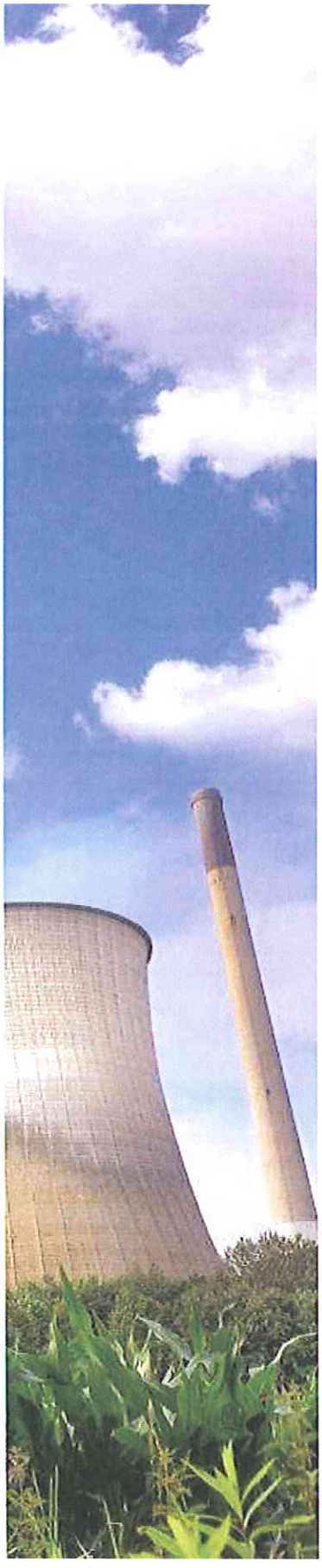
REC
Resource & Environmental Consultants Ltd

UKAS TESTING 2082



MONITORING OF EMISSIONS FROM CREMATORS, COVENTRY CREMATORIUM

6 & 7 JANUARY, 2011

Prepared for Coventry Crematorium

REC Report 71288p1r1

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REC Air Quality

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EXECUTIVE SUMMARY

Resource & Environmental Consultants (REC) Ltd was commissioned by Coventry Crematorium to monitor emissions of pollutants released from the two gas fired cremators at their site.

In accordance with the requirements of the site permit and with reference to Process Guidance Note PG 5/2 (04), monitoring has been undertaken for the following pollutants:-

- Combustion Gases including O_2 & CO
- Total Particulate Matter
- Hydrogen Chloride (HCl)
- Total Volatile Organic Compounds (VOCs) expressed as Carbon (C)

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

Species	Accreditation Status	Average Emission Concentration (mg/Nm^3)						Permit Limit (mg/Nm^3)
		Cremator 3			Cremator 4			
		Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	
Total VOCs (as C)	A	2	2	1	2	<1	<1	20
Carbon Monoxide	A	1	<1	<1	2	<1	5	100
Particulate Matter	A	81.8	125.0	73.8	94.9	134.0	126.2	80
Hydrogen Chloride	B	53.8	84.5	57.0	48.2	65.1	60.9	200

NOTE 1: All data are expressed in mg/Nm^3 at 273K, 101.3kPa, dry gas and corrected to 11% 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

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
Moisture	A	In house method MM0010 based on BS EN 14790	20	0.1%vol
Particulate Matter	A	In house method MM0004 based on BS ISO 9096	10	1 mg/m^3
Hydrogen Chloride	B	In house method MM0006 based on BS EN 1911	15	0.1 mg/m^3
Carbon Monoxide	A	In house method MM0002 based on ISO 12039	10	1 mg/m^3
Oxygen	A	In house method MM0002 based on ISO 12039	10	0.1%vol
Total VOCs (as C)	A	In house method MM0002 based on BS EN 12619	10	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.

2.2 Sampling & Analytical Methodology

Total Particulate Matter

To determine the concentration of particulate matter in emissions, isokinetic stack sampling equipment satisfying the requirements of BS ISO 9096 was utilised and in-house method MM0004 followed.

The Standard describes the methodology for measuring particulate matter under defined conditions and at discrete locations in the duct. Sampling is carried out under isokinetic sampling conditions i.e. the flowrate through the sampling nozzle is adjusted to equal the flowrate in the duct at the sampling positions. Velocity pressures were recorded throughout the monitoring period by means of an 'S' type pitot integral to the sampling probe and nozzle assembly.

A sample of the exhaust stream was removed from the stack via a titanium nozzle and titanium lined heated probe. It was then passed through a quartz fibre filter contained in a heated oven compartment. The temperature of the probe and filter box were maintained at 160ºC i.e. above the dew point of the stack gases, to ensure moisture did not condense on the filter. Each filter used complied with the requirements of Section 6.2.7 of BS EN 13284-1:2001 in that the efficiency was better than 99.5% for particles of 0.3µm diameter (or 99.9% for particles of 0.6µm diameter).

For each parameter the measured value (m.v.) and accuracy associated with this type of measurement using the Testo 330 is:

O_2	±	0.8% of full scale deflection
CO	±	2ppm (0-39.9ppm), ± 5% of m.v. (40 - 500ppm).

The analyser would be calibrated against traceable test gases prior to the survey.

The Standards describe the methodology for measuring the combustion gases listed above under defined conditions in the duct. Sampling is carried out under anisokinetic sampling conditions as it is assumed that the gas is homogenous across the sample plane.

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.

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.

Table in Section 2.1 above in accordance with calculations and methodology supplied by the Source Testing Association (STA). These uncertainties are quoted in the Tables section of this report.

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 Particulate Matter

The results of the particulate sampling runs are summarised in Tables 2 to 7. From the mass of particulate matter on the filter and in the acetone/water wash residue and volume sampled an emission concentration was calculated.

The results are expressed in mg/m^3 at 273K, 101.3kPa, dry gas and referenced to 11% O_2 content.

4.3 Hydrogen Chloride

The results of the volatile chloride sampling runs are also summarised in Tables 2 to 7. From the concentration of Cl^- and the measured volume of absorbing solution a total mass of HCl in microgram (µg) was determined. From their respective molecular weights, equivalent weights of HCl were then calculated. From the measured sample volume, an emission concentration was calculated.

The results are expressed in mg/m^3 at 273K, 101.3kPa, dry gas and referenced to 11% O_2 content.

4.4 Combustion Gases

The results of the combustion gas monitoring tests are summarised in Table 8 and Figures 1 to 6. The table presents the average of concentrations measured throughout each of the sample periods.

The results are expressed in mg/m^3 at 273K, 101.3kPa, dry gas and referenced to 11% O_2 content.

4.5 Total VOC Emission Data

The results of the VOC monitoring tests are summarised in Tables 8 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 273K, 101.3kPa, dry gas and referenced to 11% O_2 content. Measured concentrations on a wet gas basis have been converted to a dry gas basis using moisture measurements from the particulate/ HCl runs.

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Fig 1: Combustion Gas & Total VOC Emission Data, Coventry Crematorium, Cremator 3- Run 1 (06/01/11)

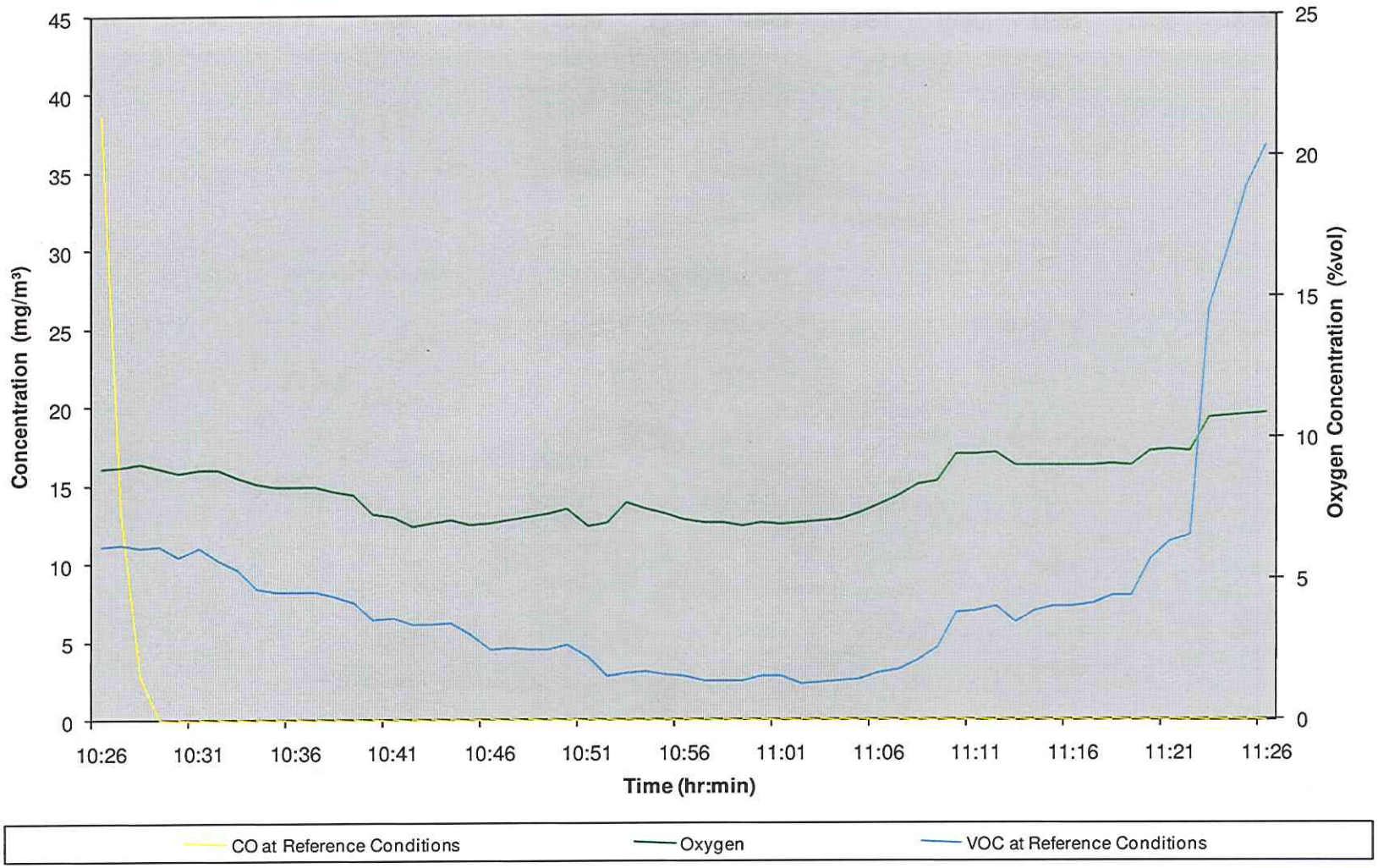


Fig 3: Combustion Gas & Total VOC Emission Data, Coventry Crematorium, Cremator 3- Run 3 (06/01/11)

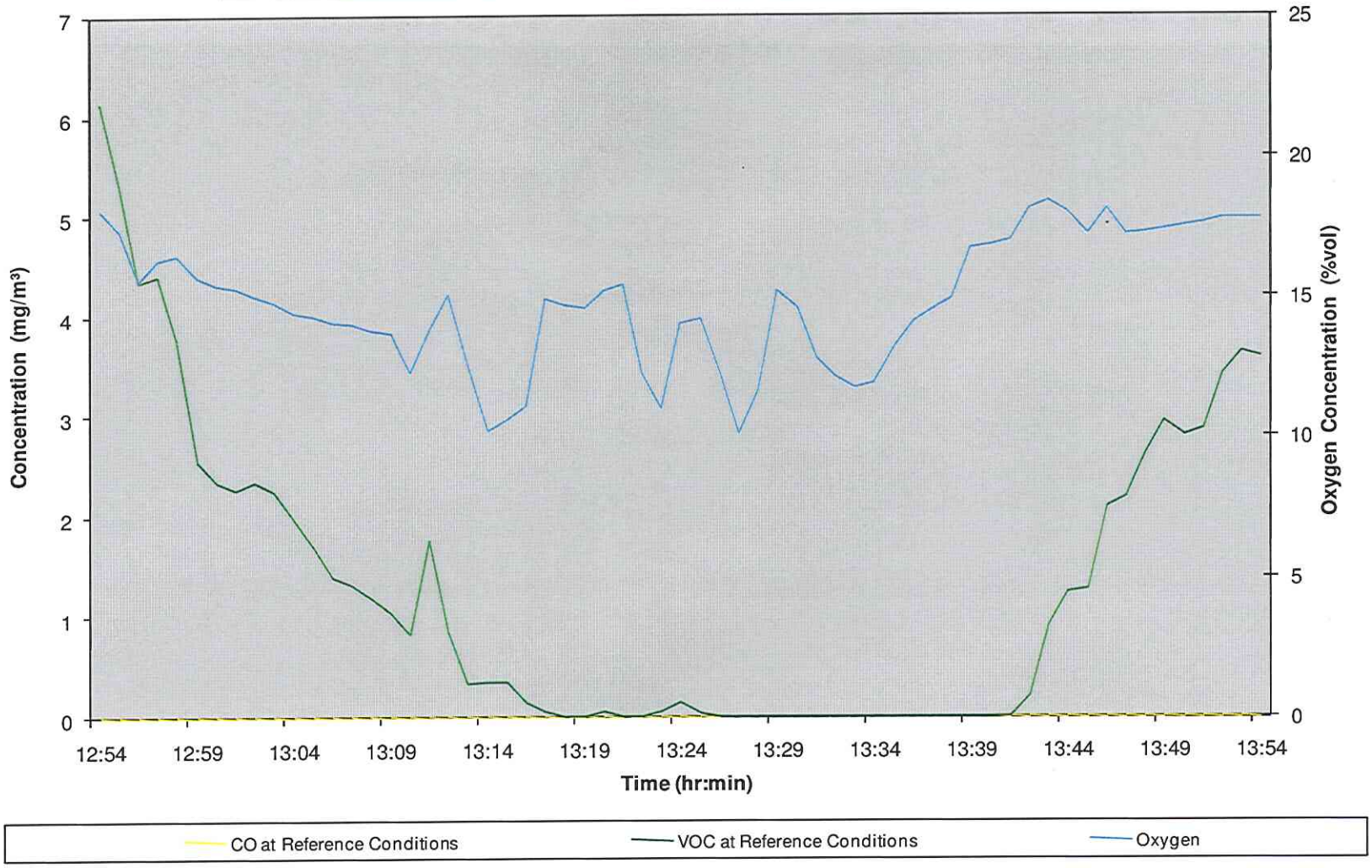
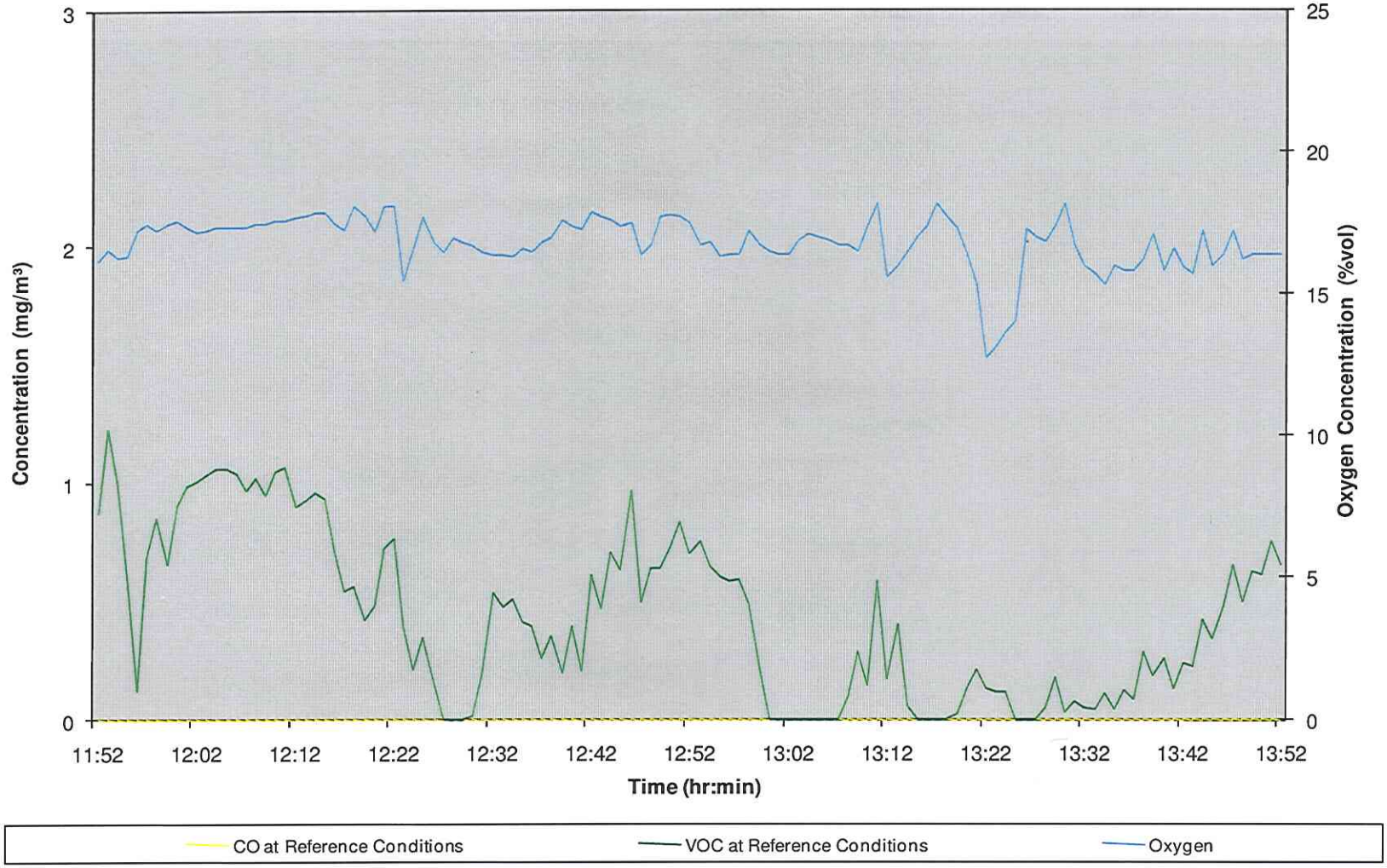


Fig 5: Combustion Gas & Total VOC Emission Data, Coventry Crematorium, Cremator 4- Run 2 (07/01/11)



TABLES

TABLE 2

PARTICULATE & HCl EMISSION SUMMARY DATA CREM 3 – RUN 1

COFFIN MASS: Medium
DATE: 06/01/11 **10:26 to 11:26**

Sampling Data	
Run Time (min)	60
Total mass H_2O collected (g)	42.0
Pitot tube constant, Cp	0.85
Dry gas meter (DGM) volume (m^3)	0.691
Temperature DGM (^oC)	19
Temperature stack (^oC)	568
Mean pitot tube pressure drop, delta P (mm H_2O)	2.7
Orifice meter pressure drop, delta H (mm H_2O)	17.4
Barometric Pressure (kPa)	99.7
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	9.8
Velocity, ntp (m/s)	3.2
Vol. Flow, actual (m^3/hr)	4,431
Vol. Flow, ntp (m^3/hr)	1,427
Volume sampled, ntp, dry gas (m^3)	0.641
Volume sampled, ntp, wet gas (m^3)	0.693
Analytical Data	
Filter Weight Gain (mg)	29.1
Acetone Wash Residue Weight (mg)	3.2
Total Particulates (mg)	32.3
Partics Field Blank (mg)	0.4
Blank % of ELV	0.1
Mass HCl (ug)	21240
HCl Field Blank (mg/l)	0.38
Absorber Efficiency (%HCl in Impingers 1+2)	78.8
Emission Data	
O_2 (%vol)	14.8
H_2O (% vol)	7.5
Percentage Isokinetic	89.6
Particulates (mg/m^3 at ref O_2)	81.8
Uncertainty (± mg/m^3)	7.3
HCl (mg/m^3) at ref O_2	53.8
Uncertainty (± mg/m^3)	4.2

TABLE 4

PARTICULATE & HCl EMISSION SUMMARY DATA CREM 3 – RUN 3

COFFIN MASS: Medium
DATE: 06/01/11 **12:54 to 13:59**

Sampling Data	
Run Time (min)	65
Total mass H_2O collected (g)	59.4
Pitot tube constant, Cp	0.85
Dry gas meter (DGM) volume (m^3)	1.049
Temperature DGM (°C)	22
Temperature stack (°C)	562
Mean pitot tube pressure drop, delta P (mm H_2O)	3.8
Orifice meter pressure drop, delta H (mm H_2O)	24.2
Barometric Pressure (kPa)	99.7
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	11.5
Velocity, ntp (m/s)	3.7
Vol. Flow, actual (m^3/hr)	5,210
Vol. Flow, ntp (m^3/hr)	1,690
Volume sampled, ntp, dry gas (m^3)	0.964
Volume sampled, ntp, wet gas (m^3)	1.038
Analytical Data	
Filter Weight Gain (mg)	34.8
Acetone Wash Residue Weight (mg)	6.9
Total Particulates (mg)	41.7
Partics Field Blank (mg)	0.4
Blank % of ELV	0.1
Mass HCl (ug)	32223
HCl Field Blank (mg/l)	0.38
Absorber Efficiency (%HCl in Impingers 1+2)	96.8
Emission Data	
O_2 (%vol)	15.1
H_2O (% vol)	7.1
Percentage Isokinetic	104.6
Particulates (mg/m^3 at ref O_2)	73.8
Uncertainty (± mg/m^3)	5.7
HCl (mg/m^3) at ref O_2	57.0
Uncertainty (± mg/m^3)	4.3

TABLE 6

PARTICULATE & HCl EMISSION SUMMARY DATA CREM 4 – RUN 2

COFFIN MASS: Medium
DATE: 07/01/11 **11:52 to 13:52**

Sampling Data	
Run Time (min)	120
Total mass H_2O collected (g)	66.8
Pitot tube constant, Cp	0.85
Dry gas meter (DGM) volume (m^3)	1.512
Temperature DGM (^oC)	30
Temperature stack (^oC)	424
Mean pitot tube pressure drop, delta P (mm H_2O)	2.1
Orifice meter pressure drop, delta H (mm H_2O)	14.9
Barometric Pressure (kPa)	95.2
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	8.0
Velocity, ntp (m/s)	3.0
Vol. Flow, actual (m^3/hr)	3,630
Vol. Flow, ntp (m^3/hr)	1,379
Volume sampled, ntp, dry gas (m^3)	1.293
Volume sampled, ntp, wet gas (m^3)	1.376
Analytical Data	
Filter Weight Gain (mg)	51.2
Acetone Wash Residue Weight (mg)	20.6
Total Particulates (mg)	71.8
Partics Field Blank (mg)	0.3
Blank % of ELV	0.0
Mass HCl (ug)	34873
HCl Field Blank (mg/l)	0.05
Absorber Efficiency (%HCl in Impingers 1+2)	99.8
Emission Data	
O_2 (%vol)	16.8
H_2O (% vol)	6.0
Percentage Isokinetic	92.1
Particulates (mg/m^3 at ref O_2)	134.0
Uncertainty (± mg/m^3)	9.5
HCl (mg/m^3) at ref O_2	65.1
Uncertainty (± mg/m^3)	3.6

TABLE9

COMBUSTION GAS & VOC EMISSION DATA SUMMARY

Stack Ref	O_2	H_2O	CO		Total VOCs		
	(%vol)	(%vol)	ppm	mg/m^3 @ ref O_2	ppm (as C_3H_8)	mg/m^3 as C (dry gas)	mg/m^3 as C @ ref O_2
Cremator 3 Run 1	14.8	7.5	0.3	0.9	1.2	2.1	4.4
Uncertainty (±)	-	0.3	-	-	-	-	3.0
Cremator 3 Run 2	16.4	4.5	<0.01	<0.01	0.9	1.5	4.0
Uncertainty (±)	-	0.2	-	-	-	-	4.1
Cremator 3 Run 3	15.1	7.1	<0.01	<0.01	0.4	0.6	1.5
Uncertainty (±)	-	0.2	-	-	-	-	3.2
Cremator 4 Run 1	16.1	6.9	0.7	2.4	1.4	2.4	4.7
Uncertainty (±)	-	0.2	-	-	-	-	3.9
Cremator 4 Run 2	16.8	6.0	<0.01	<0.01	0.1	0.2	0.4
Uncertainty (±)	-	0.2	-	-	-	-	4.5
Cremator 4 Run 3	16.9	5.2	2.4	5.0	0.1	0.2	0.4
Uncertainty (±)	-	0.2	-	-	-	-	4.8

APPENDIX 2

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)