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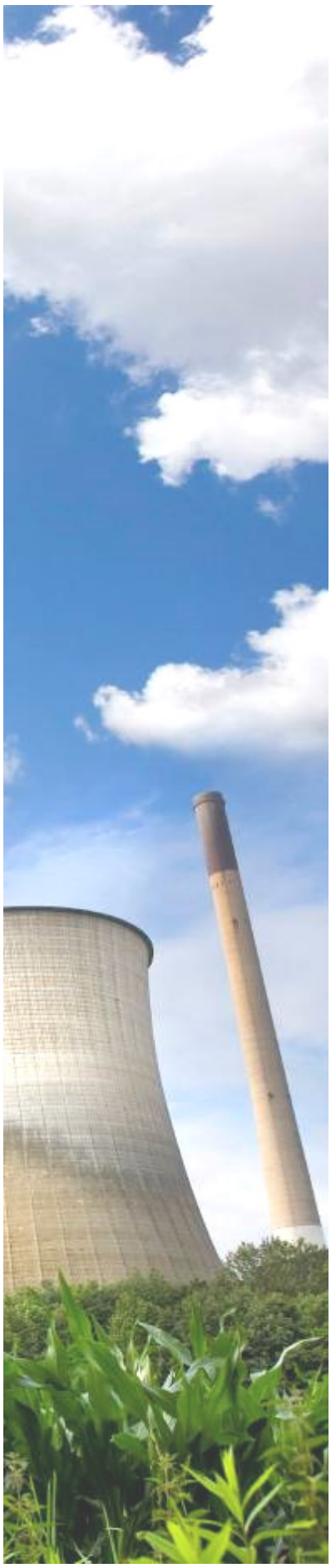
Resource & Environmental Consultants Ltd

UKAS TESTING 2082



MONITORING OF EMISSIONS FROM THE INKJET MANUFACTURING PROCESS

4-6 MARCH 2013

Prepared for Xaarjet Ltd

REC Report 71490p1r0

Issued: 27 March, 2013

REC Air Quality

GREEN ACHIEVER

SAFEcontractor APPROVED

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EXECUTIVE SUMMARY

Resource & Environmental Consultants (REC) Ltd was commissioned by Xaarjet Ltd to monitor emissions of pollutants released from the Inkjet manufacturing process at their site in Huntingdon. In accordance with the requirements of their site permit and internal requirements, monitoring has been undertaken for the following pollutants:-

- Acid gases including Hydrogen Chloride (HCl), Hydrogen Fluoride(HF), Nitric acid(HNO_3) & Sulphuric Acid (H_2S0_4)
- Fluorine
- Nickel , Lead & Zirconium
- Total Volatile Organic Compounds (VOCs) expressed as Carbon (C)
- Target VOCs, including Isopropanol & Acetone

The following results were obtained from the emission monitoring survey and are compared with the current permit limit:-

Species	Emission Source							UKAS Status	Permit Limit (mg/Nm^3)
	LEV 1	LEV 2	LEV 3	LEV 4	LEV 5	LEV 6	LEV 7		
	Emission Concentration in mg/m^3								
Total VOCs	29.1	5.5	-	-	-	-	-	A	75
Isopropanol	41.8	2.4	-	-	-	-	-	B	75
Acetone	7.0	3	-	-	-	-	-	B	75
Hydrogen Chloride	-	-	-	-	-	0.08	-	E	N/A
Hydrogen Fluoride	-	-	-	-	-	<0.01	-	E	N/A
Nitric Acid	-	-	-	-	-	0.33	0.04	E	N/A
Sulphuric Acid	-	-	-	-	-	<0.01	-	E	N/A
Nickel	-	-	-	-	-	<0.01	-	E	N/A
Fluorine	-	-	<0.8	<0.8	<0.5	-	-	E	N/A

NOTE 1: All data are expressed in mg/Nm^3 at 273K, 101.3kPa, without correction for moisture and oxygen content unless otherwise stated.
NOTE: UKAS Status:- (A) REC Ltd accredited for sampling and analysis. (B) REC Ltd accredited for sampling only, UKAS accredited analysis conducted by SAL Ltd. (C) REC Ltd accredited for sampling, sub-contracted analysis not UKAS accredited (D) REC Ltd not accredited for sampling, UKAS accredited analysis conducted by SAL Ltd. (E) REC Ltd not accredited for sampling, sub-contracted analysis not UKAS accredited.

EXECUTIVE SUMMARY (CONTINUED)

Species	Emission Source							UKAS Status	Permit Limit (mg/Nm^3)
	LEV 8	LEV 9	LEV 10	LEV 11	LEV 13	LEV 14	LEV 16		
	Emission Concentration in mg/m^3								
Total VOCs	-	1.9	-	-	9.7	0.4	0.5	A	75
Isopropanol	-	5.3	-	-	12.3	0.8	2.5	B	75
Acetone	-	2.1	-	-	14.8	1.9	1.4	B	75
Lead	0.03	-	<0.01	-	-	-	-	E	N/A
Nickel	-	-	-	-	-	-	-	E	N/A
Zirconium	<0.01	-	<0.01	-	-	-	-	E	N/A
Fluorine	-	-	-	<0.8	-	-	-	E	N/A

NOTE 1: All data are expressed in mg/Nm^3 at 273K, 101.3kPa, without correction for moisture and oxygen content unless otherwise stated.
NOTE: UKAS Status:- (A) REC Ltd accredited for sampling and analysis. (B) REC Ltd accredited for sampling only, UKAS accredited analysis conducted by SAL Ltd. (C) REC Ltd accredited for sampling, sub-contracted analysis not UKAS accredited (D) REC Ltd not accredited for sampling, UKAS accredited analysis conducted by SAL Ltd. (E) REC Ltd not accredited for sampling, sub-contracted analysis not UKAS accredited.

INTRODUCTION

1.1 Background

Xaarjet Ltd commissioned REC Ltd to conduct an emission monitoring survey on the Inkjet manufacturing process at their site in Huntingdon.

The process involves the use of solvents and acid based solutions in the production of inkjet cartridges.

1.2 Scope of the Survey

An emission monitoring survey was required to determine the release concentrations of various pollutants from the Inkjet manufacturing process. Concentrations of the following pollutants were quantified during the survey:

- Fluorine (F_2)
- Nickel (Ni)
- Lead (Pb) & Zirconium (Zr)
- Nitric acid (HNO_3)
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- Sulphuric Acid (H_2SO_4)
- Target VOCs, in particular Acetone & Isopropanol
- Total VOCs expressed as Carbon (C)

Ancillary measurements of stack dimensions, temperature and velocity were also made.

Sampling for Total VOCs was carried out on a continuous basis with measured concentrations being data-logged at 1 minute intervals over each sampling period.

All results were to be reported at 273K, 101.3kPa, wet gas, without correction for oxygen content.

1.3 Sampling Personnel

Monitoring was conducted by the following REC Ltd permanent staff:-

- Ibai Castezubi - Team Leader, MM05 674, MCERTS Level 2, TE1-4
- Aidan Wrynne - Assistant, MM08 921, MCERTS Level 1

2. METHODOLOGY

2.1 Species & Techniques

The following table shows the reference methods used for the emission monitoring survey:

Species	UKAS Status	Method	Uncertainty (±%)	Limit of Detection
Total VOCs (as C)	A	In house method MM0002 based on BS EN 13526	10	1 mg/m^3
Acetone	B	In house method MM0011 based on BS EN 13649	30	0.1 mg/m^3
Isopropyl Alcohol	B	In house method MM0011 based on BS EN 13649	30	0.1 mg/m^3
Hydrogen Chloride	E	Methodology based on NIOSH 7903	20	0.1 mg/m^3
Hydrogen Fluoride	E	Methodology based on NIOSH 7903	20	0.1 mg/m^3
Sulphuric Acid	E	Methodology based on NIOSH 7903	20	0.1 mg/m^3
Nitric Acid	E	Methodology based on NIOSH 7903	20	0.1 mg/m^3
Nickel	E	Methodology based on NIOSH 7900	20	0.01 mg/m^3
Lead	E	Methodology based on NIOSH 7900	20	0.01 mg/m^3
Zirconium	E	Methodology based on NIOSH 7900	20	0.01 mg/m^3
Fluorine	E	Methodology based on US EPA M26	20	0.1 mg/m^3

NOTE: UKAS Status:- (A) REC Ltd accredited for sampling and analysis. (B) REC Ltd accredited for sampling only, UKAS accredited analysis conducted by SAL Ltd. (C) REC Ltd accredited for sampling, sub-contracted analysis not UKAS accredited (D) REC Ltd not accredited for sampling, UKAS accredited analysis conducted by SAL Ltd. (E) REC Ltd not accredited for sampling, sub-contracted analysis not UKAS accredited.

2.2 Sampling & Analytical Methodology

Total VOCs

To determine the concentration of VOCs in emissions, a Bernath portable flame ionisation detector (FID) was employed. The analyser consists of a sintered filter, to remove particulate matter, a heated sampling line and heated FID block. This equipment satisfies the requirements of BS ENs 13526 and 12619 and in-house method MM0002 was followed.

The instrument is calibrated over a number of ranges against a traceable propane (C_3H_8) standard prior to and on completion of each test.

VOCs are detected by the FID with the output being proportional to the number of carbon atoms present in the sample. The readout displays a VOC figure expressed in ppm as carbon which is converted to mg/Nm^3 as carbon.

Target VOCs

Sampling for Isopropyl Alcohol and Acetone was carried out using charcoal adsorption tubes using methodology as per BS EN 13649 (in house method MM0011). The tubes were connected to low flow sampling pumps which were set to a flow rate of around 0.5 litres per minute (l/min) by a rotameter. The actual volume sampled was recorded on a dry gas meter.

The tubes were chemically desorbed and analysed by a high resolution GC/MS operating in the target mode to identify and quantify the compounds of interest against prepared standards. From the mass of each target VOC detected on the tube in microgram (µg/tube) and volume sampled, an emission concentration was calculated.

Acid Gases (HCl, HF, HNO_3 & H_2SO_4)

To determine the concentration of the above acids in emissions, sampling methodology based on the NIOSH Method 7903 was utilised.

A sample of the exhaust stream was removed from the stack via a PTFE probe and subsequently passed through a treated Silica gel tube. The tube was connected to a pump which was calibrated at a set flow rate of 0.5 l/min prior to and at the end of sampling.

Upon completion of sampling, the tube was capped, sealed and labelled before being stored in a cool box. The tube was subsequently analysed via an ion chromatographic (IC) technique.

Fluorine (USEPA 26A)

To determine the concentration of Fluorine (F_2) in emissions, sampling methodology based on US EPA Method 26A was utilised. A sample of the exhaust stream was removed from the stack via a PTFE probe and passed through a quartz fibre filter.

On leaving the filter, the sampled exhaust gas was passed into a series of Impingers. The first two contained dilute sodium hydroxide (0.1M NaOH) to absorb any F_2 present before passing through a dry gas meter (DGM) to measure the volume of gas sampled.

Upon completion of sampling, the contents of the first two Impingers were transferred to a sealed, labelled container, which was subsequently analysed for F_2 via an IC technique.

Nickel, Lead & Zirconium

Sampling for Nickel, Lead & Zirconium was conducted utilising methodology based on the Niosh method 7900.

A sample of the exhaust stream was extracted through a titanium probe and then passed through a quartz filter upon which any of the metals present would be collected. The sampling train was connected to a low flow pump which was set to a flow rate of 2 litres per minute.

Upon completion of sampling the filter was placed in to a petri dish, labelled and sent to the laboratory for analysis via ICP.

Stack Temperature and Velocity

To determine the stack temperature, a calibrated thermocouple and digital indicator were employed. The exhaust gas velocity was investigated using a pitot static probe (to MM0004) and digital manometer.

2.3 Laboratory Analysis

An approved UKAS accredited sub-contractor, SAL Ltd, undertook the sample analysis for the target VOCs (acetone and isopropanol), acid gases and metals. Analysis for target VOCs, lead and nickel was covered under their scope of accreditation. Analysis for acid gases, fluorine and zirconium was not covered under their UKAS scope.

A copy of their Certificate of Analysis is enclosed in Appendix 1.

3. SAMPLING AND OPERATIONAL DETAILS

3.1 Process Description

The operations at Xaarjet Ltd are authorised under a Part B permit issued by the Local Authority under the Environmental Permitting Regulations, 2010. The process is therefore under Local Authority regulation and must demonstrate compliance with the emission limits stipulated in the site permit: B22/11.

The following Guidance Note applies:- PG6/45 (11)

The main emissions covered under the permit are the VOCs with the additional testing being undertaken for internal information only.

The inkjet print head manufacturing process involves the utilisation of solvents, acids and plating solutions on a continuous basis in order to produce inks and print heads.

3.2 Sampling Positions

On LEV stacks 1 – 4, 1 x 12mm holes are located in a horizontal plane less than four hydraulic diameters downstream but greater than five hydraulic diameters upstream from potential flow disturbances. The flow criteria stipulated in the EA Technical Guidance Note M1 (EA TGN M1) was complied with in respect of LEV 3, but the LEV stacks 1, 2 & 4 did not comply with the flow criteria.

On LEV stacks 5, 7 & 8, 1 x 12mm holes are located in a vertical plane less than four hydraulic diameters downstream and upstream from potential flow disturbances. However, the gas flow criteria stipulated in EA TGN M1 was complied with.

On LEV stacks 9, 10 & 11, 1 x 12mm holes are located in a vertical plane less than four hydraulic diameters downstream and upstream from potential flow disturbances. However, the gas flow criteria stipulated in EA TGN M1was complied with.

On LEV stack 6, 1 x 12mm hole was installed in a horizontal plane greater than five hydraulic diameters downstream from any flow disturbances but less than four hydraulic diameters upstream from a bend. The flow criteria stipulated in EA TGN M1 was however complied with.

On LEV stacks 14 & 16, 1 x 25mm holes are located in a horizontal plane positioned less than five hydraulic diameters downstream from potential flow disturbances but greater than five hydraulic diameters upstream from potential flow disturbances. The flow criteria stipulated in EA TGN M1 was however complied with.

On LEV stack 13, 1 x 25mm hole is installed in a horizontal plane. The sampling plane is located less than five hydraulic diameters downstream from and less than two hydraulic diameters upstream from potential flow disturbances. The flow criteria stipulated in EA TGN M1 was however complied with.

Diagrams detailing the sampling positions and taken from Site Worksheets are provided in Appendix 2.

3.3 Uncertainty

As the pollutants are present in the gaseous phase and assumed to be homogenous across the sampling plane the standard uncertainties would apply in respect of the Total VOC and Target VOC test results.

The uncertainty values for the remaining pollutants are based on values stated in NIOSH methods. These have been included for reference purposes but lie outside the scope of RECs accreditation.

REC has calculated uncertainty budgets for the pollutants listed in the Method Details Table in Section 2.1 above, for which we are UKAS accredited, in accordance with calculations and methodology supplied by the Source Testing Association (STA). These uncertainties are quoted in the Tables section of this report.

3.4 Emission Monitoring Survey Details

The emission monitoring survey was carried out on the Inkjet manufacturing process over the period 4-6 March, 2013. The table overleaf summarises the actual sampling periods.

SAMPLING PERIODS

Stack	Parameter	Sample Time (& Date)
LEV 1	Total VOCs	14:23 - 15:23 (4/3/13)
	Target VOCs	14:26 -15:26 (4/3/13)
LEV 2	Total VOCs	15:29 -16:29 (4/3/13)
	Target VOCs	15:32 -16:32 (4/3/13)
LEV 3	Fluorine	14:03 -15:03 (4/3/13)
LEV 4	Fluorine	15:20 -16:20 (4/3/13)
LEV 5	Fluorine	13:19 - 14:19 (5/3/13)
LEV 6	HNO_3, HF / HCl /H_2SO_4	12:25 - 13:25 (5/3/13)
	Nickel	13:28 -14:28 (5/3/13)
LEV 7	HNO3	15:35 -16:35 (5/3/13)
LEV 8	Lead & Zirconium	15:35 - 16:35 (5/3/13)
LEV 9	Total VOCs	15:33 - 16:33 (5/3/13)
	Target VOCs	15:33 - 16:33 (5/3/13)
LEV 10	Lead & Zirconium	11:30 -12:30 (6/3/13)
LEV 11	Fluorine	10:50 -11:50 (5/3/13)
LEV 13	Total VOCs	12:53 -13:53 (5/3/13)
	Target VOCs	12:53 - 13:53 (5/3/13)
LEV 14	Total VOCs	11:00 -12:00 (6/3/13)
	Target VOCs	11:00 - 12:00 (6/3/13)
LEV 16	Total VOCs	10:35 -11:35 (6/3/13)
	Target VOCs	10:35 -11:35 (5/3/13)

4. RESULTS AND DISCUSSION

4.1 Initial Velocity and Temperature Traverse

An initial pitot-static pressure and temperature traverse was carried out. From these data stack velocity, expressed in metres per second (m/s), and volumetric flowrates expressed in cubic metre per hour (m^3/hr) have been calculated.

The results are reported at actual stack conditions and the volumetric flowrate is further expressed at the standard reference conditions of 273K, 101.3kPa i.e. standard temperature and pressure (STP). The results are summarised in Table 1.

4.2 Total VOCs Emission data

The results of the VOC monitoring tests are summarised in Table 2 and Figures 1 to 6. The table presents the average of concentrations measured throughout each of the sample periods.

Concentrations are expressed in mg/m^3 as carbon (C) at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour and O_2 content.

4.3 Target VOC Emission Data

The results of the VOC monitoring using adsorption tubes are summarised in Tables 3 to 5.

From the mass of each VOC detected on each tube in microgram (µg/tube), and the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

4.4 Fluorine Emission Data

The results of the Fluorine sampling runs are summarised in Tables 6 & 7.

From the concentration of Fluorine in the absorbing solution, and the measured volume of absorbing solution, a total mass of Fluorine in microgram (µg) was determined. From the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

4.5 Acid Gas Emission Data

The results of the acid gas emissions tests are summarised in Table 8.

From the mass of each respective acid gas detected on each tube in microgram, and the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

4.6 Nickel Emission Data

The results of the Nickel emissions tests are summarised in Table 9.

From the mass of Ni on the filter in microgram and the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

4.7 Lead & Zirconium Emission Data

The results of the Lead & Zirconium emissions tests are summarised in Table 10.

From the mass of Pb and Zr on the filter in microgram and the measured sample volume, an emission concentration has been calculated.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa, without correction for water vapour content and O_2 content.

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FIGURES

Fig 1: Total VOC Emission Data, XaarJet, Huntingdon, LEV 1 (04/03/13)

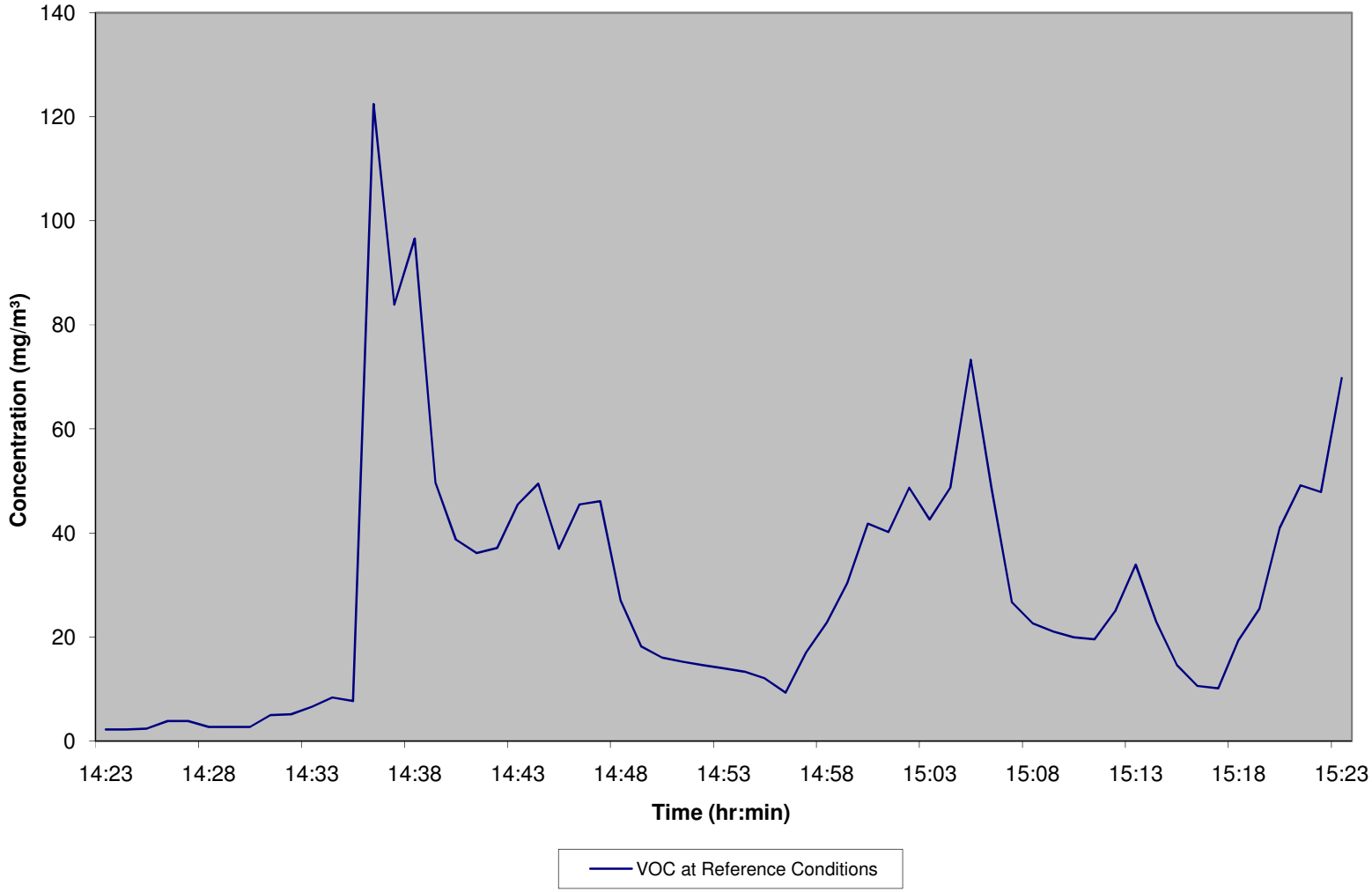


Fig 2: Total VOC Emission Data, XaarJet, Huntingdon, LEV 2 (04/03/13)

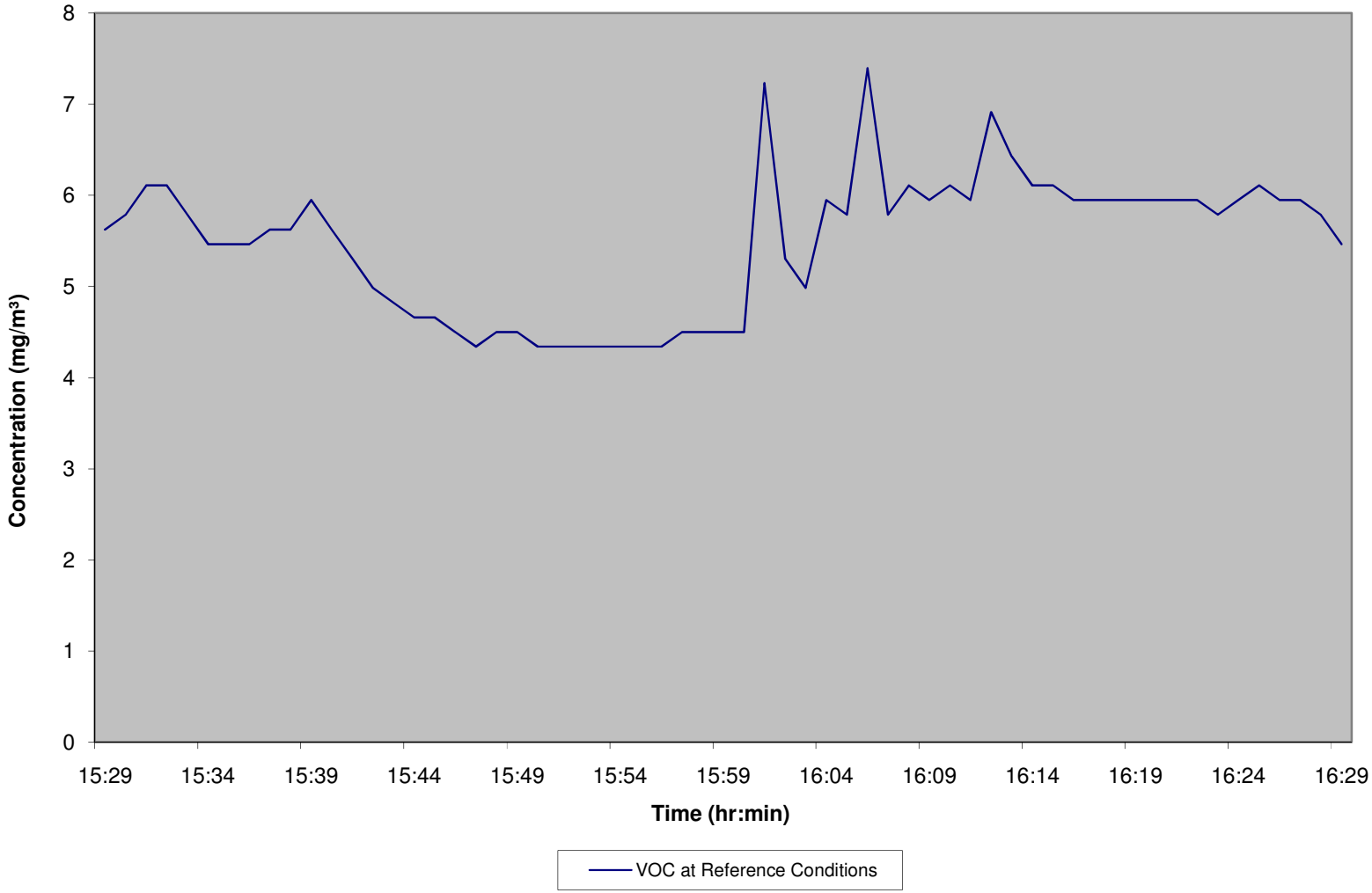


Fig 3 : Total VOC Emission Data, XaarJet, Huntingdon, LEV 9 (05/03/13)

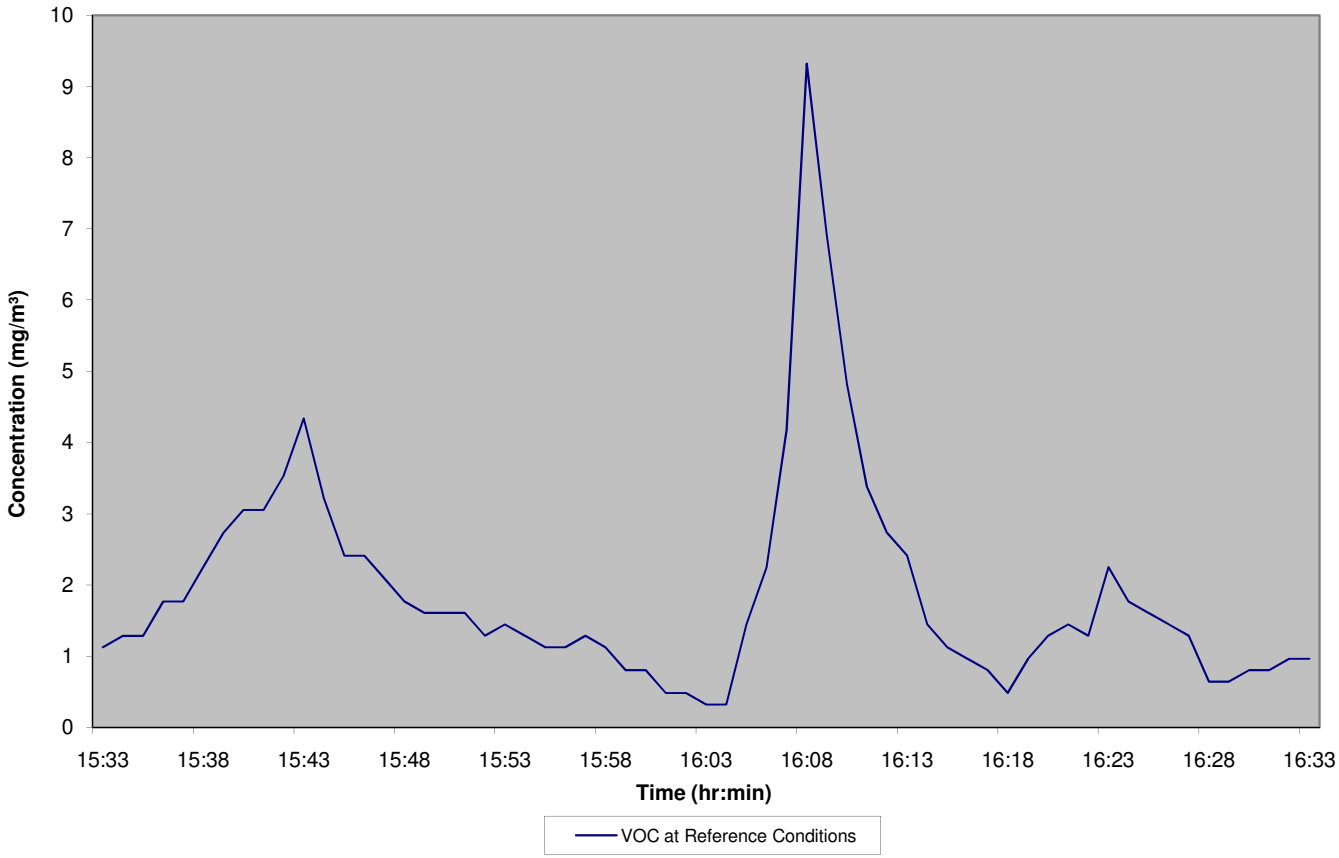


Fig 4 : Total VOC Emission Data, XaarJet, Huntingdon, LEV 13 (05/03/13)

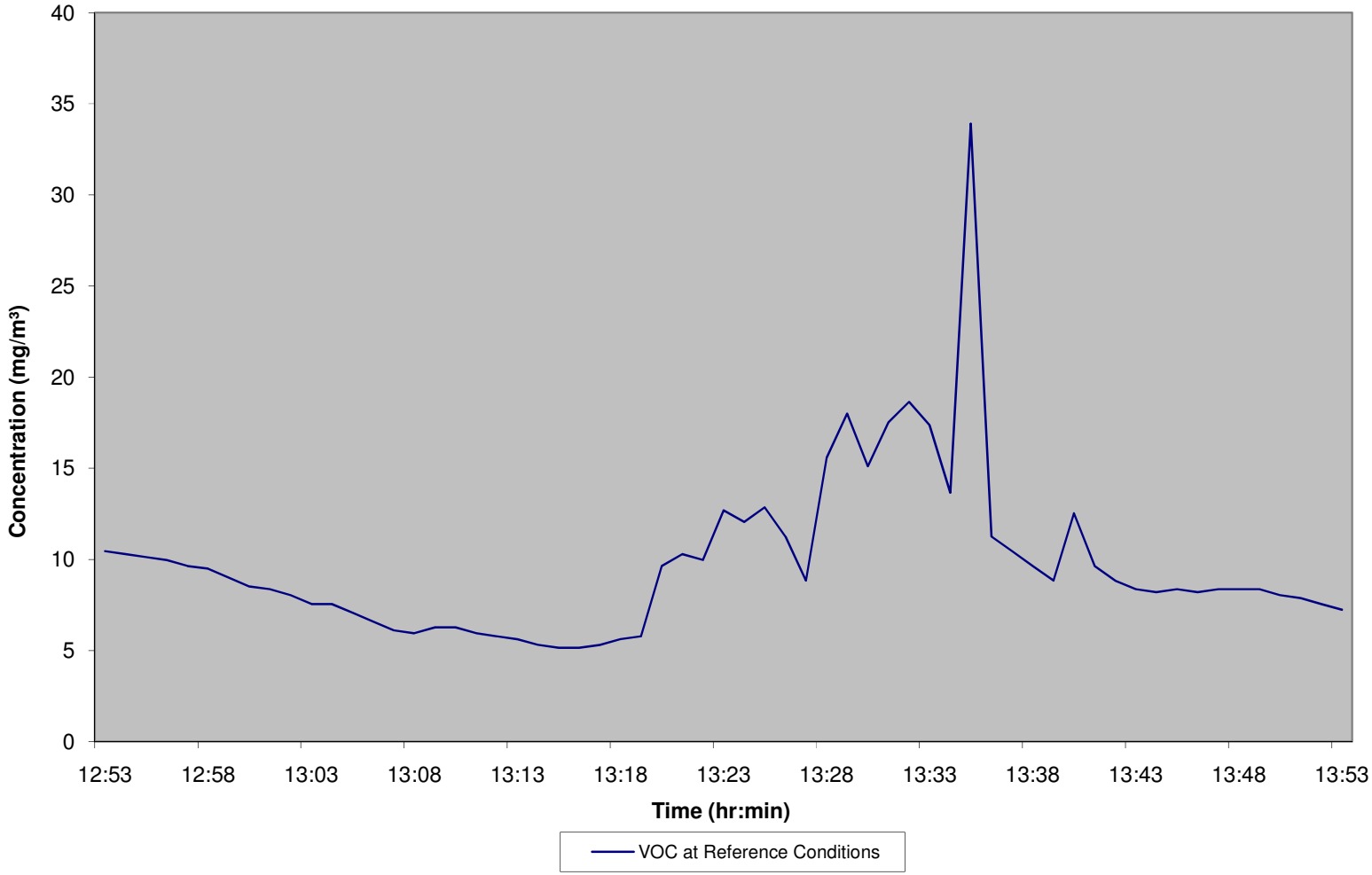


Fig 5 : Total VOC Emission Data, XaarJet, Huntingdon, LEV 14 (06/03/13)

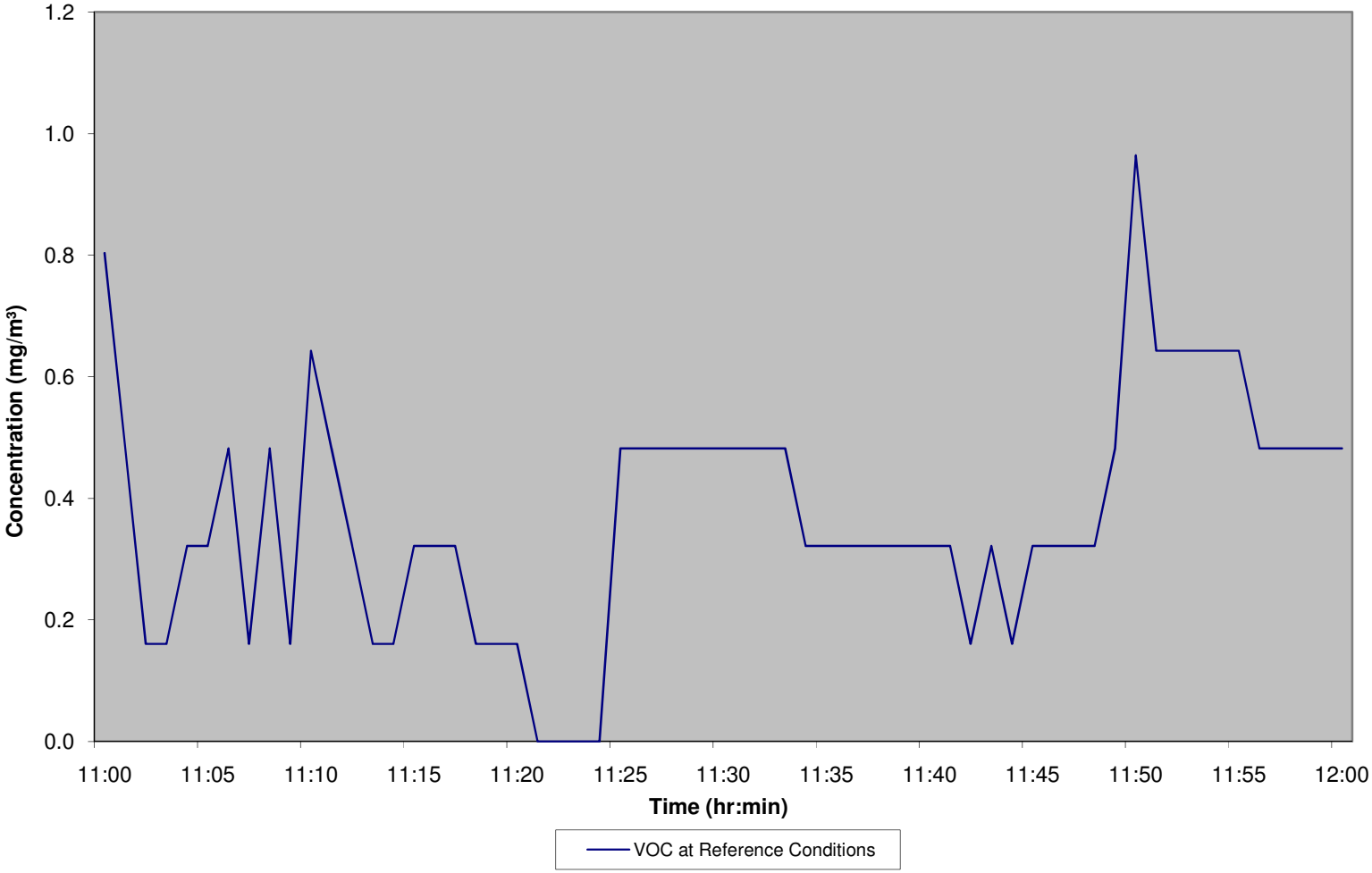
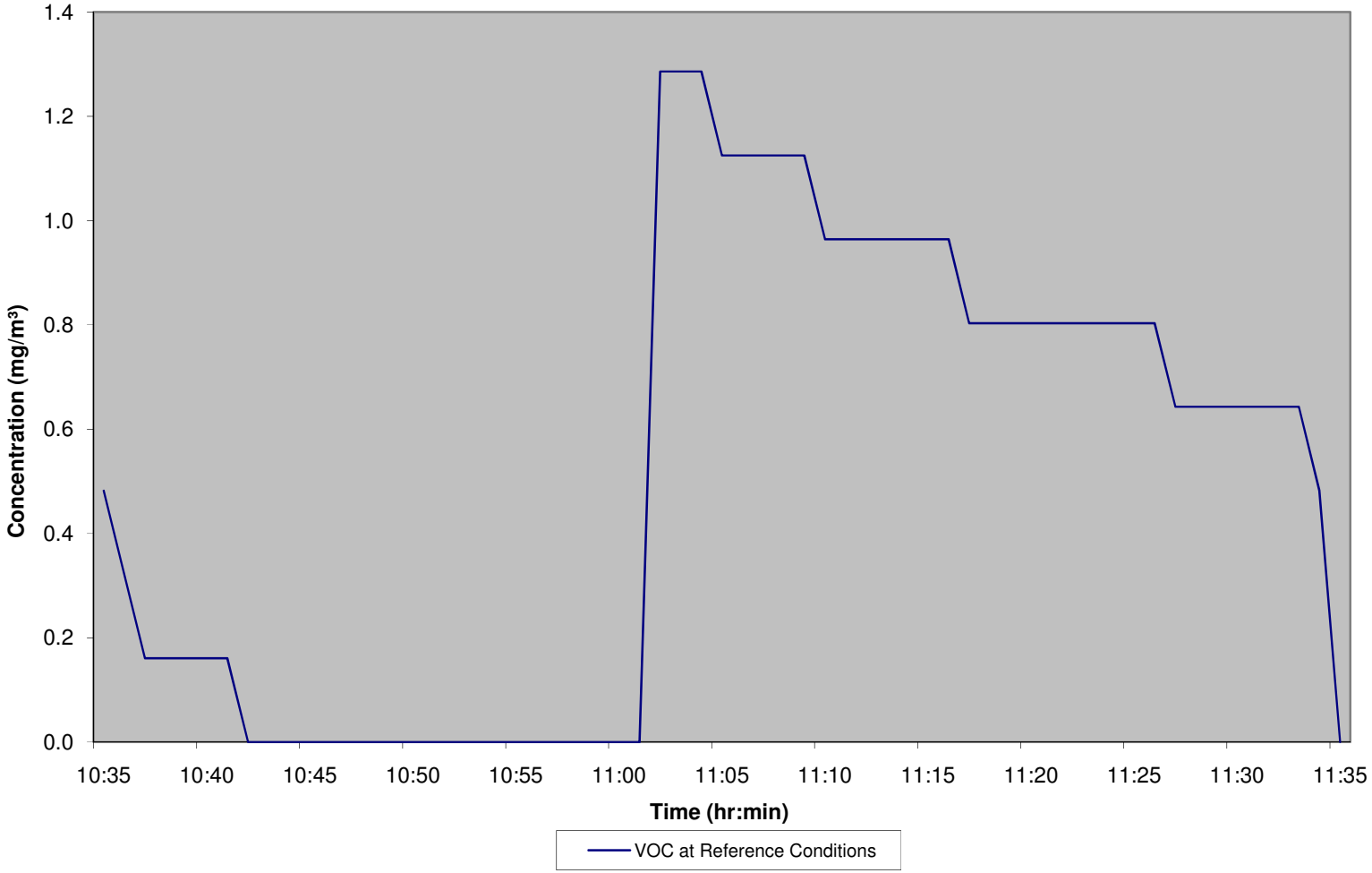


Fig 6 : Total VOC Emission Data, XaarJet, Huntingdon, LEV 16 (05/03/13)



TABLES

TABLE 1

FLOW DATA

Stack Ref.	Stack Temp	Av Pitot ΔP	Duct Diam	X-Sect. Area	Velocity (actual)	Volume Flow (m^3/hr)	
	(^{0}C)	(Pa)	(cm)	(m^2)	(m/s)	(actual)	(@ ntp)
LEV 1	21	35	40	0.126	7.6	3,440	3,201
LEV 2	22	32	30.5	0.073	7.2	1,901	1,762
LEV 3	25	7	40	0.126	3.4	1,526	1,401
LEV 4	16	22	31	0.075	6.0	1,624	1,537
LEV 5	25	51	31.5	0.078	9.2	2,580	2,367
LEV 6	21	35	45	0.159	7.6	4,358	4,046
LEV 7	22	43	30	0.071	8.4	2,137	1,979
LEV 8	22	19	31.5	0.078	5.6	1,574	1,460
LEV 9	23	21	30	0.071	5.8	1,486	1,373
LEV 10	20	10	45	0.159	4.0	2,287	2,136
LEV 11	21	9	40	0.126	3.8	1,716	1,595
LEV 13	23	45	57	0.255	8.7	7,955	7,336
LEV 14	23	65	45	0.159	10.4	5,959	5,496
LEV 16	25	47	25	0.049	8.2	1,447	1,325

TABLE 2

TOTAL VOC EMISSION DATA SUMMARY –

Stack Ref	Total VOCs	
	ppm (as C_3H_8)	mg/m^3 (as C)
LEV 1	18.1	29.1
Uncertainty (±)		2.6
LEV 2	3.4	5.5
Uncertainty (±)		2.5
LEV 9	1.2	1.9
Uncertainty (±)		2.5
LEV 13	6.1	9.7
Uncertainty (±)		2.6
LEV 14	0.2	0.4
Uncertainty (±)		2.6
LEV 16	0.3	0.5
Uncertainty (±)		2.6

TABLE 3

ACETONE & ISOPROPYL ALCOHOL EMISSION DATA – LEV 1 & 2

Sampling Data	**lev 1**	**lev 2**
DGM Ref (AQ No.)	337	337
Start Time	14:26	15:32
End Time	15:26	16:32
DGM Start (m^3)	40.0600	40.0952
DGM End (m^3)	40.0900	40.1252
Volume Sampled (litres)	30.000	30.000
Ambient Temp (^oC)	14	14
Ambient Press (kPa)	102	102
Volume Sampled, 273K, 101.3kPa (litres)	28.734	28.734
Analytical Data	**71490/1**	**71490/2**
Mass Isopropyl alcohol on tube front (µg)	1200	69
Mass Isopropyl alcohol on tube back (µg)	<10	<10
Mass on Back-up Section (%)	0.0	0.0
Mass acetone on tube front section (µg)	200	86
Mass Acetone on tube rear section (µg)	<10	<10
Mass on Back-up Section (%)	0.0	0.0
Emission Concentration Data		
VOC Isopropyl alcohol (mg/m^3)	41.8	2.4
Uncertainty (± mg/m^3)	12.5	0.7
VOC Acetone (mg/m^3)	7.0	3.0
Uncertainty (± mg/m^3)	2.1	0.9

TABLE 4

ACETONE & ISOPROPYL ALCOHOL EMISSION DATA – LEV 9 & 13

Sampling Data	lev 9	lev 13
DGM Ref (AQ No.)	337	337
Start Time	15:33	12:53
End Time	16:33	13:53
DGM Start (m^3)	40.2320	40.1910
DGM End (m^3)	40.2620	40.2210
Volume Sampled (litres)	30.000	30.000
Ambient Temp (^oC)	17	17
Ambient Press (kPa)	102	102
Volume Sampled, 273K, 101.3kPa (litres)	28.437	28.437
Analytical Data	**71490/12**	**71490/11**
Mass Isopropyl alcohol on tube front (µg)	150	350
Mass Isopropyl alcohol on tube back (µg)	<10	<10
Mass on Back-up Section (%)	0.0	0.0
Mass acetone on tube front section (µg)	59	420
Mass Acetone on tube rear section (µg)	<10	<10
Mass on Back-up Section (%)	0.0	0.0
Emission Concentration Data		
VOC Isopropyl alcohol (mg/m^3)	5.3	12.3
Uncertainty (± mg/m^3)	1.6	3.7
VOC Acetone (mg/m^3)	2.1	14.8
Uncertainty (± mg/m^3)	0.6	4.4

TABLE 5

ACETONE & ISOPROPYL ALCOHOL EMISSION DATA – LEV 14 & 16

Sampling Data	**lev 14**	**lev 16**
DGM Ref (AQ No.)	337	337
Start Time	11:00	10:35
End Time	12:00	11:35
DGM Start (m^3)	40.2750	40.1420
DGM End (m^3)	40.3050	40.1720
Volume Sampled (litres)	30.000	30.000
Ambient Temp (^oC)	17	17
Ambient Press (kPa)	102	102
Volume Sampled, 273K, 101.3kPa (litres)	28.437	28.437
Analytical Data	**71490/16**	**71490/6**
Mass Isopropyl alcohol on tube front (µg)	22	72
Mass Isopropyl alcohol on tube back (µg)	<10	<10
Mass on Back-up Section (%)	0.0	0.0
Mass acetone on tube front section (µg)	54	40
Mass Acetone on tube rear section (µg)	<10	<10
Mass on Back-up Section (%)	0.0	0.0
Emission Concentration Data		
VOC Isopropyl alcohol (mg/m^3)	0.8	2.5
Uncertainty (± mg/m^3)	0.2	0.8
VOC Acetone (mg/m^3)	1.9	1.4
Uncertainty (± mg/m^3)	0.6	0.4

TABLE 6

FLUORINE EMISSION DATA SUMMARY - LEV 3 & 4

Sampling Data	LEV 3	LEV 4
Start Time/Date	14:03, 04/03/13	15:20, 04/03/13
End Time/Date	15:03, 04/03/13	16:20, 04/03/13
Sampling Period (min)	60	60
Start flow rate (l/min))	5.000	5.000
End flow rate (l/min)	5.000	5.000
Volume Sampled (litres)	300.00	300.00
Ambient Temp (^{o}C)	14	14
Ambient Press (kPa)	102	102
Wt of Water (g)	2.8	2.0
Volume Water (m^3)	0.003	0.002
Volume Sampled, 273K, 101.3kPa (dry litres)	287.338	287.338
Volume Sampled, 273K, 101.3kPa (wet litres)	287.341	287.340
Volume NaOH Impingers (ml)	460	410
Analytical Data	**71490/3**	**71490/4**
F in NaOH Blank (mg/l)	<0.5	<0.5
F in NaOH Imps (mg/l)	0.50	0.50
F in NaOH (µg)	242	216
Emission Concentration Data (mg/m^3)		
F_2	<0.8	<0.8

TABLE 7

FLUORINE EMISSION DATA – LEV 5 & 11

Sampling Data	**LEV 5**	**LEV 11**
Start Time/Date	13:19, 05/03/13	10:50, 05/03/13
End Time/Date	14:19, 05/03/13	11:50, 04/03/13
Sampling Period (min)	60	60
Start flowrate (l/min))	5.000	5.000
End flowrate (l/min)	5.000	5.000
Volume Sampled (litres)	300.00	300.00
Ambient Temp (^{o}C)	17	17
Ambient Press (kPa)	102	102
Wt of Water (g)	0.5	1.3
Volume Water (m^3)	0.001	0.002
Volume Sampled, 273K, 101.3kPa (dry litres)	284.365	284.365
Volume Sampled, 273K, 101.3kPa (wet litres)	284.366	284.367
Volume NaOH Impingers (ml)	290	430
Analytical Data	71490/3	71490/4
F in NaOH Blank (mg/l)	<0.5	<0.5
F in NaOH Imps (mg/l)	0.50	0.50
F in NaOH (µg)	<153	<226
Emission Concentration Data (mg/m^3)		
F_2	<0.54	<0.80

TABLE 8

HNO_3 / HF / HCL & H_2SO_4 EMISSION DATA – LEV 6 & 7

Sampling Data	LEV 6	LEV 7
Start Time	12:25	15:35
End Time	13:25	16:35
Start flowrate (l/min))	0.5	1
End flowrate (l/min)	0.5	1
Sampling Period (min)	60	60.00
Volume Sampled (litres)	30.000	30.000
Ambient Temp (^oC)	17	17
Ambient Press (kPa)	102	102
Volume Sampled, 273K, 101.3kPa (litres)	28.437	28.437
Analytical Data	**71490/9**	**71490/13**
Mass HCl on tube (µg)	2.3	-
Mass HNO_3 tube (µg)	9.5	1
Mass H_2SO_4 on tube (µg)	<0.2	-
Mass HF on tube (µg)	<0.2	-
Emission Concentration Data (mg/m^3)		
HF	<0.01	-
HCl	0.08	-
H_2SO_4	<0.01	-
HNO_3	0.33	0.04
Uncertainty (± mg/m^3)	0.1	0.1

TABLE 9

NICKEL EMISSION DATA – LEV 6

Sampling Data	**LEV 6**
Start Time	13:28
End Time	14:28
Start flowrate (l/min))	1.5
End flowrate (l/min)	1.5
Sampling Period (min)	60
Volume Sampled (litres)	90.000
Ambient Temp (^{o}C)	17
Ambient Press (kPa)	102
Volume Sampled, 273K, 101.3kPa (litres)	85.310
Analytical Data	**71490/8**
Mass Nickel (μg)	<1
Emission Concentration Data (mg/m^{3})	
Nickel	<0.01
Uncertainty (± mg/m^{3})	0.01

TABLE 10

LEAD & ZIRCONIUM EMISSION DATA – LEV 8 & 10

Sampling Data	**LEV 8**	**LEV 10**
Start Time	11:30	12:05
End Time	12:30	13:05
Start flowrate (l/min))	2	2
End flowrate (l/min)	2	2
Sampling Period (min)	60	60
Volume Sampled (litres)	120.000	120.000
Ambient Temp (^{o}C)	20	20
Ambient Press (kPa)	102	102
Volume Sampled, 273K, 101.3kPa (litres)	112.581	112.581
Analytical Data	**71490/14**	**71490/8**
Mass Lead (µg)	3	<1
Mass Zirconium (µg)	<1	<1
Emission Concentration Data (mg/m^3)		
Lead	<0.01	<0.01
Zirconium	0.03	<0.01
Uncertainty (± mg/m^3)	0.01	0.01

APPENDIX 1

Certificate of Analysis

Scientific Analysis Laboratories is a
limited company registered in England and
Wales (No 2514788) whose address is at
Hadfield House, Hadfield Street, Manchester M16 9FE

Scientific Analysis Laboratories Ltd

Certificate of Analysis

Hadfield House
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Cornbrook
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Tel : 0161 874 2400
Fax : 0161 874 2404

Report Number: 320263-1

Date of Report: 18-Mar-2013

Customer: Resource Environmental Consultants Ltd
Unit 19
Bordesley Trading Estate
Bordesley Green Road
Birmingham
B8 1BZ

Customer Contact: Mr Ibai Castezubi

Customer Job Reference: 71490
Customer Site Reference: Date Collected: 4-6/3/13
Date Job Received at SAL: 11-Mar-2013
Date Analysis Started: 13-Mar-2013
Date Analysis Completed: 18-Mar-2013

The results reported relate to samples received in the laboratory
Opinions and interpretations expressed herein are outside the scope of UKAS accreditation
This report should not be reproduced except in full without the written approval of the laboratory
Tests covered by this certificate were conducted in accordance with SAL SOPs
All results have been reviewed in accordance with QP22

UKAS TESTING
1549

Report checked
and authorised by :
Mary Drury
Project Manager

Issued by :
Mary Drury
Project Manager

Signature valid
Digitally signed by Mary Drury
Date: 2013.03.18 16:06:06 GMT
Reason: Issue
Location: SAL

SAL Reference: 320263
Project Site: Date Collected: 4-6/3/13
Customer Reference: 71490

Impinger (sodium hydroxide) Analysed as Impinger (sodium hydroxide)
Miscellaneous

					SAL Reference	320263 005	320263 006	320263 011	320263 014	320263 026
					Customer Sample Reference	71490/3	71490/4	71490/7	71490/10	71490/19
					Test Sample	AR	AR	AR	AR	AR
Determinand	**Method**	**LOD**	**Units**	**Symbol**						
Fluorine	IC	0.50	mg/l	N		(13) <0.50	(13) <0.50	(13) <0.50	(13) <0.50	(13) <0.50
Volume	Vol	1	ml	U		**460**	**410**	**430**	**290**	**97**

SAL Reference: 320263
Project Site: Date Collected: 4-6/3/13
Customer Reference: 71490

Filter Analysed as Filter
Miscellaneous

					SAL Reference	320263 012	320263 020	320263 021	320263 025
					Customer Sample Reference	71490/8	71490/14	71490/15	71490/18
					Test Sample	AR	AR	AR	AR
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Lead	ICP/OES	1	µg	U		-	**3**	<1	<1
Nickel	ICP/OES	1	µg	U		<1	-	-	<1
Zirconium	ICP/OES	1	µg	N		-	<1	<1	<1

SAL Reference: 320263
Project Site: Date Collected: 4-6/3/13
Customer Reference: 71490

Tube (Silica Gel) Analysed as Tube (Silica Gel)
Suite B

					SAL Reference	320263 013	320263 019	320263 024
					Customer Sample Reference	71490/9	71490/13	71490/17
					Test Sample	AR	AR	AR
Determinand	**Method**	**LOD**	**Units**	**Symbol**				
Hydrochloric acid	IC	0.2	µg	N		(13) **2.3**	-	(13) <0.2
Hydrogen Fluoride	IC	0.2	µg	N		(13) <0.2	-	(13) <0.2
Nitric Acid	IC	0.2	µg	N		(13) **9.5**	(13) **1.0**	(13) <0.2
Sulphuric acid	IC	0.2	µg	N		(13) <0.2	-	(13) <0.2

SAL Reference: 320263
Project Site: Date Collected: 4-6/3/13
Customer Reference: 71490

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Suite C

					SAL Reference	320263 001	320263 002	320263 003	320263 004	320263 007
					Customer Sample Reference	71490/1 FRONT	71490/1 BACK	71490/2 FRONT	71490/2 BACK	71490/5 FRONT
					Test Sample	AR	AR	AR	AR	AR
Determinand	**Method**	**LOD**	**Units**	**Symbol**						
Acetone	GC/MS	10	µg	U		**200**	<10	**86**	<10	<10
Propan-2-ol	GC/MS	10	µg	U		**1200**	<10	**69**	<10	<10

SAL Reference: 320263
Project Site: Date Collected: 4-6/3/13
Customer Reference: 71490

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Suite C

				SAL Reference	**320263 008**	**320263 009**	**320263 010**	**320263 015**	**320263 016**
				Customer Sample Reference	**71490/5 BACK**	**71490/6 FRONT**	**71490/6 BACK**	**71490/11 FRONT**	**71490/11 BACK**
				Test Sample	**AR**	**AR**	**AR**	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**					
Acetone	GC/MS	10	µg	U	<10	**40**	<10	**420**	<10
Propan-2-ol	GC/MS	10	µg	U	<10	**72**	<10	**350**	<10

SAL Reference: 320263
Project Site: Date Collected: 4-6/3/13
Customer Reference: 71490

Tube (Charcoal 226-09) Analysed as Tube (Charcoal 226-09)
Suite C

				SAL Reference	**320263 017**	**320263 018**	**320263 022**	**320263 023**
				Customer Sample Reference	**71490/12 FRONT**	**71490/12 BACK**	**71490/16 FRONT**	**71490/16 BACK**
				Test Sample	**AR**	**AR**	**AR**	**AR**
Determinand	**Method**	**LOD**	**Units**	**Symbol**				
Acetone	GC/MS	10	µg	U	**59**	<10	**54**	<10
Propan-2-ol	GC/MS	10	µg	U	**150**	<10	**22**	<10

Index to symbols used in 320263-1

Value	Description
AR	As Received
13	Results have been blank corrected.
U	Analysis is UKAS accredited
N	Analysis is not UKAS accredited

APPENDIX 2

Diagrams of Sampling Points

LEV 1 -4


Outside Acid stack No.1
Outside VOC stack No.1
Outside VOC stack No.2
Outside Acid stack No.2
RHF

LEV 5 – 8


Stack No.4
Stack No.3
Stack No.2
Stack No.1

LEV 16

LEV 14

LEV 6

LEV 10, 11 & 13

APPENDIX 3

Calculations

Conversion Factors

ppm ® mg/Nm³ (at 273K, 101.3kPa: STP)

CO	x	1.25	
SO_2	x	2.86	
VOC's	x	1.61	(ppm as C_3H_8 to mg/Nm^3 as C)
NO_X	x	2.05	(ppm NO + NO_2 to mg/m^3 as NO_2)

Oxygen Correction to Reference Value

Concentration at (STP) -> Concentration at 273K, 101.3kPa, reference O_2 and Dry Gas, i.e.

Concentration X ((20.9-O_2 ref)/(20.9-O_2 measured)) = Concentration at ref Oxygen state.

Example Calculation

SO_2 concentration at STP	=	170.7 mg/Nm³
Oxygen percentage in gas stream	=	13.8%
Reference Oxygen	=	11%

SO_2 concentration at reference O_2 conditions	=	170.7 ((20.9-11)/(20.9-13.8))
	=	238 mg/Nm³ at 273K, 101.3kPa, 11% O_2 and Dry Gas

Moisture Correction (Wet to Dry)

Concentration of Gas Dry = Concentration of x 100/100-Bws Gas Wet

Concentration of Gas Wet = Concentration of x 100-Bws/100 Gas Dry

Where Bws = moisture content of gas stream in percent (Vol/Vol).

Example

VOC concentration	=	25 mg/Nm³ (Wet)
Moisture Content	=	27.1%
Concentration of VOC	=	25 (100/(100-27.1))

Carbon (C) to Trichloethylene (TCE)

ppm TCE = ppm C x 0.6715

TCE in mg/m^3 = TCE ppm x 5.864 (Mol Wt/22.4)