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**Stack Emissions Testing Report Commissioned by**  
The Phoenix Partnership

**Installation Name & Address**

Barrow Borough Council  
Thornccliffe Crematorium  
Devonshire Road  
Barrow-In-Furness  
Cumbria  
LA14 5PD

LAPPC Permit: PPC/B/10

**Stack Reference**

Cremator No.2

**Dates of the Monitoring Campaign**

6th - 7th December 2017

**Job Reference Number**

CAT-3877

<b>Report Written by</b>
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<b>Report Approved by</b>
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<b>Report Date</b>
21st December 2017

<b>Version</b>
Version 1

<b>Signature of Report Approver</b>

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## Executive Summary

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### MONITORING OBJECTIVES

Barrow Borough Council, Thorncliffe Crematorium  
Cremator No.2  
6th - 7th December 2017

#### Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by The Phoenix Partnership to carry out stack emissions testing for Barrow Borough Council on the Cremator No.2 at Thorncliffe 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, Total VOCs (as Carbon), Carbon Monoxide

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### MONITORING RESULTS

Barrow Borough Council, Thorncliffe Crematorium  
Cremator No.2  
6th - 7th December 2017

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total Particulate Matter	<sup>1</sup> mg/m <sup>3</sup>	52.1	8.2	80 <sup>†</sup> /160 <sup>‡</sup>	g/hr	81.7	28.4	120 <sup>†</sup> /240 <sup>‡</sup>
Hydrogen Chloride	<sup>1</sup> mg/m <sup>3</sup>	36.1	5.9	200	g/hr	56.7	19.9	300
Total VOCs (as Carbon)	<sup>1</sup> mg/m <sup>3</sup>	10.3	1.3	20	g/hr	16.2	5.8	30
Carbon Monoxide	<sup>1</sup> mg/m <sup>3</sup>	17.2	3.9	100 <sup>†</sup> /200 <sup>‡</sup>	g/hr	27.0	10.7	150 <sup>†</sup> /300 <sup>‡</sup>
Oxygen	% v/v	Dry 17.5	0.47					
Water Vapour	% v/v	3.8	0.21					
Stack Gas Temperature	°C	333.8						
Stack Gas Velocity	m/s	7.7	2.37					
Volumetric Flow Rate (ACTUAL)	m <sup>3</sup> /hr	10421	3223					
Volumetric Flow Rate (REF)	<sup>1</sup> m <sup>3</sup> /hr	1569	485					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY DATA TAKEN FROM AN AVERAGE OF ALL OF THE ISOKINETIC RUNS.

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

<sup>†</sup> Unless stated otherwise in the respective Permit, as per PG5/2(12), these emission limits are applicable '...for 95% of cremations'.

<sup>‡</sup> Unless stated otherwise in the respective Permit, as per PG5/2(12), these emission limits are applicable '...for all cremations'.

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### MONITORING DATE(S) & TIMES

Barrow Borough Council, Thorncliffe Crematorium

Cremator No.2

6th - 7th December 2017

Parameter	Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins	
Total Particulate Matter	R1	mg/m <sup>3</sup>	63.1	g/hr	99	06/12/2017	12:23 - 13:23	60
Total Particulate Matter	R2	mg/m <sup>3</sup>	48.6	g/hr	76.3	06/12/2017	15:12 - 16:12	60
Total Particulate Matter	R3	mg/m <sup>3</sup>	44.4	g/hr	69.8	07/12/2017	11:18 - 12:18	60
Hydrogen Chloride	R1	mg/m <sup>3</sup>	31.4	g/hr	49.3	06/12/2017	12:23 - 13:23	60
Hydrogen Chloride	R2	mg/m <sup>3</sup>	38.0	g/hr	59.6	06/12/2017	15:12 - 16:12	60
Hydrogen Chloride	R3	mg/m <sup>3</sup>	39.0	g/hr	61.1	07/12/2017	11:18 - 12:18	60
Total VOCs (as Carbon)	R1	mg/m <sup>3</sup>	17.5	g/hr	27.4	06/12/2017	12:23 - 13:23	60
Total VOCs (as Carbon)	R2	mg/m <sup>3</sup>	12.4	g/hr	19.5	06/12/2017	15:12 - 16:12	60
Total VOCs (as Carbon)	R3	mg/m <sup>3</sup>	1.1	g/hr	1.7	07/12/2017	11:18 - 12:18	60
Carbon Monoxide	R1	mg/m <sup>3</sup>	26.5	g/hr	41.6	06/12/2017	12:23 - 13:23	60
Carbon Monoxide	R2	mg/m <sup>3</sup>	16.8	g/hr	26.3	06/12/2017	15:12 - 16:12	60
Carbon Monoxide	R3	mg/m <sup>3</sup>	8.3	g/hr	13.1	07/12/2017	11:18 - 12:18	60
Oxygen	R1	% v/v	16.9			06/12/2017	12:23 - 13:23	60
Oxygen	R2	% v/v	18.0			06/12/2017	15:12 - 16:12	60
Oxygen	R3	% v/v	17.7			07/12/2017	11:18 - 12:18	60
Velocity & Volumetric Flow Rate	R1					06/12/2017	12:00 - 12:15	

All results are expressed at the respective reference conditions.

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### PROCESS DETAILS

Barrow Borough Council, Thorncliffe Crematorium

Cremator No.2

6th - 7th December 2017

#### Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	See Below
Continuous or Batch Process	Batch
Feedstock (if applicable)	N/A
Abatement System	Secondary Chamber
Abatement System Running Status	On
Fuel	Natural Gas
Plume Appearance	Not visible from sampling location

#### Site Specific Operating Conditions

Parameter	Status
Coffin Type	Standard / Standard / Standard
Sex	Female / Female / Female
Temperature in Primary Chamber	872 / 990 / 849
Temperature in Secondary Chamber	867 / 878 / 870
Cremation Number	47653 / 47654 / 47655
Size	Medium / Medium / Small

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### MONITORING & ANALYTICAL METHODS

Barrow Borough Council, Thorncliffe Crematorium

Cremator No.2

6th - 7th December 2017

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	0.44 mg/m <sup>3</sup>
Hydrogen Chloride	EN 1911	CAT-TP-11	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.06 mg/m <sup>3</sup>
Water Vapour	EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.10 % v/v
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20	Yes	CAT	Flame Ionisation Detection by Sick 3006 FID				Yes	0.32 mg/m <sup>3</sup>
Carbon Monoxide	EN 15058	CAT-TP-21	Yes	CAT	NDIR by Horiba PG-250				Yes	0.12 mg/m <sup>3</sup>
Oxygen	EN 14789	CAT-TP-21	Yes	CAT	Dry Zirconia Cell by Horiba PG-250				Yes	0.1 %
Velocity & Vol. Flow Rate	EN 16911-1 (MID)	CAT-TP-41	Yes	CAT	Pitot Tube and Thermocouple				Yes	1.8 m/s

### ANALYSIS LABORATORIES

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

Exova Catalyst (CAT)	ISO 17025 Accreditation Number: 4279
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### SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
Total Particulate Matter	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 the minimum required by the Standard

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### SUITABILITY OF SAMPLING LOCATION

#### Duct Characteristics

Parameter	Units	Value
Type	-	Rectangular
Depth	m	0.85
Width	m	0.44
Area	m <sup>2</sup>	0.37
Port Depth	cm	41
Orientation of Duct	-	Vertical
Number of Ports	-	2
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)	No
Platform has vertical base boards (approx. 0.25m high)	No
Platform has chains / self closing gates at top of ladders	No
There are no obstructions present which hamper insertion of sampling equipment	No
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	19.6	> 5 Pa	Yes
Mean Velocity	m/s	7.92	-	-
Lowest Gas Velocity	m/s	6.85	-	-
Highest Gas Velocity	m/s	8.62	-	-
Ratio of Above	: 1	1.26	< 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



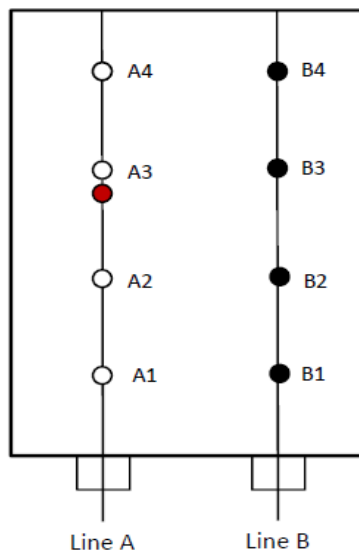
Photo 3



Photo 4



## SAMPLE POINTS



where

- = isokinetic point sampled at
- = isokinetic point not sampled at
- (red) = combustion gases sample point
- (blue) = 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	Rob Haworth	MCERTS Level 2	MM 07 797	TE1 TE2 TE3 TE4
Technician	Craig MacDonald	MCERTS Level 1	MM 11 1130	None

### 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 7.12	Horiba PG-250	CAT 9.11	Digital Manometer (1)	CAT 3.84
Control Box DGM (2)	-	Horiba PG-250 SRM	-	Digital Manometer (2)	-
Box Thermocouples (1)	CAT 3.31	Servomex 4900	-	Digital Temperature Meter	CAT 3.84
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 14.53
Umbilical (1)	CAT 3.31	ABB AO2020-URAS26	-	Barometer	CAT 13.32
Umbilical (2)	-	Testo 350 XL	-	Stack Thermocouple (1)	CAT 4.454
Oven Box (1)	CAT 12.27	JCT JCC P1 Cooler	CAT 4.64	Stack Thermocouple (2)	-
Oven Box (2)	-	Gasmet DX4000	-	Stack Thermocouple (3)	-
Heated Probe (1)	-	Gasmet Sampling System	-	1m Heated Line (1)	-
Heated Probe (2)	-	Bernath 3006 FID	CAT 8.21	1m Heated Line (2)	-
Heated Probe (3)	-	M&C PSS	CAT 12.77	1m Heated Line (3)	-
S-Pitot (1)	CAT 21S.43	Mass Flow Controller (1)	CAT 6.28	5m Heated Line (1)	-
S-Pitot (2)	-	Mass Flow Controller (2)	CAT 6.29	15m Heated Line (1)	-
L-Pitot	-	Mass View (1)	-	20m Heated Line (1)	CAT 20.88
Site Balance	CAT 17.22	Mass View (2)	-	20m Heated Line (2)	-
500g / 1Kg Check Weights	CAT 17.22	Hioki 5043 (V)	CAT 11.66	Dual Channel Heater Controller	-
Last Impinger Arm	-	Easylogger EN-EL-12 Bit	-	Single Channel Heater Controller	-
Callipers	CAT 23.13	Bioaerosols Temperature Logger	-	Laboratory Balance	CAT 1.18 / 1.18a
Tubes Kit Thermocouple	-	Electronic Refrigerator	-	Tape Measure	CAT 16.96

### METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	CAT-TP-01
Hydrogen Chloride	EN 1911	CAT-TP-11
Water Vapour	EN 14790	CAT-TP-05
Total VOCs (as Carbon)	EN 12619:2013	CAT-TP-20
Carbon Monoxide	EN 15058	CAT-TP-21
Oxygen	EN 14789	CAT-TP-21
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	0.85
Stack Width, W	m	0.44
Stack Area, A	m <sup>2</sup>	0.37
Average Stack Gas Temperature, T <sub>a</sub>	°C	311.0
Average Stack Gas Pressure	mmH <sub>2</sub> O	2.7
Average Stack Static Pressure, P <sub>static</sub>	kPa	-0.010
Average Barometric Pressure, P <sub>b</sub>	kPa	100.9
Average Pitot Tube Calibration Coefficient, C <sub>p</sub>	-	0.85

### 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 <sup>3</sup> ρ	Conc kg/m <sup>3</sup> ρ <sub>i</sub>
CO <sub>2</sub> (Estimated)	-	2.50	2.40	0.0250	44.01	1.9635	0.04909
O <sub>2</sub>	-	17.53	16.86	0.1753	32.00	1.4277	0.25023
N <sub>2</sub>	-	79.97	76.92	0.7997	28.01	1.2498	0.99954
Moisture (H <sub>2</sub> O)	-	-	3.81	0.0381	18.02	0.8037	0.03064

Where:  $\rho = M / 22.41$

$\rho_i = r \times \rho$

### Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P <sub>STD</sub>	kg/m <sup>3</sup>	1.299
Wet Density (STP), P <sub>STW</sub>	kg/m <sup>3</sup>	1.280
Dry Density (Actual), P <sub>Actual</sub>	kg/m <sup>3</sup>	0.605
Average Wet Density (Actual), P <sub>ActualW</sub>	kg/m <sup>3</sup>	0.596

Where: P<sub>STD</sub> = sum of component concentrations, kg/m<sup>3</sup> (not including water vapour)

P<sub>STW</sub> = sum of all wet concentrations / 100 x density, kg/m<sup>3</sup> (including water vapour)

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

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

### Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF <sup>1</sup>
Temperature	°C	311.0	0.0
Total Pressure	kPa	100.9	101.3
Moisture	%	3.81	0.00
Oxygen (Dry)	%	17.5	11.0

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m <sup>3</sup> /hr	10661
Gas Volumetric Flowrate (STP, Wet)	m <sup>3</sup> /hr	4964
Gas Volumetric Flowrate (STP, Dry)	m <sup>3</sup> /hr	4774
Gas Volumetric Flowrate REF <sup>1</sup>	m <sup>3</sup> /hr	1658

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	06/12/2017
Time of Survey	-	12:00 - 12:15
Atmospheric Pressure	kPa	100.9
Average Stack Static Pressure	Pa	-10
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with Liquid Incline Manometer	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, $C_p$	-	0.85
Number of Lines Available	-	2
Number of Lines Used	-	1

Traverse Point	Depth m	Sampling Line A					Sampling Line B - Cap Stuck				
		$\Delta P$ mmH <sub>2</sub> O	Temp °C	Wet Density kg/m <sup>3</sup>	Velocity m/s	Swirl °	$\Delta P$	Temp °C	Wet Density kg/m <sup>3</sup>	Velocity m/s	Swirl °
STATIC (Units: Pa)		-10.0									
<b>Mean</b>		<b>2.7</b>	<b>311.0</b>	<b>0.596</b>	<b>7.92</b>						
1	0.11	3.2	307.0	0.600	8.62	5.0					
2	0.32	3.0	310.0	0.597	8.37	3.0					
3	0.53	2.6	315.0	0.592	7.83	2.0					
4	0.74	2.0	312.0	0.595	6.85	1.0					

**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	$u(\Delta p_i)$	1.651	Pa
- Resolution	$u(res)$	0.52154	
- Calibration	$u(cal)$	0.073	
- Drift	$u(drift)$	1.096	
- Lack of Fit	$u(fit)$	0.035	
- Overall corrections to dynamic measurements	$u(C_f)$	1.725	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00003	-
- $\phi_{O_2,w}$	-	16.859	
- $\phi_{CO_2,w}$	-	2.405	
- Oxygen, dry	$u(\phi_{O_2,d})$	0.537	
- Carbon Dioxide, dry	$u(\phi_{CO_2,d})$	0.077	
- Water Vapour	$u(\phi_{H_2O})$	0.194	
- Oxygen, wet	$u(\phi_{O_2,w})$	0.517	
- Carbon Dioxide, wet	$u(\phi_{CO_2,w})$	0.074	
Standard uncertainty associated with the stack temperature	$u(T_c)$	2.980	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.700	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	1.651	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00321	-
Standard uncertainty associated with the local velocities	$u(v_i)$	2.461	Pa
Standard uncertainty associated with the mean velocity	$u(\bar{v})$	1.236	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	2.423	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	30.60	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV,w)$	3297.4	m <sup>3</sup> /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.02490	
- $u^2(qV,w)$	-	2830210	
- $u(qV,w)$	-	1682.3	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV,w)$	30.93	%

## TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Barrow Borough Council, Thorncliffe Crematorium  
Cremator No.2

### Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m <sup>3</sup>	63.1	48.6	44.4	52.1
Uncertainty	±mg/m <sup>3</sup>	8.6	8.7	7.4	8.2
Mass Emission	g/hr	99	76.3	69.8	81.7
Uncertainty	±g/hr	33.5	27.3	24.5	28.4

Parameter	Units	Run 1	Run 2	Run 3	Mean
Water Vapour	% v/v	4.8	2.9	3.7	3.8
Uncertainty	±% v/v	0.26	0.16	0.20	0.21

### Blank Runs

Parameter	Units	Blank 1	Blank 2	Maximum
Concentration	mg/m <sup>3</sup>	0.42	1.44	1.44

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	Quartz Glass
Positioning of Filter	Out Stack
Filter Size and Material	90mm Quartz 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.

**TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS**

Test	Units	Run 1	Run 2	Run 3	
<b>Absolute pressure of stack gas, P<sub>s</sub></b>					
Barometric pressure, P <sub>b</sub>	mmHg	756.8	756.8	756.8	
Stack static pressure, P <sub>static</sub>	mmH <sub>2</sub> O	-1.0	-1.0	-1.0	
P <sub>s</sub> = (P <sub>b</sub> + (P <sub>static</sub> / 13.6))	mmHg	756.7	756.7	756.7	
<b>Volume of water vapour collected, V<sub>wstd</sub></b>					
Total mass collected in impingers (liquid trap)	g	31.7	18.7	19.5	
Total mass collected in impingers (silica trap)	g	9.3	4.0	8.0	
Total mass of liquid collected, V <sub>lc</sub>	g	41.0	22.7	27.5	
V <sub>wstd</sub> = (0.001246)(V <sub>lc</sub> )	m <sup>3</sup>	0.0511	0.0283	0.0343	
<b>Volume of gas metered dry, V<sub>mstd</sub></b>					
Volume of gas sample through gas meter, V <sub>m</sub>	m <sup>3</sup>	1.1630	1.0808	1.0100	
Gas meter correction factor, Y <sub>d</sub>	-	0.9400	0.9400	0.9400	
Average dry gas meter temperature, T <sub>m</sub>	°C	20.4	21.7	19.5	
Average pressure drop across orifice, ΔH	mmH <sub>2</sub> O	35.4	30.3	26.7	
V <sub>mstd</sub> = ((0.3592)(V <sub>m</sub> )(P <sub>b</sub> + (ΔH/13.6))(Y <sub>d</sub> ) / (T <sub>m</sub> + 273))	m <sup>3</sup>	1.0164	0.9400	0.8847	
<b>Moisture content, B<sub>w0</sub> &amp; R<sub>wv</sub></b>					
B <sub>w0</sub> = V <sub>wstd</sub> / (V <sub>mstd</sub> + V <sub>wstd</sub> )	m <sup>3</sup>	0.0479	0.0292	0.0373	
B <sub>w0</sub> as a percentage	% v/v	4.79	2.92	3.73	
Reported Water Vapour, checked with Tables in EN 14790, R <sub>wv</sub>	% v/v	4.79	2.92	3.73	
<b>Volume of gas metered wet, V<sub>mstw</sub></b>					
V <sub>mstw</sub> = (V <sub>mstd</sub> )(100/(100 - R <sub>wv</sub> ))	m <sup>3</sup>	1.0675	0.9682	0.9190	
<b>Volume of gas metered at Oxygen Reference Conditions, V<sub>mstd@X%O<sub>2</sub></sub> &amp; V<sub>mstw@X%O<sub>2</sub></sub></b>					
IED & Incinerates Hazardous Material? (Yes = no positive O <sub>2</sub> correction)	-	No	No	No	
% wet oxygen measured in gas stream, ACT%O <sub>2w</sub>	% v/v	16.28	17.29	17.01	
% dry oxygen measured in gas stream, ACT%O <sub>2d</sub>	% v/v	16.92	17.98	17.68	
% oxygen reference condition, REF%O <sub>2</sub>	% v/v	11.00	11.00	11.00	
O <sub>2</sub> Reference Factor wet (O <sub>2REFw</sub> ) = (21 - REF%O <sub>2</sub> ) / (21 - ACT%O <sub>2w</sub> )	-	2.12	2.70	2.50	
O <sub>2</sub> Reference Factor dry (O <sub>2REFd</sub> ) = (21 - REF%O <sub>2</sub> ) / (21 - ACT%O <sub>2d</sub> )	-	2.45	3.31	3.01	
V <sub>mstw@X%oxygen</sub> = (V <sub>mstw</sub> ) / (O <sub>2REFw</sub> )	m <sup>3</sup>	0.5039	0.3588	0.3670	
V <sub>mstd@X%oxygen</sub> = (V <sub>mstd</sub> ) / (O <sub>2REFd</sub> )	m <sup>3</sup>	0.4143	0.2839	0.2937	
<b>Molecular weight of dry gas stream, M<sub>d</sub></b>					
CO <sub>2</sub> (Estimated)	% v/v	3.00	3.00	3.00	
O <sub>2</sub>	% v/v	16.92	17.98	17.68	
Total	% v/v	19.92	20.98	20.68	
N <sub>2</sub>	% v/v	80.08	79.02	79.32	
M <sub>d</sub> = 0.44(%CO <sub>2</sub> )+0.32(%O <sub>2</sub> )+0.28(%N <sub>2</sub> )	g/gmol	29.16	29.20	29.19	
<b>Molecular weight of stack gas (wet), M<sub>s</sub></b>					
M <sub>s</sub> = M <sub>d</sub> (1 - (R <sub>wv</sub> /100)) + 18(R <sub>wv</sub> /100)	g/gmol	28.62	28.87	28.77	
<b>Velocity of stack gas, V<sub>s</sub></b>					
Pitot tube velocity constant, K <sub>p</sub>	-	34.97	34.97	34.97	
Velocity pressure coefficient, C <sub>p</sub>	-	0.85	0.85	0.85	
Average of velocity heads, ΔP <sub>avg</sub>	mmH <sub>2</sub> O	2.72	2.32	2.28	
Average square root of velocity heads, √ΔP	√mmH <sub>2</sub> O	1.65	1.52	1.51	
Average stack gas temperature, T <sub>s</sub>	°C	312.3	312.6	376.5	
V <sub>s</sub> = ((K <sub>p</sub> )(C <sub>p</sub> )(√ΔP)(√T <sub>s</sub> + 273)) / (√(M <sub>s</sub> )(P <sub>s</sub> ))	m/s	8.05	7.41	7.76	
<b>Total flow of stack gas: Actual (Q<sub>a</sub>), Wet (Q<sub>stw</sub>), Dry (Q<sub>std</sub>), Wet@O<sub>2REF</sub> (Q<sub>stwO<sub>2</sub></sub>), Dry@O<sub>2REF</sub> (Q<sub>stdO<sub>2</sub></sub>)</b>					
Area of stack, A <sub>s</sub>	m <sup>2</sup>	0.37	0.37	0.37	
Q <sub>a</sub> = (60)(A <sub>s</sub> )(V <sub>s</sub> )	m <sup>3</sup> /min	180.7	166.2	174.1	
Conversion factor (K/mm.Hg), C <sub>f</sub>	-	0.3592	0.3592	0.3592	
Q <sub>stw</sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> ) / ((T <sub>s</sub> + 273))	m <sup>3</sup> /min	83.9	77.1	72.9	
Q <sub>std</sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )(1 - (R <sub>wv</sub> /100))) / ((T <sub>s</sub> + 273))	m <sup>3</sup> /min	79.9	74.9	70.1	
Q <sub>stwO<sub>2</sub></sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> ) / ((T <sub>s</sub> + 273)) / (O <sub>2REFw</sub> )	m <sup>3</sup> /min	39.6	28.6	29.1	
Q <sub>stdO<sub>2</sub></sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )(1 - (R <sub>wv</sub> /100))) / ((T <sub>s</sub> + 273)) / (O <sub>2REFd</sub> )	m <sup>3</sup> /min	32.6	22.6	23.3	
<b>Percent isokinetic, %I</b>					
Nozzle diameter, D <sub>n</sub>	mm	10.07	10.07	10.07	
Nozzle area, A <sub>n</sub>	mm <sup>2</sup>	79.60	79.60	79.60	
Total sampling time, q	min	60	60	60	
%I = (4.6398E <sup>9</sup> )(T <sub>s</sub> +273)(V <sub>mstd</sub> ) / (P <sub>s</sub> )(V <sub>s</sub> )(A <sub>n</sub> )(q)(1 - (R <sub>wv</sub> /100))	%	99.6	98.3	98.8	



**TOTAL PARTICULATE MATTER: SAMPLING DETAILS**

**Sample Runs**

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	12:23 - 13:23	15:12 - 16:12	11:18 - 12:18	
Sampling Dates	-	06/12/2017	06/12/2017	07/12/2017	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m <sup>3</sup>	0.4143	0.2839	0.2937	
Filter I.D. Number	-	90-4896	90-5886	90-5887	
Start Filter Mass	g	0.52756	0.53230	0.52784	
End Filter Mass	g	0.54943	0.54385	0.53876	
Total Mass on Filter	g	0.02187	0.01155	0.01092	
Probe Rinse I.D. Number	-	PR-90-4896	PR-90-5886	PR-90-5887	
Start Probe Rinse Mass	g	N/A	N/A	N/A	
End Probe Rinse Mass	g	N/A	N/A	N/A	
Total Mass in Probe Rinse	g	0.00428	0.00226	0.00213	
Total Mass Collected	mg	26.15	13.80	13.05	
Calculated Concentration	mg/m <sup>3</sup>	63.12	48.62	44.45	
Balance Uncertainty / LOD	mg/m <sup>3</sup>	0.34	0.49	0.48	

**Where:** ISO stands for Manual Isokinetic Sampling Train

**Blank Runs**

Parameter	Units	Blank 1	Blank 2	
Blank Dates	-	06/12/2017	07/12/2017	
Average Volume Sampled (REF)	m <sup>3</sup>	0.3306	0.3306	
Filter I.D. Number	-	90-5885	90-5552	
Start Filter Mass	g	0.53081	0.54324	
End Filter Mass	g	0.52738	0.54356	
Total Mass on Filter	g	-0.00343	0.00032	
Probe Rinse I.D. Number	-	PR-90-5885	PR-90-5552	
Start Probe Rinse Mass	g	2.97909	2.90214	
End Probe Rinse Mass	g	2.97916	2.90230	
Total Mass in Probe Rinse	g	0.00007	0.00016	
Total Mass Collected	mg	-3.36	0.48	
Calculated Concentration	mg/m <sup>3</sup>	-10.15	1.44	
Balance Uncertainty / LOD	mg/m <sup>3</sup>	0.42	0.42	

**TOTAL PARTICULATE MATTER: QUALITY ASSURANCE**

(PAGE 1 OF 2)

**Sample Runs**

<b>Leak Test Results</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	
Mean Sampling Rate	l/min	18.22	16.93	15.82	
Pre-Sampling Leak Rate	l/min	0.14	0.20	0.12	
Post-Sampling Leak Rate	l/min	0.20	0.15	0.12	
Allowable Leak Rate	l/min	0.36	0.34	0.32	
Leak Test Acceptable	-	Yes	Yes	Yes	
<b>Water Droplets</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	
Are Water Droplets Present	-	No	No	No	
<b>MU (Concurrent Water Vapour)</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	
Measurement Uncertainty (MU)	%	5.4	5.5	5.4	
Allowable MU	%	20	20	20	
MU Acceptable	%	Yes	Yes	Yes	
<b>Silica Gel (Concurrent Water Vapour)</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	
Less than 50% Faded	%	Yes	Yes	Yes	
<b>Isokinetic Criterion Compliance</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	
Isokinetic Variation	%	99.6	98.3	98.8	
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115	
Isokineticity Acceptable	-	Yes	Yes	Yes	
<b>Weighing Uncertainty Criteria</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	
Overall Weighing Uncertainty	± mg	0.25	0.25	0.25	
Overall Weighing Uncertainty	± mg/m <sup>3</sup>	0.61	0.89	0.86	
ELV [Daily ELV for IED]	mg/m <sup>3</sup>	160.00	160.00	160.00	
Allowable Weighing Uncertainty	mg/m <sup>3</sup>	8.00	8.00	8.00	
Weighing Uncertainty Acceptable	-	Yes	Yes	Yes	
<b>Filter Temperatures</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	
Pre-Conditioning Temperature	°C	180	180	180	
Post-Conditioning Temperature	°C	160	160	160	
Maximum Filter Temperature	°C	160	160	160	
<b>Test Conditions</b>	<b>Units</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	
Ambient Temperature Recorded?	-	Yes	Yes	Yes	

**TOTAL PARTICULATE MATTER: QUALITY ASSURANCE**

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**Blank Runs**

Leak Test Results	Units	Blank 1	Blank 2	
Expected Sampling Rate	l/min	15.00	15.00	
Pre-Sampling Leak Rate	l/min	0.10	0.14	
Post-Sampling Leak Rate	l/min	0.15	0.12	
Allowable Leak Rate	l/min	0.30	0.30	
Leak Test Acceptable	-	Yes	Yes	

Validity of Blank vs ELV	Units	Blank 1	Blank 2	
Allowable Blank	mg/m <sup>3</sup>	16.0	16.0	
Blank Acceptable	-	Yes	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			
	1	2	3	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)				
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 the minimum required by the Standard	x	x	x	

**TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS**

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V <sub>m</sub>	1.1630	1.0808	1.0100	uV <sub>m</sub>	m <sup>3</sup>	0.0233	0.0216	0.0202
Sampled Gas Temperature	T <sub>m</sub>	293.4	294.7	292.5	uT <sub>m</sub>	K	2.0	2.0	2.0
Sampled Gas Pressure	p <sub>m</sub>	100.9	100.9	100.9	uρ <sub>m</sub>	kPa	0.5	0.5	0.5
Sampled Gas Humidity	H <sub>m</sub>	0.0	0.0	0.0	uH <sub>m</sub>	% v/v	1.0	1.0	1.0
Leak	L	1.10	0.89	0.76	uL	%	-	-	-
Mass of Particulate	m	26.15	13.80	13.05	um	mg	0.14	0.14	0.14
Uncollected Mass	UCM	0.48	0.48	0.48	uUCM	mg	-	-	-

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2	Run 3	
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.68	0.68	0.68	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	1.10	0.89	0.76	≤2%
Mass of Particulate	%	0.21	0.31	0.30	<5% of ELV
Uncollected Mass	%	-	-	-	-

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient			
	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	
Sampled Volume (STP)	V <sub>m</sub>	m <sup>3</sup>	1.0164	0.9400	0.8847	62.10	51.72	50.24	
Leak	L	mg/m <sup>3</sup>	0.400	0.249	0.195	1.00	1.00	1.00	
Mass of Particulate	L <sub>r</sub>	mg	26.149	13.804	13.054	2.41	3.52	3.40	
Uncollected Mass	UCM	mg	0.28	0.28	0.28	2.41	3.52	3.40	

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m <sup>3</sup>	1.664	1.286	1.170
Leak	mg/m <sup>3</sup>	0.4000	0.2487	0.1946
Mass of Particulate	mg/m <sup>3</sup>	0.3380	0.4931	0.4767
Uncollected Mass	mg/m <sup>3</sup>	0.6643	0.9693	0.9370

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	Run 3
O <sub>2</sub> Correction Factor	-	2.45	3.31	3.01
Stack Gas O <sub>2</sub> Content	% v/v	16.92	17.98	17.68
MU for O <sub>2</sub> Correction	-	0.30	0.55	0.45
Overall MU For O <sub>2</sub> Measurement	%	12.27	16.55	15.06

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m <sup>3</sup>	1.87	1.70	1.58
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m <sup>3</sup>	3.66	3.34	3.11
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m <sup>3</sup>	8.56	8.71	7.38
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m <sup>3</sup>	8.56	8.71	7.38
Reported Uncertainty	mg/m <sup>3</sup>	8.56	8.71	7.38
Expanded uncertainty (95% confidence), without Oxygen Correction	%	5.8	6.9	7.0
Expanded uncertainty (95% confidence), with Oxygen Correction	%	13.6	17.9	16.6
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	13.6	17.9	16.6
Reported Uncertainty	%	13.6	17.9	16.6

## HYDROGEN CHLORIDE: RESULTS SUMMARY

Barrow Borough Council, Thorncliffe Crematorium  
Cremator No.2

### Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m <sup>3</sup>	31.4	38.0	39.0	36.1
Uncertainty	±mg/m <sup>3</sup>	4.5	6.9	6.5	5.9
Mass Emission	g/hr	49.3	59.6	61.1	56.7
Uncertainty	±g/hr	16.8	21.3	21.5	19.9

Parameter	Units	Run 1	Run 2	Run 3	Mean
Water Vapour	% v/v	4.8	2.9	3.7	3.8
Uncertainty	±% v/v	0.26	0.16	0.20	0.21

### Blank Runs

Parameter	Units	Blank 1	Blank 2	Maximum
Concentration	mg/m <sup>3</sup>	< 0.05	< 0.05	< 0.05

### General Sampling Information

Parameter	Value
Standard	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	12/12/2017
Probe Material	Titanium
Filter Housing Material	Quartz Glass
Impinger Material	Polyethylene
Absorption Solution	HPLC Grade Water
Positioning of Filter	Out Stack
Filter Size and Material	90mm Quartz 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	Run 2	Run 3	
<b>Absolute pressure of stack gas, P<sub>s</sub></b>					
Barometric pressure, P <sub>b</sub>	mmHg	756.8	756.8	756.8	
Stack static pressure, P <sub>static</sub>	mmH <sub>2</sub> O	-1.0	-1.0	-1.0	
P <sub>s</sub> = (P <sub>b</sub> + (P <sub>static</sub> / 13.6))	mmHg	756.7	756.7	756.7	
<b>Volume of water vapour collected, V<sub>wstd</sub></b>					
Total mass collected in impingers (liquid trap)	g	31.7	18.7	19.5	
Total mass collected in impingers (silica trap)	g	9.3	4.0	8.0	
Total mass of liquid collected, V <sub>lc</sub>	g	41.0	22.7	27.5	
V <sub>wstd</sub> = (0.001246)(V <sub>lc</sub> )	m <sup>3</sup>	0.0511	0.0283	0.0343	
<b>Volume of gas metered dry, V<sub>mstd</sub></b>					
Volume of gas sample through gas meter, V <sub>m</sub>	m <sup>3</sup>	1.1630	1.0808	1.0100	
Gas meter correction factor, Y <sub>d</sub>	-	0.9400	0.9400	0.9400	
Average dry gas meter temperature, T <sub>m</sub>	°C	20.4	21.7	19.5	
Average pressure drop across orifice, ΔH	mmH <sub>2</sub> O	35.4	30.3	26.7	
V <sub>mstd</sub> = ((0.3592)(V <sub>m</sub> )(P <sub>b</sub> + (ΔH/13.6))(Y <sub>d</sub> ) / (T <sub>m</sub> + 273))	m <sup>3</sup>	1.0164	0.9400	0.8847	
<b>Moisture content, B<sub>w0</sub> &amp; R<sub>wv</sub></b>					
B <sub>w0</sub> = V <sub>wstd</sub> / (V <sub>mstd</sub> + V <sub>wstd</sub> )	m <sup>3</sup>	0.0479	0.0292	0.0373	
B <sub>w0</sub> as a percentage	% v/v	4.79	2.92	3.73	
Reported Water Vapour, checked with Tables in EN 14790, R <sub>wv</sub>	% v/v	4.79	2.92	3.73	
<b>Volume of gas metered wet, V<sub>mstw</sub></b>					
V <sub>mstw</sub> = (V <sub>mstd</sub> )(100/(100 - R <sub>wv</sub> ))	m <sup>3</sup>	1.0675	0.9682	0.9190	
<b>Volume of gas metered at Oxygen Reference Conditions, V<sub>mstd@X%O<sub>2</sub></sub> &amp; V<sub>mstw@X%O<sub>2</sub></sub></b>					
IED & Incinerates Hazardous Material? (Yes = no positive O <sub>2</sub> correction)	-	No	No	No	
% wet oxygen measured in gas stream, ACT%O <sub>2w</sub>	% v/v	16.28	17.29	17.01	
% dry oxygen measured in gas stream, ACT%O <sub>2d</sub>	% v/v	16.92	17.98	17.68	
% oxygen reference condition, REF%O <sub>2</sub>	% v/v	11.00	11.00	11.00	
O <sub>2</sub> Reference Factor wet (O <sub>2REFw</sub> ) = (21 - REF%O <sub>2</sub> ) / (21 - ACT%O <sub>2w</sub> )	-	2.12	2.70	2.50	
O <sub>2</sub> Reference Factor dry (O <sub>2REFd</sub> ) = (21 - REF%O <sub>2</sub> ) / (21 - ACT%O <sub>2d</sub> )	-	2.45	3.31	3.01	
V <sub>mstw@X%oxygen</sub> = (V <sub>mstw</sub> ) / (O <sub>2REFw</sub> )	m <sup>3</sup>	0.5039	0.3588	0.3670	
V <sub>mstd@X%oxygen</sub> = (V <sub>mstd</sub> ) / (O <sub>2REFd</sub> )	m <sup>3</sup>	0.4143	0.2839	0.2937	
<b>Molecular weight of dry gas stream, M<sub>d</sub></b>					
CO <sub>2</sub> (Estimated)	% v/v	3.00	3.00	3.00	
O <sub>2</sub>	% v/v	16.92	17.98	17.68	
Total	% v/v	19.92	20.98	20.68	
N <sub>2</sub>	% v/v	80.08	79.02	79.32	
M <sub>d</sub> = 0.44(%CO <sub>2</sub> )+0.32(%O <sub>2</sub> )+0.28(%N <sub>2</sub> )	g/gmol	29.16	29.20	29.19	
<b>Molecular weight of stack gas (wet), M<sub>s</sub></b>					
M <sub>s</sub> = M <sub>d</sub> (1 - (R <sub>wv</sub> /100)) + 18(R <sub>wv</sub> /100)	g/gmol	28.62	28.87	28.77	
<b>Velocity of stack gas, V<sub>s</sub></b>					
Pitot tube velocity constant, K <sub>p</sub>	-	34.97	34.97	34.97	
Velocity pressure coefficient, C <sub>p</sub>	-	0.85	0.85	0.85	
Average of velocity heads, ΔP <sub>avg</sub>	mmH <sub>2</sub> O	2.72	2.32	2.28	
Average square root of velocity heads, √ΔP	√mmH <sub>2</sub> O	1.65	1.52	1.51	
Average stack gas temperature, T <sub>s</sub>	°C	312.3	312.6	376.5	
V <sub>s</sub> = ((K <sub>p</sub> )(C <sub>p</sub> )(√ΔP)(√T <sub>s</sub> + 273)) / (√(M <sub>s</sub> )(P <sub>s</sub> ))	m/s	8.05	7.41	7.76	
<b>Total flow of stack gas: Actual (Q<sub>a</sub>), Wet (Q<sub>stw</sub>), Dry (Q<sub>std</sub>), Wet@O<sub>2REF</sub> (Q<sub>stwO<sub>2</sub></sub>), Dry@O<sub>2REF</sub> (Q<sub>stdO<sub>2</sub></sub>)</b>					
Area of stack, A <sub>s</sub>	m <sup>2</sup>	0.37	0.37	0.37	
Q <sub>a</sub> = (60)(A <sub>s</sub> )(V <sub>s</sub> )	m <sup>3</sup> /min	180.7	166.2	174.1	
Conversion factor (K/mm.Hg), C <sub>f</sub>	-	0.3592	0.3592	0.3592	
Q <sub>stw</sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> ) / ((T <sub>s</sub> + 273))	m <sup>3</sup> /min	83.9	77.1	72.9	
Q <sub>std</sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )(1 - (R <sub>wv</sub> /100))) / ((T <sub>s</sub> + 273))	m <sup>3</sup> /min	79.9	74.9	70.1	
Q <sub>stwO<sub>2</sub></sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> ) / ((T <sub>s</sub> + 273)) / (O <sub>2REFw</sub> )	m <sup>3</sup> /min	39.6	28.6	29.1	
Q <sub>stdO<sub>2</sub></sub> = ((Q <sub>a</sub> )(P <sub>s</sub> )(C <sub>f</sub> )(1 - (R <sub>wv</sub> /100))) / ((T <sub>s</sub> + 273)) / (O <sub>2REFd</sub> )	m <sup>3</sup> /min	32.6	22.6	23.3	
<b>Percent isokinetic, %I</b>					
Nozzle diameter, D <sub>n</sub>	mm	10.07	10.07	10.07	
Nozzle area, A <sub>n</sub>	mm <sup>2</sup>	79.60	79.60	79.60	
Total sampling time, q	min	60	60	60	
%I = (4.6398E <sup>6</sup> )(T <sub>s</sub> +273)(V <sub>mstd</sub> ) / (P <sub>s</sub> )(V <sub>s</sub> )(A <sub>n</sub> )(q)(1 - (R <sub>wv</sub> /100))	%	99.6	98.3	98.8	

## HYDROGEN CHLORIDE: SAMPLING DETAILS

### Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	12:23 - 13:23	15:12 - 16:12	11:18 - 12:18	
Sampling Dates	-	06/12/2017	06/12/2017	07/12/2017	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m <sup>3</sup>	0.4143	0.2839	0.2937	
Laboratory Result for Front Impingers	µg/ml	45.99	26.48	41.91	
Laboratory Result for Back Impinger	µg/ml	0.48		2.51	
Volume in Front Impingers	ml	281.8	407.1	266.8	
Volume in Back Impinger	ml	118.7		104.0	
Mass in Front Impingers	µg	12960.0	10780.0	11181.6	
Mass in Back Impinger	µg	57.0		261.0	
Total Mass Collected	µg	13017.0	10780.0	11442.6	
Calculated Concentration	mg/m <sup>3</sup>	31.42	37.97	38.96	

**Where:** ISO stands for Manual Isokinetic Sampling Train

### Blank Runs

Parameter	Units	Blank 1	Blank 2	
Blank Dates	-	06/12/2017	07/12/2017	
Average Volume Sampled (REF)	m <sup>3</sup>	0.3306	0.3306	
Laboratory Result for Impingers	µg/ml	< 0.05	< 0.05	
Volume in Impingers	ml	305.4	343.4	
Total Mass Collected	µg	< 15.3	< 17.2	
Calculated Concentration	mg/m <sup>3</sup>	< 0.05	< 0.05	

## HYDROGEN CHLORIDE: QUALITY ASSURANCE

(PAGE 1 OF 2)

### Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3	
Mean Sampling Rate	l/min	18.22	16.93	15.82	
Pre-Sampling Leak Rate	l/min	0.14	0.20	0.12	
Post-Sampling Leak Rate	l/min	0.20	0.15	0.12	
Allowable Leak Rate	l/min	0.36	0.34	0.32	
Leak Test Acceptable	-	Yes	Yes	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	99.6	
Allowable Absorption Efficiency	%	N/A <sup>1</sup>	
Absorption Efficiency Acceptable	-	N/A <sup>1</sup>	

<sup>1</sup>The concentration in the last absorber was less than 5 times the analytical detection limit.

Water Droplets	Units	Run 1	Run 2	Run 3	
Are Water Droplets Present	-	No	No	No	

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3	
Measurement Uncertainty (MU)	%	5.4	5.5	5.4	
Allowable MU	%	20	20	20	
MU Acceptable	%	Yes	Yes	Yes	

Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3	
Less than 50% Faded	%	Yes	Yes	Yes	

Isokinetic Criterion Compliance	Units	Run 1	Run 2	Run 3	
Isokinetic Variation	%	99.6	98.3	98.8	
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115	
Isokineticity Acceptable	-	Yes	Yes	Yes	

Filter Temperatures	Units	Run 1	Run 2	Run 3	
Maximum Filter Temperature	°C	160	160	160	

Test Conditions	Units	Run 1	Run 2	Run 3	
Ambient Temperature Recorded?	-	Yes	Yes	Yes	



**HYDROGEN CHLORIDE: QUALITY ASSURANCE**

(PAGE 2 OF 2)

**Blank Runs**

Leak Test Results	Units	Blank 1	Blank 2	
Expected Sampling Rate	l/min	15.00	15.00	
Pre-Sampling Leak Rate	l/min	0.10	0.14	
Post-Sampling Leak Rate	l/min	0.15	0.12	
Allowable Leak Rate	l/min	0.30	0.30	
Leak Test Acceptable	-	Yes	Yes	

Validity of Blank vs ELV	Units	Blank 1	Blank 2	
Allowable Blank	mg/m <sup>3</sup>	20.0	20.0	
Blank Acceptable	-	Yes	Yes	

**Method Deviations**

Nature of Deviation	Run Number			
	1	2	3	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)				
There are no deviations associated with the sampling employed.	wx	wx	wx	

**HYDROGEN CHLORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS**

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3	Symbol	Units	Run 1	Run 2	Run 3
Sampled Volume (Actual)	V <sub>m</sub>	1.1630	1.0808	1.0100	uV <sub>m</sub>	m <sup>3</sup>	0.0233	0.0216	0.0202
Sampled Gas Temperature	T <sub>m</sub>	293.4	294.7	292.5	uT <sub>m</sub>	K	2.0	2.0	2.0
Sampled Gas Pressure	p <sub>m</sub>	100.9	100.9	100.9	uρ <sub>m</sub>	kPa	0.5	0.5	0.5
Sampled Gas Humidity	H <sub>m</sub>	0.0	0.0	0.0	uH <sub>m</sub>	% v/v	1.0	1.0	1.0
Leak	L	1.10	0.89	0.76	uL	%	-	-	-
Laboratory Result	L <sub>r</sub>	2.50	2.50	2.50	uL <sub>r</sub>	%	-	-	-

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2	Run 3	
Sampled Volume (Actual)	%	2.00	2.00	2.00	≤2%
Sampled Gas Temperature	%	0.68	0.68	0.68	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	1.10	0.89	0.76	≤2%
Laboratory Result	%	2.50	2.50	2.50	No Requirement

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient			
	Symbol	Units	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3	
Sampled Volume (STP)	V <sub>m</sub>	m <sup>3</sup>	1.0164	0.9400	0.8847	30.92	40.39	44.04	
Leak	L	mg/m <sup>3</sup>	0.1991	0.1942	0.1706	1.00	1.00	1.00	
Laboratory Result	L <sub>r</sub>	mg/m <sup>3</sup>	0.786	0.949	0.974	1.00	1.00	1.00	

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/m <sup>3</sup>	0.8282	1.0042	1.0254
Leak	mg/m <sup>3</sup>	0.199	0.194	0.171
Laboratory Result	mg/m <sup>3</sup>	0.786	0.949	0.974

Measured Quantities	Oxygen Correction Part of MU Budget			
	Units	Run 1	Run 2	Run 3
O <sub>2</sub> Correction Factor	-	2.45	3.31	3.01
Stack Gas O <sub>2</sub> Content	% v/v	16.92	17.98	17.68
MU for O <sub>2</sub> Correction	-	0.30	0.55	0.45
Overall MU For O <sub>2</sub> Measurement	%	12.27	16.55	15.06

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/m <sup>3</sup>	1.16	1.40	1.42
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m <sup>3</sup>	2.27	2.74	2.79
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m <sup>3</sup>	4.47	6.85	6.50
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m <sup>3</sup>	4.47	6.85	6.50
Reported Uncertainty	mg/m <sup>3</sup>	4.47	6.85	6.50
Expanded uncertainty (95% confidence), without Oxygen Correction	%	7.2	7.2	7.2
Expanded uncertainty (95% confidence), with Oxygen Correction	%	14.2	18.1	16.7
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	14.2	18.1	16.7
Reported Uncertainty	%	14.2	18.1	16.7

## TOTAL VOCs (as CARBON): RESULTS SUMMARY

Barrow Borough Council, Thorncliffe Crematorium  
Cremator No.2

### Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m <sup>3</sup>	17.5	12.4	1.1	10.3
Uncertainty	±mg/m <sup>3</sup>	1.2	1.5	1.3	1.3
Mass Emission	g/hr	27.4	19.5	1.7	16.2
Uncertainty	±g/hr	8.7	6.5	2.1	5.8

### General Sampling Information

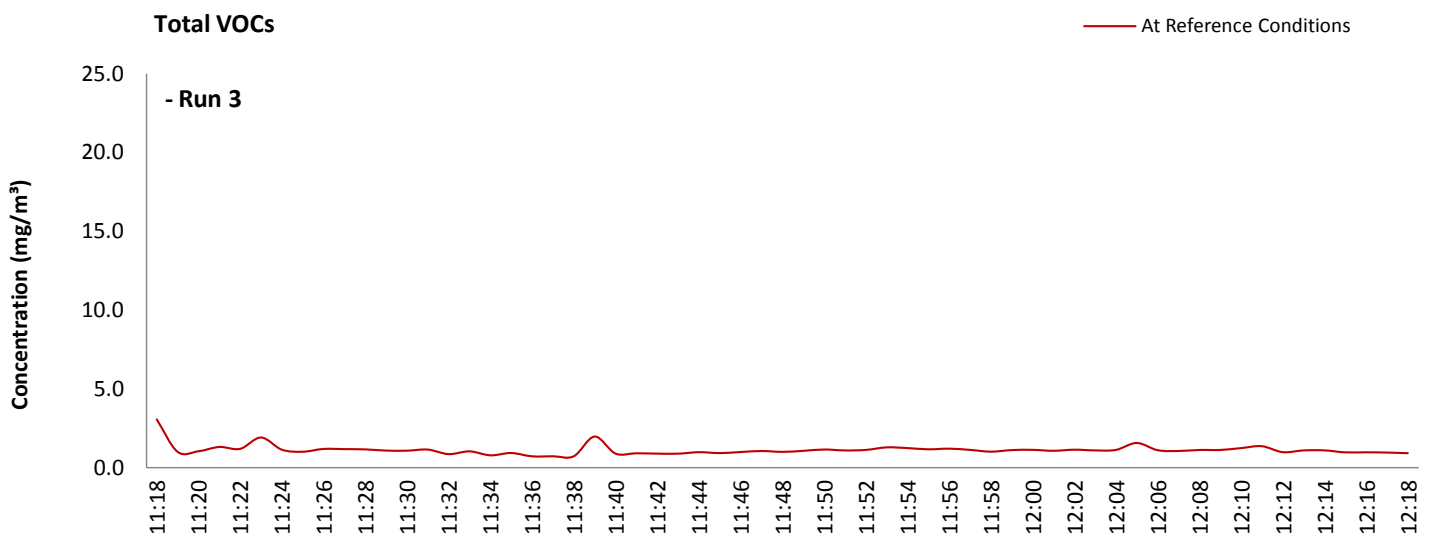
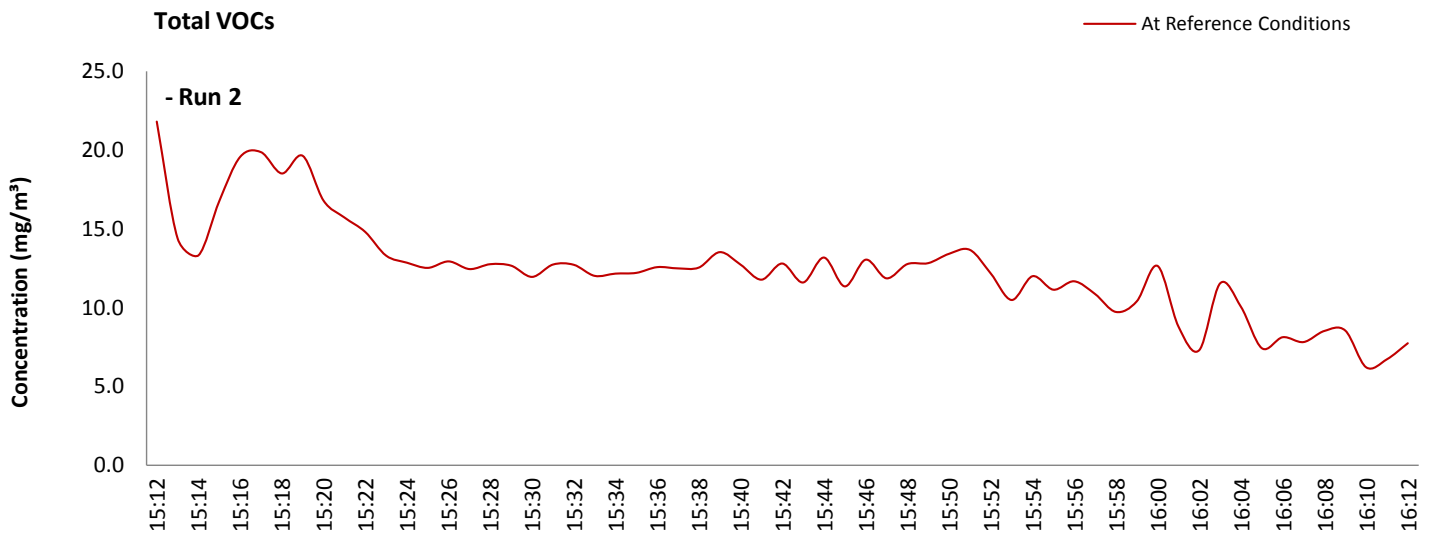
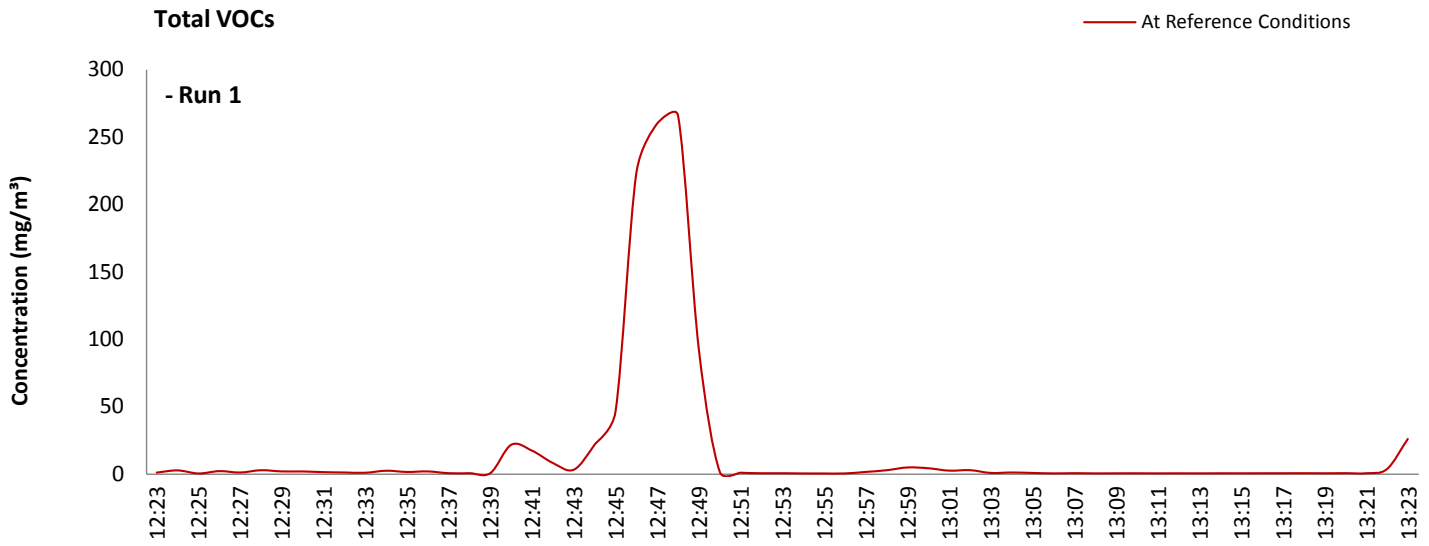
Parameter	Value	
Standard	EN 12619:2013	
Technical Procedure	CAT-TP-20	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Propane In Synthetic Air (5 Grade)	
Span Gas Reference Number	CYL 1.0309	
Span Gas Expiry Date	24/11/2022	
Span Gas Start Pressure (bar)	180	
Gas Cylinder Concentration (ppm)	80.1	
Span Gas Set Point (ppm)	80.10	
Span Gas Uncertainty (%)	N/A	
Zero Gas Type	Synthetic Air (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

### 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	Run 2	Run 3
Sampling Times	-	12:23 - 13:23	15:12 - 16:12	11:18 - 12:18
Sampling Dates	-	06/12/2017	06/12/2017	07/12/2017
Instrument Range	ppm	100	100	100
Span Gas Value	ppm	80.1	80.1	80.1

### Quality Assurance

	Zero Drift	Units	Run 1	Run 2	Run 3
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.10	0.10	0.10
	Zero Down Sampling Line (Post)	ppm	0.10	0.10	0.10
	Zero Drift	ppm	0.00	0.00	0.00
	Allowable Zero Drift	± ppm	4.01	4.01	4.01
	Zero Drift Acceptable	-	Yes	Yes	Yes

	Span Drift	Units	Run 1	Run 2	Run 3
CAL 1	Span Down Sampling Line (Pre)	ppm	79.00	79.00	80.00
	Span Down Sampling Line (Post)	ppm	79.50	79.50	80.00
	Span Drift	ppm	0.50	0.50	0.00
	Allowable Span Drift	± ppm	4.01	4.01	4.01
	Span Drift Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Run Ambient Temperature Range	°C	15 - 20	15 - 20	15 - 20

### Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number		
	1	2	3
There are no deviations associated with the sampling employed.	x	x	x

**TOTAL VOCs (as CARBON): MEASUREMENT UNCERTAINTY CALCULATIONS**

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Limit value	20.0	20.0	20.0	mg/m <sup>3</sup> (REF)
TGN M2 Allowable MU	15.0	15.0	15.0	%
Measured concentration	7.12	3.74	0.37	mg/m <sup>3</sup> (STP, dry)
Range Used	100.0	100.0	100.0	ppm
Range Used [A]	160.6	160.6	160.6	mg/m <sup>3</sup>
Cal gas conc.	80.1	80.1	80.1	ppm
Conversion	1.61	1.61	1.61	ppm to mg/m <sup>3</sup>
MCERTS Range [B]	15.0	15.0	15.0	mg/m <sup>3</sup>
Lower of [A] or [B]	15.0	15.0	15.0	mg/m <sup>3</sup>
Cal gas conc.	128.7	128.7	128.7	mg/m <sup>3</sup>

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Response time	45	45	45	seconds
Number of readings in measurement	60	60	60	-
Repeatability at zero	2.00	2.00	2.00	% full scale
Repeatability at span level	0.00	0.00	0.00	% full scale
Deviation from linearity	0.16	0.16	0.16	% of value
Zero drift	0.00	0.00	0.00	% full scale
Span drift	0.63	0.63	0.00	% full scale
Volume or pressure flow dependence	1.60	1.60	1.60	% of full scale
Atmospheric pressure dependence	0.30	0.30	0.30	% of value/kPa
Ambient temperature dependence	1.40	1.40	1.40	% full scale/10K
Combined interference	0.45	0.45	0.45	% range
Dependence on voltage	0.50	0.50	0.50	% full scale/10V
Losses in the line (leak)	1.37	1.37	0.12	% of value
Uncertainty of calibration gas	2.00	2.00	2.00	% of value

Performance characteristic	RUN 1	RUN 2	RUN 3	Units
Standard deviation of repeatability at zero	use rep at span	use rep at span	use rep at span	mg/m <sup>3</sup>
Standard deviation of repeatability at span level	0.00	0.00	0.00	mg/m <sup>3</sup>
Lack of fit	0.01	0.01	0.01	mg/m <sup>3</sup>
Drift	0.03	0.01	0.00	mg/m <sup>3</sup>
Volume or pressure flow dependence	0.00	0.00	0.00	mg/m <sup>3</sup>
Atmospheric pressure dependence	0.01	0.01	0.01	mg/m <sup>3</sup>
Ambient temperature dependence	0.20	0.20	0.20	mg/m <sup>3</sup>
Combined interference (from MCERTS Certificate)	0.04	0.04	0.04	mg/m <sup>3</sup>
Dependence on voltage	0.06	0.06	0.06	mg/m <sup>3</sup>
Losses in the line (leak)	0.06	0.03	0.00	mg/m <sup>3</sup>
Uncertainty of calibration gas	0.08	0.04	0.00	mg/m <sup>3</sup>

Measurement uncertainty	Result	RUN 1	RUN 2	RUN 3	Units
Combined uncertainty		7.12	3.74	0.37	mg/m <sup>3</sup>
Expanded uncertainty	k = 1.96	0.47	0.44	0.43	mg/m <sup>3</sup>
Uncertainty corrected to std conds. (O <sub>2</sub> )		1.16	1.46	1.29	mg/m <sup>3</sup> (REF)

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O <sub>2</sub> ) - at 95% Confidence	6.64	11.77	116.05	% of Value
Expanded uncertainty (no O <sub>2</sub> ) - at 95% Confidence	2.36	2.20	2.14	% at ELV
Overall Allowable uncertainty (no O <sub>2</sub> ) - at 95% Confidence	15.0	15.0	15.0	% at ELV
<b>Result of Compliance with Uncertainty Requirement in M2</b>	N/A	N/A	N/A	-

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (with O <sub>2</sub> ) - at 95% Confidence	7.15	12.05	116.08	% of Value
Expanded uncertainty (with O <sub>2</sub> ) - at 95% Confidence	6.37	7.74	7.00	% at ELV
Overall Allowable uncertainty (with O <sub>2</sub> ) - at 95% Confidence	15.2	15.2	15.25	% at ELV
<b>Result of Compliance with Uncertainty Requirement in M2</b>	<b>COMPLIANT</b>	<b>COMPLIANT</b>	<b>COMPLIANT</b>	-

Requirement for SRM is that Uncertainty should be <15% of the value at the ELV, on a dry gas basis, or if O<sub>2</sub> correction is applied less than 15% + the uncertainty associated with the O<sub>2</sub> correction (using sqrt of sum squares to add uncertainty components). Ref EA TGN M2.

## CARBON MONOXIDE: RESULTS SUMMARY

Barrow Borough Council, Thorncliffe Crematorium  
Cremator No.2

### Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m <sup>3</sup>	26.5	16.8	8.3	17.2
Uncertainty	±mg/m <sup>3</sup>	3.4	4.4	3.9	3.9
Mass Emission	g/hr	41.6	26.3	13.1	27.0
Uncertainty	±g/hr	13.9	10.6	7.4	10.7

### General Sampling Information

Parameter	Value
Standard	EN 15058
Technical Procedure	CAT-TP-21
Probe Material	Titanium
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 12.0104
Span Gas Expiry Date	09/08/2019
Span Gas Start Pressure (bar)	100
Gas Cylinder Concentration (ppm)	94.8
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

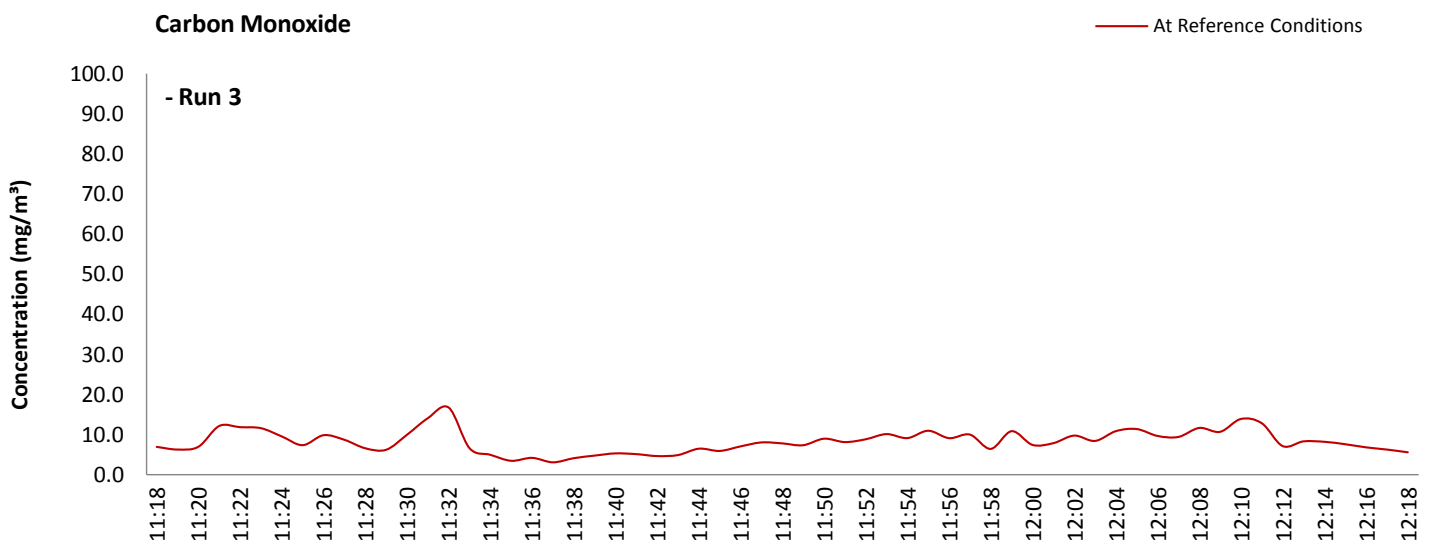
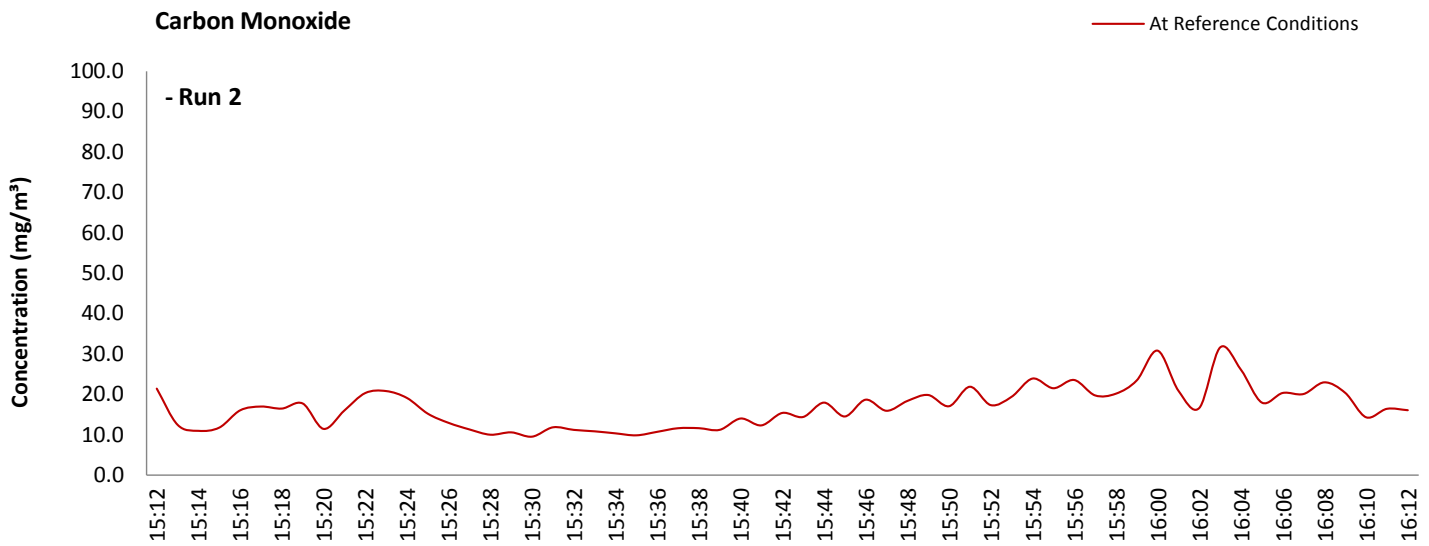
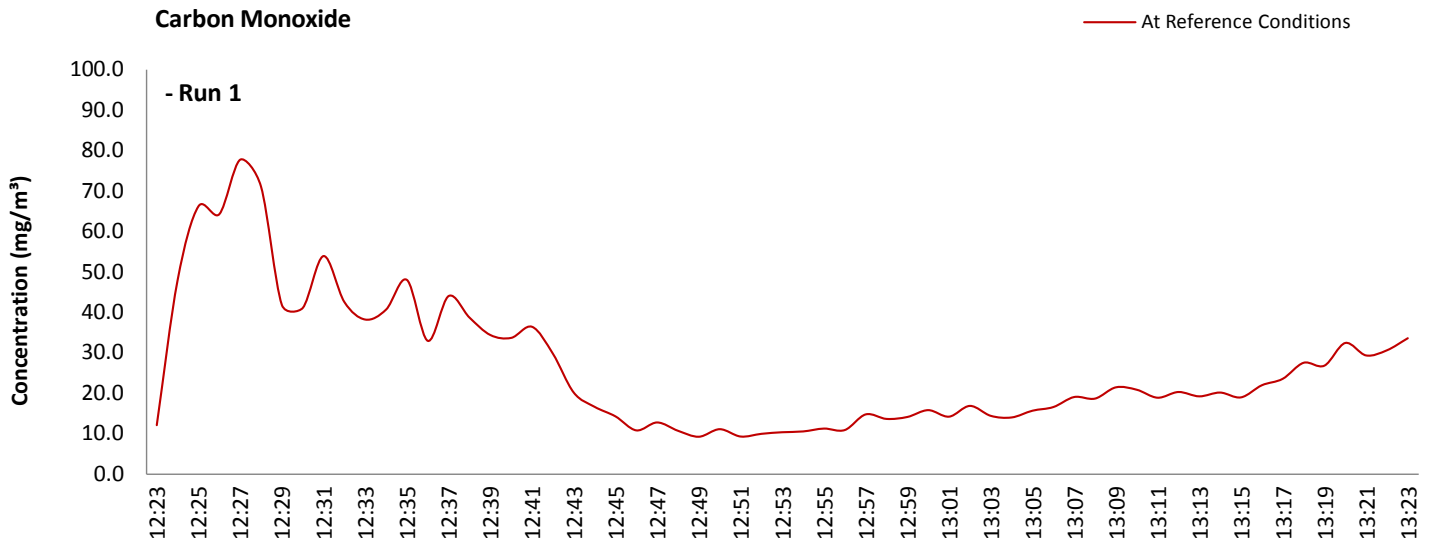
FORMAT: Number Used / Number Required

### 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	Run 2	Run 3
Sampling Times	-	12:23 - 13:23	15:12 - 16:12	11:18 - 12:18
Sampling Dates	-	06/12/2017	06/12/2017	07/12/2017
Instrument Range	ppm	100	100	200
Span Gas Value	ppm	80.1	80.1	80.1

### Quality Assurance

Conditioning Unit Temperature	Units	Run 1	Run 2	Run 3
Average Temperature	°C	2.5	2.5	2.5
Allowable Temperature	< °C	4.0	4.0	4.0
Temperature Acceptable	-	Yes	Yes	Yes

	Zero Drift	Units	Run 1	Run 2	Run 3
CAL 1	Zero Down Sampling Line (Pre)	ppm	-0.20	-0.20	0.10
	Zero Down Sampling Line (Post)	ppm	-0.20	-0.20	0.10
	Zero Drift	ppm	0.00	0.00	0.00
	Allowable Zero Drift	± ppm	4.00	4.00	4.00
	Zero Drift Acceptable	-	Yes	Yes	Yes

	Span Drift	Units	Run 1	Run 2	Run 3
CAL 1	Span Down Sampling Line (Pre)	ppm	80.00	80.00	79.80
	Span Down Sampling Line (Post)	ppm	79.80	79.80	79.00
	Span Drift	ppm	-0.20	-0.20	-0.80
	Allowable Span Drift	± ppm	4.00	4.00	4.00
	Span Drift Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Run Ambient Temperature Range	°C	15 - 20	15 - 20	15 - 20

### Method Deviations

Nature of Deviation (x = deviation applies to the associated run)	Run Number		
	1	2	3
There are no deviations associated with the sampling employed.	x	x	x

**CARBON MONOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS**

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Limit value	100.0	100.0	100.0	mg/m <sup>3</sup> (REF)
TGN M2 Allowable MU	6.0	6.0	6.0	%
Measured concentration	10.82	5.06	2.77	mg/m <sup>3</sup> (STP, dry)
Range Used	100.0	100.0	200.0	ppm
Range Used [A]	124.9	124.9	249.8	mg/m <sup>3</sup>
Cal gas conc.	80.1	80.1	80.1	ppm
Conversion	1.25	1.25	1.25	ppm to mg/m <sup>3</sup>
MCERTS Range [B]	95.0	95.0	95.0	mg/m <sup>3</sup>
Lower of [A] or [B]	95.0	95.0	95.0	mg/m <sup>3</sup>
Cal gas conc.	100.0	100.0	100.0	mg/m <sup>3</sup>

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Response time	60	60	60	seconds
Number of readings in measurement	60	60	60	-
Repeatability at zero	0.40	0.40	0.40	% full scale
Repeatability at span level	0.40	0.40	0.40	% full scale
Deviation from linearity	0.62	0.62	0.62	% of value
Zero drift	0.00	0.00	0.00	% full scale
Span drift	-0.25	-0.25	-1.00	% full scale
Volume or pressure flow dependence	0.40	0.40	0.40	% of full scale
Atmospheric pressure dependence	0.30	0.30	0.30	% of value/kPa
Ambient temperature dependence	0.05	0.05	0.05	% full scale/10K
Combined interference	0.73	0.73	0.73	% range
Dependence on voltage	0.40	0.40	0.40	% full scale/10V
Losses in the line (leak)	0.12	0.12	0.25	% of value
Uncertainty of calibration gas blending	1.40	1.40	1.40	% of value
Uncertainty of calibration gas	2.00	2.00	2.00	% of value

Performance characteristic	RUN 1	RUN 2	RUN 3	Units
Standard deviation of repeatability at zero	use rep at span	use rep at span	use rep at span	mg/m <sup>3</sup>
Standard deviation of repeatability at span level	0.05	0.05	0.05	mg/m <sup>3</sup>
Lack of fit	0.34	0.34	0.34	mg/m <sup>3</sup>
Drift	-0.02	-0.01	-0.02	mg/m <sup>3</sup>
Volume or pressure flow dependence	0.00	0.00	0.00	mg/m <sup>3</sup>
Atmospheric pressure dependence	0.08	0.08	0.08	mg/m <sup>3</sup>
Ambient temperature dependence	0.01	0.01	0.01	mg/m <sup>3</sup>
Combined interference (from MCERTS Certificate)	0.40	0.40	0.40	mg/m <sup>3</sup>
Dependence on voltage	0.05	0.05	0.05	mg/m <sup>3</sup>
Losses in the line (leak)	0.01	0.00	0.00	mg/m <sup>3</sup>
Uncertainty of calibration gas blending	0.09	0.04	0.02	mg/m <sup>3</sup>
Uncertainty of calibration gas	0.12	0.06	0.03	mg/m <sup>3</sup>

Measurement uncertainty	Result	RUN 1	RUN 2	RUN 3	Units
Combined uncertainty		10.82	5.06	2.77	mg/m <sup>3</sup>
Expanded uncertainty	k = 1.96	0.68	0.67	0.67	mg/m <sup>3</sup>
Expanded uncertainty		1.34	1.31	1.31	mg/m <sup>3</sup>
Uncertainty corrected to std conds. (O <sub>2</sub> )		3.29	4.35	3.94	mg/m <sup>3</sup> (REF)

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O <sub>2</sub> ) - at 95% Confidence	12.39	25.93	47.20	% of Value
Expanded uncertainty (no O <sub>2</sub> ) - at 95% Confidence	1.34	1.31	1.31	% at ELV
Overall Allowable uncertainty (no O <sub>2</sub> ) - at 95% Confidence	6.0	6.0	6.0	% at ELV
<b>Result of Compliance with Uncertainty Requirement in M2</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	-

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (with O <sub>2</sub> ) - at 95% Confidence	12.66	26.06	47.28	% of Value
Expanded uncertainty (with O <sub>2</sub> ) - at 95% Confidence	4.22	5.07	4.81	% at ELV
Overall Allowable uncertainty (with O <sub>2</sub> ) - at 95% Confidence	6.6	6.5	6.60	% at ELV
<b>Result of Compliance with Uncertainty Requirement in M2</b>	<b>COMPLIANT</b>	<b>COMPLIANT</b>	<b>COMPLIANT</b>	-

Requirement for SRM is that Uncertainty should be <6% of the value at the ELV, on a dry gas basis, or if O<sub>2</sub> correction is applied less than 6% + the uncertainty associated with the O<sub>2</sub> correction (using sqrt of sum squares to add uncertainty components). Ref EA TGN M2.

**OXYGEN: RESULTS SUMMARY**

Barrow Borough Council, Thorncliffe Crematorium  
Cremator No.2

**Sample Runs**

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	% v/v	16.9	18.0	17.7	17.5
Uncertainty	±% v/v	0.45	0.47	0.49	0.47

**General Sampling Information**

Parameter	Value
Standard	EN 14789
Technical Procedure	CAT-TP-21
Probe Material	Titanium
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 11.0300
Span Gas Expiry Date	11/09/2021
Span Gas Start Pressure (bar)	140
Gas Cylinder Concentration (% v/v)	21.29
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

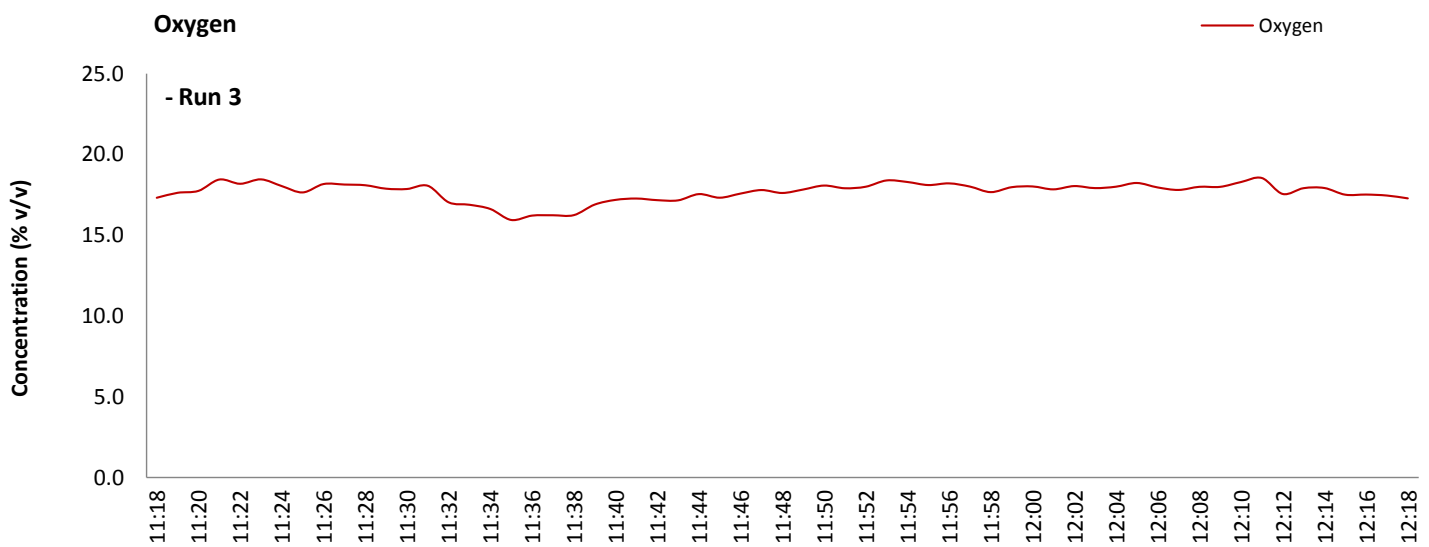
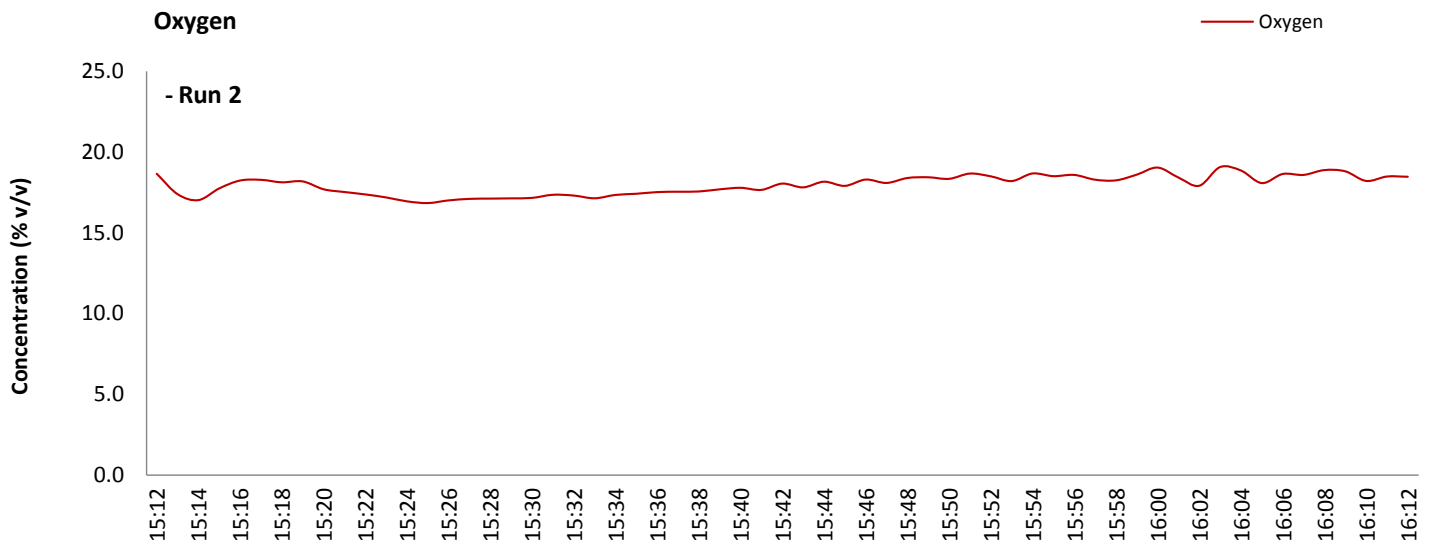
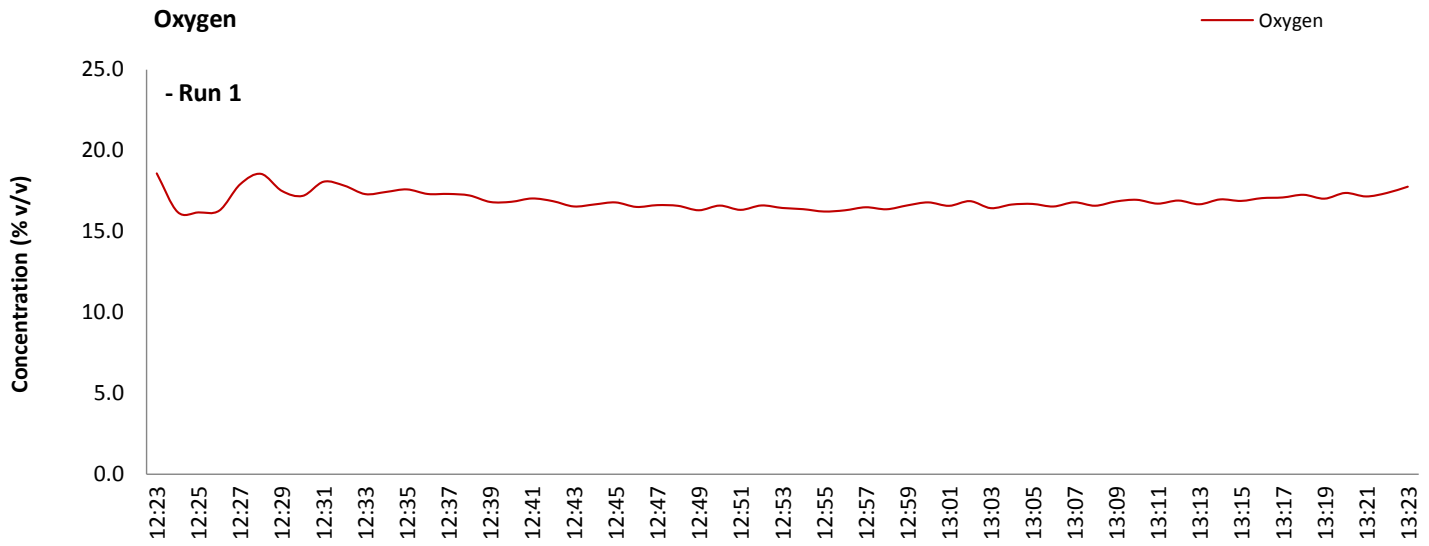
NOTE: Dilution performed to achieve correct span value

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	Run 2	Run 3
Sampling Times	-	12:23 - 13:23	15:12 - 16:12	11:18 - 12:18
Sampling Dates	-	06/12/2017	06/12/2017	07/12/2017
Instrument Range	% v/v	25	25	25
Span Gas Value	% v/v	17.00	17.00	17.00

**Quality Assurance**

Conditioning Unit Temperature	Units	Run 1	Run 2	Run 3
Average Temperature	°C	2.5	2.5	2.5
Allowable Temperature	< °C	4.0	4.0	4.0
Temperature Acceptable	-	Yes	Yes	Yes

Zero Drift	Units	Run 1	Run 2	Run 3
Zero Down Sampling Line (Pre)	% v/v	0.10	0.10	0.10
Zero Down Sampling Line (Post)	% v/v	0.10	0.10	0.12
Zero Drift	% v/v	0.00	0.00	0.02
Allowable Zero Drift	± % v/v	0.85	0.85	0.85
Zero Drift Acceptable	-	Yes	Yes	Yes

CAL 1

Span Drift	Units	Run 1	Run 2	Run 3
Span Down Sampling Line (Pre)	% v/v	17.03	17.03	16.82
Span Down Sampling Line (Post)	% v/v	17.03	17.03	16.90
Span Drift	% v/v	0.00	0.00	0.08
Allowable Span Drift	± % v/v	0.85	0.85	0.85
Span Drift Acceptable	-	Yes	Yes	Yes

CAL 1

Test Conditions	Units	Run 1	Run 2	Run 3
Run Ambient Temperature Range	°C	15 - 20	15 - 20	15 - 20

**Method Deviations**

Nature of Deviation (x = deviation applies to the associated run)	Run Number		
	1	2	3
There are no deviations associated with the sampling employed.	x	x	x

**OXYGEN: MEASUREMENT UNCERTAINTY CALCULATIONS**

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Limit value	N/A	N/A	N/A	%vol
TGN M2 Allowable MU	6.0	6.0	6.0	%
Measured concentration	16.92	17.98	17.68	%vol
Range Used	25.0	25.0	25.0	%vol
Cal gas conc.	21.3	21.3	21.3	%vol

Performance characteristics	RUN 1	RUN 2	RUN 3	Units
Response time	60	60	60	seconds
Number of readings in measurement	60	60	60	-
Repeatability at zero	0.04	0.04	0.04	% full scale
Repeatability at span level	0.04	0.04	0.04	% full scale
Deviation from linearity	0.10	0.10	0.10	% of value
Zero drift	0.00	0.00	0.12	% full scale
Span drift	0.00	0.00	0.48	% full scale
Volume or pressure flow dependence	0.20	0.20	0.20	% of full scale
Atmospheric pressure dependence	0.30	0.30	0.30	% of value/kPa
Ambient temperature dependence	-0.07	-0.07	-0.07	% full scale/10K
Combined interference	0.56	0.56	0.56	% range
Dependence on voltage	0.02	0.02	0.02	% full scale/10V
Losses in the line (leak)	0.00	0.00	0.47	% of value
Uncertainty of calibration gas	2.00	2.00	2.00	% of value

Performance characteristic	RUN 1	RUN 2	RUN 3	Units
Standard deviation of repeatability at zero	use rep at span	use rep at span	use rep at span	%vol
Standard deviation of repeatability at span level	0.01	0.01	0.01	%vol
Lack of fit	0.01	0.01	0.01	%vol
Drift	0.00	0.00	0.06	%vol
Volume or pressure flow dependence	0.00	0.00	0.00	%vol
Atmospheric pressure dependence	0.02	0.02	0.02	%vol
Ambient temperature dependence	-0.01	-0.01	-0.01	%vol
Combined interference (from MCERTS Certificate)	0.08	0.08	0.08	%vol
Dependence on voltage	0.00	0.00	0.00	%vol
Losses in the line (leak)	0.00	0.00	0.05	%vol
Uncertainty of calibration gas	0.20	0.21	0.20	%vol

Measurement uncertainty	Result	RUN 1	RUN 2	RUN 3	Units
Combined uncertainty		16.92	17.98	17.68	%vol
Expanded uncertainty	k = 1.96	0.23	0.24	0.25	%vol
		0.45	0.47	0.49	%vol

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O <sub>2</sub> ) - at 95% Confidence	2.64	2.60	2.76	% of Value
<b>Result of Compliance with Uncertainty Requirement in M2</b>	<b>COMPLIANT</b>	<b>COMPLIANT</b>	<b>COMPLIANT</b>	-

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.