average volumetric flow rate	0.45	m ³ /s at stack conditions
Average volumetric flow rate	0.41	m ³ /s (wet STP)

Sampling plane requirements Re: BS EN 13284-1:2001 5.2

a	Angel of gas flow less than 15° with regard to duct axis					
b	b No local negative flow					
С	Minimum pitot greater than 5Pa					
d	Ratio of highest to lowest local gas velocity less than 3:1					
	Minimum local gas velocity	3.7				
	Maximum local gas velocity 8.2					
	Ratio of highest to lowest local gas velocity 2.24					

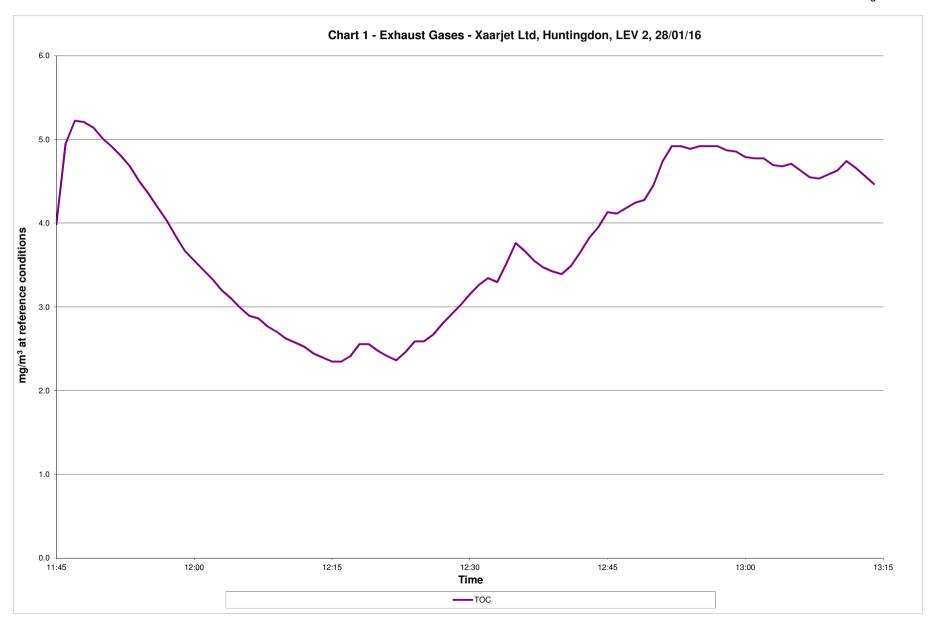
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Date	28/01/2016

From	11:45	to	12:15	30 minute mean			
Volatile organic compounds		vppm, wet	2.32	mg/m³*	3.74		
From	12:15	to	12:45	30 minute mean			
Volatile organ	ic compounds	ompounds		1.90	mg/m³*	3.05	
From	12:45	to	13:15	30 minute mean	ı		
Volatile organ		10	vppm, wet	2.90	mg/m³*	4.65	
Sampling Det	ection Limits						_
Volatile organic compounds		vppm	0.10	mg/m³*	0.16		
r craime or gain							
Reference Ga	s Details						
Species			Units	Value	Cylinder	Analyser	Uncertainity
					Reference	Range	k = 2
Nitrogen			%	99.999	VCK01959	-	± 2
Volatile organ	ic compounds		vppm	75.5	VCSMG3066	10	± 2
	ın Gas Details						
Species			units	Initial Time	11:30	Final Time	16:00
				Initial Zero	Initial Span	Final Zero	Final Span
Volatile organ	ic compounds		vppm	0.00	75.50	-0.04	75.63

Exhaust Gases - Continuous Analysis Data



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APPENDIX 3

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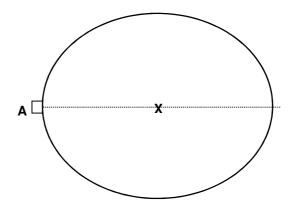
Diagram Of The Sampling Location

Diagram of sampling points across the cross section of the duct (not to scale).

Traverse length =

0.31 m

Point	% of D	Location
		cm
1	50.0	15.3





General Calculations

Stack area:

$$Area of a circle = \frac{\pi . D^2}{4}$$

D = Diameter (m) $\pi = 3.142$

Pressure conversion:

1mmH2O = 0.00980665 kPa 1mmH2O = 9.80665 Pa 1 mar = 0.1 kPa

Water vapour concentration:

From reference calculations (taken from BS EN 14790):

$$V_{WC(\%)} = \frac{\frac{M_{WC}.V_{mol(std)}}{M_W}}{\frac{M_{WC}.V_{mol(std)}}{M_W} + V_{m(std)}} \times 100$$

VWC (%) = Water vapour content on wet basis, in volume % (m³ of water vapour in m³ of wet gas)

Vm(std) = Dry gas volume measured, corrected to standard conditions (m³)

mWC = Mass of water collected in the impingers (g)

Mw = Molecular weight of water, 18.01534 rounded to 18 (g/mol)

Vmol(std) = Molar volume of water at standard conditions = 0.0224 (m3/mol)

Gas meter volume at standard conditions (STP)

From reference calculations (taken from BS EN 14790):

$$V_{m(std)} = y_d \times (V_2 - V_1) \times \frac{T_{std}}{T_m} \times \frac{p_m}{p_{std}}$$

Vm(std) = Dry gas meter volume at standard conditions (m³)

yd = Gas meter calibration coefficient

(V2-V1) = Dry gas meter volume at actual conditions (m³)

Tm = Actual Temperature (K)
Tstd = Standard temperature (273 K)

pm = Absolute pressure at the gas meter (kPa)
pstd = Standard gas pressure (101.3 kPa)

Isokenetic Ratio (%):

From reference calculations (taken from EA TGN M2):

$$IsokineticRatio(\%) = \frac{Velocity\ at\ the\ sampling\ nozzle}{Velocity\ of\ the\ stack\ gas} \times 100$$

Estimating Measurment Uncertainty

Uncertainty estimates are calculated using the general rule of uncertainty propagation. Guidance is taken from publications including UKAS document M3003 and ISO 20988:2007.

Flow Calculations

Velocity:

From reference calculations (taken from ISO 10780):

$$\overline{v} = KC \sqrt{\frac{T_s \Delta \overline{p}}{p_e M_s}}$$

 \overline{v} = Average velocity (m/s)

 \dot{C} = velocity calculation constant = 129

Ts = Average stack temperature (K)

Ms = Molar mass of gas; assume 29 kg/kmol unless the molar mass is < 27 kg/kmol or > 31 g/kmol

K = Pitot calibration coefficientPe = Absolute gas pressure (kPa)

 $\Delta p = \Delta p$ Average pitot tube pressure differencial (kPa)

Volume flow rate

From reference calculations (taken from ISO 10780):

$$q_{va} = vA$$

qva = Average flow rate (m³/s)

 \bar{v} = Average velocity (m/s)

A =Stack cross-sectional area (m²)

Volume flow rate corrected for moisture

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{(100 - H_a)}{(100 - H_m)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s) Ha = Moisture at actual conditions (%volume)

Hm = Reference moisture (%volume)

Volume flow rate corrected for temperature and pressure

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(T_m p_a\right)}{\left(T_a p_m\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

Ta = Temperature at actual conditions (K)

Tm = Reference Temperatue (K)

pa = Absolute gas pressure at actual conditions (kPa)

pm =Reference pressure (kPa)

Volume flow rate corrected for oxygen

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(20.9 - O_{2,ref}\right)}{\left(20.9 - O_{2,m}\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

O2,m = Actual oxygen concentration (%)

O2,ref = Reference oxygen concentration (%)

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Concentration Calculations

Concentration:

From reference calculations (taken from BS EN 13284-1):

$$c = \frac{m}{V}$$

c = Concentration m = Mass of substane V = Volume sampled

Mass Emission

Mass emission= $c \times q_m$

c = Concentration q = Volume flow rate

Concentration corrected for oxygen:

From reference calculations (taken from BS ISO 9096):

$$c_m = c_a \times \frac{20.9 - O_{2,ref}}{20.9 - O_{2,a}}$$

cm = Concentration at reference conditions

ca = Actual concentration
O2, ref = Reference oxygen (%)
O2, a= Actual Oxygen (%)

Concentration corrected for moisture:

From reference calculations (taken from BS ISO 9096):

Convert wet gas to dry gas

$$c_{dry} = c_{wet} \times \frac{100}{100 - H_a}$$

Convert dry gas to wet gas

$$c_{wet} = c_{dry} \times \frac{100 - H_a}{100}$$

cwet = Concentration wet gascdry = Concentration dry gasHa = Water vapour content (%vol)

Conversion of parts per million (ppm) to mg/m³

From reference calculations (taken from EA TGN M2):

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

molar volume at 273K = 22.4 litres

When Converting TOC

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight of\ carbonin\ span\ gas(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

Calculation of Uncertainty Estimates - Instrumental Monitoring Techniques

Model equation

 $C_{ppm} = C_{reading} + Corr_{fit} + Corr_{f,dr} + Corr_{s,dr} + Corr_{rep} + Corr_{adj} + \sum_{i=1}^{p} Corr_{inf} + Corr_{inf}$

Corr_{rep} Corr_{adj} Corr_{inf} $C_{,ppm}$ correction of repeatability of measurement concentration in ppm concentration given by analyser C_{NO.reading} correction of adjustment

Corr fit correction of lack of fit correction of influence quantities Corr _{0,dr} correction of zero drift

Corr s,dr correction of span drift

Calculation of partial uncertainties

u(Corr_{fit}) $\left(\frac{X_{fit,\max}}{100 \times range}\right)$

Where:

 $X_{\text{fit,max}}$ is the maximum allowable deviation from linearity

Expressed as % of the range and calculated by applying a rectangular probability distribution

u(Corr_{0.dr})

max (S_{0,rep}; S_{srep}) u(Corr_{rep}) Where:

is the standard uncertainty at zero level is the standard uncertainty at span level

u(Corr_{adj}) $u(Corr_{loss}) + u(Corr_{cal})$ $u(Corr_{loss})$ is the uncertainty due to losses in sample line

is the uncertainty due to losses in sample line is the concentration of sample loss at span level $u(Corr_{cal})$ is the expanded uncertainty of the calibration gas

 $= c_{j} \sqrt{\frac{(x_{j,\max} - x_{j,adj})^{2} + (x_{j,\min} - x_{j,adj}) \times (x_{j,\max} - x_{j,adj}) + (x_{j,\min} - x_{j,adj})^{2}}{3}}$ u(Corr inf)

is the sensitivity coefficient of the influence quantity is the minimum value of the influence quantity during monitoring

is the maximum value of the influence quantity during monitoring is the value of the influence quantity during adjustment

 $= \frac{c_{j}}{Int_{j,lest}} \sqrt{\frac{Int_{j,max}^{2} + Int_{j,min} \times Int_{j,max} + Int_{j,min}^{2}}{3}}$

 c_{j} $Int_{j,test}$ is the sensitivity coefficient of the interferent i $= \max \left[S_{Int,p}; S_{Int,n} \right]$ $u(\Sigma Corr_{int})$ is the concentration of the interferent j used to determine c is the minimum value of the interferent j quantity during monitoring is the maximum value of the interferent i quantity during monitoring

 $\mathsf{Int}_{\mathsf{j},\mathsf{adj}}$ is the concentration of the interferent j in the cal gas used to adjust the analyse

 $S_{int,p}$ is the sum of interferents with positive impact is the sum of interferents with negative impact

Combined uncertainty

 $u(C_{,ppm})$

$$\sqrt{u^2(corr_{fit}) + u^2(corr_{o,dr}) + u^2(corr_{s,dr}) + u^2(corr_{ep}) + u^2(corr_{s,yf}) + u^2(corr_{a,press}) + u^2(corr_{temp}) + u^2(corr_{volt}) + u^2(corr_{adj}) + S_{hit}}$$

Overall expanded uncertainty (k = 2)

$$U(C_m) = u(C_m) \times k$$

Uncertainty of NOx measurements

is the concentration of NOx measured by the analyser

C_{NOx} is the ratio of NO:Nox in the stack gas is the NOx converter efficiency

Combined uncertainty NOx measurements

$$\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{0,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{rep}) + u^{2}(corr_{rep}) + u^{2}(corr_{s,vf}) + u^{2}(corr_{a,press}) + u^{2}(corr_{temp}) + u^{2}(corr_{volt}) + u^{2}(corr_{adj}) + S_{lnt}^{2} + u^{2}(corr_{NOx,comv}) + u^{2}(corr_{temp}) + u^{2}(cor$$

Uncertainty of mass concentration at oxygen reference concentration

u(C, O2 ref)

$$\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{o,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{rep}) + u^{2}(corr_{s,vf}) + u^{2}(corr_{s,vf}) + u^{2}(corr_{temp}) + u^{2}(corr_{temp}) + u^{2}(corr_{o,dt}) + u^{2}(corr_{odt}) + S_{lnt}^{2}} + \left(\frac{u^{2}(O_{2,meas,dry})}{(21 - O_{2,meas,dry})^{2}}\right) + u^{2}(corr_{fit}) + u^{2}(corr_{o,dr}) +$$

u(C,O_{2,ref)} uncertainty associated with the mass concentration at O₂ ref. concentration mg/m³ C,O_{2,ref} mg/m³ mass concentration at O₂ reference concentration O2 measured concentration % volume

uncertainty associated to the measured O2 concentration % (relative to O_{2 meas})

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APPENDIX 4

Uncertainty Estimate For The Measurement Of Total Organic Carbon

	Sick Maihak		1		
Analyser Type/Model Reference Oxygen %		viainak O	(0 = No corre	ction)	
	İ	Test 1	Test 2	Test 3	
Limit value	mg/m ³	75	75	75	
imit value	ppm	46.7	46.7	46.7	
Measured concentration	ppm	2.3	1.9	2.9	
Measured concentration	mg/m ³	3.7	3.1	4.7	
Calibration gas	ppm	75.5	75.5	75.5	
Calibration gas	mg/m ³	121.3	121.3	121.3	
Analyser range	ppm	9.3	9.3	9.3	
Analyser range	mg/m³	15.0	15.0	15.0	
Correction of Lack of Fit					
Lack of fit	% range	2.0	2.0	2.0 0.11	
	u(Corr, _{fit})	0.11	0.11	0.11	
Corrections of Zero and Span Drift				assumed to be	< 5% u(m
Zero Drift	% range	0.00	0.00	0.00	
Span Drift	u(Corr, _{0dr}) % range	0.00	0.00	0.00	
ppan Dilit	u(Corr, _{sdr})	0.00	0.00	0.00	
	- (/801/				
Correction of Repeatability of Measurement Repeatability SD at span level	% range	0.0	0.0	0.0	
Not reported)	u(Corr, _{rep})	0.00	0.00	0.00	
	- (- *****iep/	2.00		2.50	
Correction of adjustment osses in the line	% rango	0.13	0.13	0.13	
OSSES III [IIE IIIIE	% range u(Corr, _{loss})	0.13	0.13	0.13	
Incertainty of calibration gas	% range	2.0	2.0	2.0	
	u(Corr, _{cal})	0.02	0.02	0.03	
Correction of Influence of Interferents					
N ₂ O	% range				
	u(Corr, _{N2O})	0.00	0.00	0.00	
CO ₂	% range	0.00	0.00	0.00	
CH₄	u(Corr, _{CO2}) % range	0.00	0.00	0.00	
5.1.4	u(Corr, _{CH4})	0.00	0.00	0.00	
Total of interferent influences	% range	2.50	2.50	2.50	
$u(\Sigma Corrint) = \max[S_{Int,p}; S_{Int,n}]$	$u(\Sigma Corr_{int})$	0.16	0.16	0.16	
Correction of Influence Quantities					
Sensitivity to sample volume flow	% range	1.60	1.60	1.60	
	u(Corr, _{flow})	0.09	0.09	0.09	
Sensitivity to atmospheric pressure Not reported)	% range	0.00	0.00	0.00	
Sensitivity to ambient temperature	u(Corr, _{press}) % range	-2.40	-2.40	-2.40	
sonowny to ambioni tomporature	u(Corr, _{temp})	-0.28	-0.28	-0.28	
Sensitivity to electrical voltage	% range	0.50	0.50	0.50	
Not reported)	u(Corr, _{volt})	0.10	0.10	0.10	
Maximum standard uncertainty	u(Corr, _{max})	0.11	0.11	0.11	
5% of maximum standard uncertainty	u(Corr,5%)	0.01	0.01	0.01	
nterferent Concentration Variations	Minimum	Maximum	Value at cal	Performance	Units
CH ₄ range	0	10	0	50	mg/m ³
l₂O range cO₂ range	0 8	12	0	20 15	mg/m ³ mg/m ³
Dxygen effect variations	Minimum	Maximum	Value at cal	Performance	Units
Dxygen effect	0	20	0	2	mg/m ³
nfluonea Quantitiv Variations					
nfluence Quantitiy Variations	Minimum	Maximum	Value at cal	Performance	Units
Sensitivity to sample volume flow	55	65	60	5	l/h
Sensitivity to atmospheric pressure	99	100	99	1	kPa
Sensitivity to ambient temperature	278	313	288	10	K
	187	250	230	5	V
Sensitivity to electrical voltage				T40	
Measurement uncertainty		Test 1	Test 2	Test 3	
Measurement uncertainty Combined uncertainty	ppm	0.37	0.37	0.37	
Measurement uncertainty Combined uncertainty	ppm mg/m ³				
Measurement uncertainty Combined uncertainty Combined uncertainty	mg/m ³	0.37 0.59	0.37	0.37	
Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of confi	mg/m ³ dence of 95%, k	0.37 0.59 =2 0.7	0.37 0.59	0.37 0.59	
Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of configureal uncertainty Overall uncertainty Overall uncertainty	mg/m³ dence of 95%, k ppm mg/m³	0.37 0.59 =2 0.7 1.2	0.37 0.59 0.7 1.2	0.37 0.59 0.7 1.2	
Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of confi Overall uncertainty Overall uncertainty Overall uncertainty Overall uncertainty relative to measured value Overall uncertainty relative to range	mg/m ³ dence of 95%, k	0.37 0.59 =2 0.7	0.37 0.59	0.37 0.59	

The uncertainty evaluation has been carried out in accordance with UKAS requirements.



Client

Xaarjet Ltd 1 Hurricane Close Ermine Business Park Huntingdon Cambridgeshire PE29 6XX

Part 1: Executive Summary

Report for the Periodic Monitoring of Emissions to Air.

Site Huntingdon Plant LEV 9

Sampling Date 28th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4





Exova (UK) Ltd

Unit C5 Emery Court The Embankment Business Park Heaton Mersey Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

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Page 6	Comments On Monitoring Procedures
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Monitoring Objectives

The monitoring was undertaken to check compliance with authorised emission limits.

All monitoring procedures were carried out to the MCERTS requirements under the Exova (UK) Ltd quality system to ISO 17025: 2005.

Monitoring was undertaken for the listed emissions from the following sampling positions:

Sampling Location	Emission
LEV 9	Total volatile organic carbon

Special Monitoring Requirements

There were no special requirements for this monitoring campaign.

Summary of Methods

Emission	Method number	Method standard
Gas velocity and volume flow	TPM/01A	BS EN ISO 16911-1:2013
тос	MM0002	BS EN 12619 : 2013

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Summary Of Results

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd** The results were measured from the sample positions downstream of the arrestment plant.

Emission at	Sampling		Emission	Authorised	Uncertainty	Detection	Mass	
Huntingdon		Time		Result	Limit	+/-	Limit	Emission
LEV 9	Date	Start	End	mg/m³∗	mg/m³*	mg/m³*	mg/m³*	g/h
тос	28/01/16	12:13	13:43	14.4	75	1.2	0.2	36.5

* at reference conditions	Stack Gas Weight	0 °C	Without correction for moisture	
	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction	%

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above) Nm³ 273 K, 101.3 kPa

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



All tests included in this report are accredited under UKAS and MCERTS accreditation schemes unless otherwise stated.

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





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Summary Of Results, Exhaust Gases

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd**The results were measured from the sample positions downstream of the arrestment plant.

	Emission at Huntingdon		Sampling Time		Emission Result	Authorised Limit	Uncertainty +/-	Detection Limit	Mass Emission
	LEV 9	Date	Start	End	mg/m ³ *	mg/m ³ *	mg/m³*	mg/m³*	g/h
TOC	Test 1	28/01/16	12:13	12:43	18.4	75	1.3	0.2	46.6
тос	Test 2	28/01/16	12:43	13:13	15.4	75	1.2	0.2	39.2
тос	Test 3	28/01/16	13:13	13:43	9.4	75	1.2	0.2	23.9

I	* at ref	Stack Gas Weight	0 °C	Without correction for moisture
	Conditions	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction %

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above)

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



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Nm³ 273 K, 101.3 kPa



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Operating Information

The table below shows details of the operating information on each sampling date for: LEV 9

Date	Process type	Process duration	Fuel	Feedstock	Abatement	Load
28/01/2016	Production and cleaning of inkjet cartridges	Continuous	N/A	N/A	N/A	Normal

No CEMs installed on the emission point.

Comments & Monitoring Deviations

A waste gas homogeneity test to BS EN 15259:2007 (MID) is not required:-

The homogeneity test is not applicable to non-combustion processes.

The homogeneity test is not applicable to duct areas less than 1m².

The homogeneity test is not usually applicable to pollutant emissions that are less than 30% of the ELV.

All monitoring was performed in accordance with the relevant procedures.



Part 2: Supporting Information

Report for the Periodic Monitoring of Emissions to Air.

Client Xaarjet Ltd Site Huntingdon Plant LEV 9

Sampling Date

28th January 2016 Report Date 25th February 2016

Job Number EM-2708 **Permit Number** B22/11

Report Prepared by: Print **Rob Jones**

> MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

> Print **Derek Myers**

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd Unit C5 Emery Court The Embankment Business Park **Heaton Mersey** Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

Xaarjet Ltd, Huntingdon, Permit No: B22/11, R/16-6519, v1

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APPENDIX 1

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Emission Monitoring Procedures And Instrumentation

Gas velocity and temperature

Documented in-house procedure TPM01/A to the main procedural requirements of BS EN ISO 16911-1:2013 Velocity and temperature measurements are performed using a calibrated Pitot tube, a calibrated pressure differential reading device and a calibrated thermocouple. Velocity and possible flow deviation measurements are carried out at selected, representative points in the gas stream.

Total organic carbon

Documented in-house procedure MM0002 to the main procedural requirements of BS EN 12619:2013. Continuous analysis using probe, sample line and multi range Flame Ionisation Detector (FID) analyser. The analyser is calibrated before and during the tests using certified gas mixtures of nitrogen, oxygen and propane. Sampling points are selected in accordance with the findings of any BS EN 15259 assessment.

Sampling Project Personnel Competency And Expiry Dates

Report prepared by:	Rob Jones	MCERTS No MM08 984	Level 1 -	Level 2 31/03/2016	TE1 31/03/2020	TE2 31/03/2016	TE3 30/09/2016	TE4 31/12/2020
Report authorised by:	Derek Myers	MM02 115	-	30/09/2017	31/05/2018	30/11/2018	30/11/2018	30/11/2018
Team leader:	Rob Jones	MM08 984	-	31/03/2016	31/03/2020	31/03/2016	30/09/2016	31/12/2020
Team leader:	Harpreet Badwal	MM03 149	-	30/09/2018	30/09/2018	30/04/2019	31/10/2019	31/10/2019

Equipment References

Equipment	Reference Number		
FID	AQ270		
Heated Line	HL33		
Stack Thermocouple	PTTS97		
Timer / Stopwatch	ST41		
Barometer	WS03		
Pitot	PT97		
Thermometer	TK24		
Manometer	PI03		

Xaarjet Ltd, Huntingdon, Permit No: B22/11, R/16-6519, v1

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APPENDIX 2

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D. L.	00/04/0040
Date	28/01/2016
Time	11:20
Pitot Cp	0.79

Barometric pressure	101.6	kPa
Duct static pressure	0.33	kPa
Stack Area	0.071	m²

Stack Diameter (circular)	0.30	m

Traverse	Traverse	Depth	ΔΡ	Т	Angle	velocity	Traverse	Depth	ΔΡ	Т	Angle	velocity
Point	Line	cm	mmH ₂ O	°C	0	m/s	Line	cm	mmH ₂ O	°C	0	m/s
1	Α						В					
2	Α						В					
3	Α	5.0	11.2	24	<15	10.7	В	5.0	10.7	24	<15	10.5
4	Α	5.3	11.9	24	<15	11.1	В	5.3	11.2	24	<15	10.7
5	Α	7.5	11.9	24	<15	11.0	В	7.5	11.4	24	<15	10.8
6	Α	10.7	12.0	24	<15	11.1	В	10.7	11.9	24	<15	11.1
7	Α	19.3	12.8	24	<15	11.5	В	19.3	11.3	24	<15	10.8
8	Α	22.5	12.2	24	<15	11.2	В	22.5	11.1	24	<15	10.7
9	Α	24.7	10.6	24	<15	10.4	В	24.7	10.7	24	<15	10.5
10	Α	25.0	10.4	24	<15	10.3	В	25.0	10.3	24	<15	10.3
11	Α						В					
12	Α						В					

Average Pitot DP	11.35	mmH₂O
Average Temperature	297.2	K
Average Velocity	10.8	m/s
Average volumetric flow rate	0.76	m ³ /s at stack conditions
Average volumetric flow rate	0.70	m ³ /s (wet STP)

Sampling plane requirements Re: BS EN 13284-1:2001 5.2

a	a Angel of gas flow less than 15° with regard to duct axis		YES
b	No local negative flow		YES
С	c Minimum pitot greater than 5Pa		YES
d	Ratio of highest to lowest local gas velocity less than 3:1		YES
	Minimum local gas velocity	10.3	
	Maximum local gas velocity 11.5		
	Ratio of highest to lowest local gas velocity	1.12	

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D-4-	00/04/0040
Date	28/01/2016

From	12:13	to	12:43	30 minute mean		
Volatile organ	ic compounds		vppm, wet	11.43	mg/m³*	18.37
From	12:43	to	13:13	30 minute mean		
Volatile organ	ic compounds		vppm, wet	9.60	mg/m³*	15.43
From	13:13	to	13:43	30 minute mean		
Volatile organ	ic compounds		vppm, wet	5.85	mg/m³*	9.40

Sampling Detection Limits

- 9				
Volatile organic compounds	vppm	0.10	mg/m³*	0.16

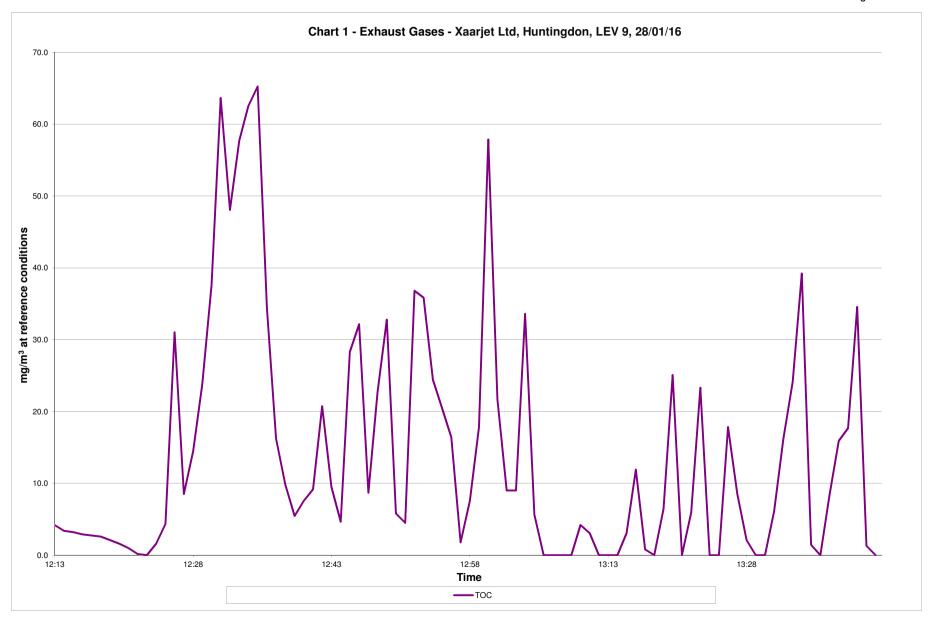
Reference Gas Details

Species	Units	Value	Cylinder Reference	Analyser Range	Uncertainity $k = 2$
Nitrogen	%	99.999	VC80548	-	± 2
Volatile organic compounds	vppm	76.6	VCD500681	100	± 2

Zero And Span Gas Details

Species	units	Initial Time	11:40	Final Time	17:26
		Initial Zero	Initial Span	Final Zero	Final Span
Volatile organic compounds	vppm	0.0	76.6	-0.8	75.6

Exhaust Gases - Continuous Analysis Data



Xaarjet Ltd, Huntingdon, Permit No: B22/11, R/16-6519, v1

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APPENDIX 3

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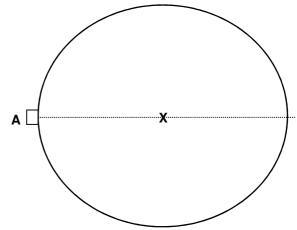
Diagram Of The Sampling Location

Diagram of sampling points across the cross section of the duct (not to scale).

Traverse length =

0.30 m

Point	% of D	Location
		cm
1	50.0	15.0





LEV 9

General Calculations

Stack area:

$$Area of a circle = \frac{\pi . D^2}{4}$$

D = Diameter (m) $\pi = 3.142$

Pressure conversion:

1mmH2O = 0.00980665 kPa 1mmH2O = 9.80665 Pa 1 mar = 0.1 kPa

Water vapour concentration:

From reference calculations (taken from BS EN 14790):

$$V_{WC(\%)} = \frac{\frac{m_{WC}.V_{mol(std)}}{M_{W}}}{\frac{m_{WC}.V_{mol(std)}}{M_{W}} + V_{m(std)}} \times 100$$

VWC (%) = Water vapour content on wet basis, in volume % (m³ of water vapour in m³ of wet gas)

Vm(std) = Dry gas volume measured, corrected to standard conditions (m³)

mWC = Mass of water collected in the impingers (g)

Mw = Molecular weight of water, 18.01534 rounded to 18 (g/mol)

Vmol(std) = Molar volume of water at standard conditions = 0.0224 (m3/mol)

Gas meter volume at standard conditions (STP)

From reference calculations (taken from BS EN 14790):

$$V_{m(std)} = y_d \times (V_2 - V_1) \times \frac{T_{std}}{T_m} \times \frac{p_m}{p_{std}}$$

Vm(std) = Dry gas meter volume at standard conditions (m³)

yd = Gas meter calibration coefficient

(V2-V1) = Dry gas meter volume at actual conditions (m³)

Tm = Actual Temperature (K)
Tstd = Standard temperature (273 K)

pm = Absolute pressure at the gas meter (kPa) pstd = Standard gas pressure (101.3 kPa)

Isokenetic Ratio (%):

From reference calculations (taken from EA TGN M2):

$$IsokineticRatio(\%) = \frac{Velocity\ at\ the\ sampling\ nozzle}{Velocity\ of\ the\ stack\ gas} \times 100$$

Estimating Measurment Uncertainty

Uncertainty estimates are calculated using the general rule of uncertainty propagation. Guidance is taken from publications including UKAS document M3003 and ISO 20988:2007.

Flow Calculations

Velocity:

From reference calculations (taken from ISO 10780):

$$\overline{v} = KC \sqrt{\frac{T_s \Delta \overline{p}}{p_e M_s}}$$

 \overline{v} = Average velocity (m/s)

C = velocity calculation constant = 129

Ts = Average stack temperature (K)

Ms = Molar mass of gas; assume 29 kg/kmol unless the molar mass is < 27 kg/kmol or > 31 g/kmol

K = Pitot calibration coefficientPe = Absolute gas pressure (kPa)

 $\Delta p = \Delta p$ Average pitot tube pressure differencial (kPa)

Volume flow rate

From reference calculations (taken from ISO 10780):

$$q_{va} = vA$$

qva = Average flow rate (m³/s)

v = v Average velocity (m/s)

A =Stack cross-sectional area (m²)

Volume flow rate corrected for moisture

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{(100 - H_a)}{(100 - H_m)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s) Ha = Moisture at actual conditions (%volume)

Hm = Reference moisture (%volume)

Volume flow rate corrected for temperature and pressure

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(T_m p_a\right)}{\left(T_a p_m\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

Ta = Temperature at actual conditions (K)

Tm = Reference Temperatue (K)

pa = Absolute gas pressure at actual conditions (kPa)

pm =Reference pressure (kPa)

Volume flow rate corrected for oxygen

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(20.9 - O_{2,ref}\right)}{\left(20.9 - O_{2,m}\right)}$$

qm = Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

O2,m = Actual oxygen concentration (%)

O2,ref = Reference oxygen concentration (%)

Concentration Calculations

Concentration:

From reference calculations (taken from BS EN 13284-1):

$$c = \frac{m}{V}$$

c = Concentration m = Mass of substane V = Volume sampled

Mass Emission

Mass emission= $c \times q_m$

c = Concentration q = Volume flow rate

Concentration corrected for oxygen:

From reference calculations (taken from BS ISO 9096):

$$c_m = c_a \times \frac{20.9 - O_{2,ref}}{20.9 - O_{2,a}}$$

cm = Concentration at reference conditions

ca = Actual concentration
O2, ref = Reference oxygen (%)
O2, a= Actual Oxygen (%)

Concentration corrected for moisture:

From reference calculations (taken from BS ISO 9096):

Convert wet gas to dry gas

$$c_{dry} = c_{wet} \times \frac{100}{100 - H_a}$$

Convert dry gas to wet gas

$$c_{wet} = c_{dry} \times \frac{100 - H_a}{100}$$

cwet = Concentration wet gascdry = Concentration dry gasHa = Water vapour content (%vol)

Conversion of parts per million (ppm) to mg/m³

From reference calculations (taken from EA TGN M2):

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

molar volume at 273K = 22.4 litres

When Converting TOC

 $Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight of\ carbonin\ span\ gas(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$

Calculation of Uncertainty Estimates - Instrumental Monitoring Techniques

Model equation

 $C_{ppm} = C_{reading} + Corr_{fit} + Corr_{f,dr} + Corr_{s,dr} + Corr_{rep} + Corr_{adj} + \sum_{i=1}^{p} Corr_{inf} + Corr_{inf}$

Corr_{rep} Corr_{adj} Corr_{inf} $C_{,ppm}$ correction of repeatability of measurement concentration in ppm concentration given by analyser C_{NO.reading} correction of adjustment Corr fit correction of lack of fit correction of influence quantities Corr _{0,dr} correction of zero drift

Corr s,dr correction of span drift

Calculation of partial uncertainties

u(Corr_{fit}) $\left(\frac{X_{fit,\max}}{100 \times range}\right)$ Where: $X_{\text{fit,max}}$ is the maximum allowable deviation from linearity

Expressed as % of the range and calculated by applying a rectangular probability distribution

max (S_{0,rep}; S_{srep}) u(Corr_{rep}) Where:

is the standard uncertainty at zero level is the standard uncertainty at span level

$$u(Corr_{inf}) = c_{j} \sqrt{\frac{(x_{j,\max} - x_{j,adj})^{2} + (x_{j,\min} - x_{j,adj}) \times (x_{j,\max} - x_{j,adj}) + (x_{j,\min} - x_{j,adj})^{2}}{3}}$$
Where,

is the sensitivity coefficient of the influence quantity is the minimum value of the influence quantity during monitoring is the maximum value of the influence quantity during monitoring is the value of the influence quantity during adjustment

$$u(Corr_{int}) = \frac{c_j}{Int_{j,test}} \sqrt{\frac{Int_{j,max}^2 + Int_{j,min} \times Int_{j,max} + Int_{j,min}^2}{3}}$$

 $= \max \left[S_{Int,p}; S_{Int,n} \right]$

 c_{j} $Int_{j,test}$ is the sensitivity coefficient of the interferent i is the concentration of the interferent j used to determine c is the minimum value of the interferent j quantity during monitoring is the maximum value of the interferent i quantity during monitoring

 $\mathsf{Int}_{\mathsf{j},\mathsf{adj}}$ is the concentration of the interferent j in the cal gas used to adjust the analyse

 $S_{int,p}$ is the sum of interferents with positive impact is the sum of interferents with negative impact

Combined uncertainty

 $u(\Sigma Corr_{int})$

$$u(C, ppm) =$$

$$\sqrt{u^2 (corr_{\mathit{fit}}) + u^2 (corr_{\mathit{o,dr}}) + u^2 (corr_{\mathit{s,dr}}) + u^2 (corr_{\mathit{rep}}) + u^2 (corr_{\mathit{s,yf}}) + u^2 (corr_{\mathit{a,press}}) + u^2 (corr_{\mathit{temp}}) + u^2 (corr_{\mathit{volt}}) + u^2 (corr_{\mathit{adj}}) + S_{\mathit{hit}}^{-2}}$$

Overall expanded uncertainty (k = 2)

$$U(C_m) = u(C_m) \times k$$

Uncertainty of NOx measurements

C_{NOx} is the concentration of NOx measured by the analyser is the ratio of NO:Nox in the stack gas is the NOx converter efficiency

Combined uncertainty NOx measurements

$$u(C_{NOx}, _{stack}) =$$

$$\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{0,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{rep}) + u^{2}(corr_{rep}) + u^{2}(corr_{s,vf}) + u^{2}(corr_{a,press}) + u^{2}(corr_{temp}) + u^{2}(corr_{volt}) + u^{2}(corr_{adj}) + S_{lnt}^{2} + u^{2}(corr_{NOx,comv}) + u^{2}(corr_{temp}) + u^{2}(cor$$

Uncertainty of mass concentration at oxygen reference concentration

$$u(C, O2 ref) =$$

$$\sqrt{u^{2}(corr_{\mathit{fit}}) + u^{2}(corr_{\mathit{o,dr}}) + u^{2}(corr_{\mathit{s,dr}}) + u^{2}(corr_{\mathit{rep}}) + u^{2}(corr_{\mathit{s,vf}}) + u^{2}(corr_{\mathit{s,vf}}) + u^{2}(corr_{\mathit{s,otr}}) + u^{2}(corr_{\mathit{sott}}) + u^{2}(corr_{\mathit{odd}}) + S_{\mathit{Int}}^{2} + \left(\frac{u^{2}(O_{2,\mathit{meas,dry}})}{(21 - O_{2,\mathit{meas,dry}})^{2}}\right)}$$

u(C,O_{2,ref)} uncertainty associated with the mass concentration at O₂ ref. concentration mg/m³ C,O_{2,ref} mg/m³ mass concentration at O₂ reference concentration O2 measured concentration % volume uncertainty associated to the measured O2 concentration % (relative to O_{2 meas})

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APPENDIX 4

Uncertainty Estimate For The Measurement Of Total Organic Carbon

Analyser Type/Model	Sick N	Maihak	1			
Analyser Type/Model Reference Oxygen %		лагпак О	(0 = No corre	(0 = No correction)		
		T 4	T+0	T+0		
Limit value	mg/m ³	Test 1 75	Test 2 75	Test 3 75		
Limit value	ppm	46.7	46.7	46.7		
Measured concentration	ppm	11.4	9.6	5.9		
Measured concentration	mg/m ³	18.4	15.4	9.4		
Calibration gas	ppm	76.6	76.6	76.6		
Calibration gas	mg/m ³	123.1	123.1	123.1		
Analyser range	ppm	9.3	9.3	9.3		
Analyser range	mg/m ³	15.0	15.0	15.0		
Correction of Lack of Fit						
_ack of fit	% range u(Corr, _{fit})	2.0 0.11	2.0 0.11	2.0 0.11		
Corrections of Zero and Span Drift Zero Drift		alculated for .: 0.00	the residual is 0.00	assumed to be	< 5% u(m	
zero Dilit	% range u(Corr, _{0dr})	0.00	0.00	0.00		
Span Drift	% range	0.00	0.00	0.00		
	u(Corr, _{sdr})	0.00	0.00	0.00		
Correction of Repeatability of Measurement						
Repeatability SD at span level	% range	0.0	0.0	0.0		
(Not reported)	u(Corr, _{rep})	0.00	0.00	0.00		
Correction of adjustment						
osses in the line	% range	1.31	1.31	1.31		
	u(Corr, _{loss})	0.09	0.07	0.04		
Incertainty of calibration gas	% range u(Corr, _{cal})	2.0 0.11	2.0 0.10	2.0 0.06		
	u(OUII,cal)	0.11	0.10	0.00		
Correction of Influence of Interferents	% range		ı			
1 20	u(Corr, _{N2O})	0.00	0.00	0.00		
CO ₂	% range					
CH ₄	u(Corr, _{CO2})	0.00	0.00	0.00		
∪ ⊓ ₄	% range u(Corr, _{CH4})	0.00	0.00	0.00		
Total of interferent influences	% range	2.50	2.50	2.50		
$u(\Sigma Corrint) = \max [S_{Int,p}; S_{Int,n}]$	$u(\Sigma Corr_{int})$	0.16	0.16	0.16		
Correction of Influence Quantities						
Sensitivity to sample volume flow	% range	1.60	1.60	1.60		
2	u(Corr, _{flow})	0.09	0.09	0.09		
Sensitivity to atmospheric pressure (Not reported)	% range u(Corr, _{press})	0.00	0.00	0.00		
Sensitivity to ambient temperature	% range	-2.40	-2.40	-2.40		
	u(Corr, _{temp})	-0.28	-0.28	-0.28		
Sensitivity to electrical voltage	% range	0.50	0.50	0.50		
(Not reported)	u(Corr, _{volt})	0.10	0.10	0.10		
Marian and American and American	I/C	0.11		0.41		
Maximum standard uncertainty 5% of maximum standard uncertainty	u(Corr, _{max}) u(Corr, _{5%})	0.11	0.11	0.11		
	3(0011,5%)	5.01	0.01	3.01		
nterferent Concentration Variations	Minimum	Maximum	Value at cal	Performance	Units	
CH ₄ range	0	10	0	50	mg/m ³	
N₂O range	0	0	0	20	mg/m ³	
CO ₂ range	8	12	0	15	mg/m ³	
Oxygen effect variations Oxygen effect	Minimum 0	Maximum 20	Value at cal 0	Performance 2	Units mg/m ³	
oxygon dileut	1 0	۷.	J		mg/m²	
nfluence Quantitiy Variations	Minimum	Maximum	Value at cal	Performance	Units	
Sensitivity to sample volume flow	55	65	60	5	l/h	
Sensitivity to atmospheric pressure	99	100	99	1	kPa	
Sensitivity to ambient temperature	278	313	288	10	K	
Sensitivity to electrical voltage	187	250	230	5	V	
Measurement uncertainty		Test 1	Test 2	Test 3		
Combined uncertainty	ppm	0.39	0.38	0.37		
Combined uncertainty	mg/m ³	0.63	0.62	0.60		
Expanded uncertainty expressed with a level of cor						
Overall uncertainty	ppm	0.8 1.3	0.8 1.2	0.7 1.2		
			. 12	1.2		
Overall uncertainty	mg/m³					
Overall uncertainty Overall uncertainty relative to measured value Overall uncertainty relative to range	mg/m³ % %	6.9	8.0 8.2	12.7 8.0		

The uncertainty evaluation has been carried out in accordance with UKAS requirements.



Client

Xaarjet Ltd 1 Hurricane Close Ermine Business Park Huntingdon Cambridgeshire PE29 6XX

Part 1: Executive Summary

Report for the Periodic Monitoring of Emissions to Air.

Site Huntingdon
Plant LEV 13

Sampling Date 28th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd

Unit C5 Emery Court The Embankment Business Park Heaton Mersey Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

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Monitoring Objectives

The monitoring was undertaken to check compliance with authorised emission limits.

All monitoring procedures were carried out to the MCERTS requirements under the Exova (UK) Ltd quality system to ISO 17025: 2005.

Monitoring was undertaken for the listed emissions from the following sampling positions:

Sampling Location	Emission
LEV 13	Total volatile organic carbon

Special Monitoring Requirements

There were no special requirements for this monitoring campaign.

Summary of Methods

Method number	Method standard
TPM/01A	BS EN ISO 16911-1:2013
MM0002	BS EN 12619 : 2013
	TPM/01A

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Summary Of Results

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd** The results were measured from the sample positions downstream of the arrestment plant.

Emission at	Sampling		Emission	Authorised	Uncertainty	Detection	Mass	
Huntingdon	Time		Result	Limit	+/-	Limit	Emission	
LEV 13	Date	Start	End	mg/m³∗	mg/m³*	mg/m³*	mg/m³*	g/h
тос	28/01/16	15:53	17:23	9.1	75	1.2	0.2	166.3

* at reference conditions	Stack Gas Weight	0 °C	Without correction for moisture		
	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction	%	

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above) Nm³ 273 K, 101.3 kPa

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



All tests included in this report are accredited under UKAS and MCERTS accreditation schemes unless otherwise stated.

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





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Summary Of Results, Exhaust Gases

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd** The results were measured from the sample positions downstream of the arrestment plant.

	Emission at Huntingdon	, , , , , , , , , , , , , , , , , , ,			Emission Result	Authorised Limit	Uncertainty +/-	Detection Limit	Mass Emission
	LEV 13	Date	Start	End	mg/m ³ *	mg/m ³ *	mg/m³*	mg/m³*	g/h
TOC	Test 1	28/01/16	15:53	16:23	8.0	75	1.2	0.2	145.6
TOC	Test 2	28/01/16	16:23	16:53	9.5	75	1.2	0.2	173.6
TOC	Test 3	28/01/16	16:53	17:23	9.8	75	1.2	0.2	179.7

I	* at ref	Stack Gas Weight	0 °C	Without correction for moisture
	Conditions	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction %

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above)

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



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Nm³ 273 K, 101.3 kPa



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Operating Information

The table below shows details of the operating information on each sampling date for: LEV 13

Date	Process type	Process duration	Fuel	Feedstock	Abatement	Load
28/01/2016	Production and cleaning of inkjet cartridges	Continuous	N/A	N/A	N/A	Normal

No CEMs installed on the emission point.

Comments & Monitoring Deviations

A waste gas homogeneity test to BS EN 15259:2007 (MID) is not required:-

The homogeneity test is not applicable to non-combustion processes.

The homogeneity test is not applicable to duct areas less than 1m².

The homogeneity test is not usually applicable to pollutant emissions that are less than 30% of the ELV.

All monitoring was performed in accordance with the relevant procedures.



Part 2: Supporting Information

Report for the Periodic Monitoring of Emissions to Air.

Client Xaarjet Ltd
Site Huntingdon
Plant LEV 13

Sampling Date 28th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd Unit C5 Emery Court

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Tel: 0161 4323286

Company Registration No SC070429

Xaarjet Ltd, Huntingdon, Permit No: B22/11, R/16-6520, v1

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Emission Monitoring Procedures And Instrumentation

Gas velocity and temperature

Documented in-house procedure TPM01/A to the main procedural requirements of BS EN ISO 16911-1:2013 Velocity and temperature measurements are performed using a calibrated Pitot tube, a calibrated pressure differential reading device and a calibrated thermocouple. Velocity and possible flow deviation measurements are carried out at selected, representative points in the gas stream.

Total organic carbon

Documented in-house procedure MM0002 to the main procedural requirements of BS EN 12619:2013. Continuous analysis using probe, sample line and multi range Flame Ionisation Detector (FID) analyser. The analyser is calibrated before and during the tests using certified gas mixtures of nitrogen, oxygen and propane. Sampling points are selected in accordance with the findings of any BS EN 15259 assessment.

Sampling Project Personnel Competency And Expiry Dates

Report prepared by:	Rob Jones	MCERTS No MM08 984	Level 1 -	Level 2 31/03/2016	TE1 31/03/2020	TE2 31/03/2016	TE3 30/09/2016	TE4 31/12/2020
Report authorised by:	Derek Myers	MM02 115	-	30/09/2017	31/05/2018	30/11/2018	30/11/2018	30/11/2018
Team leader:	Rob Jones	MM08 984	-	31/03/2016	31/03/2020	31/03/2016	30/09/2016	31/12/2020
Team leader:	Harpreet Badwal	MM03 149	-	30/09/2018	30/09/2018	30/04/2019	31/10/2019	31/10/2019

Equipment References

Equipment	Reference Number
FID	AQ270
Heated Line	HL33
Stack Thermocouple	PTTS97
Timer / Stopwatch	ST41
Barometer	WS03
Pitot	PT97
Thermometer	TK24
Manometer	PI03

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Date	28/01/2016
Time	10:30
Pitot Cp	0.79

Barometric pressure	101.6	kPa
Duct static pressure	0.20	kPa
Stack Area	0.785	m ²

Stack Diameter (circular)	1.00	m

Traverse	Traverse	Depth	ΔΡ	Т	Angle	velocity	Traverse	Depth	ΔΡ	T	Angle	velocity
Point	Line	cm	mmH ₂ O	°C	0	m/s	Line	cm	mmH ₂ O	°C	0	m/s
1	Α	5.0	2.9	25	<15	5.4	В					
2	Α	6.7	3.8	25	<15	6.2	В					
3	Α	11.8	3.4	25	<15	5.9	В					
4	Α	17.7	4.3	25	<15	6.6	В					
5	Α	25.0	5.5	25	<15	7.5	В					
6	Α	35.6	5.1	25	<15	7.2	В					
7	Α	64.4	6.1	25	<15	7.9	В					
8	Α	75.0	5.9	25	<15	7.8	В					
9	Α	82.3	5.8	25	<15	7.7	В					
10	Α	88.2	5.4	25	<15	7.5	В					
11	Α	93.3	5.1	25	<15	7.2	В					
12	Α	95.0	5.0	25	<15	7.2	В					

Average Pitot DP	4.79	mmH₂O
Average Temperature	297.7	К
Average Velocity	7.0	m/s
Average volumetric flow rate	5.51	m ³ /s at stack conditions
Average volumetric flow rate	5.08	m ³ /s (wet STP)

Sampling plane requirements Re: BS EN 13284-1:2001 5.2

YES
YES
YES
YES

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Date 28/01/2016

From	15:53	to	16:23	30 minute mean		7.00
Volatile organi	c compounds		vppm, wet	4.95	mg/m³*	7.96
From	16:23	to	16:53	30 minute mean		
Volatile organi	c compounds		vppm, wet	5.90	mg/m³*	9.49
From	16:53	to	17:23	30 minute mean		
Volatile organi	c compounds		vppm, wet	6.11	mg/m³*	9.82
_						
Sampling Dete	ection Limits					
Volatile organi	c compounds		vppm	0.10	mg/m³*	0.16

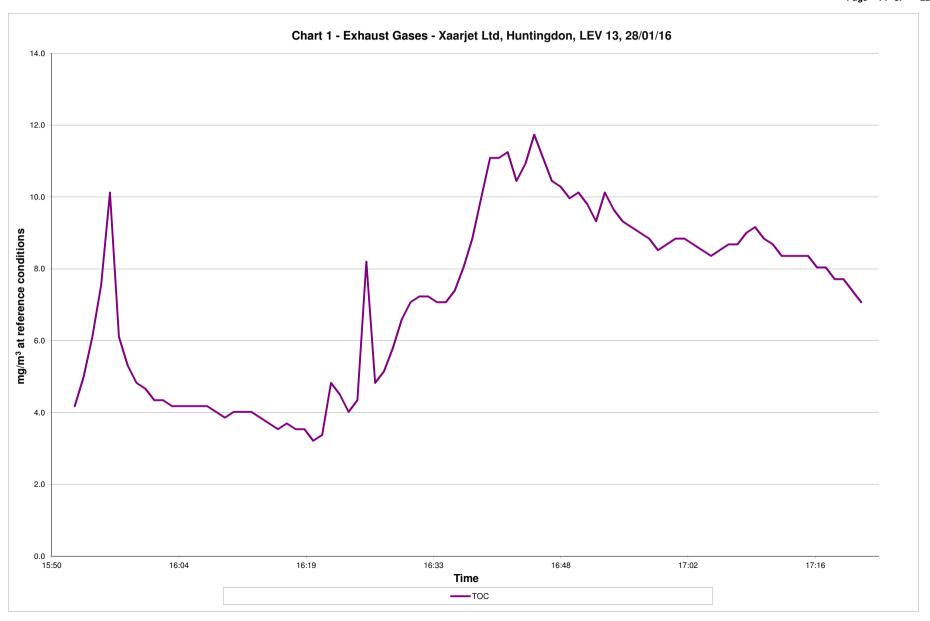
Reference Gas Details					
Species	Units	Value	Cylinder Reference	Analyser Range	Uncertainity $k = 2$
Nitrogen	%	99.999	VC80548	-	± 2
Volatile organic compounds	vppm	76.6	VCD500681	100	± 2

Zero And Span Gas Details

Species	units	Initial Time	11:40	Final Time	17:26
		Initial Zero	Initial Span	Final Zero	Final Span
Volatile organic compounds	vppm	0.0	76.6	-0.8	75.6

Exhaust Gases - Continuous Analysis Data

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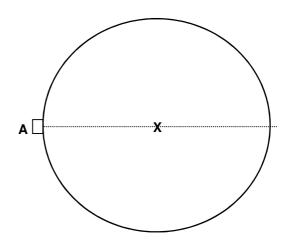
Diagram Of The Sampling Location

Diagram of sampling points across the cross section of the duct (not to scale).

Traverse length =

1.00 m

Point	% of D	Location
		cm
1	50.0	50.0





LEV 13 – Room extract

General Calculations

Stack area:

Area of a circle =
$$\frac{\pi \cdot D^2}{4}$$

D = Diameter (m) $\pi = 3.142$

Pressure conversion:

1mmH2O = 0.00980665 kPa 1mmH2O = 9.80665 Pa 1 mar = 0.1 kPa

Water vapour concentration:

From reference calculations (taken from BS EN 14790):

$$V_{WC(\%)} = \frac{\frac{M_{WC}.V_{mol(std)}}{M_{W}}}{\frac{M_{WC}.V_{mol(std)}}{M_{W}} + V_{m(std)}} \times 100$$

VWC (%) = Water vapour content on wet basis, in volume % (m³ of water vapour in m³ of wet gas)

Vm(std) = Dry gas volume measured, corrected to standard conditions (m³)

mWC = Mass of water collected in the impingers (g)

Mw = Molecular weight of water, 18.01534 rounded to 18 (g/mol)

Vmol(std) = Molar volume of water at standard conditions = 0.0224 (m3/mol)

Gas meter volume at standard conditions (STP)

From reference calculations (taken from BS EN 14790):

$$V_{m(std)} = y_d \times (V_2 - V_1) \times \frac{T_{std}}{T_m} \times \frac{p_m}{p_{std}}$$

Vm(std) = Dry gas meter volume at standard conditions (m³)

yd = Gas meter calibration coefficient

(V2-V1) = Dry gas meter volume at actual conditions (m³)

Tm = Actual Temperature (K)
Tstd = Standard temperature (273 K)

pm = Absolute pressure at the gas meter (kPa) pstd = Standard gas pressure (101.3 kPa)

Isokenetic Ratio (%):

From reference calculations (taken from EA TGN M2):

$$IsokineticRatio(\%) = \frac{Velocity\ at\ the\ sampling\ nozzle}{Velocity\ of\ the\ stack\ gas} \times 100$$

Estimating Measurment Uncertainty

Uncertainty estimates are calculated using the general rule of uncertainty propagation. Guidance is taken from publications including UKAS document M3003 and ISO 20988:2007.

Flow Calculations

Velocity:

From reference calculations (taken from ISO 10780):

$$\overline{v} = KC \sqrt{\frac{T_s \Delta \overline{p}}{p_e M_s}}$$

 \overline{v} = Average velocity (m/s)

C = velocity calculation constant = 129

Ts = Average stack temperature (K)

Ms = Molar mass of gas; assume 29 kg/kmol unless the molar mass is < 27 kg/kmol or > 31 g/kmol

K = Pitot calibration coefficientPe = Absolute gas pressure (kPa)

 $\Delta p = \Delta p$ Average pitot tube pressure differencial (kPa)

Volume flow rate

From reference calculations (taken from ISO 10780):

$$q_{va} = vA$$

qva = Average flow rate (m³/s)

v = v Average velocity (m/s)

A =Stack cross-sectional area (m²)

Volume flow rate corrected for moisture

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{(100 - H_a)}{(100 - H_m)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s) Ha = Moisture at actual conditions (%volume)

Hm = Reference moisture (%volume)

Volume flow rate corrected for temperature and pressure

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(T_m p_a\right)}{\left(T_a p_m\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

Ta = Temperature at actual conditions (K)

Tm = Reference Temperatue (K)

pa = Absolute gas pressure at actual conditions (kPa)

pm =Reference pressure (kPa)

Volume flow rate corrected for oxygen

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(20.9 - O_{2,ref}\right)}{\left(20.9 - O_{2,m}\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

O2,m = Actual oxygen concentration (%)

O2,ref = Reference oxygen concentration (%)

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Concentration Calculations

Concentration:

From reference calculations (taken from BS EN 13284-1):

$$c = \frac{m}{V}$$

c = Concentration m = Mass of substane V = Volume sampled

Mass Emission

Mass emission= $c \times q_m$

c = Concentration q = Volume flow rate

Concentration corrected for oxygen:

From reference calculations (taken from BS ISO 9096):

$$c_m = c_a \times \frac{20.9 - O_{2,ref}}{20.9 - O_{2,a}}$$

cm = Concentration at reference conditions

ca = Actual concentration
O2, ref = Reference oxygen (%)
O2, a= Actual Oxygen (%)

Concentration corrected for moisture:

From reference calculations (taken from BS ISO 9096):

Convert wet gas to dry gas

$$c_{dry} = c_{wet} \times \frac{100}{100 - H_a}$$

Convert dry gas to wet gas

$$c_{wet} = c_{dry} \times \frac{100 - H_a}{100}$$

cwet = Concentration wet gascdry = Concentration dry gasHa = Water vapour content (%vol)

Conversion of parts per million (ppm) to mg/m³

From reference calculations (taken from EA TGN M2):

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

molar volume at 273K = 22.4 litres

When Converting TOC

 $Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight of\ carbonin\ span\ gas(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$

Calculation of Uncertainty Estimates - Instrumental Monitoring Techniques

Model equation

 $C_{ppm} = C_{reading} + Corr_{fit} + Corr_{f,dr} + Corr_{s,dr} + Corr_{rep} + Corr_{adj} + \sum_{i=1}^{p} Corr_{inf} + Corr_{inf}$

 $C_{,ppm}$ correction of repeatability of measurement concentration in ppm

Corr_{rep} Corr_{adj} Corr_{inf} concentration given by analyser C_{NO.reading} correction of adjustment Corr fit correction of lack of fit correction of influence quantities Corr _{0,dr} correction of zero drift Corr s,dr correction of span drift

Calculation of partial uncertainties

u(Corr_{fit}) $\left(\frac{X_{fit,\max}}{100 \times range}\right)$ Where: $X_{\text{fit,max}}$ is the maximum allowable deviation from linearity

Expressed as % of the range and calculated by applying a rectangular probability distribution

u(Corr_{0.dr})

max (S_{0,rep}; S_{srep}) u(Corr_{rep}) Where:

is the standard uncertainty at zero level is the standard uncertainty at span level

u(Corr_{adj}) $u(Corr_{loss}) + u(Corr_{cal})$ $u(Corr_{loss})$ is the uncertainty due to losses in sample line is the uncertainty due to losses in sample line is the concentration of sample loss at span level

 $u(Corr_{cal})$ is the expanded uncertainty of the calibration gas

 $= c_{j} \sqrt{\frac{(x_{j,\max} - x_{j,adj})^{2} + (x_{j,\min} - x_{j,adj}) \times (x_{j,\max} - x_{j,adj}) + (x_{j,\min} - x_{j,adj})^{2}}{3}}$ u(Corr inf)

is the sensitivity coefficient of the influence quantity

is the minimum value of the influence quantity during monitoring is the maximum value of the influence quantity during monitoring is the value of the influence quantity during adjustment

 $= \frac{c_{j}}{Int_{j,lest}} \sqrt{\frac{Int_{j,max}^{2} + Int_{j,min} \times Int_{j,max} + Int_{j,min}^{2}}{3}}$

 c_{j} Int_{j,test} is the sensitivity coefficient of the interferent i $= \max \left[S_{Int,p}; S_{Int,n} \right]$ $u(\Sigma Corr_{int})$ is the concentration of the interferent j used to determine c is the minimum value of the interferent j quantity during monitoring is the maximum value of the interferent i quantity during monitoring

 $\mathsf{Int}_{\mathsf{j},\mathsf{adj}}$ is the concentration of the interferent j in the cal gas used to adjust the analyse

 $S_{int,p}$ is the sum of interferents with positive impact is the sum of interferents with negative impact

Combined uncertainty

 $u(C_{,ppm})$

 $\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{o,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{ep}) + u^{2}(corr_{ep}) + u^{2}(corr_{s,vf}) + u^{2}(corr_{d,oress}) + u^{2}(corr_{ep}) + u^{2}(corr_{odi}) + S_{int}^{-2}}$

 $U(C_m) = u(C_m) \times k$ Overall expanded uncertainty (k = 2)

Uncertainty of NOx measurements

C_{NOx} is the concentration of NOx measured by the analyser is the ratio of NO:Nox in the stack gas is the NOx converter efficiency

Combined uncertainty NOx measurements

 $\sqrt{u^2(corr_{fit}) + u^2(corr_{odt}) + u^2(corr_{sdt}) + u^2(corr_{sof}) + u^2(corr$

Uncertainty of mass concentration at oxygen reference concentration

u(C, O2 ref)

 $\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{o,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{rep}) + u^{2}(corr_{s,sf}) + u^{2}(corr_{s,sf}) + u^{2}(corr_{semp}) + u^{2}(corr_{temp}) + u^{2}(corr_{odi}) + S_{tat}^{2}} + \left(\frac{u^{2}(O_{2,meas,dry})}{(21 - O_{s,sf})}\right) + \frac{u^{2}(corr_{semp}) + u^{2}(corr_{semp}) + u^{2}(corr_{semp}) + u^{2}(corr_{odi}) + S_{tat}^{2}}{(21 - O_{s,sf})}$

u(C,O_{2,ref)} uncertainty associated with the mass concentration at O₂ ref. concentration mg/m³ C,O_{2,ref} mg/m³ mass concentration at O₂ reference concentration O2 measured concentration % volume uncertainty associated to the measured O2 concentration % (relative to O_{2 meas})

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Uncertainty Estimate For The Measurement Of Total Organic Carbon

_					
Analyser Type/Model Reference Oxygen %		Maihak 0	(0 = No corre	ction)	
noisionos exigen /s		-	(0 - 110 00110		
imitualua	1 , 3	Test 1	Test 2	Test 3	
Limit value Limit value	mg/m ³ ppm	75 46.7	75 46.7	75 46.7	
Measured concentration	ppm	5.0	5.9	6.1	
Measured concentration	mg/m ³	8.0	9.5	9.8	
Calibration and		76.6	70.0	76.6	
Calibration gas Calibration gas	ppm mg/m ³	76.6 123.1	76.6 123.1	76.6 123.1	
Analyser range	ppm	9.3	9.3	9.3	
nalyser range	mg/m ³	15.0	15.0	15.0	
correction of Lack of Fit ack of fit	% range	2.0	2.0	2.0	
40. C. III	u(Corr, _{fit})	0.11	0.11	0.11	
corrections of Zero and Span Drift ero Drift	(*All drift is c: % range	alculated for 0.00	the residual is	0.00	< 5% u(m
ero Dilit	u(Corr, _{0dr})	0.00	0.00	0.00	
pan Drift	% range	0.00	0.00	0.00	
	u(Corr, _{sdr})	0.00	0.00	0.00	
and the state of December 11th of Management					
Correction of Repeatability of Measurement Repeatability SD at span level	% range	0.0	0.0	0.0	
Not reported)	u(Corr, _{rep})	0.00	0.00	0.00	
•					
correction of adjustment	0/ 10000	1.01	1.01	1.04	
isses iii the line	% range u(Corr, _{loss})	1.31 0.04	1.31 0.04	1.31 0.05	
Incertainty of calibration gas	% range	2.0	2.0	2.0	
	u(Corr, _{cal})	0.05	0.06	0.06	
Correction of Influence of Interferents	% range		l	1	
20	u(Corr, _{N2O})	0.00	0.00	0.00	
SO_2	% range				
N.I.	u(Corr, _{CO2})	0.00	0.00	0.00	
CH₄	% range u(Corr, _{CH4})	0.00	0.00	0.00	
Total of interferent influences .	% range	2.50	2.50	2.50	
$u(\Sigma Corrint) = \max_{n} [S_{lnt,p}; S_{lnt,n}]$	$u(\Sigma Corr_{int})$	0.16	0.16	0.16	
Correction of Influence Quantities					
Sensitivity to sample volume flow	% range	1.60	1.60	1.60	
, , , , , , , , , , , , , , , , , , ,	u(Corr, _{flow})	0.09	0.09	0.09	
Sensitivity to atmospheric pressure	% range				
Not reported)	u(Corr, _{press})	0.00	0.00	0.00	
Sensitivity to ambient temperature	% range u(Corr, _{temp})	-2.40	-2.40 -0.28	-2.40 -0.28	
Sensitivity to electrical voltage	% range	-0.28 0.50	0.50	0.50	
Not reported)	u(Corr, _{volt})	0.10	0.10	0.10	
Maximum standard uncertainty % of maximum standard uncertainty	u(Corr, _{max}) u(Corr, _{5%})	0.11	0.11	0.11	
ло от maximum standard uncertainty	u(OOII,5%)	0.01	0.01	0.01	
nterferent Concentration Variations	Minimum	Maximum	Value at cal	Performance	Units
H₄ range ₂O range	0	10 0	0	50 20	mg/m ³
O ₂ range	8	12	0	15	mg/m ³ mg/m ³
Oxygen effect variations	Minimum	Maximum		Performance	Units
Oxygen effect	0	20	0	2	mg/m ³
ofluence Quantitiv Variations					
nfluence Quantitiy Variations	Minimum	Maximum	Value at cal	Performance	Units
•	Minimum 55	Maximum 65	Value at cal	Performance 5	Units I/h
ensitivity to sample volume flow ensitivity to atmospheric pressure	55 99	65 100	60 99	5 1	l/h kPa
ensitivity to sample volume flow ensitivity to atmospheric pressure ensitivity to ambient temperature	55 99 278	65 100 313	60 99 288	5 1 10	l/h kPa K
rensitivity to sample volume flow rensitivity to atmospheric pressure rensitivity to ambient temperature	55 99	65 100	60 99	5 1	l/h kPa
sensitivity to sample volume flow sensitivity to atmospheric pressure sensitivity to ambient temperature sensitivity to electrical voltage	55 99 278	65 100 313	60 99 288	5 1 10	l/h kPa K
sensitivity to sample volume flow sensitivity to atmospheric pressure sensitivity to ambient temperature sensitivity to electrical voltage	55 99 278	65 100 313 250	60 99 288 230	5 1 10 5	l/h kPa K
rensitivity to sample volume flow rensitivity to atmospheric pressure rensitivity to ambient temperature rensitivity to electrical voltage	55 99 278 187	65 100 313 250 Test 1	60 99 288 230	5 1 10 5 Test 3	l/h kPa K
densitivity to sample volume flow sensitivity to atmospheric pressure densitivity to ambient temperature densitivity to electrical voltage dessurement uncertainty combined uncertainty densities and uncertainty densities densit	55 99 278 187 ppm mg/m ³	65 100 313 250 Test 1 0.37 0.59	60 99 288 230 Test 2 0.37	5 1 10 5 Test 3 0.37	l/h kPa K
Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Aleasurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of confide	55 99 278 187 ppm mg/m ³	65 100 313 250 Test 1 0.37 0.59	60 99 288 230 Test 2 0.37	5 1 10 5 Test 3 0.37	l/h kPa K
Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Sombined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of confide Overall uncertainty Expanded uncertainty Expanded uncertainty	55 99 278 187 ppm mq/m³	65 100 313 250 Test 1 0.37 0.59 =2 0.7 1.2	60 99 288 230 Test 2 0.37 0.60	5 1 10 5 5 Test 3 0.37 0.60	l/h kPa K
Influence Quantitiy Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of confide Overall uncertainty Diverall uncertainty Diverall uncertainty relative to measured value Overall uncertainty relative to range	55 99 278 187 ppm mg/m³	65 100 313 250 Test 1 0.37 0.59 =2	60 99 288 230 Test 2 0.37 0.60	5 1 10 5 Test 3 0.37 0.60	l/h kPa K

The uncertainty evaluation has been carried out in accordance with UKAS requirements.



Client

Xaarjet Ltd 1 Hurricane Close Ermine Business Park Huntingdon Cambridgeshire PE29 6XX

Part 1: Executive Summary

Report for the Periodic Monitoring of Emissions to Air.

Site Huntingdon
Plant LEV 14

Sampling Date 29th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd

Unit C5 Emery Court The Embankment Business Park Heaton Mersey Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

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Monitoring Objectives

The monitoring was undertaken to check compliance with authorised emission limits.

All monitoring procedures were carried out to the MCERTS requirements under the Exova (UK) Ltd quality system to ISO 17025: 2005.

Monitoring was undertaken for the listed emissions from the following sampling positions:

Sampling Location	Emission
LEV 14	Total volatile organic carbon

Special Monitoring Requirements

There were no special requirements for this monitoring campaign.

Summary of Methods

Emission	Method number	Method standard
Gas velocity and volume flow	TPM/01A	BS EN ISO 16911-1:2013
тос	MM0002	BS EN 12619 : 2013

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Summary Of Results

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd**The results were measured from the sample positions downstream of the arrestment plant.

Emission at	Sampling		Emission	Authorised	Uncertainty	Detection	Mass	
Huntingdon	Time		Result	Limit	+/-	Limit	Emission	
LEV 14	Date	Start	End	mg/m³∗	mg/m³*	mg/m³∗	mg/m³∗	g/h
тос	29/01/16	09:45	11:15	9.1	75	1.2	0.2	16.4

* at reference conditions	Stack Gas Weight	0 °C Without correction for moisture		
	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction	%

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above) Nm³ 273 K, 101.3 kPa

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



All tests included in this report are accredited under UKAS and MCERTS accreditation schemes unless otherwise stated.

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





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Summary Of Results, Exhaust Gases

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd**The results were measured from the sample positions downstream of the arrestment plant.

	Emission at Huntingdon		Sampling Time		Emission Result	Authorised Limit	Uncertainty +/-	Detection Limit	Mass Emission
	LEV 14	Date	Start	End	mg/m ³ *	mg/m ³ *	mg/m³*	mg/m³*	g/h
TOC	Test 1	29/01/16	09:45	10:15	9.2	75	1.2	0.2	16.5
TOC	Test 2	29/01/16	10:15	10:45	8.1	75	1.2	0.2	14.6
TOC	Test 3	29/01/16	10:45	11:15	10.0	75	1.2	0.2	18.1

I	* at ref	Stack Gas Weight	0 °C	Without correction for moisture
	Conditions	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction %

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above)

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



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Nm³ 273 K, 101.3 kPa



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Operating Information

The table below shows details of the operating information on each sampling date for: LEV 14

Date	Process type	Process duration	Fuel	Feedstock	Abatement	Load
29/01/2016	Production and cleaning of inkjet cartridges	Continuous	N/A	N/A	N/A	Normal

No CEMs installed on the emission point.

Comments & Monitoring Deviations

A waste gas homogeneity test to BS EN 15259:2007 (MID) is not required:-

The homogeneity test is not applicable to non-combustion processes.

The homogeneity test is not applicable to duct areas less than 1m².

The homogeneity test is not usually applicable to pollutant emissions that are less than 30% of the ELV.

All monitoring was performed in accordance with the relevant procedures.



Part 2: Supporting Information

Report for the Periodic Monitoring of Emissions to Air.

Client Xaarjet Ltd
Site Huntingdon
Plant LEV 14

Sampling Date 29th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd Unit C5 Emery Court The Embankment Business Park Heaton Mersey Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

Xaarjet Ltd, Huntingdon, Permit No: B22/11, R/16-6521, v1

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Emission Monitoring Procedures And Instrumentation

Gas velocity and temperature

Documented in-house procedure TPM01/A to the main procedural requirements of BS EN ISO 16911-1:2013 Velocity and temperature measurements are performed using a calibrated Pitot tube, a calibrated pressure differential reading device and a calibrated thermocouple. Velocity and possible flow deviation measurements are carried out at selected, representative points in the gas stream.

Total organic carbon

Documented in-house procedure MM0002 to the main procedural requirements of BS EN 12619:2013. Continuous analysis using probe, sample line and multi range Flame Ionisation Detector (FID) analyser. The analyser is calibrated before and during the tests using certified gas mixtures of nitrogen, oxygen and propane. Sampling points are selected in accordance with the findings of any BS EN 15259 assessment.

Sampling Project Personnel Competency And Expiry Dates

Report prepared by:	Rob Jones	MCERTS No MM08 984	Level 1 -	Level 2 31/03/2016	TE1 31/03/2020	TE2 31/03/2016	TE3 30/09/2016	TE4 31/12/2020
Report authorised by:	Derek Myers	MM02 115	-	30/09/2017	31/05/2018	30/11/2018	30/11/2018	30/11/2018
Team leader:	Rob Jones	MM08 984	-	31/03/2016	31/03/2020	31/03/2016	30/09/2016	31/12/2020
Team leader:	Harpreet Badwal	MM03 149	-	30/09/2018	30/09/2018	30/04/2019	31/10/2019	31/10/2019

Equipment References

Equipment	Reference Number
FID	AQ271
Heated Line	HL40
Stack Thermocouple	PTTS97
Timer / Stopwatch	ST41
Barometer	WS03
Pitot	PT97
Thermometer	TK24
Manometer	PI03

Xaarjet Ltd, Huntingdon, Permit No: B22/11, R/16-6521, v1

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Date	29/01/2016
Time	09:08
Pitot Cp	0.79

Barometric pressure	101.6	kPa
Duct static pressure	0.04	kPa
Stack Area	0.159	m²

Stack Diameter (circular)	0.45	m
		_

Traverse	Traverse	Depth	ΔΡ	Т	Angle	velocity	Traverse	Depth	ΔΡ	Т	Angle	velocity
Point	Line	cm	mmH ₂ O	°C	0	m/s	Line	cm	mmH ₂ O	°C	0	m/s
1	Α						В					
2	Α	5.0	1.8	26	<15	4.4	В	5.0	2.4	26	<15	5.0
3	Α	5.3	1.0	26	<15	3.2	В	5.3	1.9	26	<15	4.5
4	Α	8.0	0.8	26	<15	2.9	В	8.0	1.5	26	<15	4.0
5	Α	11.3	0.7	26	<15	2.7	В	11.3	1.7	26	<15	4.2
6	Α	16.0	0.8	26	<15	2.9	В	16.0	1.1	26	<15	3.4
7	Α	29.0	0.8	26	<15	2.9	В	29.0	0.8	26	<15	2.9
8	Α	33.8	0.9	26	<15	3.1	В	33.8	0.6	26	<15	2.5
9	Α	37.0	1.5	26	<15	4.0	В	37.0	0.6	26	<15	2.5
10	Α	39.7	1.6	26	<15	4.1	В	39.7	0.8	26	<15	2.9
11	Α	40.0	1.0	26	<15	3.2	В	40.0	1.2	26	<15	3.6
12	Α						В				_	

Average Pitot DP	1.15	mmH ₂ O
Average Temperature	299.2	К
Average Velocity	3.4	m/s
Average volumetric flow rate	0.55	m ³ /s at stack conditions
Average volumetric flow rate	0.50	m ³ /s (wet STP)

Sampling plane requirements Re: BS EN 13284-1:2001 5.2

	-			
a Angel of gas flow less than 15° with regard to duct axis			YES	
b No local negative flow				
c Minimum pitot greater than 5Pa				
d	Ratio of highest to lowest local gas velocity less than 3:1			
Minimum local gas velocity 2.5				
Maximum local gas velocity 5.0				
Ratio of highest to lowest local gas velocity 2.00				

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Date	29/01/2016

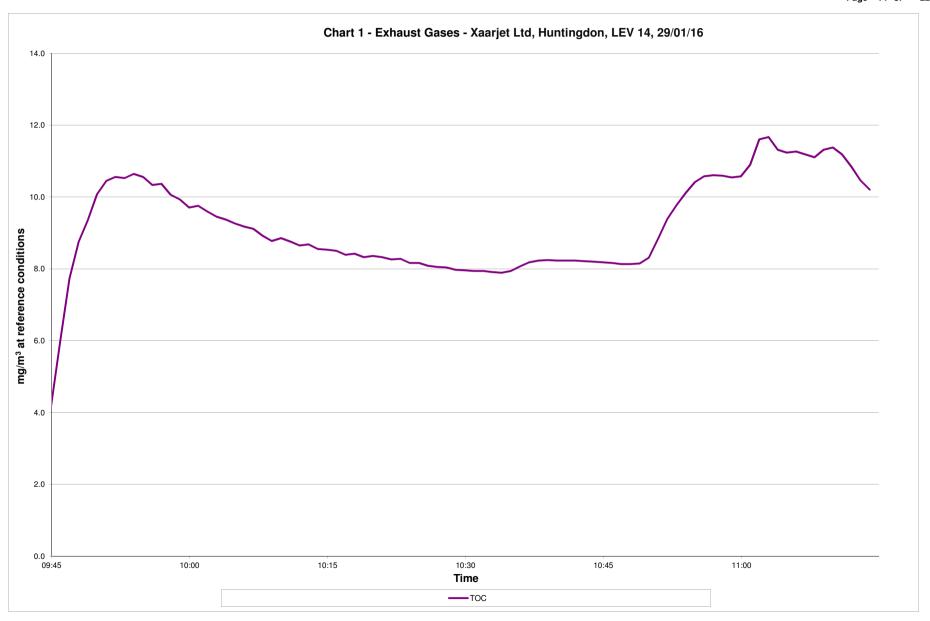
From	09:45	to	10:15	30 minute mean		
Volatile organ	nic compounds		vppm, wet	5.69	mg/m³*	9.15
From	10:15	to	10:45	30 minute mean		
Volatile organ	nic compounds		vppm, wet	5.02	mg/m³*	8.06
				•		
From	10:45	to	11:15	30 minute mean		
Volatile organ	nic compounds		vppm, wet	6.24	mg/m³*	10.03
Sampling De	tection Limits					
Volatile organ	nic compounds		vppm	0.10	mg/m³*	0.16
Reference G	as Details					
Cassias			Linita	Value	Cylinder	Analyser

Species	Units	Value	Cylinder Reference	Analyser Range	Uncertainity $k = 2$
Nitrogen	%	99.999	VCK01959	-	± 2
Volatile organic compounds	vppm	75.50	VCSMG3066	10	± 2

Zero And Span Gas Details

Species	units	Initial Time	09:35	Final Time	11:26
		Initial Zero	Initial Span	Final Zero	Final Span
Volatile organic compounds	vppm	0.00	75.50	0.14	75.66

Exhaust Gases - Continuous Analysis Data



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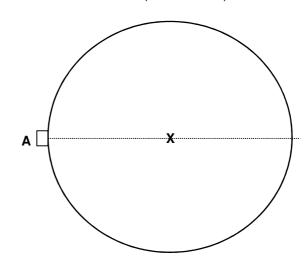
Diagram Of The Sampling Location

Diagram of sampling points across the cross section of the duct (not to scale).

Traverse length =

0	.45	m

Point	% of D	Location
		cm
1	50.0	22.5





LEV 14 Room extract

General Calculations

Stack area:

Area of a circle =
$$\frac{\pi \cdot D^2}{4}$$

D = Diameter (m) $\pi = 3.142$

Pressure conversion:

1mmH2O = 0.00980665 kPa 1mmH2O = 9.80665 Pa 1 mar = 0.1 kPa

Water vapour concentration:

From reference calculations (taken from BS EN 14790):

$$V_{WC(\%)} = \frac{\frac{m_{WC}.V_{mol(std)}}{M_{W}}}{\frac{m_{WC}.V_{mol(std)}}{M_{W}} + V_{m(std)}} \times 100$$

VWC (%) = Water vapour content on wet basis, in volume % (m³ of water vapour in m³ of wet gas)

Vm(std) = Dry gas volume measured, corrected to standard conditions (m³)

mWC = Mass of water collected in the impingers (g)

Mw = Molecular weight of water, 18.01534 rounded to 18 (g/mol)

Vmol(std) = Molar volume of water at standard conditions = 0.0224 (m3/mol)

Gas meter volume at standard conditions (STP)

From reference calculations (taken from BS EN 14790):

$$V_{m(std)} = y_d \times (V_2 - V_1) \times \frac{T_{std}}{T_m} \times \frac{p_m}{p_{std}}$$

Vm(std) = Dry gas meter volume at standard conditions (m³)

yd = Gas meter calibration coefficient

(V2-V1) = Dry gas meter volume at actual conditions (m³)

Tm = Actual Temperature (K)
Tstd = Standard temperature (273 K)

pm = Absolute pressure at the gas meter (kPa) pstd = Standard gas pressure (101.3 kPa)

Isokenetic Ratio (%):

From reference calculations (taken from EA TGN M2):

$$IsokineticRatio(\%) = \frac{Velocity\ at\ the\ sampling\ nozzle}{Velocity\ of\ the\ stack\ gas} \times 100$$

Estimating Measurment Uncertainty

Uncertainty estimates are calculated using the general rule of uncertainty propagation. Guidance is taken from publications including UKAS document M3003 and ISO 20988:2007.

Flow Calculations

Velocity:

From reference calculations (taken from ISO 10780):

$$\overline{v} = KC \sqrt{\frac{T_s \Delta \overline{p}}{p_e M_s}}$$

 \overline{v} = Average velocity (m/s)

C = velocity calculation constant = 129

Ts = Average stack temperature (K)

Ms = Molar mass of gas; assume 29 kg/kmol unless the molar mass is < 27 kg/kmol or > 31 g/kmol

K = Pitot calibration coefficientPe = Absolute gas pressure (kPa)

 $\Delta p = \Delta p$ Average pitot tube pressure differencial (kPa)

Volume flow rate

From reference calculations (taken from ISO 10780):

$$q_{va} = vA$$

qva = Average flow rate (m³/s)

 \bar{v} = Average velocity (m/s)

A =Stack cross-sectional area (m²)

Volume flow rate corrected for moisture

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{(100 - H_a)}{(100 - H_m)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s) Ha = Moisture at actual conditions (%volume)

Hm = Reference moisture (%volume)

Volume flow rate corrected for temperature and pressure

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(T_m p_a\right)}{\left(T_a p_m\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

Ta = Temperature at actual conditions (K)

Tm = Reference Temperatue (K)

pa = Absolute gas pressure at actual conditions (kPa)

pm =Reference pressure (kPa)

Volume flow rate corrected for oxygen

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(20.9 - O_{2,ref}\right)}{\left(20.9 - O_{2,m}\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

O2,m = Actual oxygen concentration (%)

O2,ref = Reference oxygen concentration (%)

Concentration Calculations

Concentration:

From reference calculations (taken from BS EN 13284-1):

$$c = \frac{m}{V}$$

c = Concentration m = Mass of substane V = Volume sampled

Mass Emission

Mass emission= $c \times q_m$

c = Concentration q = Volume flow rate

Concentration corrected for oxygen:

From reference calculations (taken from BS ISO 9096):

$$c_m = c_a \times \frac{20.9 - O_{2,ref}}{20.9 - O_{2,a}}$$

cm = Concentration at reference conditions

ca = Actual concentration
O2, ref = Reference oxygen (%)
O2, a= Actual Oxygen (%)

Concentration corrected for moisture:

From reference calculations (taken from BS ISO 9096):

Convert wet gas to dry gas

$$c_{dry} = c_{wet} \times \frac{100}{100 - H_a}$$

Convert dry gas to wet gas

$$c_{wet} = c_{dry} \times \frac{100 - H_a}{100}$$

cwet = Concentration wet gascdry = Concentration dry gasHa = Water vapour content (%vol)

Conversion of parts per million (ppm) to mg/m³

From reference calculations (taken from EA TGN M2):

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

molar volume at 273K = 22.4 litres

When Converting TOC

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight of\ carbonin\ span\ gas(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

Calculation of Uncertainty Estimates - Instrumental Monitoring Techniques

Model equation

 $C_{ppm} = C_{reading} + Corr_{fit} + Corr_{f,dr} + Corr_{s,dr} + Corr_{rep} + Corr_{adj} + \sum_{i=1}^{p} Corr_{inf} + Corr_{inf}$

Corr_{rep} Corr_{adj} Corr_{inf} $C_{,ppm}$ correction of repeatability of measurement concentration in ppm concentration given by analyser C_{NO.reading} correction of adjustment

Corr fit correction of lack of fit correction of influence quantities Corr _{0,dr} correction of zero drift Corr s,dr correction of span drift

Calculation of partial uncertainties

u(Corr_{fit}) $\left(\frac{X_{fit,\max}}{100 \times range}\right)$ Where: $X_{\text{fit,max}}$ is the maximum allowable deviation from linearity

Expressed as % of the range and calculated by applying a rectangular probability distribution

u(Corr_{0.dr})

max (S_{0,rep}; S_{srep}) u(Corr_{rep}) Where:

is the standard uncertainty at zero level is the standard uncertainty at span level

u(Corr_{adj}) $u(Corr_{loss}) + u(Corr_{cal})$ $u(Corr_{loss})$ is the uncertainty due to losses in sample line is the uncertainty due to losses in sample line is the concentration of sample loss at span level $u(Corr_{cal})$ is the expanded uncertainty of the calibration gas

 $= c_{j} \sqrt{\frac{(x_{j,\max} - x_{j,adj})^{2} + (x_{j,\min} - x_{j,adj}) \times (x_{j,\max} - x_{j,adj}) + (x_{j,\min} - x_{j,adj})^{2}}{3}}$ u(Corr inf)

is the sensitivity coefficient of the influence quantity is the minimum value of the influence quantity during monitoring

is the maximum value of the influence quantity during monitoring is the value of the influence quantity during adjustment

 $= \frac{c_{j}}{Int_{j,lest}} \sqrt{\frac{Int_{j,max}^{2} + Int_{j,min} \times Int_{j,max} + Int_{j,min}^{2}}{3}}$

 c_{j} Int_{j,test} is the sensitivity coefficient of the interferent i $= \max \left[S_{Int,p}; S_{Int,n} \right]$ $u(\Sigma Corr_{int})$ is the concentration of the interferent j used to determine c is the minimum value of the interferent j quantity during monitoring is the maximum value of the interferent i quantity during monitoring

 $\mathsf{Int}_{\mathsf{j},\mathsf{adj}}$ is the concentration of the interferent j in the cal gas used to adjust the analyse

 $S_{int,p}$ is the sum of interferents with positive impact is the sum of interferents with negative impact

Combined uncertainty

 $u(C_{,ppm})$

 $\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{o,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{ep}) + u^{2}(corr_{ep}) + u^{2}(corr_{s,vf}) + u^{2}(corr_{d,oress}) + u^{2}(corr_{ep}) + u^{2}(corr_{odi}) + S_{int}^{-2}}$

 $U(C_m) = u(C_m) \times k$ Overall expanded uncertainty (k = 2)

Uncertainty of NOx measurements

C_{NOx} is the concentration of NOx measured by the analyser is the ratio of NO:Nox in the stack gas is the NOx converter efficiency

Combined uncertainty NOx measurements

 $\sqrt{u^2(corr_{fit}) + u^2(corr_{odt}) + u^2(corr_{sdt}) + u^2(corr_{sof}) + u^2(corr$

Uncertainty of mass concentration at oxygen reference concentration

u(C, O2 ref)

 $\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{o,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{rep}) + u^{2}(corr_{s,sf}) + u^{2}(corr_{s,sf}) + u^{2}(corr_{semp}) + u^{2}(corr_{temp}) + u^{2}(corr_{odi}) + S_{tat}^{2}} + \left(\frac{u^{2}(O_{2,meas,dry})}{(21 - O_{s,sf})}\right) + \frac{u^{2}(corr_{semp}) + u^{2}(corr_{semp}) + u^{2}(corr_{semp}) + u^{2}(corr_{odi}) + S_{tat}^{2}}{(21 - O_{s,sf})}$

u(C,O_{2,ref)} uncertainty associated with the mass concentration at O₂ ref. concentration mg/m³ C,O_{2,ref} mg/m³ mass concentration at O₂ reference concentration O2 measured concentration % volume uncertainty associated to the measured O2 concentration % (relative to O_{2 meas})

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Uncertainty Estimate For The Measurement Of Total Organic Carbon

Analyser Type/Model Reference Oxygen %		Maihak 0	(0 = No corre	ction)	
TOTOTOTO ON SYGNI /0	<u> </u>		1 0 - 140 COILE	oudii)	
		Test 1	Test 2	Test 3	
imit value	mg/m ³	75	75	75	
imit value	ppm	46.7	46.7	46.7	
Measured concentration	ppm	5.7	5.0	6.2	
Measured concentration	mg/m ³	9.2	8.1	10.0	
Calibration and	nnm	75.5	75.5	75.5	
Calibration gas Calibration gas	ppm	121.3	121.3	121.3	
	mg/m³	9.3	9.3	9.3	
Analyser range Analyser range	ppm mg/m ³	15.0	15.0	15.0	
marysor range	mq/m	10.0	10.0	10.0	
Correction of Lack of Fit			1		
ack of fit	% range	2.0	2.0	2.0	
	u(Corr, _{fit})	0.11	0.11	0.11	
Corrections of Zero and Span Drift	(*All drift is c	alculated for .:	the residual is	assumed to be	< 5% u(m
Zero Drift	% range	0.00	0.00	0.00	
	u(Corr, _{Odr})	0.00	0.00	0.00	
Span Drift	% range	0.00	0.00	0.00	
	u(Corr, _{sdr})	0.00	0.00	0.00	
Correction of Repeatability of Measurement	0/ 20000	0.0	0.0	0.0	
Repeatability SD at span level	% range	0.0	0.0	0.0	
Not reported)	u(Corr, _{rep})	0.00	0.00	0.00	
Correction of adjustment					
osses in the line	% range	0.21	0.21	0.21	
	u(Corr, _{loss})	0.01	0.01	0.01	
Incertainty of calibration gas	% range	2.0	2.0	2.0	
· 	u(Corr, _{cal})	0.06	0.05	0.06	
Correction of Influence of Interferents N ₂ O	0/, range		1		
•2○	% range u(Corr, _{N2O})	0.00	0.00	0.00	
OO ₂	% range	5.50	0.00	5.50	
-	u(Corr, _{CO2})	0.00	0.00	0.00	
CH ₄	% range				
	u(Corr, _{CH4})	0.00	0.00	0.00	
Total of interferent influences	% range	2.50	2.50	2.50	
$u(\Sigma Corrint) = \max[S_{lnt,p}; S_{lnt,n}]$	$u(\Sigma Corr_{int})$	0.16	0.16	0.16	
Correction of Influence Quantities					
Sensitivity to sample volume flow	% range	1.60	1.60	1.60	
sensitivity to sample volume now	u(Corr, _{flow})	0.09	0.09	0.09	
Sensitivity to atmospheric pressure	% range	0.09	0.09	0.09	
Not reported)	u(Corr, _{press})	0.00	0.00	0.00	
Sensitivity to ambient temperature		-2.40	-2.40	-2.40	
эспэшчку го атыгын гетгрегацие	% range u(Corr, _{temp})	-0.28	-2.40	-2.40	
Sensitivity to electrical voltage	% range	0.50	0.50	0.50	
Not reported)	u(Corr, _{volt})	0.50	0.50	0.50	
•	- (= , voit)				
Maximum standard uncertainty	u(Corr, _{max})	0.11	0.11	0.11	
5% of maximum standard uncertainty	u(Corr,5%)	0.01	0.01	0.01	
nterferent Concentration Variations	Minimum	Maximum	Value at cal	Performance	Units
CH ₄ range	0	10	0	50	mg/m ³
I ₂ O range	0	0	0	20	mg/m ³
CO ₂ range	8	12	0	15	mg/m ³
Oxygen effect variations	Minimum	Maximum		Performance	Units
Dxygen effect	0	20	0	2	mg/m ³
nfluence Quantitiy Variations					
muence Quantity variations	Minimum	Maximum	Value at cal	Performance	Units
Sensitivity to sample volume flow	55	65	60	5	l/h
Sensitivity to atmospheric pressure	99	100	99	1	kPa
Sensitivity to ambient temperature	278	313	288	10	K
Sensitivity to electrical voltage	187	250	230	5	V
Measurement uncertainty		Test 1	Test 2	Test 3	
Combined uncertainty	ppm	0.37	0.37	0.37	
Combined uncertainty	mg/m ³	0.59	0.59	0.59	
Expanded uncertainty expressed with a level of co	nfidence of 95%, k	=2			
	ppm	0.7	0.7	0.7	
Overall uncertainty					
	mg/m ³	1.2	1.2	1.2	
Overall uncertainty	%	1.2 13.0	1.2 14.7	11.9	
Overall uncertainty Overall uncertainty Overall uncertainty relative to measured value Overall uncertainty relative to range					

The uncertainty evaluation has been carried out in accordance with UKAS requirements.



Client

Xaarjet Ltd 1 Hurricane Close Ermine Business Park Huntingdon Cambridgeshire PE29 6XX

Part 1: Executive Summary

Report for the Periodic Monitoring of Emissions to Air.

Site Huntingdon Plant LEV 17

Sampling Date 29th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd

Unit C5 Emery Court The Embankment Business Park Heaton Mersey Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

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Monitoring Objectives

The monitoring was undertaken to check compliance with authorised emission limits.

All monitoring procedures were carried out to the MCERTS requirements under the Exova (UK) Ltd quality system to ISO 17025: 2005.

Monitoring was undertaken for the listed emissions from the following sampling positions:

Sampling Location	Emission
LEV 17	Total volatile organic carbon

Special Monitoring Requirements

There were no special requirements for this monitoring campaign.

Summary of Methods

Emission	Method number	Method standard
Gas velocity and volume flow	TPM/01A	BS EN ISO 16911-1:2013
тос	MM0002	BS EN 12619 : 2013

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Summary Of Results

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd**The results were measured from the sample positions downstream of the arrestment plant.

Emission at	Sampling		Emission	Authorised	Uncertainty	Detection	Mass	
Huntingdon		Time		Result	Limit	+/-	Limit	Emission
LEV 17	Date	Start	End	mg/m ³ *	mg/m³*	mg/m³∗	mg/m³∗	g/h
тос	29/01/16	10:05	11:35	10.3	75	1.2	0.2	5.1

* at reference conditions	Stack Gas Weight	0 °C	Without correction for moisture		
	29.00 Kg/kmol	101.3 kPa	Oxygen	No Correction	%

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above) Nm³ 273 K, 101.3 kPa

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



All tests included in this report are accredited under UKAS and MCERTS accreditation schemes unless otherwise stated.

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





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Summary Of Results, Exhaust Gases

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd** The results were measured from the sample positions downstream of the arrestment plant.

	Emission at Huntingdon		Sampling Time		Emission Result	Authorised Limit	Uncertainty +/-	Detection Limit	Mass Emission
	LEV 17	Date	Start	End	mg/m ³ *	mg/m ³ *	mg/m³*	mg/m³*	g/h
TOC	Test 1	29/01/16	10:05	10:35	9.1	75	1.2	0.2	4.6
TOC	Test 2	29/01/16	10:35	11:05	13.4	75	1.2	0.2	6.7
TOC	Test 3	29/01/16	11:05	11:35	8.2	75	1.2	0.2	4.1

I	* at ref	Stack Gas Weight	0 °C	Without correction for moisture
	Conditions	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction %

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above)

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



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Nm³ 273 K, 101.3 kPa



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Operating Information

The table below shows details of the operating information on each sampling date for: LEV 17

Date	Process type	Process duration	Fuel	Feedstock	Abatement	Load
29/01/2016	Production and cleaning of inkjet cartridges	Continuous	N/A	N/A	N/A	Normal

No CEMs installed on the emission point.

Comments & Monitoring Deviations

A waste gas homogeneity test to BS EN 15259:2007 (MID) is not required:-

The homogeneity test is not applicable to non-combustion processes.

The homogeneity test is not applicable to duct areas less than 1m².

The homogeneity test is not usually applicable to pollutant emissions that are less than 30% of the ELV.

All monitoring was performed in accordance with the relevant procedures.



Part 2: Supporting Information

Report for the Periodic Monitoring of Emissions to Air.

Client Xaarjet Ltd
Site Huntingdon
Plant LEV 17

Sampling Date 29th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd Unit C5 Emery Court

The Embankment Business Park Heaton Mersey Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

Xaarjet Ltd, Huntingdon, Permit No: B22/11, R/16-6522, v1

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Emission Monitoring Procedures And Instrumentation

Gas velocity and temperature

Documented in-house procedure TPM01/A to the main procedural requirements of BS EN ISO 16911-1:2013 Velocity and temperature measurements are performed using a calibrated Pitot tube, a calibrated pressure differential reading device and a calibrated thermocouple. Velocity and possible flow deviation measurements are carried out at selected, representative points in the gas stream.

Total organic carbon

Documented in-house procedure MM0002 to the main procedural requirements of BS EN 12619:2013. Continuous analysis using probe, sample line and multi range Flame Ionisation Detector (FID) analyser. The analyser is calibrated before and during the tests using certified gas mixtures of nitrogen, oxygen and propane. Sampling points are selected in accordance with the findings of any BS EN 15259 assessment.

Sampling Project Personnel Competency And Expiry Dates

Report prepared by:	Rob Jones	MCERTS No MM08 984	Level 1 -	Level 2 31/03/2016	TE1 31/03/2020	TE2 31/03/2016	TE3 30/09/2016	TE4 31/12/2020
Report authorised by:	Derek Myers	MM02 115	-	30/09/2017	31/05/2018	30/11/2018	30/11/2018	30/11/2018
Team leader:	Rob Jones	MM08 984	-	31/03/2016	31/03/2020	31/03/2016	30/09/2016	31/12/2020
Team leader:	Harpreet Badwal	MM03 149	-	30/09/2018	30/09/2018	30/04/2019	31/10/2019	31/10/2019

Equipment References

Equipment	Reference Number
FID	AQ270
Heated Line	HL33
Stack Thermocouple	PTTS97
Timer / Stopwatch	ST41
Barometer	WS03
Pitot	PT97
Thermometer	TK24
Manometer	PI03

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Date	29/01/2016
Time	12:05
Pitot Cp	0.79

Barometric pressure	101.6	kPa
Duct static pressure	0.14	kPa
Stack Area	0.049	m²

Stack Diameter (circular)	0.25	m
		_

Traverse	Traverse	Depth	ΔΡ	T	Angle	velocity	Traverse	Depth	ΔΡ	Т	Angle	velocity
Point	Line	cm	mmH ₂ O	°C	0	m/s	Line	cm	mmH ₂ O	°C	0	m/s
1	Α						В					
2	Α						В					
3	Α						В					
4	Α	5.0	0.6	19	>15	2.5	В	5.0	0.6	19	>15	2.5
5	Α	6.3	0.9	19	<15	3.0	В	6.3	0.8	19	<15	2.9
6	Α	8.9	1.0	19	<15	3.2	В	8.9	0.9	19	<15	3.0
7	Α	16.1	1.4	19	<15	3.8	В	16.1	1.0	19	<15	3.2
8	Α	18.8	1.0	19	<15	3.2	В	18.8	1.2	19	<15	3.5
9	Α	20.0	0.7	19	<15	2.7	В	20.0	0.8	19	<15	2.9
10	Α						В					
11	Α						В					
12	Α						В					

Average Pitot DP	0.91	mmH₂O
Average Temperature	294.7	К
Average Velocity	3.0	m/s
Average volumetric flow rate	0.15	m ³ /s at stack conditions
Average volumetric flow rate	0.14	m ³ /s (wet STP)

Sampling plane requirements Re: BS EN 13284-1:2001 5.2

a	Angel of gas flow less than 15° with regard to duct axis		YES
b	b No local negative flow		YES
c Minimum pitot greater than 5Pa		YES	
d	Ratio of highest to lowest local gas velocity less than 3:1		YES
	Minimum local gas velocity	2.5	
	Maximum local gas velocity	3.8	
	Ratio of highest to lowest local gas velocity	1.53	

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D-1-	00/04/0040
Date	29/01/2016

From	10:05	to	10:35	30 minute mean			
Volatile orga	nic compounds		vppm, wet	5.67	mg/m³*	9.	11
From	10:35	to	11:05	30 minute mean			
	nic compounds	10	vppm, wet	8.36	mg/m³*	13	.44
				•			
From	11:05	to	11:35	30 minute mean			
Volatile organ	nic compounds		vppm, wet	5.13	mg/m³*	8.	24
Sampling De	tection Limits						
Volatile orga	nic compounds		vppm	0.10	mg/m³*	0.	16
			_			_	_
Reference G	as Details						
0	_		I Indian	Value	Cylinder	Analyser	I be a substantial to a

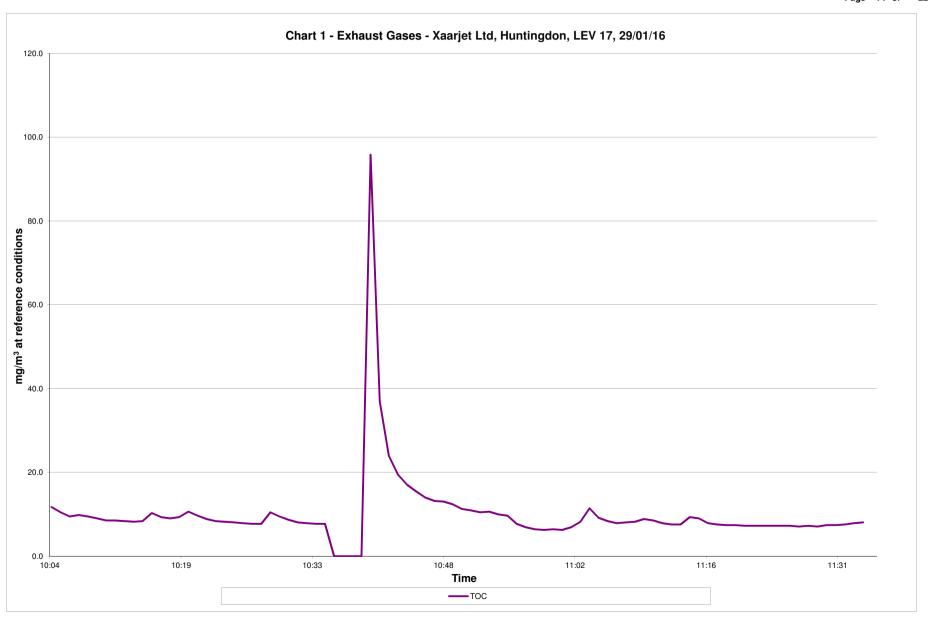
Species	Units	Value	Cylinder Reference	Analyser Range	Uncertainity $k = 2$
Nitrogen	%	99.999	VC80548	-	± 2
Volatile organic compounds	vppm	76.6	VCD500681	100	± 2

Zero And Span Gas Details

Species	units	Initial Time	09:54	Final Time	11:57
		Initial Zero	Initial Span	Final Zero	Final Span
Volatile organic compounds	vppm	0.0	76.6	-0.4	76.1

Exhaust Gases - Continuous Analysis Data

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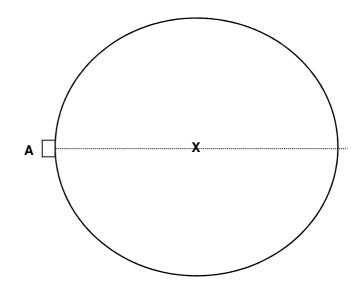
Diagram Of The Sampling Location

Diagram of sampling points across the cross section of the duct (not to scale).

Traverse length =

0.25 m

Point	% of D	Location
		cm
1	50.0	12.5



General Calculations

Stack area:

Area of a circle =
$$\frac{\pi \cdot D^2}{4}$$

D = Diameter (m) $\pi = 3.142$

Pressure conversion:

1mmH2O = 0.00980665 kPa 1mmH2O = 9.80665 Pa 1 mar = 0.1 kPa

Water vapour concentration:

From reference calculations (taken from BS EN 14790):

$$V_{WC(\%)} = \frac{\frac{M_{WC}.V_{mol(std)}}{M_{W}}}{\frac{M_{WC}.V_{mol(std)}}{M_{W}} + V_{m(std)}} \times 100$$

VWC (%) = Water vapour content on wet basis, in volume % (m³ of water vapour in m³ of wet gas)

Vm(std) = Dry gas volume measured, corrected to standard conditions (m³)

mWC = Mass of water collected in the impingers (g)

Mw = Molecular weight of water, 18.01534 rounded to 18 (g/mol)

Vmol(std) = Molar volume of water at standard conditions = 0.0224 (m3/mol)

Gas meter volume at standard conditions (STP)

From reference calculations (taken from BS EN 14790):

$$V_{m(std)} = y_d \times (V_2 - V_1) \times \frac{T_{std}}{T_m} \times \frac{p_m}{p_{std}}$$

Vm(std) = Dry gas meter volume at standard conditions (m³)

yd = Gas meter calibration coefficient

(V2-V1) = Dry gas meter volume at actual conditions (m³)

Tm = Actual Temperature (K)
Tstd = Standard temperature (273 K)

pm = Absolute pressure at the gas meter (kPa)
pstd = Standard gas pressure (101.3 kPa)

Isokenetic Ratio (%):

From reference calculations (taken from EA TGN M2):

$$IsokineticRatio(\%) = \frac{Velocity\ at\ the\ sampling\ nozzle}{Velocity\ of\ the\ stack\ gas} \times 100$$

Estimating Measurment Uncertainty

Uncertainty estimates are calculated using the general rule of uncertainty propagation. Guidance is taken from publications including UKAS document M3003 and ISO 20988:2007.

Flow Calculations

Velocity:

From reference calculations (taken from ISO 10780):

$$\overline{v} = KC \sqrt{\frac{T_s \Delta \overline{p}}{p_e M_s}}$$

v = Average velocity (m/s)

 \dot{C} = velocity calculation constant = 129

Ts = Average stack temperature (K)

Ms = Molar mass of gas; assume 29 kg/kmol unless the molar mass is < 27 kg/kmol or > 31 g/kmol

K = Pitot calibration coefficientPe = Absolute gas pressure (kPa)

 $\Delta p = \Delta p$ Average pitot tube pressure differencial (kPa)

Volume flow rate

From reference calculations (taken from ISO 10780):

$$q_{va} = vA$$

qva = Average flow rate (m³/s)

 \bar{v} = Average velocity (m/s)

A =Stack cross-sectional area (m²)

Volume flow rate corrected for moisture

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{(100 - H_a)}{(100 - H_m)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s) Ha = Moisture at actual conditions (%volume)

Hm = Reference moisture (%volume)

Volume flow rate corrected for temperature and pressure

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(T_m p_a\right)}{\left(T_a p_m\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

Ta = Temperature at actual conditions (K)

Tm = Reference Temperatue (K)

pa = Absolute gas pressure at actual conditions (kPa)

pm = Reference pressure (kPa)

Volume flow rate corrected for oxygen

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(20.9 - O_{2,ref}\right)}{\left(20.9 - O_{2,m}\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

O2,m = Actual oxygen concentration (%)

O2,ref = Reference oxygen concentration (%)

Concentration Calculations

Concentration:

From reference calculations (taken from BS EN 13284-1):

$$c = \frac{m}{V}$$

c = Concentration m = Mass of substane V = Volume sampled

Mass Emission

Mass emission= $c \times q_m$

c = Concentration q = Volume flow rate

Concentration corrected for oxygen:

From reference calculations (taken from BS ISO 9096):

$$c_m = c_a \times \frac{20.9 - O_{2,ref}}{20.9 - O_{2,a}}$$

cm = Concentration at reference conditions

ca = Actual concentration
O2, ref = Reference oxygen (%)
O2, a= Actual Oxygen (%)

Concentration corrected for moisture:

From reference calculations (taken from BS ISO 9096):

Convert wet gas to dry gas

$$c_{dry} = c_{wet} \times \frac{100}{100 - H_a}$$

Convert dry gas to wet gas

$$c_{wet} = c_{dry} \times \frac{100 - H_a}{100}$$

cwet = Concentration wet gascdry = Concentration dry gasHa = Water vapour content (%vol)

Conversion of parts per million (ppm) to mg/m³

From reference calculations (taken from EA TGN M2):

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

molar volume at 273K = 22.4 litres

When Converting TOC

 $Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight of\ carbonin\ span\ gas(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$

Calculation of Uncertainty Estimates - Instrumental Monitoring Techniques

Model equation

 $C_{ppm} = C_{reading} + Corr_{fit} + Corr_{f,dr} + Corr_{s,dr} + Corr_{rep} + Corr_{adj} + \sum_{i=1}^{p} Corr_{inf} + Corr_{inf}$

 $C_{,ppm}$ correction of repeatability of measurement concentration in ppm

Corr_{rep} Corr_{adj} Corr_{inf} concentration given by analyser C_{NO.reading} correction of adjustment Corr fit correction of lack of fit correction of influence quantities Corr _{0,dr} correction of zero drift Corr s,dr correction of span drift

Calculation of partial uncertainties

u(Corr_{fit}) $\left(\frac{X_{fit,\max}}{100 \times range}\right)$ Where: $X_{\text{fit,max}}$ is the maximum allowable deviation from linearity

Expressed as % of the range and calculated by applying a rectangular probability distribution

max (S_{0,rep}; S_{srep}) u(Corr_{rep}) Where:

is the standard uncertainty at zero level is the standard uncertainty at span level

$$u(\text{Corr}_{\text{loss}}) \qquad = \qquad u(\text{Corr}_{\text{loss}}) + u(\text{Corr}_{\text{cal}}) \qquad \qquad \text{Where:} \\ u(\text{Corr}_{\text{loss}}) \qquad \qquad \text{is the uncertainty due to losses in sample line} \\ u(\text{Corr}_{\text{loss}}) \qquad \qquad = \qquad \frac{C_{j,loss}}{\sqrt{3}} \qquad \qquad u(\text{Corr}_{\text{cal}}) \qquad \qquad \text{is the uncertainty due to losses in sample line} \\ cj_{\text{loss}} \qquad \qquad cj_{\text{loss}} \qquad \qquad \text{is the concentration of sample loss at span level}$$

$$u(Corr_{cal}) = \frac{U_{cal}}{2}$$
 is the expanded uncertainty of the calibration gas
$$\frac{U_{cal}}{2}$$

$$u(Corr_{int}) = c_{j} \sqrt{\frac{(x_{j,\max} - x_{j,adj})^{2} + (x_{j,\min} - x_{j,adj}) \times (x_{j,\max} - x_{j,adj}) + (x_{j,\min} - x_{j,adj})^{2}}{3}}$$

is the sensitivity coefficient of the influence quantity is the minimum value of the influence quantity during monitoring is the maximum value of the influence quantity during monitoring is the value of the influence quantity during adjustment

$$u(Corr_{int}) = \frac{c_j}{Int_{j,lest}} \sqrt{\frac{Int_{j,max}^2 + Int_{j,min} \times Int_{j,max} + Int_{j,min}^2}{3}}$$

$$u(\Sigma Corr_{int}) = \max_{i} \left[S_{Int,p}; S_{Int,n} \right] \\ = \min_{i} \left[S_{Int,p}; S_{Int,p} \right] \\ = \min_{i} \left[S_{Int,p}; S_{Int,p$$

 $\mathsf{Int}_{\mathsf{j},\mathsf{adj}}$ is the concentration of the interferent j in the cal gas used to adjust the analyse

 $S_{int,p}$ is the sum of interferents with positive impact is the sum of interferents with negative impact

Combined uncertainty

$$u(C, ppm) =$$

$$\sqrt{u^2 (corr_{\mathit{fit}}) + u^2 (corr_{\mathit{o,dr}}) + u^2 (corr_{\mathit{s,dr}}) + u^2 (corr_{\mathit{rep}}) + u^2 (corr_{\mathit{s,yf}}) + u^2 (corr_{\mathit{a,press}}) + u^2 (corr_{\mathit{temp}}) + u^2 (corr_{\mathit{volt}}) + u^2 (corr_{\mathit{adj}}) + S_{\mathit{hit}}^{-2}}$$

Overall expanded uncertainty (k = 2)

$$U(C_m) = u(C_m) \times k$$

Uncertainty of NOx measurements

$$u(C_{NOx},_{conv}) = \frac{C_{NOx} \times R \times \eta}{\sqrt{3}}$$

$$= \frac{C_{NOx}}{\sqrt{3}}$$

$$= \frac{C_{NOx}}{\sqrt{3}} \times R \times \eta$$

$$= \frac{C_{NOx}}{\sqrt{3}} \times R \times \eta$$
is the concentration of NOx measured by the analyser is the ratio of NO:Nox in the stack gas is the NOx converter efficiency

Combined uncertainty NOx measurements

$$u(C_{NOx}, _{stack}) =$$

$$\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{o,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{rep}) + u^{2}(corr_{rep}) + u^{2}(corr_{s,vf}) + u^{2}(corr_{a,press}) + u^{2}(corr_{temp}) + u^{2}(corr_{volt}) + u^{2}(corr_{adj}) + S_{lnt}^{2} + u^{2}(corr_{NOs,conv})}$$

Uncertainty of mass concentration at oxygen reference concentration

$$u(C, O2 ref) =$$

$$\sqrt{u^{2}(corr_{\mathit{fit}}) + u^{2}(corr_{\mathit{o,dr}}) + u^{2}(corr_{\mathit{s,dr}}) + u^{2}(corr_{\mathit{rep}}) + u^{2}(corr_{\mathit{s,vf}}) + u^{2}(corr_{\mathit{s,vf}}) + u^{2}(corr_{\mathit{s,otr}}) + u^{2}(corr_{\mathit{sott}}) + u^{2}(corr_{\mathit{odd}}) + S_{\mathit{Int}}^{2} + \left(\frac{u^{2}(O_{2,\mathit{meas,dry}})}{(21 - O_{2,\mathit{meas,dry}})^{2}}\right)}$$

u(C,O_{2,ref)} uncertainty associated with the mass concentration at O₂ ref. concentration mg/m³ C,O_{2,ref} mg/m³ mass concentration at O₂ reference concentration O2 measured concentration % volume uncertainty associated to the measured O2 concentration % (relative to O_{2 meas})

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Uncertainty Estimate For The Measurement Of Total Organic Carbon

			e For The Measurement Of		
Analyser Type/Model Reference Oxygen %	Sick N	Maihak D	(0 = No correction)		
	ſ	Test 1	Test 2	Test 3	
Limit value	mg/m ³	75	75	75	
Limit value	ppm	46.7	46.7	46.7	
Measured concentration	ppm	5.7	8.4	5.1	
Measured concentration	mg/m ³	9.1	13.4	8.2	
Calibration gas	ppm	76.6	76.6	76.6	
Calibration gas	mg/m ³	123.1	123.1	123.1	
Analyser range	ppm	9.3	9.3	9.3	
Analyser range	mg/m ³	15.0	15.0	15.0	
Correction of Lack of Fit Lack of fit	% range	2.0	2.0	2.0	
add of m	u(Corr, _{fit})	0.11	0.11	0.11	
				<u> </u>	
Corrections of Zero and Span Drift				assumed to be	< 5% u(
Zero Drift	% range	0.00	0.00	0.00	
Span Drift	u(Corr, _{0dr})	0.00	0.00	0.00	
pan Driit	% range u(Corr, _{sdr})	0.00	0.00	0.00	
	a(GG:1;sgr)	0.00	0.00	0.00	
Correction of Repeatability of Measurement					
Repeatability SD at span level	% range	0.0	0.0	0.0	
Not reported)	u(Corr, _{rep})	0.00	0.00	0.00	
Correction of adjustment					
osses in the line	% range	0.65	0.65	0.65	
	u(Corr, _{loss})	0.02	0.03	0.02	
Incertainty of calibration gas	% range	2.0	2.0	2.0	
	u(Corr, _{cal})	0.06	0.08	0.05	
Correction of Influence of Interferents					
I ₂ O	% range				
	u(Corr, _{N2O})	0.00	0.00	0.00	
CO ₂	% range				
N.I.	u(Corr, _{CO2})	0.00	0.00	0.00	
CH₄	% range u(Corr, _{CH4})	0.00	0.00	0.00	
otal of interferent influences .	% range	2.50	2.50	2.50	
$u(\Sigma Corrint) = \max_{n \in S_{Int,p}, S_{Int,n}} [S_{Int,p}, S_{Int,n}]$	$u(\Sigma Corr_{int})$	0.16	0.16	0.16	
Correction of Influence Quantities	0/	4.00	1.00	4.00	
Sensitivity to sample volume flow	% range	1.60 0.09	1.60 0.09	1.60 0.09	
Sensitivity to atmospheric pressure	u(Corr, _{flow}) % range	0.09	0.09	0.09	
Not reported)	u(Corr, _{press})	0.00	0.00	0.00	
Sensitivity to ambient temperature	% range	-2.40	-2.40	-2.40	
, , , , , , , , , , , , , , , , , , , ,	u(Corr, _{temp})	-0.28	-0.28	-0.28	
Sensitivity to electrical voltage	% range	0.50	0.50	0.50	
Not reported)	u(Corr, _{volt})	0.10	0.10	0.10	
Maximum standard uncertainty	u(Corr, _{max})	0.11	0.11	0.11	
5% of maximum standard uncertainty	u(Corr, _{5%})	0.01	0.01	0.01	
·					
nterferent Concentration Variations	Minimum	Maximum	Value at cal	Performance	Units
CH ₄ range	0	10	0	50	mg/m
I ₂ O range	0	0	0	20	mg/m
O ₂ range	8	12	0	15	mg/m
Oxygen effect variations	Minimum	Maximum	Value at cal	Performance	Units
Oxygen effect	0	20	0	2	mg/m
nfluence Quantitiy Variations					
macrice Quartity variations				Performance	Units
	Minimum	Maximum	Value at cal		
Sensitivity to sample volume flow	Minimum 55	Maximum 65	Value at cal 60	5	l/h
	55 99		60 99		l/h kPa
ensitivity to atmospheric pressure ensitivity to ambient temperature	55 99 278	65 100 313	60 99 288	5 1 10	kPa K
ensitivity to atmospheric pressure ensitivity to ambient temperature	55 99	65 100	60 99	5 1	kPa
ensitivity to atmospheric pressure rensitivity to ambient temperature rensitivity to electrical voltage	55 99 278	65 100 313 250	60 99 288 230	5 1 10 5	kPa K
ensitivity to atmospheric pressure ensitivity to ambient temperature ensitivity to electrical voltage fleasurement uncertainty	55 99 278 187	65 100 313 250 Test 1	60 99 288 230 Test 2	5 1 10 5	kPa K
ensitivity to atmospheric pressure lensitivity to ambient temperature lensitivity to electrical voltage leasurement uncertainty combined uncertainty	55 99 278 187	65 100 313 250 Test 1 0.37	60 99 288 230 Test 2 0.38	5 1 10 5 Test 3 0.37	kPa K
ensitivity to atmospheric pressure ensitivity to ambient temperature ensitivity to electrical voltage fleasurement uncertainty combined uncertainty combined uncertainty	55 99 278 187 ppm mg/m³	65 100 313 250 Test 1 0.37 0.59	60 99 288 230 Test 2	5 1 10 5	kPa K
Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of confi	55 99 278 187 ppm mg/m³	65 100 313 250 Test 1 0.37 0.59	60 99 288 230 Test 2 0.38 0.60	5 1 10 5 Test 3 0.37 0.59	kPa K
Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Aleasurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty Expanded uncertainty Expanded uncertainty Expanded uncertainty Expanded uncertainty	55 99 278 187 ppm mg/m³	65 100 313 250 Test 1 0.37 0.59 =2	60 99 288 230 Test 2 0.38 0.60	5 1 10 5 Test 3 0.37 0.59	kPa K
Sensitivity to atmospheric pressure Jensitivity to ambient temperature Sensitivity to electrical voltage Jeasurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of confi Derall uncertainty Derall uncertainty	55 99 278 187 ppm mg/m³ idence of 95%, k ppm mg/m³	65 100 313 250 Test 1 0.37 0.59 =2 0.7 1.2	60 99 288 230 Test 2 0.38 0.60	5 1 10 5 Test 3 0.37 0.59	kPa K
Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty expressed with a level of confi Diverall uncertainty Diverall uncertainty Diverall uncertainty Diverall uncertainty Diverall uncertainty relative to measured value Diverall uncertainty relative to range	55 99 278 187 ppm mg/m³	65 100 313 250 Test 1 0.37 0.59 =2	60 99 288 230 Test 2 0.38 0.60	5 1 10 5 Test 3 0.37 0.59	kPa K

The uncertainty evaluation has been carried out in accordance with UKAS requirements.



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

Part 1: Executive Summary

Report for the Periodic Monitoring of Emissions to Air.

Site Huntingdon
Plant LEV 19

Sampling Date 28th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







Exova (UK) Ltd

Unit C5 Emery Court The Embankment Business Park Heaton Mersey Stockport SK4 3GL

Tel: 0161 4323286

Company Registration No SC070429

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Monitoring Objectives

The monitoring was undertaken to check compliance with authorised emission limits.

All monitoring procedures were carried out to the MCERTS requirements under the Exova (UK) Ltd quality system to ISO 17025: 2005.

Monitoring was undertaken for the listed emissions from the following sampling positions:

Sampling Location	Emission
LEV 19	Total volatile organic carbon

Special Monitoring Requirements

There were no special requirements for this monitoring campaign.

Summary of Methods

Emission	Method number	Method standard
Gas velocity and volume flow	TPM/01A	BS EN ISO 16911-1:2013
тос	MM0002	BS EN 12619 : 2013

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Summary Of Results

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd** The results were measured from the sample positions downstream of the arrestment plant.

Emission at	Sampling		Emission	Authorised	Uncertainty	Detection	Mass	
Huntingdon		Time		Result	Limit	+/-	Limit	Emission
LEV 19	Date	Start	End	mg/m³∗	mg/m³*	mg/m³*	mg/m³*	g/h
тос	28/01/16	13:54	15:24	8.8	75	1.2	0.2	31.7

* at reference conditions	Stack Gas Weight	0 °C	Without correction	for moisture	
	29.00 Kg/kmol	101.3 kPa	Oxygen	No Correction	%

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above) Nm³ 273 K, 101.3 kPa

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



All tests included in this report are accredited under UKAS and MCERTS accreditation schemes unless otherwise stated.

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





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Summary Of Results, Exhaust Gases

The table presents the atmospheric emissions from the tests undertaken on behalf of **Xaarjet Ltd**The results were measured from the sample positions downstream of the arrestment plant.

	Emission at Huntingdon	Sampling Time		Emission Result	Authorised Limit	Uncertainty +/-	Detection Limit	Mass Emission	
	LEV 19	Date	Start	End	mg/m³*	mg/m³*	mg/m³*	mg/m³*	g/h
TOC	Test 1	28/01/16	13:54	14:24	5.1	75	1.2	0.2	18.3
TOC	Test 2	28/01/16	14:24	14:54	8.2	75	1.2	0.2	29.4
TOC	Test 3	28/01/16	14:54	15:24	13.1	75	1.2	0.2	47.3

* at ref	Stack Gas Weight	0 °C	Without correction for moisture
Conditions	29.00 Kg/kmol	101.3 kPa	Oxygen No Correction %

Where applicable Oxides of nitrogen results are expressed as nitrogen dioxide

TOC results are expressed as total carbon

Throughout Report: * Reference conditions (see above)

** Analysis not required #- UKAS accredited only
ND Non detectable ##- Not Accredited
s - Subcontracted laboratory analysis N/A Not applicable

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a 95% confidence level. The uncertainty evaluation has been carried out in accordance with UKAS requirements.



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Nm³ 273 K, 101.3 kPa



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Operating Information

The table below shows details of the operating information on each sampling date for: LEV 19

Date	Process type	Process duration	Fuel	Feedstock	Abatement	Load
28/01/2016	Production and cleaning of inkjet cartridges	Continuous	N/A	N/A	N/A	Normal

No CEMs installed on the emission point.

Comments & Monitoring Deviations

A waste gas homogeneity test to BS EN 15259:2007 (MID) is not required:-

The homogeneity test is not applicable to non-combustion processes.

The homogeneity test is not applicable to duct areas less than 1m².

The homogeneity test is not usually applicable to pollutant emissions that are less than 30% of the ELV.

All monitoring was performed in accordance with the relevant procedures.



Part 2: Supporting Information

Report for the Periodic Monitoring of Emissions to Air.

Client Xaarjet Ltd
Site Huntingdon
Plant LEV 19

Sampling Date 28th January 2016 Report Date 25th February 2016

Job Number EM-2708 Permit Number B22/11

Report Prepared by: Print Rob Jones

MCERTS No. MM08 984 Level 2 TE: 1,2,3,4

Report Approved by: Sign

Print Derek Myers

MCERTS No. MM02 115 Level 2 TE: 1,2,3,4







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Tel: 0161 4323286

Company Registration No SC070429

Xaarjet Ltd, Huntingdon, Permit No: B22/11, R/16-6523, v1

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Emission Monitoring Procedures And Instrumentation

Gas velocity and temperature

Documented in-house procedure TPM01/A to the main procedural requirements of BS EN ISO 16911-1:2013 Velocity and temperature measurements are performed using a calibrated Pitot tube, a calibrated pressure differential reading device and a calibrated thermocouple. Velocity and possible flow deviation measurements are carried out at selected, representative points in the gas stream.

Total organic carbon

Documented in-house procedure MM0002 to the main procedural requirements of BS EN 12619:2013. Continuous analysis using probe, sample line and multi range Flame Ionisation Detector (FID) analyser. The analyser is calibrated before and during the tests using certified gas mixtures of nitrogen, oxygen and propane. Sampling points are selected in accordance with the findings of any BS EN 15259 assessment.

Sampling Project Personnel Competency And Expiry Dates

Report prepared by:	Rob Jones	MCERTS No MM08 984	Level 1 -	Level 2 31/03/2016	TE1 31/03/2020	TE2 31/03/2016	TE3 30/09/2016	TE4 31/12/2020
Report authorised by:	Derek Myers	MM02 115	-	30/09/2017	31/05/2018	30/11/2018	30/11/2018	30/11/2018
Team leader:	Rob Jones	MM08 984	-	31/03/2016	31/03/2020	31/03/2016	30/09/2016	31/12/2020
Team leader:	Harpreet Badwal	MM03 149	-	30/09/2018	30/09/2018	30/04/2019	31/10/2019	31/10/2019

Equipment References

Equipment	Reference Number
FID	AQ270
Heated Line	HL33
Stack Thermocouple	PTTS97
Timer / Stopwatch	ST41
Barometer	WS03
Pitot	PT97
Thermometer	TK24
Manometer	PI03

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Date	28/01/2016
Time	12:15
Pitot Cp	0.79

Barometric pressure	101.6	kPa
Duct static pressure	-1.10	kPa
Stack Area	0.096	m²

Stack Diameter (circular)	0.35	m

Traverse	Traverse	Depth	ΔΡ	Т	Angle	velocity	Traverse	Depth	ΔΡ	Т	Angle	velocity
Point	Line	cm	mmH ₂ O	°C	0	m/s	Line	cm	mmH ₂ O	°C	0	m/s
1	Α						В					
2	Α						В					
3	Α	5.0	13.5	20	<15	11.7	В	5.0	12.5	20	<15	11.3
4	Α	6.2	13.5	20	<15	11.7	В	6.2	13.0	20	<15	11.6
5	Α	8.8	12.1	20	<15	11.1	В	8.8	13.8	20	<15	11.9
6	Α	12.5	10.8	20	<15	10.5	В	12.5	13.1	20	<15	11.6
7	Α	22.5	12.2	20	<15	11.2	В	22.5	12.7	20	<15	11.4
8	Α	26.3	12.7	20	<15	11.4	В	26.3	11.7	20	<15	11.0
9	Α	28.8	12.3	20	<15	11.2	В	28.8	11.4	20	<15	10.8
10	Α	30.0	12.2	20	<15	11.2	В	30.0	10.5	20	<15	10.4
11	Α						В					
12	Α						В					

Average Pitot DP	12.37	mmH ₂ O
Average Temperature	293.2	К
Average Velocity	11.3	m/s
Average volumetric flow rate	1.08	m ³ /s at stack conditions
Average volumetric flow rate	1.00	m ³ /s (wet STP)

Sampling plane requirements Re: BS EN 13284-1:2001 5.2

а	Angel of gas flow less than 15° with regard to duct axis		YES
b	No local negative flow		YES
С	Minimum pitot greater than 5Pa		YES
d	Ratio of highest to lowest local gas velocity less than 3:1		YES
	Minimum local gas velocity	10.4	
	Maximum local gas velocity	11.9	
	Ratio of highest to lowest local gas velocity	1.14	

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D-4-	00/04/0040
Date	28/01/2016

From	13:54	to	14:24	30 minute mean		
Volatile organ	ic compounds		vppm, wet	3.16	mg/m³*	5.08
From	14:24	to	14:54	30 minute mean		
Volatile organ	ic compounds		vppm, wet	5.08	mg/m³*	8.16
From	14:54	to	15:24	30 minute mean		
Volatile organ	ic compounds		vppm, wet	8.16	mg/m³*	13.11

Sampling Detection Limits

Volatile organic compounds	vppm	0.10	mg/m³*	0.16

Reference Gas Details

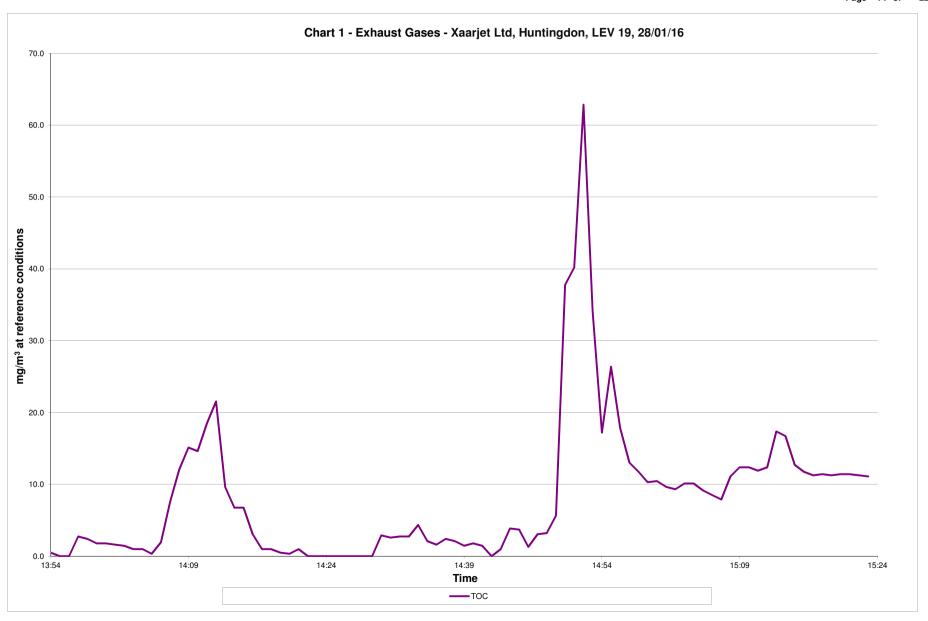
Species	Units	Value	Cylinder Reference	Analyser Range	Uncertainity $k = 2$
Nitrogen	%	99.999	VC80548	-	± 2
Volatile organic compounds	vppm	76.6	VCD500681	100	± 2

Zero And Span Gas Details

Species	units	Initial Time	11:40	Final Time	17:26
		Initial Zero	Initial Span	Final Zero	Final Span
Volatile organic compounds	vppm	0.0	76.6	-0.8	75.6

Exhaust Gases - Continuous Analysis Data

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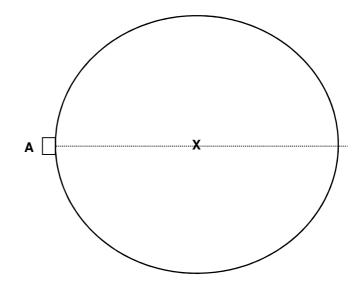
Diagram Of The Sampling Location

Diagram of sampling points across the cross section of the duct (not to scale).

Traverse length =

0.35 m

Point	% of D	Location
		cm
1	50.0	17.5



General Calculations

Stack area:

$$Area of a circle = \frac{\pi . D^2}{4}$$

D = Diameter (m) $\pi = 3.142$

Pressure conversion:

1mmH2O = 0.00980665 kPa 1mmH2O = 9.80665 Pa 1 mar = 0.1 kPa

Water vapour concentration:

From reference calculations (taken from BS EN 14790):

$$V_{WC(\%)} = \frac{\frac{M_{WC}.V_{mol(std)}}{M_{W}}}{\frac{M_{WC}.V_{mol(std)}}{M_{W}} + V_{m(std)}} \times 100$$

VWC (%) = Water vapour content on wet basis, in volume % (m³ of water vapour in m³ of wet gas)

Vm(std) = Dry gas volume measured, corrected to standard conditions (m³)

mWC = Mass of water collected in the impingers (g)

Mw = Molecular weight of water, 18.01534 rounded to 18 (g/mol)

Vmol(std) = Molar volume of water at standard conditions = 0.0224 (m3/mol)

Gas meter volume at standard conditions (STP)

From reference calculations (taken from BS EN 14790):

$$V_{m(std)} = y_d \times (V_2 - V_1) \times \frac{T_{std}}{T_m} \times \frac{p_m}{p_{std}}$$

Vm(std) = Dry gas meter volume at standard conditions (m³)

yd = Gas meter calibration coefficient

(V2-V1) = Dry gas meter volume at actual conditions (m³)

Tm = Actual Temperature (K)
Tstd = Standard temperature (273 K)

pm = Absolute pressure at the gas meter (kPa) pstd = Standard gas pressure (101.3 kPa)

Isokenetic Ratio (%):

From reference calculations (taken from EA TGN M2):

$$IsokineticRatio(\%) = \frac{Velocity\ at\ the\ sampling\ nozzle}{Velocity\ of\ the\ stack\ gas} \times 100$$

Estimating Measurment Uncertainty

Uncertainty estimates are calculated using the general rule of uncertainty propagation. Guidance is taken from publications including UKAS document M3003 and ISO 20988:2007.

Flow Calculations

Velocity:

From reference calculations (taken from ISO 10780):

$$\overline{v} = KC \sqrt{\frac{T_s \Delta \overline{p}}{p_e M_s}}$$

 $\bar{v} = \text{Average velocity (m/s)}$

 \dot{C} = velocity calculation constant = 129

Ts = Average stack temperature (K)

Ms = Molar mass of gas; assume 29 kg/kmol unless the molar mass is < 27 kg/kmol or > 31 g/kmol

K = Pitot calibration coefficientPe = Absolute gas pressure (kPa)

 $\Delta p = \Delta p$ Average pitot tube pressure differencial (kPa)

Volume flow rate

From reference calculations (taken from ISO 10780):

$$q_{va} = vA$$

qva = Average flow rate (m³/s)

v = v Average velocity (m/s)

A =Stack cross-sectional area (m²)

Volume flow rate corrected for moisture

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{(100 - H_a)}{(100 - H_m)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s) Ha = Moisture at actual conditions (%volume)

Hm = Reference moisture (%volume)

Volume flow rate corrected for temperature and pressure

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(T_m p_a\right)}{\left(T_a p_m\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

Ta = Temperature at actual conditions (K)

Tm = Reference Temperatue (K)

pa = Absolute gas pressure at actual conditions (kPa)

pm =Reference pressure (kPa)

Volume flow rate corrected for oxygen

From reference calculations (taken from BS ISO 9096):

$$q_m = q_{va} \frac{\left(20.9 - O_{2,ref}\right)}{\left(20.9 - O_{2,m}\right)}$$

qm =Corrected volume flowrate (m³/s)

qva = Volume flow rate at actual conditions (m³/s)

O2,m = Actual oxygen concentration (%)

O2,ref = Reference oxygen concentration (%)

Concentration Calculations

Concentration:

From reference calculations (taken from BS EN 13284-1):

$$c = \frac{m}{V}$$

c = Concentration m = Mass of substane V = Volume sampled

Mass Emission

Mass emission= $c \times q_m$

c = Concentration q = Volume flow rate

Concentration corrected for oxygen:

From reference calculations (taken from BS ISO 9096):

$$c_m = c_a \times \frac{20.9 - O_{2,ref}}{20.9 - O_{2,a}}$$

cm = Concentration at reference conditions

ca = Actual concentration
O2, ref = Reference oxygen (%)
O2, a= Actual Oxygen (%)

Concentration corrected for moisture:

From reference calculations (taken from BS ISO 9096):

Convert wet gas to dry gas

$$c_{dry} = c_{wet} \times \frac{100}{100 - H_a}$$

Convert dry gas to wet gas

$$c_{wet} = c_{dry} \times \frac{100 - H_a}{100}$$

cwet = Concentration wet gascdry = Concentration dry gasHa = Water vapour content (%vol)

Conversion of parts per million (ppm) to mg/m³

From reference calculations (taken from EA TGN M2):

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

molar volume at 273K = 22.4 litres

When Converting TOC

$$Concentration(mg/m^3) = \frac{Concentration(ppm) \times molecular\ weight of\ carbonin\ span\ gas(g)}{molar\ volume(l)\ at\ a\ given\ temperature}$$

Calculation of Uncertainty Estimates - Instrumental Monitoring Techniques

Model equation

 $C_{ppm} = C_{reading} + Corr_{fit} + Corr_{f,dr} + Corr_{s,dr} + Corr_{rep} + Corr_{adj} + \sum_{i=1}^{p} Corr_{inf} + Corr_{inf}$

Corr_{rep} Corr_{adj} Corr_{inf} $C_{,ppm}$ correction of repeatability of measurement concentration in ppm concentration given by analyser C_{NO.reading} correction of adjustment Corr fit correction of lack of fit correction of influence quantities

Corr _{0,dr} correction of zero drift Corr s,dr correction of span drift

Calculation of partial uncertainties

u(Corr_{fit}) $\left(\frac{X_{fit,\max}}{100 \times range}\right)$ Where: $X_{\text{fit,max}}$ is the maximum allowable deviation from linearity

Expressed as % of the range and calculated by applying a rectangular probability distribution

max (S_{0,rep}; S_{srep}) u(Corr_{rep}) Where:

is the standard uncertainty at zero level is the standard uncertainty at span level

$$u(Corr_{int}) = c_{j} \sqrt{\frac{(x_{j,\max} - x_{j,adj})^{2} + (x_{j,\min} - x_{j,adj}) \times (x_{j,\max} - x_{j,adj}) + (x_{j,\min} - x_{j,adj})^{2}}{3}}$$
Where:

is the sensitivity coefficient of the influence quantity is the minimum value of the influence quantity during monitoring is the maximum value of the influence quantity during monitoring is the value of the influence quantity during adjustment

$$u(Corr_{int}) = \frac{c_j}{Int_{j,test}} \sqrt{\frac{Int_{j,max}^2 + Int_{j,min} \times Int_{j,max} + Int_{j,min}^2}{3}}$$

$$u(\Sigma Corr_{int}) = \max_{i} \left[S_{Int,p}; S_{Int,n} \right] \\ = \min_{i} \left[S_{Int,p}; S_{Int,p} \right] \\ = \min_{i} \left[S_{Int,p}; S_{Int,p$$

 $\mathsf{Int}_{\mathsf{j},\mathsf{adj}}$ is the concentration of the interferent j in the cal gas used to adjust the analyse

 $S_{int,p}$ is the sum of interferents with positive impact is the sum of interferents with negative impact

Combined uncertainty

$$u(C_{ppm}) =$$

$$\sqrt{u^2 (corr_{\mathit{fit}}) + u^2 (corr_{\mathit{o,dr}}) + u^2 (corr_{\mathit{s,dr}}) + u^2 (corr_{\mathit{rep}}) + u^2 (corr_{\mathit{s,yf}}) + u^2 (corr_{\mathit{a,press}}) + u^2 (corr_{\mathit{temp}}) + u^2 (corr_{\mathit{volt}}) + u^2 (corr_{\mathit{adj}}) + S_{\mathit{hit}}^{-2}}$$

Overall expanded uncertainty (k = 2)

$$U(C_m) = u(C_m) \times k$$

Uncertainty of NOx measurements

$$u(C_{NOx},_{conv}) = \frac{C_{NOx} \times R \times \eta}{\sqrt{3}}$$
 Where:
$$C_{NOx}$$
 is the concentration of NOx measured by the analyser is the ratio of NO:Nox in the stack gas is the NOx converter efficiency

Combined uncertainty NOx measurements

$$u(C_{NOx}, _{stack}) =$$

$$\sqrt{u^{2}(corr_{fit}) + u^{2}(corr_{o,dr}) + u^{2}(corr_{s,dr}) + u^{2}(corr_{rep}) + u^{2}(corr_{rep}) + u^{2}(corr_{s,vf}) + u^{2}(corr_{a,press}) + u^{2}(corr_{temp}) + u^{2}(corr_{volt}) + u^{2}(corr_{odj}) + S_{lnt}^{2} + u^{2}(corr_{NOx,conv})}$$

Uncertainty of mass concentration at oxygen reference concentration

$$u(C, O2 ref) =$$

$$\sqrt{u^{2}(corr_{\mathit{fit}}) + u^{2}(corr_{\mathit{o,dr}}) + u^{2}(corr_{\mathit{s,dr}}) + u^{2}(corr_{\mathit{rep}}) + u^{2}(corr_{\mathit{s,vf}}) + u^{2}(corr_{\mathit{s,vf}}) + u^{2}(corr_{\mathit{s,otr}}) + u^{2}(corr_{\mathit{sott}}) + u^{2}(corr_{\mathit{odd}}) + S_{\mathit{Int}}^{2} + \left(\frac{u^{2}(O_{2,\mathit{meas,dry}})}{(21 - O_{2,\mathit{meas,dry}})^{2}}\right)}$$

u(C,O_{2,ref)} uncertainty associated with the mass concentration at O₂ ref. concentration mg/m³ C,O_{2,ref} mg/m³ mass concentration at O₂ reference concentration O2 measured concentration % volume uncertainty associated to the measured O2 concentration % (relative to O_{2 meas})

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Uncertainty Estimate For The Measurement Of Total Organic Carbon

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Analyser Type/Model	Sick N	//aihak	1		
Reference Oxygen %		0	(0 = No corre	ction)	
imit value		Test 1	Test 2	Test 3	
Limit value Limit value	mg/m ³ ppm	75 46.7	75 46.7	75 46.7	
Measured concentration	ppm	3.2	5.1	8.2	
Measured concentration	mg/m ³	5.1	8.2	13.1	
	1 1114/111				
Calibration gas	ppm	76.6	76.6	76.6	
Calibration gas	mg/m ³	123.1	123.1	123.1	
Analyser range	ppm	9.3	9.3	9.3	
Analyser range	mg/m³	15.0	15.0	15.0	
Correction of Look of Fit					
Correction of Lack of Fit Lack of fit	% range	2.0	2.0	2.0	
Lack of its	u(Corr, _{fit})	0.11	0.11	0.11	
	-(0	0	0	
Corrections of Zero and Span Drift	(*All drift is ca	alculated for	the residual is	assumed to be	< 5% u(
Zero Drift	% range	0.00	0.00	0.00	,
	u(Corr, _{0dr})	0.00	0.00	0.00	
Span Drift	% range	0.00	0.00	0.00	
	u(Corr, _{sdr})	0.00	0.00	0.00	
Down the of Down to billion of Management					
Correction of Repeatability of Measurement Repeatability SD at span level	0/. rango	0.0	0.0	0.0	
Not reported)	% range u(Corr,ren)	0.00	0.00	0.00	
	3(00/11rep/	5.00	0.00	3.00	
Correction of adjustment					
osses in the line	% range	1.31	1.31	1.31	
	u(Corr, _{loss})	0.02	0.04	0.06	
Incertainty of calibration gas	% range	2.0	2.0	2.0	
	u(Corr, _{cal})	0.03	0.05	0.08	
Correction of Influence of Interferents N ₂ O	% range		ı		
N ₂ O	u(Corr, _{N2O})	0.00	0.00	0.00	
CO ₂	% range	0.00	0.00	0.00	
2	u(Corr,coz)	0.00	0.00	0.00	
CH₄	% range				
	u(Corr, _{CH4})	0.00	0.00	0.00	
Total of interferent influences	% range	2.50	2.50	2.50	
$u(\Sigma Corrint) = \max[S_{Int,p}; S_{Int,n}]$	$u(\Sigma Corr_{int})$	0.16	0.16	0.16	
Correction of Influence Quantities Sensitivity to sample volume flow	0/ 10000	1.60	1.60	1.60	
sensitivity to sample volume now	% range u(Corr, _{flow})	0.09	0.09	0.09	
Sensitivity to atmospheric pressure	% range	0.09	0.09	0.09	
(Not reported)	u(Corr, _{press})	0.00	0.00	0.00	
Sensitivity to ambient temperature	% range	-2.40	-2.40	-2.40	
	u(Corr, _{temp})	-0.28	-0.28	-0.28	
	% range	0.50	0.50	0.50	
Sensitivity to electrical voltage		0.50		0.50	
	u(Corr, _{volt})	0.50	0.10	0.10	
Not reported)	u(Corr, _{voit})	0.10	0.10	0.10	
Not reported) Maximum standard uncertainty	u(Corr, _{volt})	0.10	0.10	0.10	
Not reported) Maximum standard uncertainty	u(Corr, _{voit})	0.10	0.10	0.10	
Not reported) Maximum standard uncertainty	u(Corr, _{volt})	0.10	0.10	0.10	
Not reported) Maximum standard uncertainty % of maximum standard uncertainty	u(Corr, _{volt})	0.10	0.10 0.11 0.01	0.10	Units
Not reported) Maximum standard uncertainty % of maximum standard uncertainty nterferent Concentration Variations	u(Corr, _{volt}) u(Corr, _{max}) u(Corr, _{5%})	0.10 0.11 0.01	0.10	0.10 0.11 0.01	Units mg/m
Not reported) Maximum standard uncertainty % of maximum standard uncertainty Interferent Concentration Variations CH ₄ range	u(Corr, _{vott}) u(Corr, _{max}) u(Corr, _{5%})	0.10 0.11 0.01 Maximum	0.10 0.11 0.01 Value at cal	0.10 0.11 0.01 Performance	
Not reported) Maximum standard uncertainty 5% of maximum standard uncertainty Interferent Concentration Variations CH ₄ range V ₂ O range CO ₂ range	u(Corr _{,vot}) u(Corr _{,pos}) u(Corr _{,5os}) Minimum 0 0 8	0.10 0.11 0.01 Maximum 10	0.10 0.11 0.01 Value at cal 0 0 0	0.10 0.11 0.01 Performance 50 20 15	mg/m
Not reported) Waximum standard uncertainty 5% of maximum standard uncertainty Interferent Concentration Variations CH ₄ range V ₂ O range CO ₂ range Cxygen effect variations	u(Corr _{vest}) u(Corr _{sss}) u(Corr _{sss}) Minimum 0 0 8 Minimum	0.10 0.11 0.01 Maximum 10 0 12 Maximum	0.10 0.11 0.01 Value at cal 0 0 Value at cal	0.10 0.11 0.01 Performance 50 20 15 Performance	mg/m mg/m mg/m Units
Not reported) Maximum standard uncertainty % of maximum standard uncertainty Interferent Concentration Variations H ₄ range V ₂ O range D ₂ range Dxygen effect variations	u(Corr _{,vot}) u(Corr _{,pos}) u(Corr _{,5os}) Minimum 0 0 8	0.10 0.11 0.01 Maximum 10 0 12	0.10 0.11 0.01 Value at cal 0 0 0	0.10 0.11 0.01 Performance 50 20 15	mg/m mg/m mg/m
Not reported) Maximum standard uncertainty % of maximum standard uncertainty Interferent Concentration Variations CH ₄ range V ₂ O range CO ₂ range Coxygen effect variations Coxygen effect	u(Corr _{vest}) u(Corr _{sss}) u(Corr _{sss}) Minimum 0 0 8 Minimum	0.10 0.11 0.01 Maximum 10 0 12 Maximum	0.10 0.11 0.01 Value at cal 0 0 Value at cal	0.10 0.11 0.01 Performance 50 20 15 Performance	mg/m mg/m mg/m Units
Not reported) Maximum standard uncertainty % of maximum standard uncertainty Interferent Concentration Variations CH ₄ range V ₂ O range CO ₂ range Coxygen effect variations Coxygen effect	u(Corr _{vest}) u(Corr _{ses}) u(Corr _{ses}) Minimum 0 0 8 Minimum 0	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20	0.10 0.11 0.01 Value at cal 0 0 Value at cal 0 0 Value at cal	0.10 0.11 0.01 Performance 50 20 15 Performance 2	mg/m mg/m mg/m Units mg/m
Maximum standard uncertainty % of maximum standard uncertainty % of maximum standard uncertainty Interferent Concentration Variations H ₄ range H ₂ O range TO ₂ range Doxygen effect variations Doxygen effect variations Doxygen effect Influence Quantity Variations	u(Corr, _{max}) u(Corr, _{max}) u(Corr, _{5%}) Minimum 0 0 8 Minimum 0	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20	0.10 0.11 0.01 Value at cal 0 0 0 Value at cal 0 Value at cal	0.10 0.11 0.01 Performance 50 20 15 Performance 2	mg/m mg/m mg/m Units mg/m
Not reported) Maximum standard uncertainty % of maximum standard uncertainty Interferent Concentration Variations CH ₄ range 20 range Dxygen effect variations Dxygen effect variations Dxygen effect Influence Quantitiy Variations Sensitivity to sample volume flow	U(Corr, _{vost})	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65	0.10 0.11 0.01 Value at cal 0 0 Value at cal 0 Value at cal 0	0.10 0.11 0.01 Performance 50 20 15 Performance 2 Performance 5	mg/m mg/m Units mg/m
Not reported) Maximum standard uncertainty % of maximum standard uncertainty Interferent Concentration Variations Interferent Concentration Variation	U(Corr _{vost})	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100	0.10 0.11 0.01 Value at cal 0 0 Value at cal 0 Value at cal 0 Value at cal 0 Value at cal 90	0.10 0.11 0.01 Performance 50 20 15 Performance 2 Performance 5 1	mg/m mg/m Units mg/m Units I/h
Not reported) Maximum standard uncertainty % of maximum standard uncertainty whetherent Concentration Variations H ₄ range I ₂ O range NO ₂ range NO ₂ range NOyene effect variations Doxygen effect variations Doxygen effect Influence Quantity Variations Sensitivity to sample volume flow Bensitivity to ambient temperature	U(Corr, _{vost})	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65	0.10 0.11 0.01 Value at cal 0 0 Value at cal 0 Value at cal 0	0.10 0.11 0.01 Performance 50 20 15 Performance 2 Performance 5	mg/m mg/m Units mg/m
Not reported) Maximum standard uncertainty % of maximum standard uncertainty nterferent Concentration Variations H ₄ range I ₂ O range I ₂ O range I ₃ O range I ₄ O range I ₄ O range I ₅ O range	U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{5%}) Minimum 0 0 8 Minimum 0 0 Minimum 55 99 278	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100 313	0.10 0.11 0.01 Value at cal 0 0 0 Value at cal 0 0 Value at cal 60 99 288	0.10 0.11	mg/m mg/m Units mg/m Units KPa
Maximum standard uncertainty 5% of maximum standard uncertainty 5% of maximum standard uncertainty Interferent Concentration Variations CH ₄ range N ₂ O range CO ₂ range Coxygen effect variations Coxygen effect variations Coxygen effect Influence Quantity Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage	U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{5%}) Minimum 0 0 8 Minimum 0 0 Minimum 55 99 278	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100 313	0.10 0.11 0.01 Value at cal 0 0 0 Value at cal 0 0 Value at cal 60 99 288	0.10 0.11	mg/m mg/m Units mg/m Units KPa
Not reported) Maximum standard uncertainty 5% of maximum standard uncertainty 5% of maximum standard uncertainty Interferent Concentration Variations SH ₄ range N ₂ O range SO ₂ range SO ₂ range Soxygen effect variations Soxygen effect variations Soxygen effect Influence Quantity Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty	U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{5%}) Minimum 0 0 8 Minimum 0 0 Minimum 55 99 278	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100 313 250 Test 1 0.37	0.10 O.11 O.01 Value at cal O O Value at cal O Value at cal O Test 2 O.37	0.10 O.11	mg/m mg/m Units mg/m Units KPa
Not reported) Maximum standard uncertainty % of maximum standard uncertainty % of maximum standard uncertainty Interferent Concentration Variations OH4 range % O range OD2 range OD2 range OD2 range Oxygen effect variations Oxygen effect variations Oxygen effect Influence Quantitiy Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Ombined uncertainty	U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{5%}) Minimum 0 0 8 Minimum 0 0 Minimum 55 99 278 187	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100 313 250	0.10 O.11 O.11 O.01 Value at cal O Value at cal O Value at cal 60 99 288 230 Test 2	0.10 0.11	mg/m mg/m Units mg/m Units KPa
Not reported) Maximum standard uncertainty 5% of maximum standard uncertainty 5% of maximum standard uncertainty Interferent Concentration Variations SH ₄ range N ₂ O range TO ₂ range TO ₂ range TO ₃ range TO ₄ range TO ₅ range TO ₆ range TO ₇ range TO ₈ rang	U(Corr,max) U(Corr,max) U(Corr,max) U(Corr,max) U(Corr,5%) Minimum 0 0 8 Minimum 0 0 Minimum 55 99 278 187 187 ppm pm mg/m ³	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100 313 250 Test 1 0.37 0.59	0.10 O.11 O.01 Value at cal O O Value at cal O Value at cal O Test 2 O.37	0.10 O.11	mg/m mg/m Units mg/m Units KPa
Not reported) Maximum standard uncertainty % of maximum standard uncertainty nterferent Concentration Variations CH ₄ range \$\frac{1}{2}\text{O} range} CO_2 range CO_	U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{max}) U(Corr, _{5%}) Minimum 0 0 8 Minimum 55 99 278 187 187 ppm mg/m ³	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100 313 250 Test 1 0.37 0.59	0.10 O.11 O.11 O.01 Value at cal O O Value at cal 60 99 288 230 Test 2 0.37 0.60	0.10 0.11	mg/m mg/m Units mg/m Units KPa
Not reported) Maximum standard uncertainty % of maximum standard uncertainty % of maximum standard uncertainty Interferent Concentration Variations SH ₄ range NO range DO ₂ range DO ₂ range DOygen effect variations Doygen effect variations Doygen effect variations Doygen effect variations Sensitivity to sample volume flow Sensitivity to ambient temperature Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Dombined uncertainty Expanded uncertainty expressed with a level of con Doverall uncertainty	U(Corr, max) U(Co	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100 313 250 Test 1 0.37 0.59 =2 0.7	0.10 O.11 O.11 O.01 Value at cal O Value at cal 60 99 288 230 Test 2 0.37 0.60	0.10 0.11	mg/m mg/m Units mg/m Units KPa
Maximum standard uncertainty 5% of maximum standard uncertainty 5% of maximum standard uncertainty Interferent Concentration Variations CH ₄ range N ₂ O range CO ₂ range CO ₂ range COxygen effect variations Coxygen effect variations Coxygen effect Influence Quantity Variations Sensitivity to sample volume flow Sensitivity to atmospheric pressure Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty Expanded uncertainty Doverall uncertainty Doverall uncertainty Doverall uncertainty	U(Corr,max) U(Corr,max) U(Corr,max) U(Corr,max) U(Corr,sss,)	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100 313 250 Test 1 0.37 0.59 =2 0.7 1.2	0.10 Value at cal	0.10 Performance 50 20 15 Performance 2 Performance 5 1 10 5 Test 3 0.38 0.61	mg/m mg/m Units mg/m Units KPa
Sensitivity to electrical voltage (Not reported) Maximum standard uncertainty 5% of maximum standard uncertainty 5% of maximum standard uncertainty Interferent Concentration Variations CH ₄ range N ₂ O range CO ₂ range Oxygen effect variations Oxygen effect variations Oxygen effect variations Sensitivity to sample volume flow Sensitivity to ambient temperature Sensitivity to ambient temperature Sensitivity to ambient temperature Sensitivity to electrical voltage Measurement uncertainty Combined uncertainty Combined uncertainty Expanded uncertainty Overall uncertainty Overall uncertainty Overall uncertainty Overall uncertainty relative to measured value Overall uncertainty relative to measured value Overall uncertainty relative to measured value	U(Corr, max) U(Co	0.10 0.11 0.01 Maximum 10 0 12 Maximum 20 Maximum 65 100 313 250 Test 1 0.37 0.59 =2 0.7	0.10 O.11 O.11 O.01 Value at cal O Value at cal 60 99 288 230 Test 2 0.37 0.60	0.10 0.11	mg/m mg/m Units mg/m Units KPa

The uncertainty evaluation has been carried out in accordance with UKAS requirements.