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Stack Emissions Testing Report Commissioned by
ATI Environment UK Ltd

Installation Name & Address

Ipswich Borough Council
Ipswich Crematorium
Cemetery Lane
Ipswich
IP4 2TQ

LAPPC Guidance Note: PG 5/2 (12)

Stack Reference

A1 - Combined Cremator Flue

Dates of the Monitoring Campaign

7th May 2015

Job Reference Number

CSW-1820

Report Written by
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Report Approved by
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Report Date
4th June 2015

Version
Version 1

Signature of Report Approver

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Executive Summary

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MONITORING OBJECTIVES

Ipswich Borough Council, Ipswich Crematorium
A1 - Combined Cremator Flue
7th May 2015

Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by ATI Environment UK Ltd to carry out stack emissions testing for Ipswich Borough Council on the A1 - Combined Cremator Flue at Ipswich Crematorium.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Permit.

Special Requirements

There were no special requirements.

Target Parameters

Total Particulate Matter, Hydrogen Chloride, Mercury, Total VOCs (as Carbon), Carbon Monoxide

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MONITORING RESULTS

Ipswich Borough Council, Ipswich Crematorium

A1 - Combined Cremator Flue

7th May 2015

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total Particulate Matter	¹ mg/m ³	5.3	0.74	20	g/hr	12.8	1.9	-
Hydrogen Chloride	¹ mg/m ³	11.1	1.1	30	g/hr	26.8	3.1	-
Mercury	¹ mg/m ³	0.026	0.004	0.05	g/hr	0.062	0.010	-
Total VOCs (as Carbon)	¹ mg/m ³	2.1	0.67	20	g/hr	5.1	1.6	-
Carbon Monoxide	¹ mg/m ³	13.7	2.0	100	g/hr	33.0	5.2	-
Oxygen	% v/v	Dry 14.3	0.58					
Water Vapour	% v/v	8.1	0.42					
Stack Gas Temperature	°C	152.8						
Stack Gas Velocity	m/s	11.6	0.30					
Volumetric Flow Rate (ACTUAL)	m ³ /hr	6057	315					
Volumetric Flow Rate (REF)	¹ m ³ /hr	2409	125					

NOTE: VOLUMETRIC FLOW RATE DATA TAKEN FROM THE PRELIMINARY VELOCITY TRAVERSE.

¹ Reference Conditions (REF) are: 273K, 101.3kPa, dry gas, 11% oxygen.

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MONITORING DATE(S) & TIMES

Ipswich Borough Council, Ipswich Crematorium

A1 - Combined Cremator Flue

7th May 2015

Parameter	Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins	
Total Particulate Matter	R1	mg/m ³	5.3	g/hr	12.8	07/05/2015	11:39 - 12:39	60
Hydrogen Chloride	R1	mg/m ³	11.1	g/hr	26.8	07/05/2015	11:39 - 12:39	60
Mercury	R1	mg/m ³	0.026	g/hr	0.062	07/05/2015	13:53 - 14:53	60
Total VOCs (as Carbon)	R1	mg/m ³	2.1	g/hr	5.1	07/05/2015	11:51 - 12:51	60
Carbon Monoxide	R1	mg/m ³	13.5	g/hr	32.6	07/05/2015	11:51 - 12:21	30
	R2	mg/m ³	13.9	g/hr	33.5	07/05/2015	12:21 - 12:51	30
Oxygen	R1	% v/v	14.5			07/05/2015	11:51 - 12:51	60
Velocity & Volumetric Flow Rate	R1					07/05/2015	10:43 - 10:55	

All results are expressed at the respective reference conditions.

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PROCESS DETAILS

Ipswich Borough Council, Ipswich Crematorium
 A1 - Combined Cremator Flue
 7th May 2015

Standard Operating Conditions

Parameter	Value
Process Status	Normal
Capacity (of 100%) and Tonnes / Hour	N/A
Continuous or Batch Process	Batch
Feedstock (if applicable)	N/A
Abatement System	Carbon Dosing
Abatement System Running Status	On
Fuel	Natural Gas
Plume Appearance	None Visible

Site Specific Operating Conditions

Parameter	Status
Coffin Type	Standard / Standard
Sex	Female / Female
Temperature in Primary Chamber	725 / 728
Temperature in Secondary Chamber	867 / 898
Cremation Number	128645 / 128646
Size	Medium / Medium

Executive Summary

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MONITORING & ANALYTICAL METHODS

Ipswich Borough Council, Ipswich Crematorium

A1 - Combined Cremator Flue

7th May 2015

Parameter	Monitoring				Analysis				MCERTS Testing	LOD (Average)
	Standard	Technical Procedure	ISO 17025 Testing	Testing Lab	Analytical Procedure	Analytical Technique	ISO 17025 Analysis	Analysis Lab		
Total Particulate Matter	EN 13284-1	CAT-TP-01	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.28 mg/m ³
Hydrogen Chloride	BS EN 1911	CAT-TP-11	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.055 mg/m ³
Mercury	EN 13211	CAT-TP-06	Yes	CAT	M112	CV-AFS	Yes	RPS	Yes	0.0004 mg/m ³
Water Vapour	EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.1 % v/v
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20	Yes	CAT	Flame Ionisation Detection by Sick 3006 FID				Yes	0.21 mg/m ³
Carbon Monoxide	EN 15058	CAT-TP-39	Yes	CAT	NDIR by Horiba PG-350E				Yes	0.46 mg/m ³
Oxygen	EN 14789	CAT-TP-39	Yes	CAT	Dry Paramagnetic Cell by Horiba PG-350E				Yes	0.1 %
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	Yes	CAT	Pitot Tube and Thermocouple				Yes	1.2 m/s

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Exova Catalyst (CAT)	ISO 17025 Accreditation Number: 4279
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All Isokinetic	All	One out of two sampling lines was used due to sampling location restrictions, however the number of sample points used on the available line were increased to meet the requirements of the Standard.

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SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.43
Width	m	-
Area	m ²	0.15
Port Depth	cm	15
Orientation of Duct	-	Horizontal
Sample Port Size	-	4" BSP

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Permanent
Inside / Outside	Inside

Platform Details

EA Technical Guidance Note M1 / EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	No
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

All platforms should be designed in accordance with the requirements in the Environment Agency's Technical Guidance Note M1 and EN 15259.

EN 15259 Homogeneity Test Requirements

There is no requirement to perform a EN 15259 Homogeneity Test on this Stack.

Sampling Plane Validation Criteria (from EN 15259)

Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	62.5	> 5 Pa	Yes
Mean Velocity	m/s	11.59	-	-
Lowest Gas Velocity	m/s	10.33	-	-
Highest Gas Velocity	m/s	12.94	-	-
Ratio of Above	: 1	1.25	< 3 : 1	Yes
Maximum Angle of Swirl	°	5	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

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PLANT PHOTOS

Photo 1



Photo 2



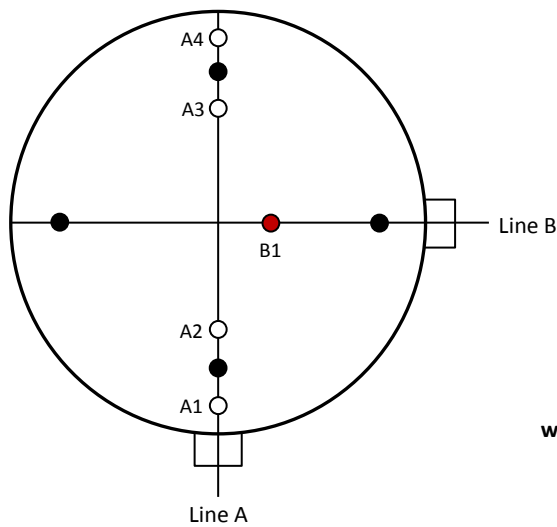
Photo 3



Photo 4



SAMPLE POINTS



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

APPENDICES

APPENDIX CONTENTS

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Andrew Benson	MCERTS Level 2	MM 06 752	TE1 TE2 TE3 TE4
Technician	Wayne Possouw	MCERTS Level 1	MM 10 1083	TE1 TE2 TE3 TE4

LIST OF EQUIPMENT

Extractive Sampling		Instrumental Analysers		Miscellaneous Items	
Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.
Control Box DGM (1)	CAT 7.40	Horiba PG-350E	CAT 39.1	Digital Manometer (1)	CAT 3.35
Control Box DGM (2)	-	Horiba PG-250	-	Digital Manometer (2)	CAT 3.85
Box Thermocouples (1)	CAT 3.011	Servomex 4900	-	Digital Temperature Meter	-
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 14.53
Umbilical (1)	CAT 3.011	ABB AO2020-URAS26	-	Barometer	CAT 13.8
Umbilical (2)	-	Servomex 5200MP	-	Stack Thermocouple (1)	CAT 4.584
Oven Box (1)	CAT 12.961	JCT JCC P1 Cooler	CAT 4.46	Stack Thermocouple (2)	-
Oven Box (2)	-	Gasmeter DX4000	-	Stack Thermocouple (3)	-
Heated Probe (1)	CAT 5.85	Gasmeter Sampling System	-	1m Heated Line (1)	-
Heated Probe (2)	-	Bernath 3006 FID	CAT 8.90	1m Heated Line (2)	-
Heated Probe (3)	-	Ankersmid APP100	CAT 12.64	1m Heated Line (3)	-
S-Pitot (1)	CAT 21P.76	Mass Flow Controller (1)	CAT 6.30	5m Heated Line (1)	-
S-Pitot (2)	-	Mass Flow Controller (2)	CAT 6.31	15m Heated Line (1)	-
L-Pitot	-	Mass View (1)	CAT 25.5	20m Heated Line (1)	CAT 20.24
500g Check Weight	CAT 17.8	Mass View (2)	CAT 25.6	20m Heated Line (2)	-
1Kg Check Weight	CAT 17.8	Easylogger EN-EL-12 Bit	CAT 11.24	Dual Channel Heater Controller	-
Last Impinger Arm	-	Easylogger EN-EL-12 Bit	CAT 11.43	Single Channel Heater Controller	-
Callipers	CAT 23.9	Bioaerosols Temperature Logger	-	Laboratory Balance	CAT 1.18 / 1.18a
Tubes Kit Thermocouple	CAT 4.218	Electronic Refrigerator	-	Tape Measure	CAT 16.19

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	CAT-TP-01
Hydrogen Chloride	BS EN 1911	CAT-TP-11
Mercury	EN 13211	CAT-TP-06
Water Vapour	EN 14790	CAT-TP-05
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20
Carbon Monoxide	EN 15058	CAT-TP-39
Oxygen	EN 14789	CAT-TP-39
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	0.43
Stack Width, W	m	-
Stack Area, A	m ²	0.15
Average Stack Gas Temperature, T _a	°C	152.8
Average Stack Gas Pressure	Pa	79.4
Average Stack Static Pressure, P _{static}	kPa	0.075
Average Barometric Pressure, P _b	kPa	102.1
Average Pitot Tube Calibration Coefficient, C _p	-	0.84

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m ³ p	Conc kg/m ³ p _i
CO ₂ (Estimated)	-	6.00	5.52	0.0600	44.01	1.9635	0.11781
O ₂	-	14.31	13.16	0.1431	32.00	1.4277	0.20432
N ₂	-	79.69	73.27	0.7969	28.01	1.2498	0.99599
Moisture (H ₂ O)	-	-	8.05	0.0805	18.02	0.8037	0.06472

Where: $p = M / 22.41$

$p_i = r \times p$

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P _{STD}	kg/m ³	1.318
Wet Density (STP), P _{STW}	kg/m ³	1.277
Dry Density (Actual), P _{Actual}	kg/m ³	0.853
Average Wet Density (Actual), P _{ActualW}	kg/m ³	0.826

Where: P_{STD} = sum of component concentrations, kg/m³ (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m³ (including water vapour)

$P_{Actual} = P_{STD} \times (T_{STP} / (P_{STP})) \times ((P_{static} + P_b) / T_a)$

$P_{ActualW}$ (at each sampling point) = P_{STW} x (T_s / P_s) x (P_a / T_a)

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF ¹
Temperature	°C	152.8	0.0
Total Pressure	kPa	102.2	101.3
Moisture	%	8.05	0.00
Oxygen (Dry)	%	14.3	11.0

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m ³ /hr	6057
Gas Volumetric Flowrate (STP, Wet)	m ³ /hr	3918
Gas Volumetric Flowrate (STP, Dry)	m ³ /hr	3602
Gas Volumetric Flowrate REF ¹	m ³ /hr	2409

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	07/05/2015
Time of Survey	-	10:43 - 10:55
Atmospheric Pressure	kPa	102.1
Average Stack Static Pressure	Pa	75
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 200 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Horizontal
Pitot Tube, C _p	-	0.84
Number of Lines Available	-	2
Number of Lines Used	-	1

Sampling Line A						
Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m ³	Velocity m/s	Swirl °
STATIC (Units: Pa)		75.0				
Mean		79.4	152.8	0.826	11.59	
1	0.03	98.5	152.0	0.827	12.94	5.0
2	0.11	84.5	153.0	0.825	12.00	3.0
3	0.32	72.2	152.0	0.827	11.08	4.0
4	0.40	62.5	154.0	0.823	10.33	2.0

Sampling Line B - Restricted Access				
ΔP	Temp °C	Wet Density kg/m ³	Velocity m/s	Swirl °

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

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	$u(k)$	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	$u(\Delta p_i)$	1.490	Pa
- Resolution	$u(res)$	0.00087	
- Calibration	$u(cal)$	0.657	
- Drift	$u(drift)$	0.083	
- Lack of Fit	$u(fit)$	0.479	
- Overall corrections to dynamic measurements	$u(C_f)$	1.220	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00005	-
- $\phi_{O_2,w}$	-	13.159	
- $\phi_{CO_2,w}$	-	5.517	
- Oxygen, dry	$u(\phi_{O_2,d})$	0.438	
- Carbon Dioxide, dry	$u(\phi_{CO_2,d})$	0.184	
- Water Vapour	$u(\phi_{H_2O})$	0.411	
- Oxygen, wet	$u(\phi_{O_2,w})$	0.407	
- Carbon Dioxide, wet	$u(\phi_{CO_2,w})$	0.171	
Standard uncertainty associated with the stack temperature	$u(T_c)$	2.172	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.698	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	1.490	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00445	-
Standard uncertainty associated with the local velocities	$u(v_i)$	0.180	Pa
Standard uncertainty associated with the mean velocity	$u(\underline{v})$	0.151	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	0.297	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	2.56	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV,w)$	315.0	m ³ /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00070	
- $u^2(qV,w)$	-	25837	
- $u(qV,w)$	-	160.7	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV,w)$	5.20	%

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Ipswich Borough Council, Ipswich Crematorium
A1 - Combined Cremator Flue

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	5.3	5.3
Uncertainty	±mg/m ³	0.74	0.74
Mass Emission	g/hr	12.8	12.8
Uncertainty	±g/hr	1.9	1.9

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	8.3	8.3
Uncertainty	±% v/v	0.43	0.43

Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m ³	0.28	0.28

NOTE: Where the Balance Uncertainty / Limit of Detection is higher than the Blank concentration, the Balance Uncertainty / Limit of Detection concentration has been reported.

General Sampling Information

Parameter	Value
Standard	EN 13284-1
Technical Procedure	CAT-TP-01
Probe Material	Titanium
Filter Housing Material	Titanium
Positioning of Filter	In Stack
Filter Size and Material	47mm Glass Fibre
Number of Sampling Lines Used	1 / 2
Number of Sampling Points Used	4 / 4
Sample Point I.D.'s	A1 - A4

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P _b	mmHg	765.8	
Stack static pressure, P _{static}	mmH ₂ O	7.6	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	766.3	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	44.7	
Total mass collected in impingers (silica trap)	g	6.2	
Total mass of liquid collected, V _{lc}	g	50.9	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.0634	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V _m	m ³	0.7570	
Gas meter correction factor, Y _d	-	0.9890	
Average dry gas meter temperature, T _m	°C	22.0	
Average pressure drop across orifice, ΔH	mmH ₂ O	15.1	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	0.6992	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.0832	
B _{wo} as a percentage	% v/v	8.32	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	8.32	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd}) / (100 / (100 - R_{wv}))$	m ³	0.7626	
Volume of gas metered at Oxygen Reference Conditions, V_{mstd@X%O₂} & V_{mstw@X%O₂}			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	13.13	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	14.28	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet (O _{2REFw}) = (21 - REF%O ₂) / (21 - ACT%O _{2w})	-	1.27	
O ₂ Reference Factor dry (O _{2REFd}) = (21 - REF%O ₂) / (21 - ACT%O _{2d})	-	1.49	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	0.6005	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	0.4702	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	6.00	
O ₂	% v/v	14.28	
Total	% v/v	20.28	
N ₂	% v/v	79.72	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	29.53	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.57	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K _p	-	34.97	
Velocity pressure coefficient, C _p	-	0.84	
Average of velocity heads, ΔP _{avg}	mmH ₂ O	7.16	
Average square root of velocity heads, √ΔP	√mmH ₂ O	2.68	
Average stack gas temperature, T _s	°C	150.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(T_s + 273)) / (V(M_s)(P_s))$	m/s	10.92	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO₂}), Dry@O_{2REF} (Q_{stdO₂})			
Area of stack, A _s	m ²	0.15	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	95.2	
Conversion factor (K/mm.Hg), C _f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	61.9	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	56.8	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	48.8	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	38.2	
Percent isokinetic, %I			
Nozzle diameter, D _n	mm	5.87	
Nozzle area, A _n	mm ²	27.10	
Total sampling time, q	min	60	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	110.0	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	11:39 - 12:39	
Sampling Dates	-	07/05/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	0.4702	
Filter I.D. Number	-	47-25107	
Start Filter Mass	g	0.15012	
End Filter Mass	g	0.15172	
Total Mass on Filter	g	0.00160	
Probe Rinse I.D. Number	-	PR-47-25107	
Start Probe Rinse Mass	g	3.04836	
End Probe Rinse Mass	g	3.04925	
Total Mass in Probe Rinse	g	0.00089	
Total Mass Collected	mg	2.49	
Calculated Concentration	mg/m ³	5.30	
Balance Uncertainty / LOD	mg/m ³	0.28	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	07/05/2015	
Average Volume Sampled (REF)	m ³	0.4702	
Filter I.D. Number	-	47-25106	
Start Filter Mass	g	0.15009	
End Filter Mass	g	0.15015	
Total Mass on Filter	g	0.00006	
Probe Rinse I.D. Number	-	PR-47-25106	
Start Probe Rinse Mass	g	3.06649	
End Probe Rinse Mass	g	3.06650	
Total Mass in Probe Rinse	g	0.00001	
Total Mass Collected	mg	0.07	
Calculated Concentration	mg/m ³	0.15	
Balance Uncertainty / LOD	mg/m ³	0.28	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	12.48	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.09	
Allowable Leak Rate	l/min	0.25	
Leak Test Acceptable	-	Yes	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.1	
Allowable MU	%	20	
MU Acceptable	%	Yes	

Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	

Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	110.0	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

Weighing Uncertainty Criteria	Units	Run 1	
Overall Weighing Uncertainty	± mg	0.24	
Overall Weighing Uncertainty	± mg/m ³	0.51	
ELV [Daily ELV for IED]	mg/m ³	20.00	
Allowable Weighing Uncertainty	mg/m ³	1.00	
Weighing Uncertainty Acceptable	-	Yes	

Filter Temperatures	Units	Run 1	
Pre-Conditioning Temperature	°C	180	
Post-Conditioning Temperature	°C	160	
Maximum Filter Temperature	°C	150	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	18.00	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.10	
Allowable Leak Rate	l/min	0.36	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	2.0	
Blank Acceptable	-	Yes	

Acetone / Water Rinse Blank	Units	Blank
Acetone / Water Rinse Value	mg/l	2.7
Allowable Blank	mg/l	10
Blank Acceptable	-	Yes

Method Deviations

Nature of Deviation	Run Number
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1
One out of two sampling lines was used due to sampling location restrictions, however the number of sample points used on the available line were increased to meet the requirements of the Standard.	x

TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	0.7570		uV _m	m ³	0.0151	
Sampled Gas Temperature	T _m	295.0		uT _m	K	2.0	
Sampled Gas Pressure	p _m	102.2		up _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	0.72		uL	%	-	
Mass of Particulate	m	2.49		um	mg	0.13	
Uncollected Mass	UCM	0.07		uUCM	mg	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.68		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.72		≤2%
Mass of Particulate	%	1.38		<5% of ELV
Uncollected Mass	%	-		-

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	0.6992		7.57	
Leak	L	mg/m ³	0.022		1.00	
Mass of Particulate	L _r	mg	2.490		2.13	
Uncollected Mass	UCM	mg	0.04		2.13	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.134	
Leak	mg/m ³	0.0221	
Mass of Particulate	mg/m ³	0.2765	
Uncollected Mass	mg/m ³	0.0860	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	1.49	
Stack Gas O ₂ Content	% v/v	14.28	
MU for O ₂ Correction	-	0.11	
Overall MU For O ₂ Measurement	%	7.44	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	0.32	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.63	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	0.74	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.74	
Reported Uncertainty	mg/m ³	0.74	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	11.8	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	14.0	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	14.0	
Reported Uncertainty	%	14.0	

HYDROGEN CHLORIDE: RESULTS SUMMARY

Ipswich Borough Council, Ipswich Crematorium
A1 - Combined Cremator Flue

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	11.1	11.1
Uncertainty	±mg/m ³	1.1	1.1
Mass Emission	g/hr	26.8	26.8
Uncertainty	±g/hr	3.1	3.1

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	8.3	8.3
Uncertainty	±% v/v	0.43	0.43

Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m ³	< 0.036	< 0.036

General Sampling Information

Parameter	Value
Standard	BS EN 1911
Technical Procedure	CAT-TP-11
Name of Analytical Laboratory	CAT
Analytical Laboratory's Procedure	CAT-AP-01
ISO 17025 Accredited Analysis?	Yes
Date of Sample Analysis	15/05/2015
Probe Material	Titanium
Filter Housing Material	Titanium
Impinger Material	Polyethylene
Absorption Solution	HPLC Grade Water
Positioning of Filter	In Stack
Filter Size and Material	47mm Glass Fibre
Number of Sampling Lines Used	1 / 2
Number of Sampling Points Used	4 / 4
Sample Point I.D.'s	A1 - A4

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

HYDROGEN CHLORIDE: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P _b	mmHg	765.8	
Stack static pressure, P _{static}	mmH ₂ O	7.6	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	766.3	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	44.7	
Total mass collected in impingers (silica trap)	g	6.2	
Total mass of liquid collected, V _{lc}	g	50.9	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.0634	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V _m	m ³	0.7570	
Gas meter correction factor, Y _d	-	0.9890	
Average dry gas meter temperature, T _m	°C	22.0	
Average pressure drop across orifice, ΔH	mmH ₂ O	15.1	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	0.6992	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.0832	
B _{wo} as a percentage	% v/v	8.32	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	8.32	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd}) / (100 / (100 - R_{wv}))$	m ³	0.7626	
Volume of gas metered at Oxygen Reference Conditions, V_{mstd@X%O₂} & V_{mstw@X%O₂}			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	13.13	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	14.28	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet (O _{2REFw}) = (21 - REF%O ₂) / (21 - ACT%O _{2w})	-	1.27	
O ₂ Reference Factor dry (O _{2REFd}) = (21 - REF%O ₂) / (21 - ACT%O _{2d})	-	1.49	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	0.6005	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	0.4702	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	6.00	
O ₂	% v/v	14.28	
Total	% v/v	20.28	
N ₂	% v/v	79.72	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	29.53	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.57	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K _p	-	34.97	
Velocity pressure coefficient, C _p	-	0.84	
Average of velocity heads, ΔP _{avg}	mmH ₂ O	7.16	
Average square root of velocity heads, √ΔP	√mmH ₂ O	2.68	
Average stack gas temperature, T _s	°C	150.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(T_s + 273)) / (V(M_s)(P_s))$	m/s	10.92	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO₂}), Dry@O_{2REF} (Q_{stdO₂})			
Area of stack, A _s	m ²	0.15	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	95.2	
Conversion factor (K/mm.Hg), C _f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	61.9	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	56.8	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	48.8	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	38.2	
Percent isokinetic, %I			
Nozzle diameter, D _n	mm	5.87	
Nozzle area, A _n	mm ²	27.10	
Total sampling time, q	min	60	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	110.0	

HYDROGEN CHLORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	11:39 - 12:39	
Sampling Dates	-	07/05/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	0.4702	
Laboratory Result for Front Impingers	µg/ml	15.19	
Laboratory Result for Back Impinger	µg/ml	0.05	
Volume in Front Impingers	ml	344.1	
Volume in Back Impinger	ml	169.9	
Mass in Front Impingers	µg	5226.9	
Mass in Back Impinger	µg	< 8.5	
Total Mass Collected	µg	5235.4	
Calculated Concentration	mg/m ³	11.13	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	07/05/2015	
Average Volume Sampled (REF)	m ³	0.4702	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	335.0	
Total Mass Collected	µg	< 16.8	
Calculated Concentration	mg/m ³	< 0.04	

HYDROGEN CHLORIDE: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	12.48	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.09	
Allowable Leak Rate	l/min	0.25	
Leak Test Acceptable	-	Yes	
Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	100.0	
Allowable Absorption Efficiency	%	N/A	
Absorption Efficiency Acceptable	-	N/A	
Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	
MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.1	
Allowable MU	%	20	
MU Acceptable	%	Yes	
Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	110.0	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	
Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	150	
Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

HYDROGEN CHLORIDE: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	18.00	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.10	
Allowable Leak Rate	l/min	0.36	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	3.0	
Blank Acceptable	-	Yes	

Method Deviations

Nature of Deviation	Run Number	
	(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1
There are no deviations associated with the sampling employed.	wx	

HYDROGEN CHLORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V_m	0.7570		uV_m	m^3	0.0151	
Sampled Gas Temperature	T_m	295.0		uT_m	K	2.0	
Sampled Gas Pressure	p_m	102.2		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.72		uL	%	-	
Laboratory Result	L_r	2.50		uL_r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.68		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.72		≤2%
Laboratory Result	%	2.50		No Requirement

Measured Quantities	Uncertainty in Measurement Units			Sensitivity Coefficient	
	Symbol	Units	Run 1	Run 1	
Sampled Volume (STP)	V_m	m^3	0.6992	15.93	
Leak	L	mg/m^3	0.0464	1.00	
Laboratory Result	L_r	mg/m^3	0.278	1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m^3	0.2814	
Leak	mg/m^3	0.046	
Laboratory Result	mg/m^3	0.278	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	1.49	
Stack Gas O ₂ Content	% v/v	14.28	
MU for O ₂ Correction	-	0.11	
Overall MU For O ₂ Measurement	%	7.44	

Parameter	Units	Run 1	
Combined uncertainty	mg/m^3	0.40	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.78	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	1.14	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	1.14	
Reported Uncertainty	mg/m^3	1.14	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	7.0	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	10.2	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	10.2	
Reported Uncertainty	%	10.2	

MERCURY: RESULTS SUMMARY

Ipswich Borough Council, Ipswich Crematorium
A1 - Combined Cremator Flue

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	0.026	0.026
Uncertainty	±mg/m ³	0.004	0.004
Mass Emission	g/hr	0.062	0.062
Uncertainty	±g/hr	0.010	0.010

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	7.5	7.5
Uncertainty	±% v/v	0.40	0.40

Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m ³	< 0.00035	< 0.00035

General Sampling Information

Parameter	Value
Standard	EN 13211
Technical Procedure	CAT-TP-06
Name of Analytical Laboratory	RPS
Analytical Laboratory's Procedure	M112
ISO 17025 Accredited Analysis?	Yes
Date of Sample Analysis	19/05/2015
Probe Material	Titanium
Filter Housing Material	Borosilicate Glass
Impinger Material	Borosilicate Glass
Absorption Solution	Nitric Peroxide & Potassium Dichromate
Positioning of Filter	Out Stack
Filter Size and Material	47mm Quartz Fibre
Number of Sampling Lines Used	1 / 2
Number of Sampling Points Used	4 / 4
Sample Point I.D.'s	A1 - 4

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

MERCURY: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P _b	mmHg	765.8	
Stack static pressure, P _{static}	mmH ₂ O	7.6	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	766.3	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	48.8	
Total mass collected in impingers (silica trap)	g	8.9	
Total mass of liquid collected, V _{lc}	g	57.7	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.0719	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V _m	m ³	0.9780	
Gas meter correction factor, Y _d	-	0.9890	
Average dry gas meter temperature, T _m	°C	28.9	
Average pressure drop across orifice, ΔH	mmH ₂ O	27.3	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	0.8835	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.0753	
B _{wo} as a percentage	% v/v	7.53	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	7.53	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd}) / (100 / (100 - R_{wv}))$	m ³	0.9554	
Volume of gas metered at Oxygen Reference Conditions, V_{mstd@X%O₂} & V_{mstw@X%O₂}			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	12.87	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	14.00	
% oxygen reference condition, REF%O ₂	% v/v	11.00	
O ₂ Reference Factor wet (O _{2REFw}) = (21 - REF%O ₂) / (21 - ACT%O _{2w})	-	1.23	
O ₂ Reference Factor dry (O _{2REFd}) = (21 - REF%O ₂) / (21 - ACT%O _{2d})	-	1.43	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	0.7763	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	0.6183	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	6.00	
O ₂	% v/v	14.00	
Total	% v/v	20.00	
N ₂	% v/v	80.00	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	29.52	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.65	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K _p	-	34.97	
Velocity pressure coefficient, C _p	-	0.84	
Average of velocity heads, ΔP _{avg}	mmH ₂ O	7.25	
Average square root of velocity heads, √ΔP	√mmH ₂ O	2.69	
Average stack gas temperature, T _s	°C	160.9	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(T_s + 273)) / (v(M_s)(P_s))$	m/s	11.12	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO₂}), Dry@O_{2REF} (Q_{stdO₂})			
Area of stack, A _s	m ²	0.15	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	96.9	
Conversion factor (K/mm.Hg), C _f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min	61.5	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	56.8	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	49.9	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	39.8	
Percent isokinetic, %I			
Nozzle diameter, D _n	mm	6.79	
Nozzle area, A _n	mm ²	36.21	
Total sampling time, q	min	60	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.9	

MERCURY: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	13:53 - 14:53	
Sampling Dates	-	07/05/2015	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	0.6183	
Mass on Filter / in Rinse	µg	1.72	
Mass in Front Impinger/s	µg	13.84	
Mass in Final Impinger	µg	0.47	
Total Mass Collected	µg	16.03	
Calculated Concentration	mg/m ³	0.0259	
Reported Concentration	mg/m ³	0.0259	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	07/05/2015	
Average Volume Sampled (REF)	m ³	0.6183	
Mass on Filter / in Rinse	µg	< 0.03	
Mass in Front Impinger/s	µg	< 0.12	
Mass in Final Impinger	µg	< 0.07	
Total Mass Collected	µg	< 0.22	
Calculated Concentration	mg/m ³	< 0.0004	
Reported Concentration	mg/m ³	< 0.0004	

MERCURY: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	16.12	
Pre-Sampling Leak Rate	l/min	0.22	
Post-Sampling Leak Rate	l/min	0.22	
Allowable Leak Rate	l/min	0.32	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	97.1	
Allowable Absorption Efficiency	%	95	
Absorption Efficiency Acceptable	-	Yes	

Concentration in Final Impinger	Units	Run 1	
Concentration in Final Impinger	µg/m ³	0.76	
Allowable Concentration	µg/m ³	N/A	
Concentration Acceptable	-	N/A	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.4	
Allowable MU	%	20	
MU Acceptable	%	Yes	

Silica Gel (Concurrent Water Vapour)	Units	Run 1	
Less than 50% Faded	%	Yes	

Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	103.9	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	180	

Impingers Exit Temperature	Units	Run 1	
Maximum Temperature Recorded	°C	16	
Maximum Allowable Temperature	°C	30	
Exit Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

MERCURY: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	18.00	
Pre-Sampling Leak Rate	l/min	0.20	
Post-Sampling Leak Rate	l/min	0.20	
Allowable Leak Rate	l/min	0.36	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	0.0050	
Blank Acceptable	-	Yes	

Method Deviations

Nature of Deviation	Run Number	
	(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1
One out of two sampling lines was used due to sampling location restrictions, however the number of sample points used on the available line were increased to meet the requirements of the Standard.	x	

MERCURY: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	0.9780		uV _m	m ³	0.0196	
Sampled Gas Temperature	T _m	301.9		uT _m	K	2.0	
Sampled Gas Pressure	p _m	102.2		up _m	kPa	0.5	
Sampled Gas Humidity	H _m	0.0		uH _m	% v/v	1.0	
Leak	L	1.36		uL	%	-	
Laboratory Result	L _r	6.00		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.66		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	1.36		≤2%
Laboratory Result	%	6.00		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	0.8835		0.03	
Leak	L	mg/m ³	0.0002		1.00	
Laboratory Result	L _r	mg/m ³	0.0016		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.0007	
Leak	mg/m ³	0.0002	
Laboratory Result	mg/m ³	0.0016	

Measured Quantities	Oxygen Correction Part of MU Budget		
	Units	Run 1	
O ₂ Correction Factor	-	1.43	
Stack Gas O ₂ Content	% v/v	14.00	
MU for O ₂ Correction	-	0.10	
Overall MU For O ₂ Measurement	%	7.14	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	0.0017	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.0033	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	0.0038	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.0038	
Reported Uncertainty	mg/m ³	0.0038	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	12.9	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	14.7	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	14.7	
Reported Uncertainty	%	14.7	

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Ipswich Borough Council, Ipswich Crematorium
A1 - Combined Cremator Flue

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	2.1	2.1
Uncertainty	±mg/m ³	0.67	0.67
Mass Emission	g/hr	5.1	5.1
Uncertainty	±g/hr	1.6	1.6

General Sampling Information

Parameter	Value
Standard	EN 12619:2013
Technical Procedure	CAT-TP-20
Probe Material	Stainless Steel
Filtration Type / Size	0.1µm Glass Fibre
Heated Head Filter Used	Yes
Heated Line Temperature	180°C
Span Gas Type	Propane in 11% O ₂ in N ₂ (5 Grade)
Span Gas Reference Number	CYL 1.0130n in N ₂ CYL 1.0140a in AIR
Span Gas Expiry Date	23/12/19 23/12/19
Span Gas Start Pressure (bar)	150 180
Gas Cylinder Concentration (ppm)	85.13 80.28
Span Gas Set Point (ppm)	79.08
Span Gas Uncertainty (%)	2 2
Zero Gas Type	11% O ₂ in N ₂ (5 Grade)
Number of Sampling Lines Used	1 / 1
Number of Sampling Points Used	1 / 1
Sample Point I.D.'s	A1

This is the blended concentration of both propane cylinders

FORMAT: Number Used / Number Required

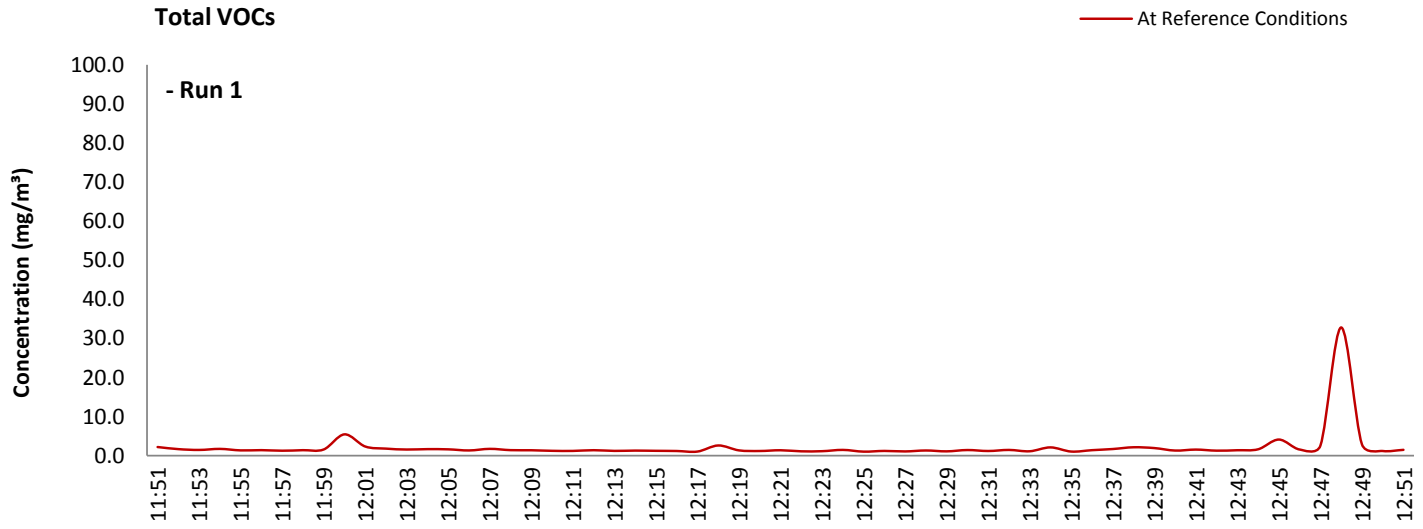
FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

TOTAL VOCs (as CARBON): DATA TREND

Graphical Trend of Data



TOTAL VOCs (as CARBON): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	
Sampling Times	-	11:51 - 12:51	
Sampling Dates	-	07/05/2015	
Instrument Range	ppm	100	
Span Gas Value	ppm	79.1	

Quality Assurance

	Zero Drift	Units	Run 1	
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.00	
	Zero Down Sampling Line (Post)	ppm	-0.02	
	Zero Drift	ppm	-0.02	
	Allowable Zero Drift	± ppm	3.95	
	Zero Drift Acceptable	-	Yes	

	Span Drift	Units	Run 1	
CAL 1	Span Down Sampling Line (Pre)	ppm	79.60	
	Span Down Sampling Line (Post)	ppm	78.40	
	Span Drift	ppm	-1.20	
	Allowable Span Drift	± ppm	3.95	
	Span Drift Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Run Ambient Temperature Range	°C	21 - 22	

Method Deviations

Nature of Deviation	Run Number	
	(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x	

TOTAL VOCs (as CARBON): MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1	Units
Limit value	20.0	mg/m ³ (REF)
TGN M2 Allowable MU	15.0	%
Measured concentration	1.37	mg/m ³ (STP, dry)
Range Used	100.0	ppm
Range Used [A]	160.6	mg/m ³
Cal gas conc.	79.1	ppm
Conversion	1.61	ppm to mg/m ³
MCERTS Range [B]	15.0	mg/m ³
Lower of [A] or [B]	15.0	mg/m ³
Cal gas conc.	127.0	mg/m ³

Performance characteristics	RUN 1	Units
Response time	45	seconds
Number of readings in measurement	60	-
Repeatability at zero	2.00	% full scale
Repeatability at span level	0.00	% full scale
Deviation from linearity	0.20	% of value
Zero drift	-0.03	% full scale
Span drift	-1.51	% full scale
Volume or pressure flow dependence	1.60	% of full scale
Atmospheric pressure dependence	0.30	% of value/kPa
Ambient temperature dependence	1.40	% full scale/10K
Combined interference	0.45	% range
Dependence on voltage	0.50	% full scale/10V
Losses in the line (leak)	0.00	% of value
Uncertainty of calibration gas	2.83	% of value

Performance characteristic	RUN 1	Units
Standard deviation of repeatability at zero	use rep at span	mg/m ³
Standard deviation of repeatability at span level	0.00	mg/m ³
Lack of fit	0.02	mg/m ³
Drift	-0.03	mg/m ³
Volume or pressure flow dependence	0.00	mg/m ³
Atmospheric pressure dependence	0.01	mg/m ³
Ambient temperature dependence	0.20	mg/m ³
Combined interference (from MCERTS Certificate)	0.04	mg/m ³
Dependence on voltage	0.06	mg/m ³
Losses in the line (leak)	0.00	mg/m ³
Uncertainty of calibration gas	0.02	mg/m ³

Measurement uncertainty	Result	RUN 1	Units
Combined uncertainty		1.37	mg/m ³
Expanded uncertainty	k = 1.96	0.43	mg/m ³
Uncertainty corrected to std conds. (O ₂)		0.67	mg/m ³ (REF)

	RUN 1	Units
Expanded uncertainty (no O ₂) - at 95% Confidence	31.79	% of Value
Expanded uncertainty (no O ₂) - at 95% Confidence	2.17	% at ELV
Overall Allowable uncertainty (no O ₂) - at 95% Confidence	15.0	% at ELV
Result of Compliance with Uncertainty Requirement in M2	N/A	-

	RUN 1	Units
Expanded uncertainty (with O ₂) - at 95% Confidence	32.05	% of Value
Expanded uncertainty (with O ₂) - at 95% Confidence	5.27	% at ELV
Overall Allowable uncertainty (with O ₂) - at 95% Confidence	15.5	% at ELV
Result of Compliance with Uncertainty Requirement in M2	COMPLIANT	-

Requirement for SRM is that Uncertainty should be <15% of the value at the ELV, on a dry gas basis, or if O₂ correction is applied less than 15% + the uncertainty associated with the O₂ correction (using sqrt of sum squares to add uncertainty components). Ref EA TGN M2.

CARBON MONOXIDE: RESULTS SUMMARY

Ipswich Borough Council, Ipswich Crematorium
A1 - Combined Cremator Flue

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	13.7	13.7
Uncertainty	±mg/m ³	2.0	2.0
Mass Emission	g/hr	33.0	33.0
Uncertainty	±g/hr	5.2	5.2

General Sampling Information

Parameter	Value
Standard	EN 15058
Technical Procedure	CAT-TP-39
Probe Material	Stainless Steel
Filtration Type / Size	0.1µm Glass Fibre
Heated Head Filter Used	Yes
Heated Line Temperature	180°C
Span Gas Type	Carbon Monoxide
Span Gas Reference Number	CYL 2.0076
Span Gas Expiry Date	31/07/2018
Span Gas Start Pressure (bar)	40
Gas Cylinder Concentration (ppm)	403.11
Span Gas Uncertainty (%)	2
Zero Gas Type	Nitrogen (5 Grade)
Number of Sampling Lines Used	1 / 1
Number of Sampling Points Used	1 / 1
Sample Point I.D.'s	A1

NOTE: Dilution performed to achieve correct span value

FORMAT: Number Used / Number Required

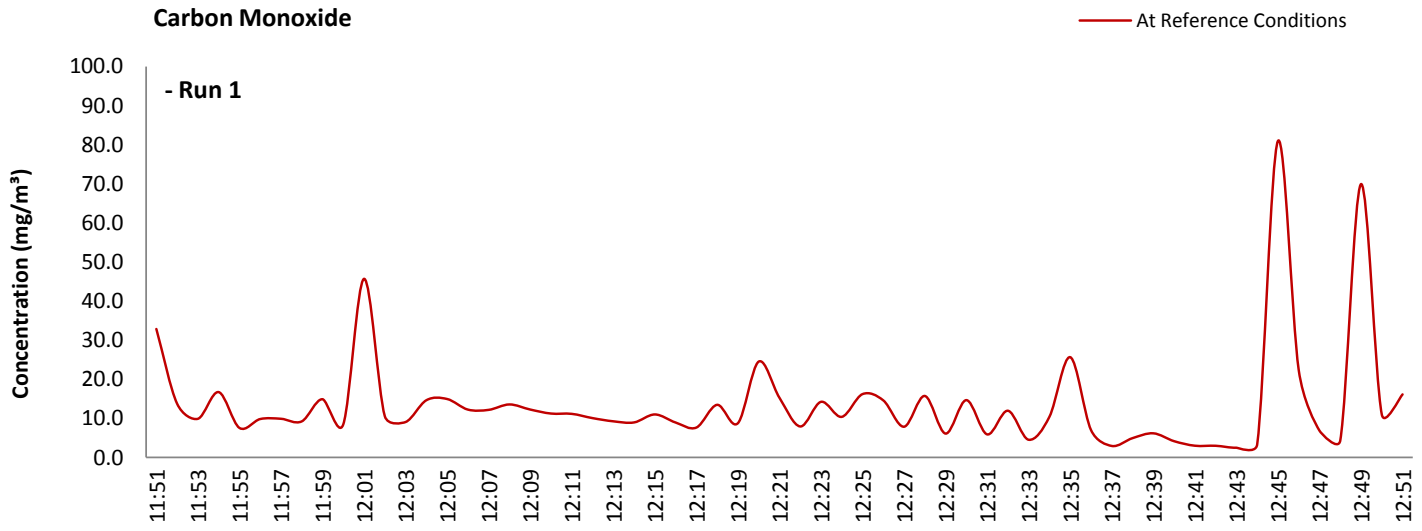
FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 11% oxygen.

CARBON MONOXIDE: DATA TREND

Graphical Trend of Data



CARBON MONOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	
Sampling Times	-	11:51 - 12:51	
Sampling Dates	-	07/05/2015	
Instrument Range	ppm	100	
Span Gas Value	ppm	80.1	

Quality Assurance

Conditioning Unit Temperature	Units	Run 1	
Average Temperature	°C	2.6	
Allowable Temperature	< °C	4.0	
Temperature Acceptable	-	Yes	

	Zero Drift	Units	Run 1	
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.00	
	Zero Down Sampling Line (Post)	ppm	-0.60	
	Zero Drift	ppm	-0.60	
	Allowable Zero Drift	± ppm	4.00	
	Zero Drift Acceptable	-	Yes	

	Span Drift	Units	Run 1	
CAL 1	Span Down Sampling Line (Pre)	ppm	79.40	
	Span Down Sampling Line (Post)	ppm	78.10	
	Span Drift	ppm	-1.30	
	Allowable Span Drift	± ppm	4.00	
	Span Drift Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Run Ambient Temperature Range	°C	21 - 22	

Method Deviations

Nature of Deviation	Run Number
(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x

CARBON MONOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1	Units
Limit value	100.0	mg/m ³ (REF)
TGN M2 Allowable MU	6.0	%
Measured concentration	8.93	mg/m ³ (STP, dry)
Range Used	100.0	ppm
Range Used [A]	124.9	mg/m ³
Cal gas conc.	80.1	ppm
Conversion	1.25	ppm to mg/m ³
MCERTS Range [B]	75.0	mg/m ³
Lower of [A] or [B]	75.0	mg/m ³
Cal gas conc.	100.0	mg/m ³

Performance characteristics	RUN 1	Units
Response time	28	seconds
Number of readings in measurement	60	-
Repeatability at zero	0.10	% full scale
Repeatability at span level	0.20	% full scale
Deviation from linearity	0.49	% of value
Zero drift	-0.76	% full scale
Span drift	-1.64	% full scale
Volume or pressure flow dependence	0.10	% of full scale
Atmospheric pressure dependence	0.22	% of value/kPa
Ambient temperature dependence	-0.20	% full scale/10K
Combined interference	-0.48	% range
Dependence on voltage	-0.35	% full scale/10V
Losses in the line (leak)	0.87	% of value
Uncertainty of calibration gas blending	1.40	% of value
Uncertainty of calibration gas	2.00	% of value

Performance characteristic	RUN 1	Units
Standard deviation of repeatability at zero	use rep at span	mg/m ³
Standard deviation of repeatability at span level	0.03	mg/m ³
Lack of fit	0.21	mg/m ³
Drift	-0.52	mg/m ³
Volume or pressure flow dependence	0.00	mg/m ³
Atmospheric pressure dependence	0.05	mg/m ³
Ambient temperature dependence	-0.03	mg/m ³
Combined interference (from MCERTS Certificate)	-0.21	mg/m ³
Dependence on voltage	-0.04	mg/m ³
Losses in the line (leak)	0.05	mg/m ³
Uncertainty of calibration gas blending	0.07	mg/m ³
Uncertainty of calibration gas	0.10	mg/m ³

Measurement uncertainty	Result	RUN 1	Units
Combined uncertainty		8.93	mg/m ³
Expanded uncertainty	k =	1.28	mg/m ³
Uncertainty corrected to std conds. (O ₂)	1.96	1.96	mg/m ³ (REF)

	RUN 1	Units
Expanded uncertainty (no O ₂) - at 95% Confidence	14.33	% of Value
Expanded uncertainty (no O ₂) - at 95% Confidence	1.28	% at ELV
Overall Allowable uncertainty (no O ₂) - at 95% Confidence	6.0	% at ELV
Result of Compliance with Uncertainty Requirement in M2	N/A	-

	RUN 1	Units
Expanded uncertainty (with O ₂) - at 95% Confidence	14.90	% of Value
Expanded uncertainty (with O ₂) - at 95% Confidence	4.53	% at ELV
Overall Allowable uncertainty (with O ₂) - at 95% Confidence	7.3	% at ELV
Result of Compliance with Uncertainty Requirement in M2	COMPLIANT	-

Requirement for SRM is that Uncertainty should be <6% of the value at the ELV, on a dry gas basis, or if O₂ correction is applied less than 6% + the uncertainty associated with the O₂ correction (using sqrt of sum squares to add uncertainty components). Ref EA TGN M2.

OXYGEN: RESULTS SUMMARY

Ipswich Borough Council, Ipswich Crematorium
A1 - Combined Cremator Flue

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	% v/v	14.5	14.5
Uncertainty	±% v/v	0.59	0.59

General Sampling Information

Parameter	Value
Standard	EN 14789
Technical Procedure	CAT-TP-39
Probe Material	Stainless Steel
Filtration Type / Size	0.1µm Glass Fibre
Heated Head Filter Used	Yes
Heated Line Temperature	180°C
Span Gas Type	Synthetic Air (5 Grade)
Span Gas Reference Number	CYL 11.0159
Span Gas Expiry Date	15/02/2019
Span Gas Start Pressure (bar)	20
Gas Cylinder Concentration (% v/v)	20.9
Span Gas Uncertainty (%)	2
Zero Gas Type	Nitrogen (5 Grade)
Number of Sampling Lines Used	1 / 1
Number of Sampling Points Used	1 / 1
Sample Point I.D.'s	A1

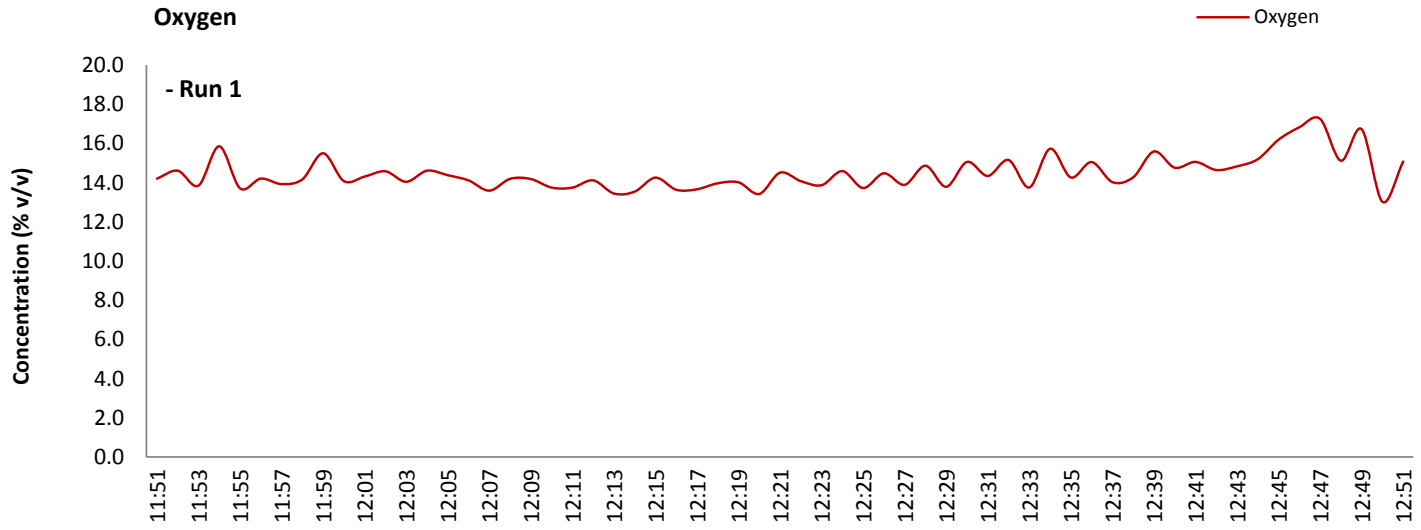
NOTE: Dilution performed to achieve correct span value

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

OXYGEN: DATA TREND

Graphical Trend of Data



OXYGEN: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	
Sampling Times	-	11:51 - 12:51	
Sampling Dates	-	07/05/2015	
Instrument Range	% v/v	25	
Span Gas Value	% v/v	11.00	

Quality Assurance

Conditioning Unit Temperature	Units	Run 1	
Average Temperature	°C	2.6	
Allowable Temperature	< °C	4.0	
Temperature Acceptable	-	Yes	

Zero Drift	Units	Run 1	
Zero Down Sampling Line (Pre)	% v/v	0.04	
Zero Down Sampling Line (Post)	% v/v	-0.11	
Zero Drift	% v/v	-0.15	
Allowable Zero Drift	± % v/v	0.55	
Zero Drift Acceptable	-	Yes	

CAL 1

Span Drift	Units	Run 1	
Span Down Sampling Line (Pre)	% v/v	10.90	
Span Down Sampling Line (Post)	% v/v	10.80	
Span Drift	% v/v	-0.10	
Allowable Span Drift	± % v/v	0.55	
Span Drift Acceptable	-	Yes	

CAL 1

Test Conditions	Units	Run 1	
Run Ambient Temperature Range	°C	21 - 22	

Method Deviations

Nature of Deviation	Run Number	
	(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x	

OXYGEN: MEASUREMENT UNCERTAINTY CALCULATIONS

Performance characteristics	RUN 1	Units
Limit value	N/A	%vol
TGN M2 Allowable MU	6.0	%
Measured concentration	14.48	%vol
Range Used	25.0	%vol
Cal gas conc.	20.9	%vol

Performance characteristics	RUN 1	Units
Response time	41	seconds
Number of readings in measurement	60	-
Repeatability at zero	0.02	% full scale
Repeatability at span level	0.02	% full scale
Deviation from linearity	0.02	% of value
Zero drift	-1.38	% full scale
Span drift	-0.92	% full scale
Volume or pressure flow dependence	0.10	% of full scale
Atmospheric pressure dependence	0.19	% of value/kPa
Ambient temperature dependence	-0.21	% full scale/10K
Combined interference	0.00	% range
Dependence on voltage	0.02	% full scale/10V
Losses in the line (leak)	0.64	% of value
Uncertainty of calibration gas		% of value

Performance characteristic	RUN 1	Units
Standard deviation of repeatability at zero	use rep at span	%vol
Standard deviation of repeatability at span level	0.00	%vol
Lack of fit	0.00	%vol
Drift	-0.24	%vol
Volume or pressure flow dependence	0.00	%vol
Atmospheric pressure dependence	0.01	%vol
Ambient temperature dependence	-0.03	%vol
Combined interference (from MCERTS Certificate)	0.00	%vol
Dependence on voltage	0.00	%vol
Losses in the line (leak)	0.05	%vol
Uncertainty of calibration gas	0.17	%vol

Measurement uncertainty	Result	RUN 1	Units
Combined uncertainty		14.48	%vol
Expanded uncertainty	k = 1.96	0.30	%vol
		0.59	%vol

	RUN 1	Units
Expanded uncertainty (no O ₂) - at 95% Confidence	4.08	% of Value
Result of Compliance with Uncertainty Requirement in M2	COMPLIANT	-

Requirement for SRM is that Uncertainty should be 0.5%vol absolute or 6% relative whichever is the lower, on a dry gas basis. Ref EA TGN M2.