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Stack Emissions Testing Report Commissioned by

The Phoenix Partnership

Installation Name & Address

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

LAPPC Permit: PPC/B/10

Stack Reference

Cremator No. 2

Dates of the Monitoring Campaign

11th January 2017

Job Reference Number

CAT-3158

Report Written by

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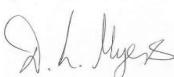
Report Date

26th January 2017

Version

Version 1

Signature of Report Approver



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APPENDIX 2 - Raw Data, Sampling Equations & Charts

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Executive Summary

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MONITORING OBJECTIVES

Barrow Borough Council, Barrow-In-Furness

Cremator No. 2

11th January 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 Barrow-In-Furness.

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, Barrow-In-Furness

Cremator No. 2

11th January 2017

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	66.5	10.0	80 [†] /160 [‡]		g/hr	96.1	15.4	120 [†] /240 [‡]
Hydrogen Chloride	¹ mg/m ³	51.3	8.1	200		g/hr	74.2	12.5	300
Total VOCs (as Carbon)	¹ mg/m ³	1.1	1.6	20		g/hr	1.6	2.3	30
Carbon Monoxide	¹ mg/m ³	18.2	5.0	100 [†] /200 [‡]		g/hr	26.3	7.4	150 [†] /300 [‡]
Oxygen	% v/v	Dry 17.4	0.46						
Water Vapour	% v/v	4.4	0.23						
Stack Gas Temperature	°C	326							
Stack Gas Velocity	m/s	6.9	0.23						
Volumetric Flow Rate (ACTUAL)	m ³ /hr	9341	527						
Volumetric Flow Rate (REF)	¹ m ³ /hr	1446	82						

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

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

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

[‡] 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, Barrow-In-Furness

Cremator No. 2

11th January 2017

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m³	65.7	g/hr	95.0	11/01/2017	11:16 - 12:16	60
Total Particulate Matter	R2	mg/m³	57.2	g/hr	82.7	11/01/2017	12:59 - 13:59	60
Total Particulate Matter	R3	mg/m³	76.6	g/hr	111	11/01/2017	14:19 - 15:19	60
Hydrogen Chloride	R1	mg/m³	51.9	g/hr	75.1	11/01/2017	11:16 - 12:16	60
Hydrogen Chloride	R2	mg/m³	53.8	g/hr	77.7	11/01/2017	12:59 - 13:59	60
Hydrogen Chloride	R3	mg/m³	48.3	g/hr	69.7	11/01/2017	14:19 - 15:19	60
Total VOCs (as Carbon)	R1	mg/m³	1.0	g/hr	1.4	11/01/2017	11:16 - 12:16	60
Total VOCs (as Carbon)	R2	mg/m³	1.2	g/hr	1.8	11/01/2017	12:59 - 13:59	60
Total VOCs (as Carbon)	R3	mg/m³	1.2	g/hr	1.8	11/01/2017	14:19 - 15:19	60
Carbon Monoxide	R1	mg/m³	17.0	g/hr	24.6	11/01/2017	11:16 - 12:16	60
Carbon Monoxide	R2	mg/m³	19.2	g/hr	27.7	11/01/2017	12:59 - 13:59	60
Carbon Monoxide	R3	mg/m³	18.5	g/hr	26.7	11/01/2017	14:19 - 15:19	60
Oxygen	R1	% v/v	16.8			11/01/2017	11:16 - 12:16	60
Oxygen	R2	% v/v	17.9			11/01/2017	12:59 - 13:59	60
Oxygen	R3	% v/v	17.3			11/01/2017	14:19 - 15:19	60
Velocity & Volumetric Flow Rate	R1					11/01/2017	10:55 - 11:02	

All results are expressed at the respective reference conditions.

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PROCESS DETAILS

Barrow Borough Council, Barrow-In-Furness

Cremator No. 2

11th January 2017

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	N/A
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 the sampling location

Site Specific Operating Conditions

Parameter	Status
Coffin Type	Standard / Standard / Standard
Sex	Male / Female / Female
Temperature in Primary Chamber	957 / 936 / 960
Temperature in Secondary Chamber	867 / 871 / 860
Cremation Number	46782 / 46784 / 46786
Size	Medium / Medium / Small

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MONITORING & ANALYTICAL METHODS

Barrow Borough Council, Barrow-In-Furness

Cremator No. 2

11th January 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	0.45 mg/m ³
Hydrogen Chloride	EN 1911	CAT-TP-11	Yes	CAT	CAT AP-01	IC	Yes	CAT	Yes	0.053 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	0.32 mg/m ³
Carbon Monoxide	EN 15058	CAT-TP-21	Yes	CAT	NDIR by Horiba PG-250				Yes	0.56 mg/m ³
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	1.2 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 Runs	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 ²	0.37
Port Depth	cm	41
Orientation of Duct	-	Vertical
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	14.0		> 5 Pa	Yes
Mean Velocity	m/s	6.25		-	-
Lowest Gas Velocity	m/s	5.73		-	-
Highest Gas Velocity	m/s	6.67		-	-
Ratio of Above	: 1	1.16		< 3 : 1	Yes
Maximum Angle of Swirl	°	4		< 15°	Yes
No Local Negative Flow	-	Yes		-	Yes

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PLANT PHOTOS

Photo 1



Photo 2



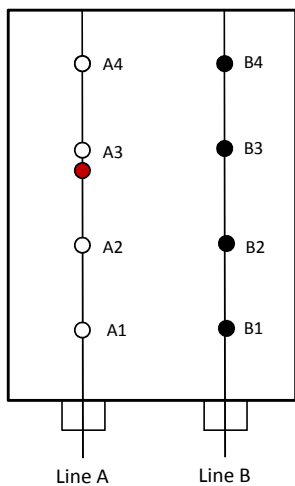
Photo 3



Photo 4



SAMPLE POINTS



where

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

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	Brian Jacob	MCERTS Level 2	MM 06 693	TE1 TE2 TE3 TE4
Technician	Darius Niknejad	MCERTS Level 1	MM 09 1036	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 7.39	Horiba PG-250	CAT 9.9	Digital Manometer (1)	CAT 3.25
Control Box DGM (2)	-	Horiba PG-250	-	Digital Manometer (2)	-
Box Thermocouples (1)	CAT 3.10	Servomex 4900	-	Digital Temperature Meter	CAT 3.25
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 14.53
Umbilical (1)	CAT 3.10	ABB AO2020-URAS26	-	Barometer	CAT 13.20
Umbilical (2)	-	Servomex 5200MP	-	Stack Thermocouple (1)	CAT HOT
Oven Box (1)	CAT 12.3	JCT JCC P1 Cooler	-	Stack Thermocouple (2)	-
Oven Box (2)	-	Gasmet DX4000	-	Stack Thermocouple (3)	-
Heated Probe (1)	CAT HOT	Gasmet Sampling System	-	1m Heated Line (1)	-
Heated Probe (2)	-	Bernath 3006 FID	CAT 8.7	1m Heated Line (2)	-
Heated Probe (3)	-	M&C PSS	CAT 12.93	1m Heated Line (3)	-
S-Pitot (1)	CAT HOT	Mass Flow Controller (1)	CAT 6.65	5m Heated Line (1)	-
S-Pitot (2)	-	Mass Flow Controller (2)	CAT 6.66	15m Heated Line (1)	-
L-Pitot	-	Mass View (1)	-	20m Heated Line (1)	CAT 20.69
Site Balance	CAT 17.13	Mass View (2)	-	20m Heated Line (2)	-
500g / 1Kg Check Weights	CAT 17.13	Easylogger EN-EL-12 Bit	CAT 11.55	Dual Channel Heater Controller	-
Last Impinger Arm	CAT 4.17	Easylogger EN-EL-12 Bit	-	Single Channel Heater Controller	-
Callipers	CAT 23/10	Bioaerosols Temperature Logger	-	Laboratory Balance	CAT 1.18 / 1.18a
Tubes Kit Thermocouple	-	Electronic Refrigerator	-	Tape Measure	CAT 16.14

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 ²	0.37
Average Stack Gas Temperature, T _a	°C	301.3
Average Stack Gas Pressure	Pa	16.8
Average Stack Static Pressure, P _{static}	kPa	0.011
Average Barometric Pressure, P _b	kPa	100.1
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)	-	3.00	2.85	0.0300	44.01	1.9635	0.05891
O ₂	-	17.38	16.51	0.1738	32.00	1.4277	0.24807
N ₂	-	79.62	75.64	0.7962	28.01	1.2498	0.99518
Moisture (H ₂ O) (Estimated)	-	-	5.00	0.0500	18.02	0.8037	0.04019

NOTE: Moisture has been estimated as no moisture test was performed on the date(s) of testing

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	1.302
Wet Density (STP), P _{STW}	kg/m ³	1.277
Dry Density (Actual), P _{Actual}	kg/m ³	0.612
Average Wet Density (Actual), P _{ActualW}	kg/m ³	0.600

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)

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

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

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF ¹
Temperature	°C	301.3	0.0
Total Pressure	kPa	100.1	101.3
Moisture	%	4.39	0.00
Oxygen (Dry)	%	17.4	11.0

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m ³ /hr	8420
Gas Volumetric Flowrate (STP, Wet)	m ³ /hr	3955
Gas Volumetric Flowrate (STP, Dry)	m ³ /hr	3782
Gas Volumetric Flowrate REF ¹	m ³ /hr	1371

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	11/01/2017
Time of Survey	-	10:55 - 11:02
Atmospheric Pressure	kPa	100.1
Average Stack Static Pressure	Pa	11
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	-	Vertical
Pitot Tube, C_p	-	0.84
Number of Lines Available	-	2
Number of Lines Used	-	1

Sampling Line A							Sampling Line B - Cap Stuck				
Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °	ΔP	Temp °C	Wet Density kg/m³	Velocity m/s	Swirl °
STATIC (Units: Pa)		11.0									
Mean		16.8	301.3	0.600	6.25						
1	0.11	18.0	301.2	0.600	6.49	3.0					
2	0.32	19.0	301.3	0.600	6.67	3.0					
3	0.53	16.0	301.3	0.600	6.12	4.0					
4	0.74	14.0	301.4	0.600	5.73	0.0					

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	$u(\Delta p_i)$	1.057	Pa
- Resolution	$u(res)$	0.00087	
- Calibration	$u(cal)$	0.029	
- Drift	$u(drift)$	0.083	
- Lack of Fit	$u(fit)$	0.004	
- Overall corrections to dynamic measurements	$u(C_f)$	0.117	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00004	-
- $\varphi_{O_2,w}$	-	16.507	
- $\varphi_{CO_2,w}$	-	2.850	
- Oxygen, dry	$u(\phi_{O_2,d})$	0.532	
- Carbon Dioxide, dry	$u(\phi_{CO_2,d})$	0.092	
- Water Vapour	$u(\phi_{H_2O})$	0.255	
- Oxygen, wet	$u(\phi_{O_2,w})$	0.507	
- Carbon Dioxide, wet	$u(\phi_{CO_2,w})$	0.088	
Standard uncertainty associated with the stack temperature	$u(T_c)$	2.930	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.695	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	1.057	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00324	-
Standard uncertainty associated with the local velocities	$u(v_i)$	0.203	Pa
Standard uncertainty associated with the mean velocity	$u(\bar{v})$	0.108	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	0.211	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	3.37	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV,w)$	475.4	m ³ /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00083	
- $u^2(qV,w)$	-	58821	
- $u(qV,w)$	-	242.5	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV,w)$	5.65	%

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Barrow Borough Council, Barrow-In-Furness
Cremator No. 2

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m ³	65.7	57.2	76.6		66.5
Uncertainty	±mg/m ³	8.7	10.0	11.2		10.0
Mass Emission	g/hr	95.0	82.7	111		96.1
Uncertainty	±g/hr	13.7	15.2	17.4		15.4

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	4.3	4.4	4.5		4.4
Uncertainty	±% v/v	0.23	0.23	0.23		0.23

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	0.44		0.44

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	Borosilicate Glass	
Positioning of Filter	Out Stack	
Filter Size and Material	90mm Quartz Fibre	
Number of Sampling Lines Used	1 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	4 / 4	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1 - A4	

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	
Absolute pressure of stack gas, P_s					
Barometric pressure, P _b	mmHg	751.5	751.5	751.5	
Stack static pressure, P _{static}	mmH ₂ O	1.1	1.1	1.1	
P _s = (P _b + (P _{static} / 13.6))	mmHg	751.6	751.6	751.6	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	15.5	16.9	16.3	
Total mass collected in impingers (silica trap)	g	15.3	16.7	16.3	
Total mass of liquid collected, V _{lc}	g	30.8	33.6	32.6	
V _{wstd} = (0.001246)(V _{lc})	m ³	0.0384	0.0419	0.0406	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V _m	m ³	0.9450	0.9920	0.9590	
Gas meter correction factor, Y _d	-	0.9900	0.9900	0.9900	
Average dry gas meter temperature, T _m	°C	21.1	22.0	22.0	
Average pressure drop across orifice, ΔH	mmH ₂ O	24.2	25.6	25.5	
V _{mstd} = ((0.3592)(V _m)(P _b + (ΔH/13.6))(Y _d) / (T _m + 273))	m ³	0.8607	0.9010	0.8709	
Moisture content, B_{wo} & R_{wv}					
B _{wo} = V _{wstd} / (V _{mstd} + V _{wstd})	m ³	0.0427	0.0444	0.0446	
B _{wo} as a percentage	% v/v	4.27	4.44	4.46	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	4.27	4.44	4.46	
Volume of gas metered wet, V_{mstw}					
V _{mstw} = (V _{mstd})(100/(100 - R _{wv}))	m ³	0.8990	0.9429	0.9115	
Volume of gas metered at Oxygen Reference Conditions, V_{mstd@X%O₂} & V_{mstw@X%O₂}					
IED & Incinerates Hazardous Material? (Yes = no positive Q _c correction)	-	No	No	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	16.14	17.20	16.58	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	16.88	17.99	17.35	
% oxygen reference condition, REF%O ₂	% v/v	11.00	11.00	11.00	
O ₂ Reference Factor wet (O _{2REFw}) = (21 - REF%O ₂) / (21 - ACT%O _{2w})	-	2.06	2.63	2.26	
O ₂ Reference Factor dry (O _{2REFd}) = (21 - REF%O ₂) / (21 - ACT%O _{2d})	-	2.43	3.32	2.74	
V _{mstw@X%oxygen} = (V _{mstw}) / (O _{2REFw})	m ³	0.4371	0.3583	0.4025	
V _{mstd@X%oxygen} = (V _{mstd}) / (O _{2REFd})	m ³	0.3547	0.2712	0.3183	
Molecular weight of dry gas stream, M_d					
CO ₂ (Estimated)	% v/v	2.50	3.00	3.00	
O ₂	% v/v	16.88	17.99	17.35	
Total	% v/v	19.38	20.99	20.35	
N ₂	% v/v	80.62	79.01	79.65	
M _d = 0.44(%CO ₂) + 0.32(%O ₂) + 0.28(%N ₂)	g/gmol	29.08	29.20	29.17	
Molecular weight of stack gas (wet), M_s					
M _s = M _d (1 - (R _{wv} /100)) + 18(R _{wv} /100)	g/gmol	28.60	28.70	28.68	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K _p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C _p	-	0.84	0.84	0.84	
Average of velocity heads, ΔP _{avg}	mmH ₂ O	2.02	2.00	2.00	
Average square root of velocity heads, √ΔP	√mmH ₂ O	1.42	1.41	1.41	
Average stack gas temperature, T _s	°C	349.7	312.5	316.3	
V _s = ((K _p)(C _p)(√ΔP)(√T _s + 273)) / (√(M _s)(P _s))	m/s	7.10	6.84	6.87	
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	0.37	0.37	0.37	
Q _a = (60)(A _s)(V _s)	m ³ /min	159.3	153.6	154.2	
Conversion factor (K/mm.Hg), C _f	-	0.3592	0.3592	0.3592	
Q _{stw} = ((Q _a)(P _s)(C _f)) / ((T _s) + 273)	m ³ /min	69.1	70.8	70.6	
Q _{std} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s) + 273)	m ³ /min	66.1	67.7	67.5	
Q _{stwO₂} = ((Q _a)(P _s)(C _f)) / ((T _s) + 273) / (O _{2REFw})	m ³ /min	33.6	26.9	31.2	
Q _{stdO₂} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s) + 273) / (O _{2REFd})	m ³ /min	27.2	20.4	24.7	
Percent isokinetic, %I					
Nozzle diameter, D _n	mm	9.97	9.97	9.97	
Nozzle area, A _n	mm ²	78.08	78.08	78.08	
Total sampling time, q	min	60	60	60	
%I = (4.6398E ⁶)(T _s +273)(V _{mstd}) / (P _s)(V _s)(A _n)(q)(1 - (R _{wv} /100))	%	103.9	106.3	103.1	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	11:16 - 12:16	12:59 - 13:59	14:19 - 15:19	
Sampling Dates	-	11/01/2017	11/01/2017	11/01/2017	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m ³	0.3547	0.2712	0.3183	
Filter I.D. Number	-	90-5376	90-5385	90-5177	
Start Filter Mass	g	0.53422	0.53415	0.53240	
End Filter Mass	g	0.55379	0.54718	0.55287	
Total Mass on Filter	g	0.01957	0.01303	0.02047	
Probe Rinse I.D. Number	-	PR-90-5376	PR-90-5385	PR-90-5177	
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	0.00372	0.00248	0.00390	
Total Mass Collected	mg	23.30	15.51	24.37	
Calculated Concentration	mg/m ³	65.69	57.19	76.56	
Balance Uncertainty / LOD	mg/m ³	0.39	0.52	0.44	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	11/01/2017	
Average Volume Sampled (REF)	m ³	0.3147	
Filter I.D. Number	-	90-5390	
Start Filter Mass	g	0.53540	
End Filter Mass	g	0.53552	
Total Mass on Filter	g	0.00012	
Probe Rinse I.D. Number	-	PR-90-5390	
Start Probe Rinse Mass	g	2.95784	
End Probe Rinse Mass	g	2.95785	
Total Mass in Probe Rinse	g	0.00001	
Total Mass Collected	mg	0.13	
Calculated Concentration	mg/m ³	0.41	
Balance Uncertainty / LOD	mg/m ³	0.44	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3	
Mean Sampling Rate	l/min	15.59	16.37	15.82	
Pre-Sampling Leak Rate	l/min	0.11	0.13	0.13	
Post-Sampling Leak Rate	l/min	0.15	0.13	0.13	
Allowable Leak Rate	l/min	0.31	0.33	0.32	
Leak Test Acceptable	-	Yes	Yes	Yes	
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)	%	5.3	5.2	5.2	
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	%	103.9	106.3	103.1	
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115	
Isokineticity Acceptable	-	Yes	Yes	Yes	
Weighing Uncertainty Criteria	Units	Run 1	Run 2	Run 3	
Overall Weighing Uncertainty	± mg	0.25	0.25	0.25	
Overall Weighing Uncertainty	± mg/m ³	0.71	0.93	0.79	
ELV [Daily ELV for IED]	mg/m ³	80.00	80.00	80.00	
Allowable Weighing Uncertainty	mg/m ³	4.00	4.00	4.00	
Weighing Uncertainty Acceptable	-	Yes	Yes	Yes	
Filter Temperatures	Units	Run 1	Run 2	Run 3	
Pre-Conditioning Temperature	°C	180	180	180	
Post-Conditioning Temperature	°C	160	160	160	
Maximum Filter Temperature	°C	150	150	150	
Test Conditions	Units	Run 1	Run 2	Run 3	
Ambient Temperature Recorded?	-	Yes	Yes	Yes	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

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

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	8.0	
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			
	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					Symbol	Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3			Units	Run 1	Run 2	Run 3	
Sampled Volume (Actual)	V _m	0.9450	0.9920	0.9590		uV _m	m ³	0.0189	0.0198	0.0192	
Sampled Gas Temperature	T _m	294.1	295.0	295.0		uT _m	K	2.0	2.0	2.0	
Sampled Gas Pressure	p _m	100.2	100.2	100.2		up _m	kPa	0.5	0.5	0.5	
Sampled Gas Humidity	H _m	0.0	0.0	0.0		uH _m	% v/v	1.0	1.0	1.0	
Leak	L	0.96	0.79	0.82		uL	%	-	-	-	
Mass of Particulate	m	23.30	15.51	24.37		um	mg	0.14	0.14	0.14	
Uncollected Mass	UCM	0.13	0.13	0.13		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	%	0.96	0.79	0.82		≤2%
Mass of Particulate	%	0.49	0.65	0.55		<5% of ELV
Uncollected Mass	%	-	-	-		-

Measured Quantities	Uncertainty in Measurement Units					Symbol	Sensitivity Coefficient			
	Units	Run 1	Run 2	Run 3			Run 1	Run 2	Run 3	
Sampled Volume (STP)	V _m	m ³	0.8607	0.9010	0.8709		76.33	63.48	87.91	
Leak	L	mg/m ³	0.365	0.262	0.363		1.00	1.00	1.00	
Mass of Particulate	L _r	mg	23.298	15.513	24.369		2.82	3.69	3.14	
Uncollected Mass	UCM	mg	0.08	0.08	0.08		2.82	3.69	3.14	

Measured Quantities	Uncertainty in Result				
	Units	Run 1	Run 2	Run 3	
Sampled Volume (STP)	mg/m ³	1.679	1.465	1.961	
Leak	mg/m ³	0.3649	0.2623	0.3632	
Mass of Particulate	mg/m ³	0.3948	0.5161	0.4398	
Uncollected Mass	mg/m ³	0.2116	0.2767	0.2358	

Measured Quantities	Oxygen Correction Part of MU Budget				
	Units	Run 1	Run 2	Run 3	
O ₂ Correction Factor	-	2.43	3.32	2.74	
Stack Gas O ₂ Content	% v/v	16.88	17.99	17.35	
MU for O ₂ Correction	-	0.29	0.55	0.37	
Overall MU For O ₂ Measurement	%	12.13	16.61	13.68	

Parameter	Units	Run 1	Run 2	Run 3	
Combined uncertainty	mg/m ³	1.78	1.60	2.06	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	3.48	3.13	4.03	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	8.70	10.00	11.22	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	8.70	10.00	11.22	
Reported Uncertainty	mg/m ³	8.70	10.00	11.22	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	5.3	5.5	5.3	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	13.2	17.5	14.7	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	13.2	17.5	14.7	
Reported Uncertainty	%	13.2	17.5	14.7	

HYDROGEN CHLORIDE: RESULTS SUMMARY

Barrow Borough Council, Barrow-In-Furness
Cremator No. 2

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m ³	51.9	53.8	48.3		51.3
Uncertainty	±mg/m ³	7.3	9.7	7.4		8.1
Mass Emission	g/hr	75.1	77.7	69.7		74.2
Uncertainty	±g/hr	11.4	14.7	11.4		12.5

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	4.3	4.4	4.5		4.4
Uncertainty	±% v/v	0.23	0.23	0.23		0.23

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	< 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	16/01/2017
Probe Material	Titanium
Filter Housing Material	Borosilicate 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	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg	751.5	751.5	751.5	
Stack static pressure, P_{static}	mmH ₂ O	1.1	1.1	1.1	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	751.6	751.6	751.6	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	15.5	16.9	16.3	
Total mass collected in impingers (silica trap)	g	15.3	16.7	16.3	
Total mass of liquid collected, V_{lc}	g	30.8	33.6	32.6	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.0384	0.0419	0.0406	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m ³	0.9450	0.9920	0.9590	
Gas meter correction factor, Y_d	-	0.9900	0.9900	0.9900	
Average dry gas meter temperature, T_m	°C	21.1	22.0	22.0	
Average pressure drop across orifice, ΔH	mmH ₂ O	24.2	25.6	25.5	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	0.8607	0.9010	0.8709	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.0427	0.0444	0.0446	
B_{wo} as a percentage	% v/v	4.27	4.44	4.46	
Reported Water Vapour, checked with Tables in EN 14790, R_{wv}	% v/v	4.27	4.44	4.46	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m ³	0.8990	0.9429	0.9115	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$					
IED & Incinerates Hazardous Material? (Yes = no positive Q_c correction)	-	No	No	No	
% wet oxygen measured in gas stream, ACT% O_{2w}	% v/v	16.14	17.20	16.58	
% dry oxygen measured in gas stream, ACT% O_{2d}	% v/v	16.88	17.99	17.35	
% oxygen reference condition, REF% O_2	% v/v	11.00	11.00	11.00	
O_2 Reference Factor wet ($O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$)	-	2.06	2.63	2.26	
O_2 Reference Factor dry ($O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$)	-	2.43	3.32	2.74	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	0.4371	0.3583	0.4025	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	0.3547	0.2712	0.3183	
Molecular weight of dry gas stream, M_d					
CO ₂ (Estimated)	% v/v	2.50	3.00	3.00	
O ₂	% v/v	16.88	17.99	17.35	
Total	% v/v	19.38	20.99	20.35	
N ₂	% v/v	80.62	79.01	79.65	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	29.08	29.20	29.17	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.60	28.70	28.68	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.84	0.84	0.84	
Average of velocity heads, ΔP_{avg}	mmH ₂ O	2.02	2.00	2.00	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	1.42	1.41	1.41	
Average stack gas temperature, T_s	°C	349.7	312.5	316.3	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s	7.10	6.84	6.87	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO_2}), Dry@O_{2REF} (Q_{stdO_2})					
Area of stack, A_s	m ²	0.37	0.37	0.37	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	159.3	153.6	154.2	
Conversion factor (K/mm.Hg), C_t	-	0.3592	0.3592	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_t)) / ((T_s) + 273)$	m ³ /min	69.1	70.8	70.6	
$Q_{std} = ((Q_a)(P_s)(C_t)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	66.1	67.7	67.5	
$Q_{stwO_2} = ((Q_a)(P_s)(C_t)) / ((T_s) + 273) / (O_{2REFw})$	m ³ /min	33.6	26.9	31.2	
$Q_{stdO_2} = ((Q_a)(P_s)(C_t)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m ³ /min	27.2	20.4	24.7	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm	9.97	9.97	9.97	
Nozzle area, A_n	mm ²	78.08	78.08	78.08	
Total sampling time, q	min	60	60	60	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.9	106.3	103.1	

HYDROGEN CHLORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	11:16 - 12:16	12:59 - 13:59	14:19 - 15:19	
Sampling Dates	-	11/01/2017	11/01/2017	11/01/2017	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m ³	0.3547	0.2712	0.3183	
Laboratory Result for Front Impingers	µg/ml	85.44	45.34	47.14	
Laboratory Result for Back Impinger	µg/ml	0.10			
Volume in Front Impingers	ml	215.4	321.7	325.8	
Volume in Back Impinger	ml	123.2			
Mass in Front Impingers	µg	18403.8	14585.9	15358.2	
Mass in Back Impinger	µg	12.3			
Total Mass Collected	µg	18416.1	14585.9	15358.2	
Calculated Concentration	mg/m ³	51.93	53.77	48.25	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	11/01/2017	
Average Volume Sampled (REF)	m ³	0.3147	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	311.0	
Total Mass Collected	µg	< 15.6	
Calculated Concentration	mg/m ³	< 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	15.59	16.37	15.82	
Pre-Sampling Leak Rate	l/min	0.11	0.13	0.13	
Post-Sampling Leak Rate	l/min	0.15	0.13	0.13	
Allowable Leak Rate	l/min	0.31	0.33	0.32	
Leak Test Acceptable	-	Yes	Yes	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	99.9	
Allowable Absorption Efficiency	%	N/A ¹	
Absorption Efficiency Acceptable	-	N/A ¹	

¹ 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)	%	5.3	5.2	5.2	
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	%	103.9	106.3	103.1	
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	150	150	150	

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	
Expected Sampling Rate	l/min	15.00	
Pre-Sampling Leak Rate	l/min	0.12	
Post-Sampling Leak Rate	l/min	0.15	
Allowable Leak Rate	l/min	0.30	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	20.0	
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)				
There are no deviations associated with the sampling employed.	wx	wx	wx	

HYDROGEN CHLORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value					Symbol	Standard uncertainty				
	Symbol	Run 1	Run 2	Run 3			Units	Run 1	Run 2	Run 3	
Sampled Volume (Actual)	V _m	0.9450	0.9920	0.9590		uV _m	m ³	0.0189	0.0198	0.0192	
Sampled Gas Temperature	T _m	294.1	295.0	295.0		uT _m	K	2.0	2.0	2.0	
Sampled Gas Pressure	p _m	100.2	100.2	100.2		up _m	kPa	0.5	0.5	0.5	
Sampled Gas Humidity	H _m	0.0	0.0	0.0		uH _m	% v/v	1.0	1.0	1.0	
Leak	L	0.96	0.79	0.82		uL	%	-	-	-	
Laboratory Result	L _r	2.50	2.50	2.50		uL _r	%	-	-	-	

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	%	0.96	0.79	0.82		≤2%
Laboratory Result	%	2.50	2.50	2.50		No Requirement

Measured Quantities	Uncertainty in Measurement Units					Symbol	Sensitivity Coefficient			
	Units	Run 1	Run 2	Run 3			Run 1	Run 2	Run 3	
Sampled Volume (STP)	V _m	m ³	0.8607	0.9010	0.8709		60.33	59.68	55.40	
Leak	L	mg/m ³	0.2884	0.2466	0.2289		1.00	1.00	1.00	
Laboratory Result	L _r	mg/m ³	1.298	1.344	1.206		1.00	1.00	1.00	

Measured Quantities	Uncertainty in Result				
	Units	Run 1	Run 2	Run 3	
Sampled Volume (STP)	mg/m ³	1.3273	1.3770	1.2357	
Leak	mg/m ³	0.288	0.247	0.229	
Laboratory Result	mg/m ³	1.298	1.344	1.206	

Measured Quantities	Oxygen Correction Part of MU Budget				
	Units	Run 1	Run 2	Run 3	
O ₂ Correction Factor	-	2.43	3.32	2.74	
Stack Gas O ₂ Content	% v/v	16.88	17.99	17.35	
MU for O ₂ Correction	-	0.29	0.55	0.37	
Overall MU For O ₂ Measurement	%	12.13	16.61	13.68	

Parameter	Units	Run 1	Run 2	Run 3	
Combined uncertainty	mg/m ³	1.88	1.94	1.74	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	3.68	3.80	3.41	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	7.30	9.71	7.43	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	7.30	9.71	7.43	
Reported Uncertainty	mg/m ³	7.30	9.71	7.43	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	7.1	7.1	7.1	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	14.1	18.1	15.4	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	14.1	18.1	15.4	
Reported Uncertainty	%	14.1	18.1	15.4	

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Barrow Borough Council, Barrow-In-Furness
Cremator No. 2

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m ³	0.96	1.2	1.2	1.1
Uncertainty	±mg/m ³	1.4	1.9	1.5	1.6
Mass Emission	g/hr	1.4	1.8	1.8	1.6
Uncertainty	±g/hr	2.0	2.7	2.2	2.3

General Sampling Information

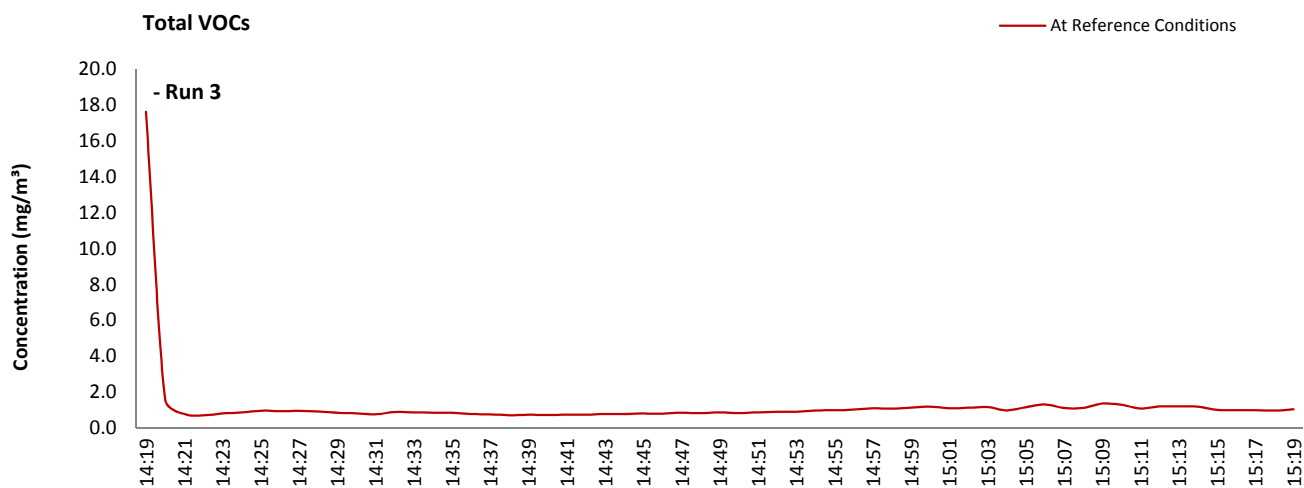
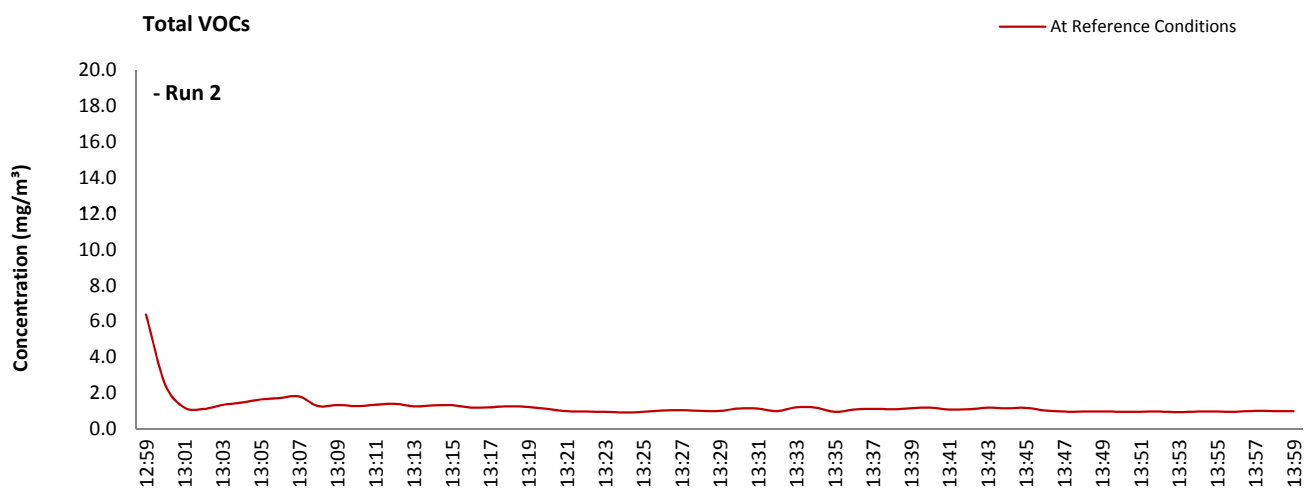
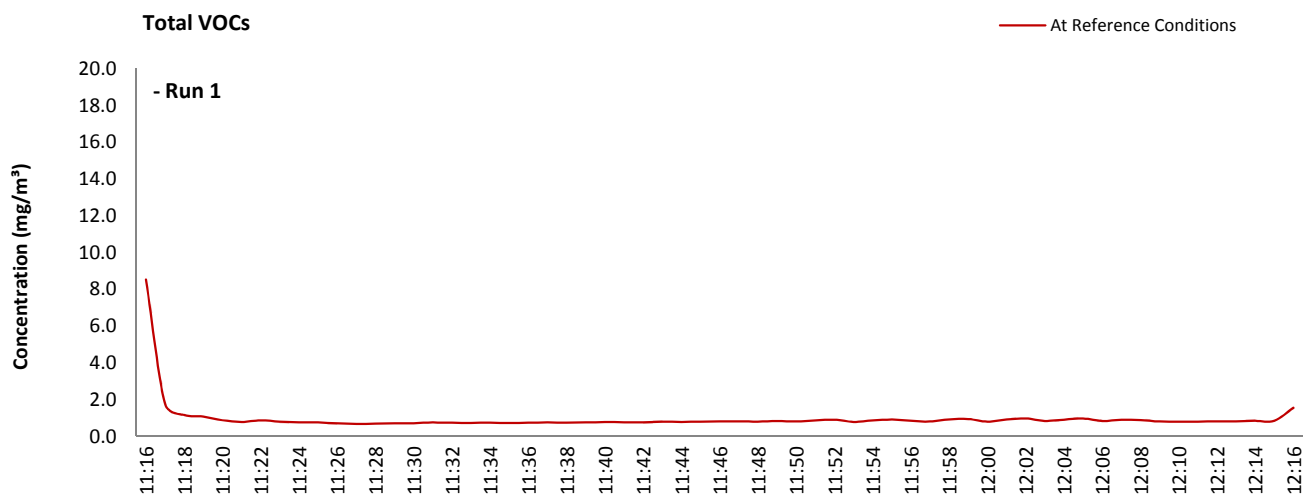
Parameter	Value	
Standard	EN 12619:2013	
Technical Procedure	CAT-TP-20	
Probe Material	Titanium	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Type	Propane In Synthetic Air (5 Grade)	
Span Gas Reference Number	CYL 0206a	
Span Gas Expiry Date	10/01/2021	
Span Gas Start Pressure (bar)	150	
Gas Cylinder Concentration (ppm)	80.4	
Span Gas Set Point (ppm)	80.40	
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	A3	

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	-	11:16 - 12:16	12:59 - 13:59	14:19 - 15:19
Sampling Dates	-	11/01/2017	11/01/2017	11/01/2017
Instrument Range	ppm	100	100	100
Span Gas Value	ppm	80.4	80.4	80.4

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	0.20	0.20	0.20
	Allowable Zero Drift	± ppm	4.02	4.02	4.02
	Zero Drift Acceptable	-	Yes	Yes	Yes

	Span Drift	Units	Run 1	Run 2	Run 3
CAL 1	Span Down Sampling Line (Pre)	ppm	79.80	79.80	79.80
	Span Down Sampling Line (Post)	ppm	77.80	77.80	77.80
	Span Drift	ppm	-2.00	-2.00	-2.00
	Allowable Span Drift	± ppm	4.02	4.02	4.02
	Span Drift Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Run Ambient Temperature Range	°C	17 - 18	18 - 19	18 - 19

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 ³ (REF)
TGN M2 Allowable MU	15.0	15.0	15.0	%
Measured concentration	0.40	0.37	0.44	mg/m ³ (STP, dry)
Range Used	100.0	100.0	100.0	ppm
Range Used [A]	160.6	160.6	160.6	mg/m ³
Cal gas conc.	80.4	80.4	80.4	ppm
Conversion	1.61	1.61	1.61	ppm to mg/m ³
MCERTS Range [B]	15.0	15.0	15.0	mg/m ³
Lower of [A] or [B]	15.0	15.0	15.0	mg/m ³
Cal gas conc.	129.1	129.1	129.1	mg/m ³

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	0.05	0.05	0.05	% of value
Zero drift	0.25	0.25	0.25	% full scale
Span drift	0.00	0.00	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)	0.75	0.75	0.75	% 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 ³
Standard deviation of repeatability at span level	0.00	0.00	0.00	mg/m ³
Lack of fit	0.00	0.00	0.00	mg/m ³
Drift	0.19	0.19	0.19	mg/m ³
Volume or pressure flow dependence	0.00	0.00	0.00	mg/m ³
Atmospheric pressure dependence	0.01	0.01	0.01	mg/m ³
Ambient temperature dependence	0.20	0.20	0.20	mg/m ³
Combined interference (from MCERTS Certificate)	0.04	0.04	0.04	mg/m ³
Dependence on voltage	0.06	0.06	0.06	mg/m ³
Losses in the line (leak)	0.00	0.00	0.00	mg/m ³
Uncertainty of calibration gas	0.00	0.00	0.01	mg/m ³

Measurement uncertainty	Result	RUN 1	RUN 2	RUN 3	Units
Combined uncertainty		0.40	0.37	0.44	mg/m ³
Expanded uncertainty	k = 1.96	0.56	0.56	0.56	mg/m ³
Uncertainty corrected to std conds. (O ₂)		1.36	1.87	1.54	mg/m ³ (REF)

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O ₂) - at 95% Confidence	141.76	152.30	127.05	% of Value
Expanded uncertainty (no O ₂) - at 95% Confidence	2.81	2.81	2.81	% at ELV
Overall Allowable uncertainty (no O ₂) - at 95% Confidence	15.0	15.0	15.0	% at ELV
Result of Compliance with Uncertainty Requirement in M2	N/A	N/A	N/A	-

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (with O ₂) - at 95% Confidence	141.79	152.33	127.08	% of Value
Expanded uncertainty (with O ₂) - at 95% Confidence	7.32	9.70	8.13	% at ELV
Overall Allowable uncertainty (with O ₂) - at 95% Confidence	15.2	15.2	15.23	% at ELV
Result of Compliance with Uncertainty Requirement in M2	COMPLIANT	COMPLIANT	COMPLIANT	-

Requirement for SRM is that Uncertainty should be <15% of the value at the ELV, on a dry gas basis, or if Q 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

Barrow Borough Council, Barrow-In-Furness
Cremator No. 2

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	mg/m ³	17.0	19.2	18.5	18.2
Uncertainty	±mg/m ³	4.3	5.9	4.9	5.0
Mass Emission	g/hr	24.6	27.7	26.7	26.3
Uncertainty	±g/hr	6.4	8.7	7.2	7.4

General Sampling Information

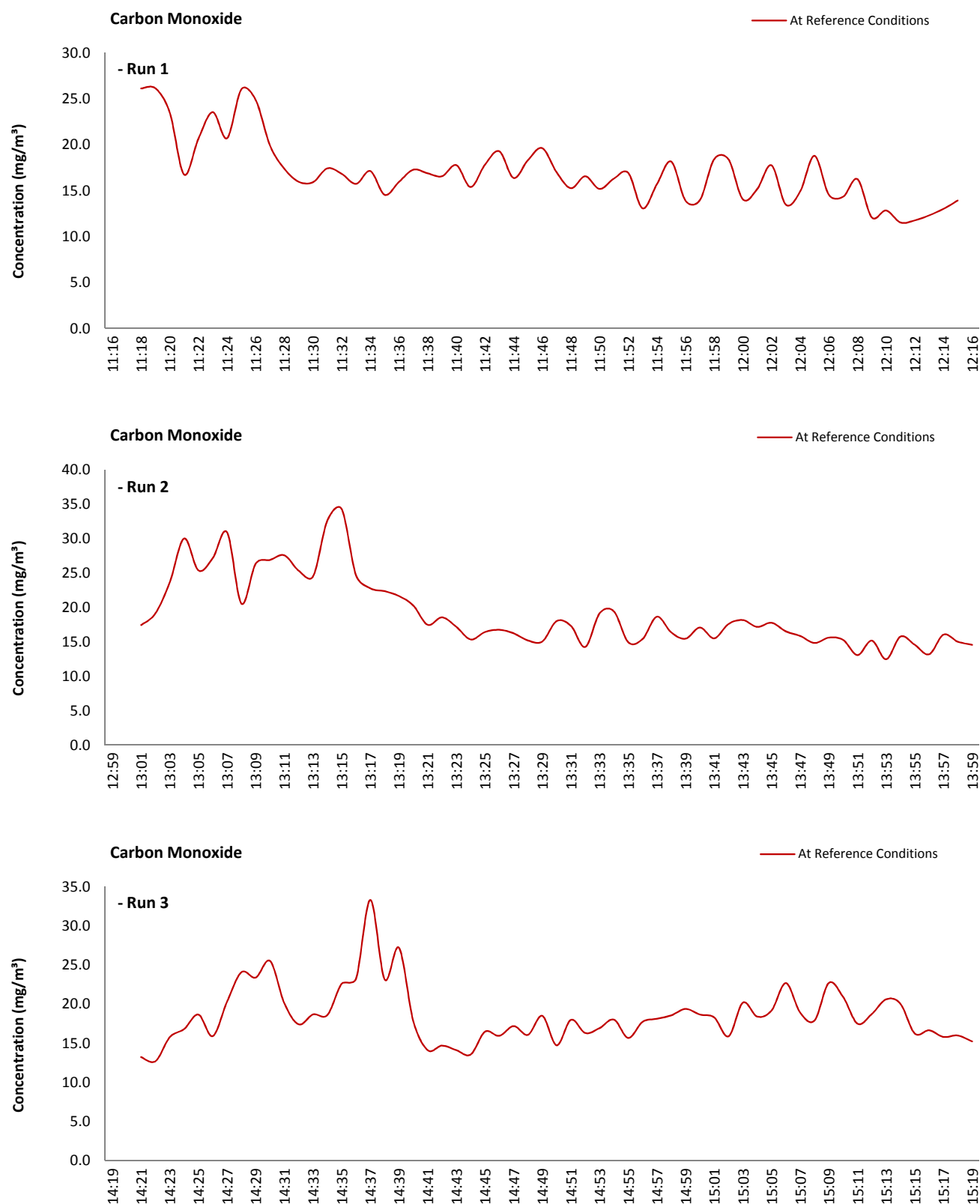
Parameter	Value	
Standard	EN 15058	
Technical Procedure	CAT-TP-21	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	No	
Heated Line Temperature	Orsat Used	
Span Gas Type	Carbon Monoxide	
Span Gas Reference Number	CYL 2.0107	
Span Gas Expiry Date	05/03/2020	
Span Gas Start Pressure (bar)	100	
Gas Cylinder Concentration (ppm)	400.24	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (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	A2	

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	-	11:16 - 12:16	12:59 - 13:59	14:19 - 15:19
Sampling Dates	-	11/01/2017	11/01/2017	11/01/2017
Instrument Range	ppm	200	200	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	N/A	N/A	N/A
Allowable Temperature	< °C	N/A	N/A	N/A
Temperature Acceptable	-	N/A	N/A	N/A

Zero Drift	Units	Run 1	Run 2	Run 3
Zero Down Sampling Line (Pre)	ppm	0.20	0.20	0.20
Zero Down Sampling Line (Post)	ppm	-0.80	-0.80	-0.80
Zero Drift	ppm	-1.00	-1.00	-1.00
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
Span Down Sampling Line (Pre)	ppm	80.60	80.60	80.60
Span Down Sampling Line (Post)	ppm	78.80	78.80	78.80
Span Drift	ppm	-1.80	-1.80	-1.80
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	17 - 18	18 - 19	18 - 19

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 ³ (REF)
TGN M2 Allowable MU	6.0	6.0	6.0	%
Measured concentration	7.20	5.91	6.92	mg/m ³ (STP, dry)
Range Used	200.0	200.0	200.0	ppm
Range Used [A]	249.8	249.8	249.8	mg/m ³
Cal gas conc.	80.1	80.1	80.1	ppm
Conversion	1.25	1.25	1.25	ppm to mg/m ³
MCERTS Range [B]	95.0	95.0	95.0	mg/m ³
Lower of [A] or [B]	95.0	95.0	95.0	mg/m ³
Cal gas conc.	100.0	100.0	100.0	mg/m ³

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	0.10	0.10	0.10	% of value
Zero drift	-1.24	-1.24	-1.24	% full scale
Span drift	0.00	0.00	0.00	% 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)	0.00	0.00	0.00	% 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 ³
Standard deviation of repeatability at span level	0.05	0.05	0.05	mg/m ³
Lack of fit	0.05	0.05	0.05	mg/m ³
Drift	-0.72	-0.72	-0.72	mg/m ³
Volume or pressure flow dependence	0.00	0.00	0.00	mg/m ³
Atmospheric pressure dependence	0.08	0.08	0.08	mg/m ³
Ambient temperature dependence	0.01	0.01	0.01	mg/m ³
Combined interference (from MCERTS Certificate)	0.40	0.40	0.40	mg/m ³
Dependence on voltage	0.05	0.05	0.05	mg/m ³
Losses in the line (leak)	0.00	0.00	0.00	mg/m ³
Uncertainty of calibration gas blending	0.06	0.05	0.06	mg/m ³
Uncertainty of calibration gas	0.08	0.07	0.08	mg/m ³

		RUN 1	RUN 2	RUN 3	Units
Measurement uncertainty	Result	7.20	5.91	6.92	mg/m ³
Combined uncertainty		0.92	0.92	0.92	mg/m ³
Expanded uncertainty	k = 1.96	1.81	1.81	1.81	mg/m ³
Uncertainty corrected to std conds. (O ₂)		4.28	5.87	4.84	mg/m ³ (REF)

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O ₂) - at 95% Confidence	25.18	30.60	26.18	% of Value
Expanded uncertainty (no O ₂) - at 95% Confidence	1.81	1.81	1.81	% at ELV
Overall Allowable uncertainty (no O ₂) - at 95% Confidence	6.0	6.0	6.0	% at ELV
Result of Compliance with Uncertainty Requirement in M2	N/A	N/A	N/A	-

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (with O ₂) - at 95% Confidence	25.32	30.71	26.31	% of Value
Expanded uncertainty (with O ₂) - at 95% Confidence	5.04	6.42	5.51	% at ELV
Overall Allowable uncertainty (with O ₂) - at 95% Confidence	6.6	6.5	6.55	% at ELV
Result of Compliance with Uncertainty Requirement in M2	COMPLIANT	COMPLIANT	COMPLIANT	-

Requirement for SRM is that Uncertainty should be <6% of the value at the ELV, on a dry gas basis, or if Q 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

Barrow Borough Council, Barrow-In-Furness
Cremator No. 2

Sample Runs

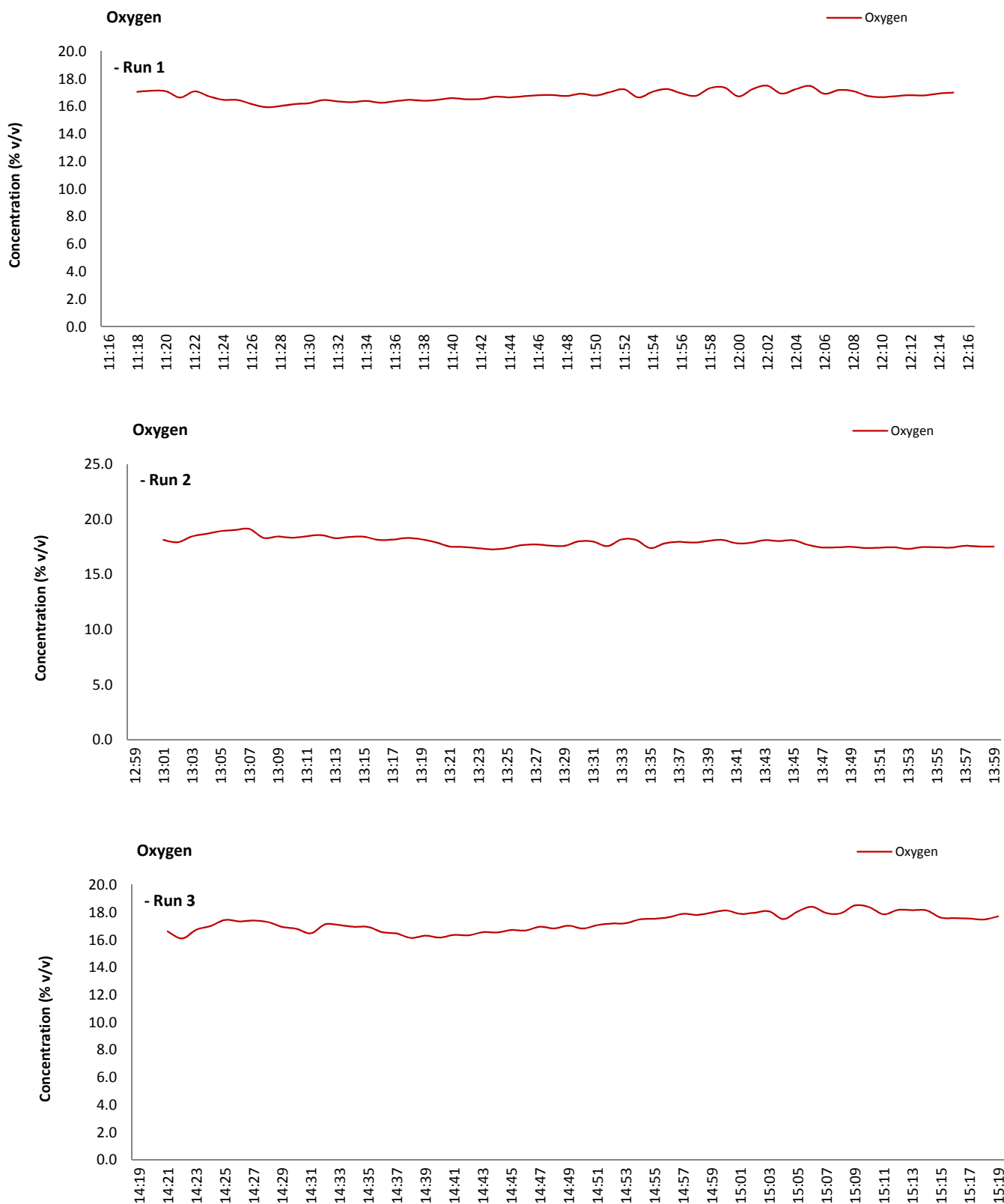
Parameter	Units	Run 1	Run 2	Run 3	Mean
Concentration	% v/v	16.8	17.9	17.3	17.3
Uncertainty	±% v/v	0.44	0.47	0.45	0.46

General Sampling Information

Parameter	Value	
Standard	EN 14789	
Technical Procedure	CAT-TP-21	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	No	
Heated Line Temperature	Orsat Used	
Span Gas Type	Synthetic Air (5 Grade)	
Span Gas Reference Number	CYL 11.0262	
Span Gas Expiry Date	18/11/2021	
Span Gas Start Pressure (bar)	100	
Gas Cylinder Concentration (% v/v)	21.33	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (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	A2	

OXYGEN: DATA TREND

Graphical Trend of Data



OXYGEN: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	Run 2	Run 3
Sampling Times	-	11:16 - 12:16	12:59 - 13:59	14:19 - 15:19
Sampling Dates	-	11/01/2017	11/01/2017	11/01/2017
Instrument Range	% v/v	25	25	25
Span Gas Value	% v/v	21.33	21.33	21.33

Quality Assurance

Conditioning Unit Temperature	Units	Run 1	Run 2	Run 3
Average Temperature	°C	N/A	N/A	N/A
Allowable Temperature	< °C	N/A	N/A	N/A
Temperature Acceptable	-	N/A	N/A	N/A

Zero Drift	Units	Run 1	Run 2	Run 3
Zero Down Sampling Line (Pre)	% v/v	0.03	0.03	0.03
Zero Down Sampling Line (Post)	% v/v	0.13	0.13	0.13
Zero Drift	% v/v	0.10	0.10	0.10
Allowable Zero Drift	± % v/v	1.07	1.07	1.07
Zero Drift Acceptable	-	Yes	Yes	Yes

Span Drift	Units	Run 1	Run 2	Run 3
Span Down Sampling Line (Pre)	% v/v	21.31	21.31	21.31
Span Down Sampling Line (Post)	% v/v	21.21	21.21	21.21
Span Drift	% v/v	-0.10	-0.10	-0.10
Allowable Span Drift	± % v/v	1.07	1.07	1.07
Span Drift Acceptable	-	Yes	Yes	Yes

Test Conditions	Units	Run 1	Run 2	Run 3
Run Ambient Temperature Range	°C	17 - 18	18 - 19	18 - 19

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	16.77	17.92	17.26	%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	0.06	0.06	0.06	% of value
Zero drift	0.47	0.47	0.47	% full scale
Span drift	-0.47	-0.47	-0.47	% 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)	0.09	0.09	0.09	% 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	0.01	0.01	0.01	%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)	0.01	0.01	0.01	%vol
Uncertainty of calibration gas	0.19	0.21	0.20	%vol

		RUN 1	RUN 2	RUN 3	Units
Measurement uncertainty	Result	16.77	17.92	17.26	%vol
Combined uncertainty		0.23	0.24	0.23	%vol
Expanded uncertainty	k = 1.96	0.44	0.47	0.45	%vol

	RUN 1	RUN 2	RUN 3	Units
Expanded uncertainty (no O ₂) - at 95% Confidence	2.65	2.61	2.63	% of Value
Result of Compliance with Uncertainty Requirement in M2	COMPLIANT	COMPLIANT	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.