UKAS TESTING 2082

MONITORING OF EMISSIONS FROM COVENTRY CREMATORIUM 5 & 6 November, 2009

For Coventry Crematorium

Prepared for:

Coventry Crematorium
The Lodge
Cannon Hill Road
Coventry
CV4 7DF

Prepared by:

REC Ltd
Unit 19, Bordesley Trading Estate
Bordesley Green Road
Birmingham
B8 1BZ
Tel : 0121 326 7007
Fax : 0121 328 1689
E-mail : sales@recltd.co.uk

Issued : 21 January, 2010
Reference : 71142p1r0

Prepared by : [redacted]
M Edwards, Env Technician, MM05 659, MCERTS L1

Reviewed by : [redacted]
P Jones, Ops Manager, MM02 021, MCERTS L2 TE1-4

CONTENTS **Page No.**

TABLES (19 Additional Pages)

APPENDICES (1 Additional Page)

EXECUTIVE SUMMARY

Resource & Environmental Consultants (REC) Ltd was commissioned by Coventry Crematorium to monitor EMISSION of pollutants released from the cremation process at their site.

In accordance with the requirements of their site permit, 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	
Total VOCs (as C)	A	18.4	21.7	20
Carbon Monoxide	A	1	<1	100
Particulate Matter	A	82.4	76.0	80
Hydrogen Chloride	B	50.3	21.7	200

NOTE 1: All data are expressed in mg/Nm^3 at 273K, 101.3kPa, dry gas 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. (C) REC Ltd accredited for sampling, sub-contracted analysis by SAL Ltd 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 by SAL Ltd not UKAS accredited.

1. INTRODUCTION

1.1 Background

Coventry Crematorium commissioned REC Ltd to conduct an emission monitoring survey on their cremation process at their site. There are 4No. gas fired cremators operating at the Crematorium.

1.2 Scope of the Survey

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

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

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

Monitoring was to be carried out when the cremator was at its usual operating capacity and over three full cremation cycles on each cremator as per the requirements of PG 5/2 (04). Each run was to start two minutes after cremation begins in order to avoid the volatilisation of the remains and end two minutes prior to the end of cremation to avoid raking of ash.

Sampling for combustion gases and VOCs was carried out on a continuous basis with measured concentrations being data-logged at 1 minute intervals over the sampling period. All other pollutants were sampled in duplicate.

All results were to be reported at 273K, 101.3kPa, dry gas and corrected to 11% oxygen content.

1.3 Sampling Personnel

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

- David Burns - MM 05 579, MCERTS Level 2, TE1 & 2
- Michelle Edwards - MM 05 659, MCERTS Level 1, TE 1

2. METHODOLOGY

2.1 Species and Techniques

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

Species	Accreditation 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 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 13526	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. (C) REC Ltd accredited for sampling, sub-contracted analysis by SAL Ltd 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 by SAL Ltd not UKAS accredited.

2.2 Sampling & Analytical Methodology

Total Particulate Matter

To determine the concentration of particulate matter in EMISSION, 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 160°C 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).

The impinger train was seated in a water bath to cool the gas stream and condense out less volatile gases and water vapour.

The first two impingers encountered by the gas stream contained deionised water. The third impinger was left empty and the fourth contained anhydrous silica gel which was used to dry the gas stream before passing it through a dry gas meter (DGM) to measure the volume of gas sampled.

All the impingers were weighed before and after the sampling run in order to determine the mass of water condensed by the impinger train (in house Method MM0010).

The sample volume collected was in excess of the minimum requirement stated in MM0004. The minimum sample volume ensures the results would be representative of normal plant operating conditions.

Upon completion of sampling, the filter was removed to a clean petri dish, labelled and sealed. The probe and filter housing were rinsed with acetone and water. The washings were collected in a container and submitted for analysis along with the filter.

HCl

To determine the concentration of HCl in EMISSION, isokinetic stack sampling equipment satisfying the requirements of BS EN 1911 was utilised and in-house method MM0006 followed.

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 above 155°C in accordance with MM0006. On leaving the filter, the sampled exhaust gas was passed into a series of impingers.

The first three impingers encountered by the gas stream contained deionised water to capture and absorb the volatile chloride (Cl^-) ions. The fourth impinger was left empty and the fifth contained anhydrous silica gel which was used to dry the gas stream before passing it through a dry gas meter (DGM) to measure the volume of gas sampled.

Upon completion of sampling, the contents of impingers 1 &2 were transferred to a sealed, labelled container. The contents of impinger 3 were transferred to a separate container. The absorbing solution was subsequently analysed for chloride (Cl^-) via an ion chromatographic (IC) technique.

Combustion Gases

To determine the concentration of combustion gases (CO and O_2) in EMISSION, a Testotherm Model 350XL multigas analyser was used. The analyser incorporates a gas conditioner to enable the gas stream to be presented to the electrochemical cells on a dry gas basis. In house method MM0002 was followed.

The analyser satisfies the requirements of the following Standards:-

CO & O_2	-	ISO 12039

For each parameter the measured value (m.v.) and accuracy associated with this type of measurement using the Testo 350XL 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 EMISSION, 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.

3. SAMPLING AND OPERATIONAL DETAILS

3.1 Process Description

The operation of the process at Coventry Crematorium is classified as a Part B process under the Environmental Permitting Regs 2007. The process is therefore under Local Authority regulation and must demonstrate compliance with the standards published in the site permit based upon Secretary of States Process Guidance Note PG 5/2(04).

Monitoring is carried out over a whole cremation cycle from 2 minutes after loading to prior to raking.

3.2 Sampling Positions

On Cremator 3, 2 x 4" BSP sampling ports were installed at 90° to each other in the same horizontal plane. The sampling points provided were at least 5 x hydraulic diameters from any flow disturbance both upstream and downstream from the sampling plane. However due access restrictions caused by the temporary scaffolding provided for access, sampling could only be carried out across one sampling plane at a single sample point.

On Cremator 4, 2 x 4" BSP sampling ports were installed at 90° to each other. However, due to one port being located on the vertical plane, only one port could be utilised for sampling.
The sampling points provided were at least 5 x hydraulic diameters from any flow disturbance both upstream and downstream from the sampling plane.

The sample port sizes do not fully comply with the positional requirements of Environment Agency Technical Guidance Note M1 (EA TGN M1). TGN M1 requires 5"BSP sockets to be fitted. However the initial temperature and velocity traverses conducted along the sample planes showed that the flow requirements of TGN M1 were met.

3.3 Uncertainty

Due to restrictions on Cremator 3, only one sampling plane could be utilised. However the number of sample points was increased along this plane and therefore the standard particulate uncertainty would still apply.

Due to access restrictions on Cremator 4, only a single sampling plane could be utilised and at a limited number of points. This will increase the measurement uncertainty of the particulate phase tests from the standard ±10% quoted.

The monitoring deviations above will have no effect on the HCl, combustion gas and VOC concentrations as they are present in the gaseous phase and are assumed to be homogenous across the sample plane.

3.4 Emission Monitoring Survey Details

The emission monitoring survey was carried out on the Cremators over the period 5 & 6 November, 2009. The table below summarises the actual sampling periods.

SAMPLING PERIODS

Stack Ref.	Parameter	Sample Time (& Date)
Cremator 3	Particulates, HCl Run 1	11:26 to 12:56 (05/11/09)
	Particulates, HCl Run 2	13:15 to 14:55 (05/11/09)
	Particulates, HCl Run 3	15:00 to 16:10 (05/11/09)
	Combustion Gas & VOC's	Concurrent with the above
Cremator 4	Particulates, HCl Run 1	09:06 to 10:46 (06/11/09)
	Particulates, HCl Run 2	10:53 to 12:03 (06/11/09)
	Particulates, HCl Run 3	12:27 to 13:42 (06/11/09)
	Combustion Gas & VOC's	Concurrent with the above

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, on dry gas basis and referenced to 11% O_2 content.

4.3 Hydrogen Chloride

The results of the volatile chloride sampling runs are summarised in Tables 8 to 13. From the concentration of Cl^- and the measured volume of absorbing solution a total mass of HCl in microgram (µg) was determined. From the measured sample volume an emission concentration was then calculated.

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

4.4 Combustion Gases

The results of the combustion gas monitoring tests are summarised in Table 14 and Figures 1 to 6. The table presents the averages of concentrations measured throughout each of the sample periods.

Concentrations are expressed in mg/m^3 at the standard reference conditions of 273K, 101.3kPa on dry gas basis and referenced to 11% O_2 content.

4.5 Total VOC Emission Data

The results of the VOC monitoring tests are summarised in Table 15 and Figures 1 to 6. The table presents the averages 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 on dry gas basis and referenced to 11% O_2 content. Concentrations have been corrected from wet gas to dry gas basis using the moisture concentrations from the particulate/HCl runs.

====== End of Report Text ======

FIGURES

Fig 1: Combustion Gas & Total VOC Emission Data, Coventry Crematorium, Cremator 3, Run 1 (06/11/09)

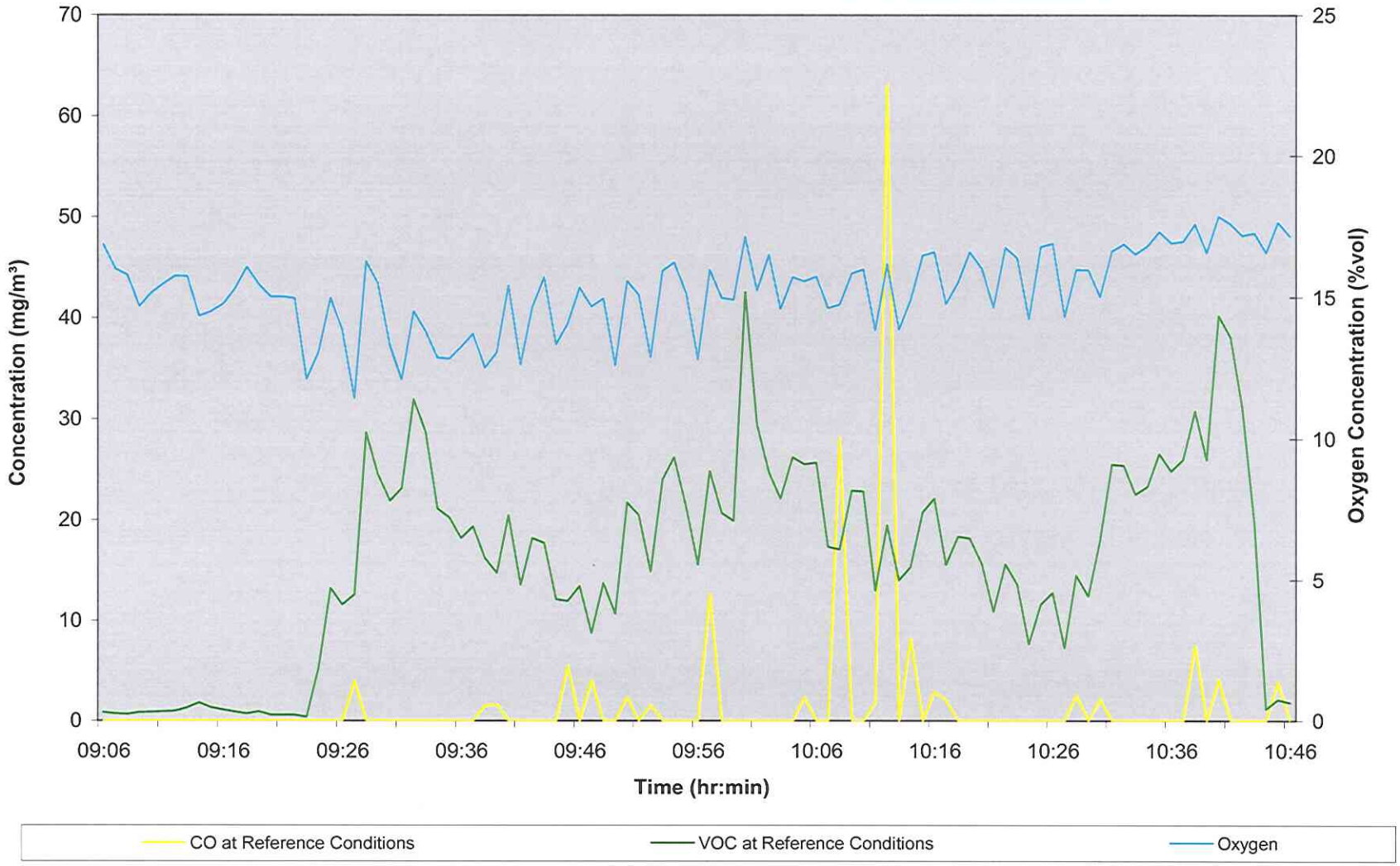


Fig 2: Combustion Gas & Total VOC Emission Data, Coventry Crematorium, Cremator 3, Run 2 (06/11/09)

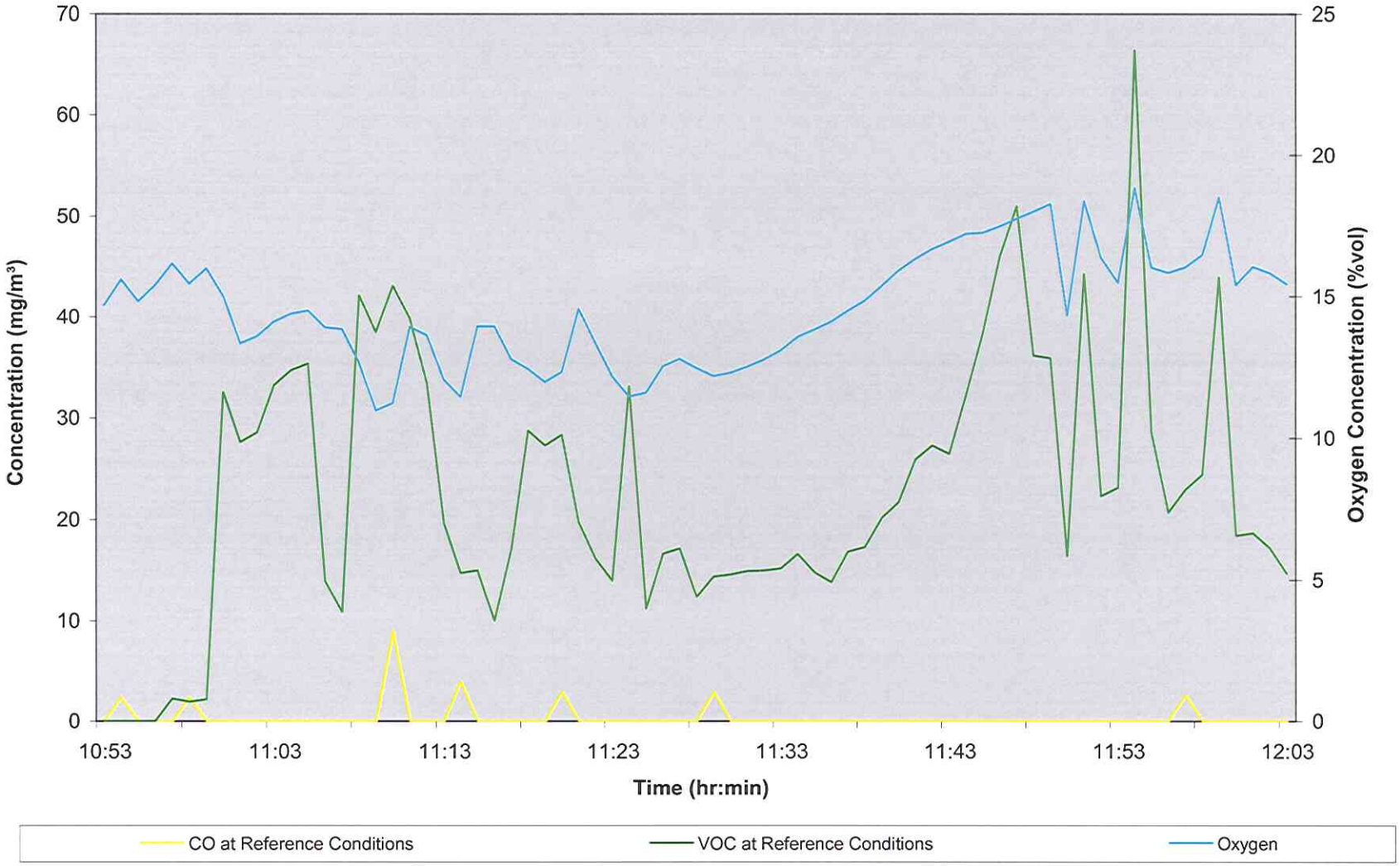


Fig 3: Combustion Gas & Total VOC Emission Data, Coventry Crematorium, Cremator 3, Run 3 (06/11/09)

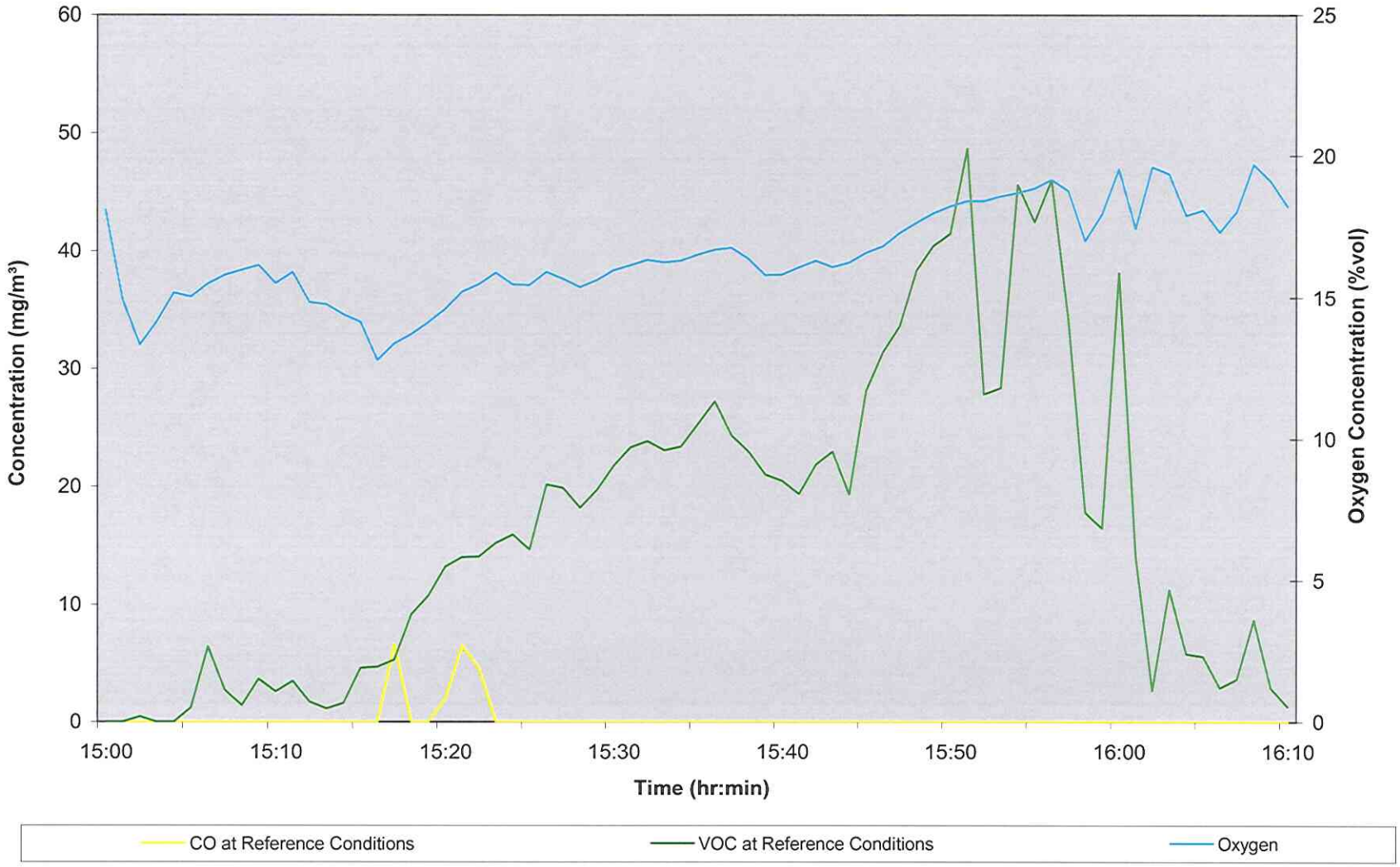


Fig 4: Combustion Gas & Total VOC Emission Data, Coventry Crematorium , Cremator 4, Run 1, (05/11/09)

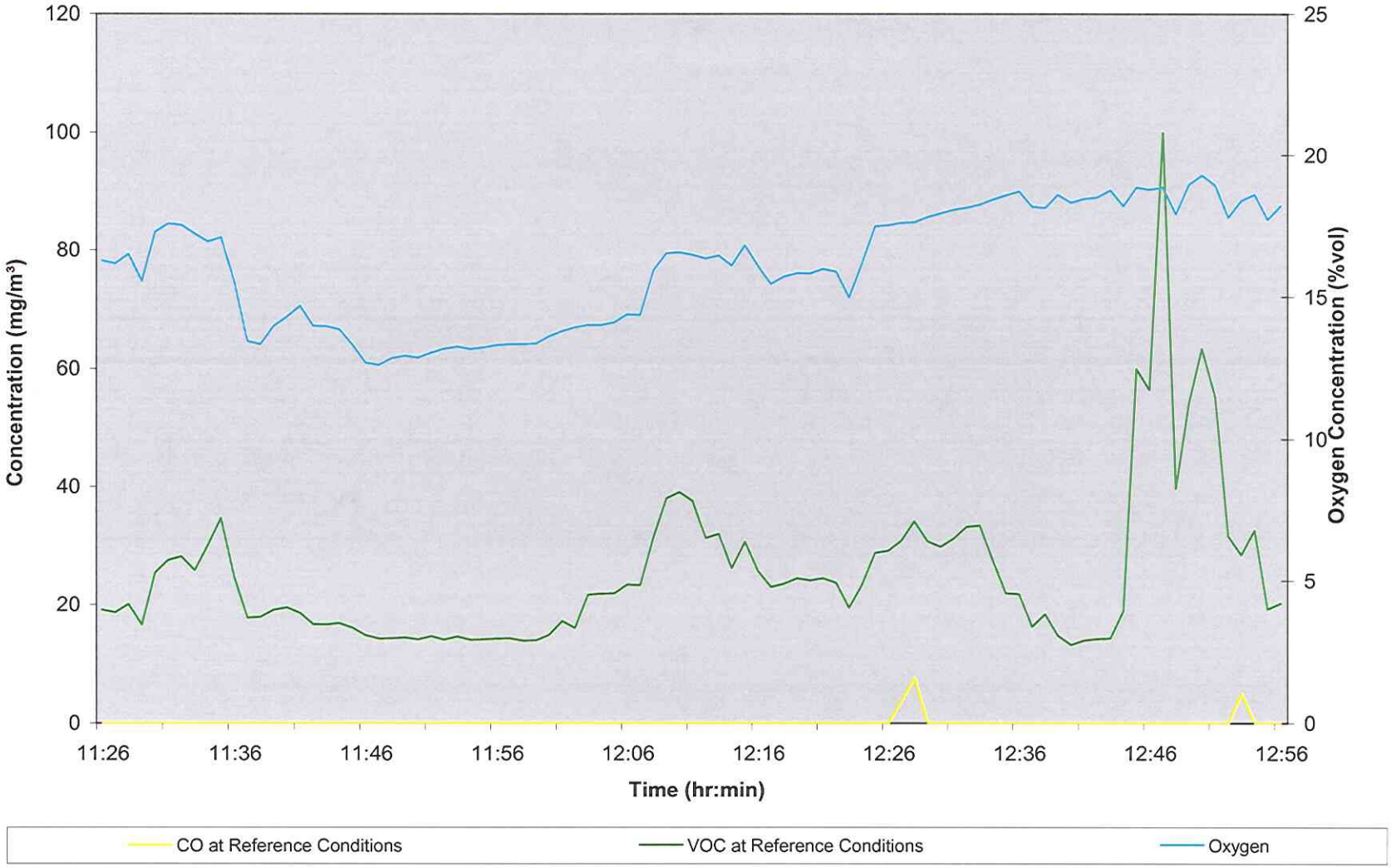


Fig 5: Combustion Gas & Total VOC Emission Data, Coventry Crematorium , Cremator 4, Run 2, (05/11/09)

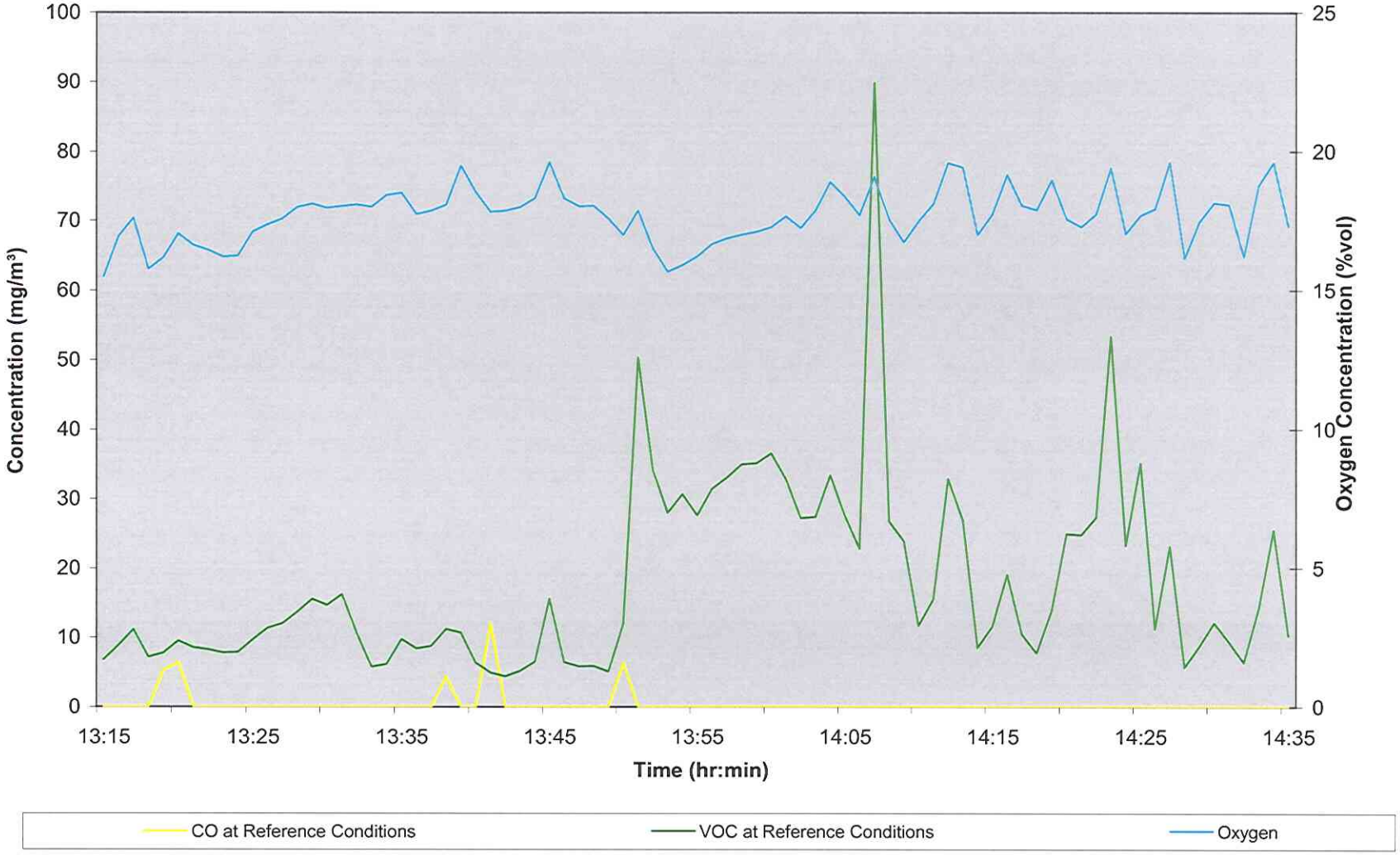
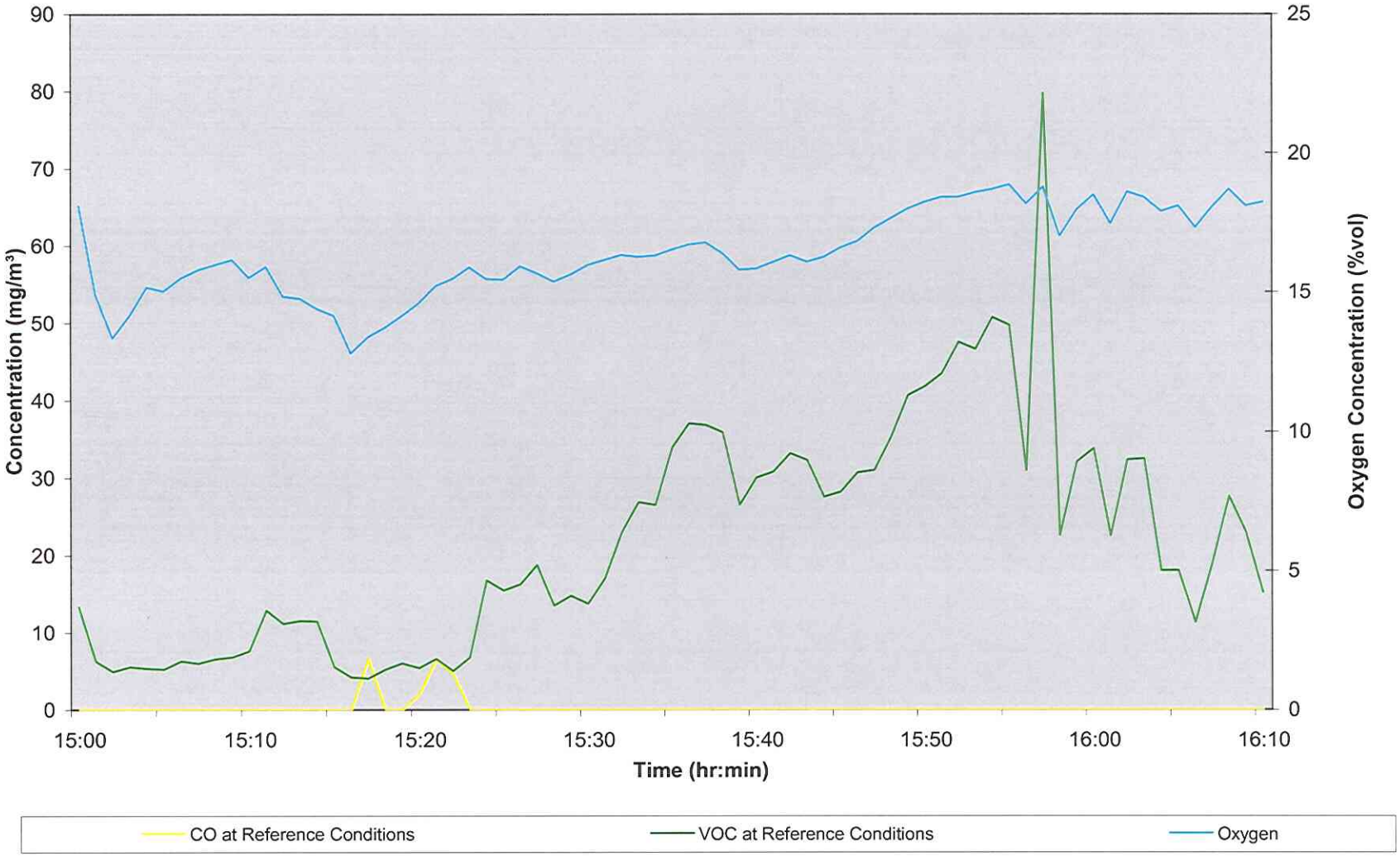


Fig 6: Combustion Gas & Total VOC Emission Data, Coventry Crematorium , Cremator 4, Run 3, (05/11/09)



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)
Cremator 3	490	20	40	0.126	9.2	4,169	1,493
Cremator 4	416	42	40	0.126	12.7	5,742	2,277

TABLE 2

PARTICULATE EMISSION DATA- CREM 3, RUN 1

DATE: 6/11/09 09:06 to 10:46

Sampling Data	
Run Time (min)	140
Total mass H_2O collected (g)	72.7
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	1.465
Temperature DGM (°C)	17
Temperature stack (°C)	465
Mean pitot tube pressure drop, delta P (mm H_2O)	1.9
Orifice meter pressure drop, delta H (mm H_2O)	12.3
Barometric Pressure (kPa)	101.5
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	7.5
Velocity, ntp (m/s)	2.8
Vol. Flow, actual (m^3/hr)	3,415
Vol. Flow, ntp (m^3/hr)	1,264
Volume sampled, ntp, dry gas (m^3)	1.374
Volume sampled, ntp, wet gas (m^3)	1.465
Analytical Data	
Filter Weight Gain (mg)	48.8
Acetone Wash Residue Weight (mg)	17.5
Total Particulates (mg)	66.3
Partics Field Blank (mg)	0.7
Blank % of ELV	0.6
Emission Data	
O_2 (%vol)	15.3
H_2O (% vol)	6.2
Percentage Isokinetic	91.6
Particulates (mg/m^3 at ref O_2)	85.3
Uncertainty (± mg/m^3)	5.5

TABLE 3

PARTICULATE EMISSION DATA- CREM 3, RUN 2

DATE: 6/11/09 10:53 to 12:03

Sampling Data	
Run Time (min)	70
Total mass H_2O collected (g)	55.7
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	0.824
Temperature DGM (^oC)	21
Temperature stack (^oC)	488
Mean pitot tube pressure drop, delta P (mm H_2O)	2.3
Orifice meter pressure drop, delta H (mm H_2O)	14.7
Barometric Pressure (kPa)	101.5
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	8.3
Velocity, ntp (m/s)	3.0
Vol. Flow, actual (m^3/hr)	3,765
Vol. Flow, ntp (m^3/hr)	1,352
Volume sampled, ntp, dry gas (m^3)	0.763
Volume sampled, ntp, wet gas (m^3)	0.832
Analytical Data	
Filter Weight Gain (mg)	52.0
Acetone Wash Residue Weight (mg)	6.8
Total Particulates (mg)	58.8
Partics Field Blank (mg)	0.7
Blank % of ELV	1.1
Emission Data	
O_2 (%vol)	15.3
H_2O (% vol)	8.3
Percentage Isokinetic	97.3
Particulates (mg/m^3 at ref O_2)	136.3
Uncertainty (± mg/m^3)	9.1

TABLE 4

PARTICULATE EMISSION DATA- CREM 3, RUN 3

DATE: 6/11/09 12:27 to 13:42

Sampling Data	
Run Time (min)	75
Total mass H_2O collected (g)	42.0
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	0.859
Temperature DGM (°C)	20
Temperature stack (°C)	485
Mean pitot tube pressure drop, delta P (mm H_2O)	2.1
Orifice meter pressure drop, delta H (mm H_2O)	13.4
Barometric Pressure (kPa)	101.5
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)	2.9
Vol. Flow, actual (m^3/hr)	3,635
Vol. Flow, ntp (m^3/hr)	1,310
Volume sampled, ntp, dry gas (m^3)	0.797
Volume sampled, ntp, wet gas (m^3)	0.849
Analytical Data	
Filter Weight Gain (mg)	6.4
Acetone Wash Residue Weight (mg)	2.6
Total Particulates (mg)	9.0
Partics Field Blank (mg)	0.7
Blank % of ELV	1.1
Emission Data	
O_2 (%vol)	16.5
H_2O (% vol)	6.2
Percentage Isokinetic	95.6
Particulates (mg/m^3 at ref O_2)	25.5
Uncertainty (± mg/m^3)	6.9

TABLE 5

PARTICULATE EMISSION DATA- CREM 4, RUN 1

DATE: 5/11/09 11:26 to 12:56

Sampling Data	
Run Time (min)	90
Total mass H_2O collected (g)	56.4
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	1.203
Temperature DGM (^oC)	18
Temperature stack (^oC)	383
Mean pitot tube pressure drop, delta P (mm H_2O)	2.9
Orifice meter pressure drop, delta H (mm H_2O)	20.5
Barometric Pressure (kPa)	102.3
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	8.7
Velocity, ntp (m/s)	3.6
Vol. Flow, actual (m^3/hr)	3,942
Vol. Flow, ntp (m^3/hr)	1,648
Volume sampled, ntp, dry gas (m^3)	1.134
Volume sampled, ntp, wet gas (m^3)	1.204
Analytical Data	
Filter Weight Gain (mg)	23.9
Acetone Wash Residue Weight (mg)	6.2
Total Particulates (mg)	30.1
Partics Field Blank (mg)	1.5
Blank % of ELV	1.7
Emission Data	
O_2 (%vol)	16.1
H_2O (% vol)	5.8
Percentage Isokinetic	89.9
Particulates (mg/m^3 at ref O_2)	54.8
Uncertainty (± mg/m^3)	5.3

TABLE 6

PARTICULATE EMISSION DATA- CREM 4, RUN 2

DATE: 5/11/09 13:15 to 14:35

Sampling Data	
Run Time (min)	80
Total mass H_2O collected (g)	41.9
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	1.164
Temperature DGM (°C)	22
Temperature stack (°C)	369
Mean pitot tube pressure drop, delta P (mm H_2O)	3.0
Orifice meter pressure drop, delta H (mm H_2O)	22.7
Barometric Pressure (kPa)	102.3
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	8.7
Velocity, ntp (m/s)	3.7
Vol. Flow, actual (m^3/hr)	3,951
Vol. Flow, ntp (m^3/hr)	1,688
Volume sampled, ntp, dry gas (m^3)	1.081
Volume sampled, ntp, wet gas (m^3)	1.133
Analytical Data	
Filter Weight Gain (mg)	15.9
Acetone Wash Residue Weight (mg)	10.4
Total Particulates (mg)	26.3
Partics Field Blank (mg)	10.5
Blank % of ELV	12.1
Emission Data	
O_2 (%vol)	17.7
H_2O (% vol)	4.6
Percentage Isokinetic	92.9
Particulates (mg/m^3 at ref O_2)	75.3
Uncertainty (± mg/m^3)	8.7

TABLE 7

PARTICULATE EMISSION DATA- CREM 4, RUN 3

DATE: 5/11/09 15:00 to 16:10

Sampling Data	
Run Time (min)	70
Total mass H_2O collected (g)	40.2
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	0.878
Temperature DGM (^oC)	22
Temperature stack (^oC)	401
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)	102.3
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	7.5
Velocity, ntp (m/s)	3.1
Vol. Flow, actual (m^3/hr)	3,405
Vol. Flow, ntp (m^3/hr)	1,386
Volume sampled, ntp, dry gas (m^3)	0.814
Volume sampled, ntp, wet gas (m^3)	0.864
Analytical Data	
Filter Weight Gain (mg)	32.0
Acetone Wash Residue Weight (mg)	4.2
Total Particulates (mg)	36.2
Partics Field Blank (mg)	1.5
Blank % of ELV	2.3
Emission Data	
O_2 (%vol)	16.4
H_2O (% vol)	5.8
Percentage Isokinetic	98.7
Particulates (mg/m^3 at ref O_2)	97.8
Uncertainty (± mg/m^3)	8.6

TABLE 8

HCl EMISSION DATA- CREM 3, RUN 1

DATE: 6/11/09 09:06 to 10:46

Sampling Data	
Run Time (min)	140
Total mass H_2O collected (g)	72.7
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	1.465
Temperature DGM (^oC)	17
Temperature stack (^oC)	465
Mean pitot tube pressure drop, delta P (mm H_2O)	1.9
Orifice meter pressure drop, delta H (mm H_2O)	12.3
Barometric Pressure (kPa)	101.5
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	7.5
Velocity, ntp (m/s)	2.8
Vol. Flow, actual (m^3/hr)	3,414
Vol. Flow, ntp (m^3/hr)	1,264
Volume sampled, ntp, dry gas (m^3)	1.374
Volume sampled, ntp, wet gas (m^3)	1.465
Analytical Data	
Mass HCl (ug)	31526
HCl Field Blank (mg/l)	0.1
Absorber Efficiency (%HCl in Impingers 1+2)	97.4
Emission Data	
O_2 (%vol)	15.3
H_2O (% vol)	6.2
Percentage Isokinetic	91.6
HCl (mg/m^3) at ref O_2	22.9
Uncertainty (± mg/m^3)	2.8

TABLE 9

HCl EMISSION DATA- CREM 3, RUN 2

DATE: 6/11/09 10:53 to 12:03

Sampling Data	
Run Time (min)	70
Total mass H_2O collected (g)	55.7
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	0.824
Temperature DGM (°C)	21
Temperature stack (°C)	488
Mean pitot tube pressure drop, delta P (mm H_2O)	2.3
Orifice meter pressure drop, delta H (mm H_2O)	14.7
Barometric Pressure (kPa)	101.5
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	8.3
Velocity, ntp (m/s)	3.0
Vol. Flow, actual (m^3/hr)	3,765
Vol. Flow, ntp (m^3/hr)	1,352
Volume sampled, ntp, dry gas (m^3)	0.763
Volume sampled, ntp, wet gas (m^3)	0.832
Analytical Data	
Mass HCl (ug)	72274
HCl Field Blank (mg/l)	0.1
Absorber Efficiency (%HCl in Impingers 1+2)	99.9
Emission Data	
O_2 (%vol)	15.3
H_2O (% vol)	8.3
Percentage Isokinetic	97.3
HCl (mg/m^3) at ref O_2	94.8
Uncertainty (± mg/m^3)	11.3

TABLE 10

HCl EMISSION DATA- CREM 3, RUN 3

DATE: 6/11/09 **12:27 to 13:42**

Sampling Data	
Run Time (min)	75
Total mass H_2O collected (g)	55.7
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	0.859
Temperature DGM (°C)	20
Temperature stack (°C)	485
Mean pitot tube pressure drop, delta P (mm H_2O)	2.1
Orifice meter pressure drop, delta H (mm H_2O)	13.4
Barometric Pressure (kPa)	101.5
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	8.1
Velocity, ntp (m/s)	2.9
Vol. Flow, actual (m^3/hr)	3,648
Vol. Flow, ntp (m^3/hr)	1,315
Volume sampled, ntp, dry gas (m^3)	0.797
Volume sampled, ntp, wet gas (m^3)	0.866
Analytical Data	
Mass HCl (ug)	26532
HCl Field Blank (mg/l)	0.1
Absorber Efficiency (%HCl in Impingers 1+2)	93.6
Emission Data	
O_2 (%vol)	16.5
H_2O (% vol)	8.0
Percentage Isokinetic	97.2
HCl (mg/m^3) at ref O_2	33.3
Uncertainty (± mg/m^3)	4.1

TABLE 11

HCl EMISSION DATA- CREM 4, RUN 1

DATE: 5/11/09 11:26 to 12:56

Sampling Data	
Run Time (min)	90
Total mass H_2O collected (g)	56.4
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	1.203
Temperature DGM (^oC)	18
Temperature stack (^oC)	383
Mean pitot tube pressure drop, delta P (mm H_2O)	2.9
Orifice meter pressure drop, delta H (mm H_2O)	20.5
Barometric Pressure (kPa)	102.3
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	8.7
Velocity, ntp (m/s)	3.6
Vol. Flow, actual (m^3/hr)	3,942
Vol. Flow, ntp (m^3/hr)	1,648
Volume sampled, ntp, dry gas (m^3)	1.134
Volume sampled, ntp, wet gas (m^3)	1.204
Analytical Data	
Mass HCl (ug)	54340
HCl Field Blank (mg/l)	0.1
Absorber Efficiency (%HCl in Impingers 1+2)	57.3
Emission Data	
O_2 (%vol)	16.1
H_2O (% vol)	5.8
Percentage Isokinetic	89.9
HCl (mg/m^3) at ref O_2	47.9
Uncertainty (± mg/m^3)	5.9

TABLE 12

HCl EMISSION DATA- CREM 4, RUN 2

DATE: 5/11/09 13:15 to 14:35

Sampling Data	
Run Time (min)	80
Total mass H_2O collected (g)	41.9
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	1.164
Temperature DGM (°C)	22
Temperature stack (°C)	369
Mean pitot tube pressure drop, delta P (mm H_2O)	3.0
Orifice meter pressure drop, delta H (mm H_2O)	22.7
Barometric Pressure (kPa)	102.3
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	8.7
Velocity, ntp (m/s)	3.7
Vol. Flow, actual (m^3/hr)	3,951
Vol. Flow, ntp (m^3/hr)	1,688
Volume sampled, ntp, dry gas (m^3)	1.081
Volume sampled, ntp, wet gas (m^3)	1.133
Analytical Data	
Mass HCl (ug)	23639
HCl Field Blank (mg/l)	0.1
Absorber Efficiency (%HCl in Impingers 1+2)	98.1
Emission Data	
O_2 (%vol)	17.7
H_2O (% vol)	4.6
Percentage Isokinetic	92.9
HCl (mg/m^3) at ref O_2	21.9
Uncertainty (± mg/m^3)	2.9

TABLE 13

HCl EMISSION DATA- CREM 4, RUN 3

DATE: 5/11/09 15:00 to 16:10

Sampling Data	
Run Time (min)	70
Total mass H_2O collected (g)	40.2
Pitot tube constant, Cp	0.84
Dry gas meter (DGM) volume (m^3)	0.878
Temperature DGM (^oC)	22
Temperature stack (^oC)	401
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)	102.3
X-sectional area of stack (m^2)	0.126
Nozzle size (mm)	9.31
Flow Data	
Velocity, actual (m/s)	7.5
Velocity, ntp (m/s)	3.1
Vol. Flow, actual (m^3/hr)	3,405
Vol. Flow, ntp (m^3/hr)	1,386
Volume sampled, ntp, dry gas (m^3)	0.814
Volume sampled, ntp, wet gas (m^3)	0.864
Analytical Data	
Filter Weight Gain (mg)	32.1
Acetone Wash Residue Weight (mg)	8.0
Total Particulates (mg)	40.1
Partics Field Blank (mg)	1.5
Blank % of ELV	2.3
Emission Data	
O_2 (%vol)	16.4
H_2O (% vol)	5.8
Percentage Isokinetic	98.7
Particulates (mg/m^3 at ref O_2)	108.3
Uncertainty (± mg/m^3)	9.0

TABLE 14

COMBUSTION GAS EMISSION DATA SUMMARY

Stack Ref	O_2	H_2O	CO	
	(%vol)	(%vol)	ppm	mg/m^3 @ ref O_2
Cremator 3, Run 1	15.3	6.2	0.7	1.6
Cremator 3, Run 2	14.6	8.3	0.3	0.4
Cremator 3, Run 3	16.5	8.0	0.1	0.3
Cremator 4, Run 1	16.1	5.8	0.0	0.2
Cremator 4, Run 2	17.7	4.6	0.1	0.4
Cremator 4, Run 3	16.4	5.8	0.1	0.3

TABLE 15

TOTAL VOC EMISSION DATA SUMMARY

Stack Ref	O_2	H_2O	Total VOCs		
	(%vol)	(%vol)	ppm (as C_3H_8)	mg/m^3 (as C) (dry gas)	mg/m^3 (as C) @ ref O_2
Cremator 3, Run 1	15.3	6.2	5.1	8.7	16.0
Cremator 3, Run 2	14.6	8.3	7.8	13.7	22.8
Cremator 3, Run 3	16.5	8.0	3.7	6.4	16.5
Cremator 4, Run 1	16.1	5.8	6.3	10.8	25.3
Cremator 4, Run 2	17.7	4.6	3.3	5.6	17.9
Cremator 4, Run 3	16.4	5.8	4.9	8.3	22.0

APPENDIX 1

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)