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Stack Emissions Testing Report Commissioned by
Furness Brick and Tile Company Ltd

Installation Name & Address
Furness Brick and Tile Company Ltd
Dalton Road
Askam-in-Furness
Cumbria
LA16 7HF

PPC Permit: PPC/A2/01

Stack Reference
Main Kiln Stack

Dates of the Monitoring Campaign
8th - 9th December 2011

Job Reference Number
CEK-0649

Report Written by
Craig Robertson Team Leader MCERTS Level 2 MM 03 201 TE1 TE2 TE3 TE4

Report Approved by
Craig Robertson Team Leader MCERTS Level 2 MM 03 201 TE1 TE2 TE3 TE4

Report Date
8th January 2012

Version
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Signature of Report Approver


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Executive Summary

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MONITORING OBJECTIVES

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack
8th - 9th December 2011

Overall Aim of the Monitoring Campaign

Catalyst Environmental Ltd were commissioned by Furness Brick and Tile Company Ltd to carry out stack emissions testing on the Main Kiln Stack at Askam-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

The monitoring campaign for HF was performed over a 24 hour period.

Target Parameters

Total Particulate Matter, Hydrogen Fluoride

Executive Summary

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MONITORING RESULTS

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack
8th - 9th December 2011

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total Particulate Matter	¹ mg/m ³	34.22	1.79	100	g/hr	2973.0	155.4	-
Hydrogen Fluoride	¹ mg/m ³	0.66	0.12	10	g/hr	57.1	10.2	-
Water Vapour	% v/v	1.13	0.1					
Stack Gas Temperature	°C	40.6						
Stack Gas Velocity	m/s	6.10						
Volumetric Flow Rate (ACTUAL)	m ³ /hr	102478						
Volumetric Flow Rate (REF)	¹ m ³ /hr	86891						

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

¹ Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

Executive Summary

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MONITORING DATE(S) & TIMES

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack
8th - 9th December 2011

Parameter		Units	Concentration	Sampling Date(s)	Sampling Times	Duration (mins)
Total Particulate Matter	Run 1	mg/m ³	11.2	08/12/2011	22:35 - 23:25	50
Total Particulate Matter	Run 2	mg/m ³	57.2	09/12/2011	09:35 - 11:15	100
Hydrogen Fluoride	Run 1	mg/m ³	1.00	08/12/2011	11:11 - 16:11	300
Hydrogen Fluoride	Run 3	mg/m ³	0.78	08/12/2011	22:35 - 23:25	50
Hydrogen Fluoride	Run 5	mg/m ³	0.62	09/12/2011	09:35 - 11:15	100
Hydrogen Fluoride	Run 2	mg/m ³	0.53	08/12/2011	16:23 - 22:23	360
Hydrogen Fluoride	Run 4	mg/m ³	0.35	08-09/12/2011	23:37 - 09:27	550
Velocity & Volumetric Flow Rate	Run 1			08/12/2011	10:45 - 10:55	

All results are expressed at the respective reference conditions.

Executive Summary

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PROCESS DETAILS

Furness Brick and Tile Company Ltd, Askam-in-Furness

Main Kiln Stack

8th - 9th December 2011

Standard Operating Conditions

Parameter	Value
Process Status	Normal
Continuous or Batch Process	Continuous Batch Feed - 5 Week Cycles
Feedstock (if applicable)	Bricks
Fuel	Coal
Plume Appearance	None Visible

Executive Summary

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MONITORING & ANALYTICAL METHODS

Furness Brick and Tile Company Ltd, Askam-in-Furness

Main Kiln Stack

8th - 9th December 2011

	Monitoring				Analysis					
Parameter	Standard	Technical Procedure	UKAS Testing	Testing Lab	Analytical Procedure	Analytical Technique	UKAS Analysis	Analysis Lab	MCERTS Testing	LOD (Average)
Total Particulate Matter	BS ISO 9096	CAT-TP-02	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.05 mg/m³
Hydrogen Fluoride	BS ISO 15713	CAT-TP-10	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.011 mg/m³
Hydrogen Fluoride	BS ISO 15713	CAT-TP-10	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.005 mg/m³
Water Vapour	BS EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.1 % v/v
Velocity & Vol. Flow Rate	BS EN 13284-1	CAT-TP-04	Yes	CAT	Pitot Tube and Thermocouple				Yes	N/A

ANALYSIS LABORATORIES

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

Catalyst Environmental Ltd (CAT)	UKAS Accreditation Number: 4279
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SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
Total Particulate Matter	1, 2 & 3	Only one sampling line was installed on the stack, however the number of sample points used on the available line were increased to meet the requirements of the Standard.

Executive Summary

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SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Rectangular
Depth	m	1.57
Width	m	2.97
Area	m ²	4.66
Port Depth	cm	87
Orientation of Duct	-	Vertical
Sample Port Size	-	4" BSP

Location of Sampling Platform

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

Platform Details

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

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and BS EN 15259, and therefore there are no improvement recommendations.

BS EN 15259 Homogeneity Test Requirements

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

Sampling Plane Validation Criteria (from EA Technical Guidance Document (Monitoring) M1)

Criteria in M1	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	18.6	> 5 Pa	Yes
Mean Velocity	m/s	6.10	-	-
Lowest Gas Velocity	m/s	4.84	-	-
Highest Gas Velocity	m/s	7.19	-	-
Ratio of Above	: 1	1.49	< 3 : 1	Yes
Maximum Angle of Swirl	°	6	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

Executive Summary

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PLANT PHOTOS

Photo 1

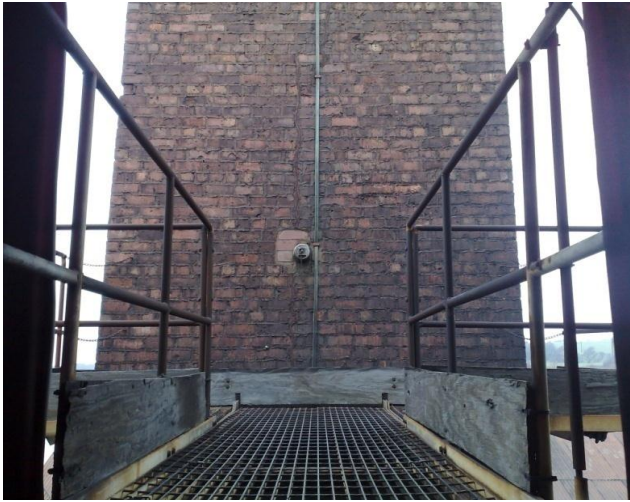
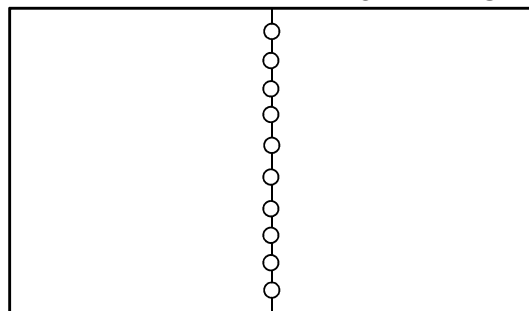


Photo 2



SAMPLE POINTS



Line A

where ○ = isokinetic point sampled at
● = isokinetic point not sampled at
● = non-isokinetic / combustion gases 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

APPENDIX 1

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Craig Robertson	MCERTS Level 2	MM 03 201	TE1 TE2 TE3 TE4
Trainee	Steve Royle	MCERTS Trainee	MM 11 1125	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	CAT 7.11	Horiba PG-250	-	Digital Manometer (1)	CAT 3.19
Box Thermocouples	CAT 3.8	Servomex 4900	-	Digital Manometer (2)	-
Umbilical	CAT 3.8	Eco Physics CLD 822Mh	-	Digital Temperature Meter	CAT 3.19
Oven Box	CAT 12.15	Testo 350 XL	-	Stopwatch	CAT 14.10 / 14.11
Probe	CAT 5.13	Servomex 5200MP	-	Barometer	CAT 13.7
S-Pitot (1)	CAT 21P.18	JCT JCC P-1 Cooler	-	Stack Thermocouple (1)	CAT 4.42
S-Pitot (2)	CAT 21P.19	5m FT-IR	-	Stack Thermocouple (2)	-
L-Pitot	CAT 21L.10	5m FT-IR Sampling System	-	1m Heated Line (1)	-
500g Check Weight	CAT 17.7	Bernath 3006 FID	-	1m Heated Line (2)	-
1Kg Check Weight	CAT 17.7	Heated Head Filter	-	1m Heated Line (3)	-
Last Impinger Arm	-	Mass Flow Controller (1)	-	5m Heated Line (1)	-
Callipers	CAT 23.8	Mass Flow Controller (2)	-	15m Heated Line (1)	-
Small DGM	-	Mass View (1)	-	15m Heated Line (2)	-
Laboratory Balance	CAT 1.18	Mass View (2)	-	20m Heated Line (1)	-
Tape Measure	CAT 16.7	Easylogger EN-EL-12 Bit	-	Dual Channel Heater Controller	-

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	BS ISO 9096	CAT-TP-02
Hydrogen Fluoride	BS ISO 15713	CAT-TP-10
Hydrogen Fluoride	BS ISO 15713	CAT-TP-10
Water Vapour	BS EN 14790	CAT-TP-05
Velocity & Vol. Flow Rate	BS EN 13284-1	CAT-TP-04

APPENDIX 2

PRELIMINARY STACK SURVEY: CALCULATIONS

General Stack Details

Stack Details (from Traverse)	Units	Value
Stack Diameter / Depth, D	m	1.57
Stack Width, W	m	2.97
Stack Area, A	m ²	4.66
Average Stack Gas Temperature, T _a	°C	40.6
Average Stack Gas Pressure	mmH ₂ O	3.1
Average Stack Static Pressure, P _{static}	kPa	-0.034
Average Barometric Pressure, P _b	kPa	98.7
Average Pitot Tube Calibration Coefficient, C _p	-	0.83

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)	-	2.00	1.98	0.0200	44.01	1.9635	0.03927
O ₂ (Estimated)	-	18.00	17.80	0.1800	32.00	1.4277	0.25698
N ₂	-	80.00	79.10	0.8000	28.01	1.2498	0.99988
Moisture (H ₂ O)	-	-	1.13	0.0113	18.02	0.8037	0.00907

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	1.296
Wet Density (STP), P _{STW}	kg/m ³	1.291
Dry Density (Actual), P _{Actual}	kg/m ³	1.099
Average Wet Density (Actual), P _{ActualW}	kg/m ³	1.094

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	40.6	0.0
Total Pressure	kPa	98.7	101.3
Moisture	%	1.13	1.13

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m ³ /hr	102478
Gas Volumetric Flowrate (STP, Wet)	m ³ /hr	86891
Gas Volumetric Flowrate (STP, Dry)	m ³ /hr	85910
Gas Volumetric Flowrate REF ¹	m ³ /hr	86891

APPENDIX 2

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE

(1 of 1)

Parameter	Units	Value
Date of Survey	-	08/12/2011
Time of Survey	-	10:45 - 10:55
Atmospheric Pressure	kPa	98.7
Stack Static Pressure	Pa	-34
Type of Pitot Used	-	S-Type Pitot
Are Water Droplets Present?	-	No

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C _p	-	0.83
Number of Lines Available	-	1
Number of Lines Used	-	1

Swirl Point (taken at the sampling points used during testing)																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Angle of Swirl (°)	3	3	4	4	5	6	1	2	3	3										

Sampling Line A					
Traverse Point	Depth m	ΔP mmH ₂ O	Temp °C	Wet Density kg/m ³	Velocity m/s
1	0.08	2.1	40.3	1.095	5.09
2	0.24	1.9	40.3	1.095	4.84
3	0.39	3.1	40.3	1.095	6.18
4	0.55	4.1	40.4	1.095	7.11
5	0.71	4.2	40.4	1.095	7.19
6	0.86	3.5	40.5	1.095	6.57
7	1.02	3.6	40.5	1.095	6.66
8	1.18	3.7	40.9	1.093	6.76
9	1.33	2.3	41.1	1.093	5.33
10	1.49	2.3	41.3	1.092	5.33
Mean		3.1	40.6	1.094	6.10

APPENDIX 2

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack

Sample Runs

Parameter	Units		Run 1	Run 2		Mean
Concentration	mg/m ³		11.21	57.22		34.22
Uncertainty	±mg/m ³		0.69	2.89		1.79
Mass Emission	g/hr		974.0	4972.0		2973.0
Uncertainty	±g/hr		60.0	250.8		155.4

Parameter	Units		Run 1	Run 2		Mean
Water Vapour	% v/v		0.90	1.29		1.09
Uncertainty	±% v/v		0.06	0.07		0.06

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	0.10		0.10

General Sampling Information

Parameter	Value	
Standard	BS ISO 9096	
Technical Procedure	CAT-TP-02	
Probe Material	Monel	
Filter Housing Material	Monel	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	10 / 10	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, A3, A4, A5, A6, A7, A8, A9 & A10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

APPENDIX 2

TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS

Test	Units		Run 1	Run 2	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg		743.3	749.3	
Stack static pressure, P_{static}	mmH ₂ O		-3.5	-3.5	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg		743.0	749.0	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g		5.6	21.4	
Total mass collected in impingers (silica trap)	g		3.6	5.1	
Total mass of liquid collected, V_{lc}	g		9.2	26.5	
$V_{wstd} = (0.001246)(V_{lc})$	m ³		0.0114	0.0330	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m ³		1.3649	2.7727	
Gas meter correction factor, Y_d	-		0.9880	0.9880	
Average dry gas meter temperature, T_m	°C		15.0	20.4	
Average pressure drop across orifice, ΔH	mmH ₂ O		71.9	74.1	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³		1.2590	2.5309	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³		0.0090	0.0129	
B_{wo} as a percentage	% v/v		0.90	1.29	
Reported Water Vapour, checked with Tables in BS EN 14790, R_{wv}	% v/v		0.90	1.29	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd} / (100 / (100 - R_{wv})))$	m ³		1.2704	2.5639	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$					
WID & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-		No	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v		N/A	N/A	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v		N/A	N/A	
% oxygen reference condition, REF%O ₂	% v/v		N/A	N/A	
O ₂ Reference Factor wet ($O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$)	-		N/A	N/A	
O ₂ Reference Factor dry ($O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$)	-		N/A	N/A	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³		N/A	N/A	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³		N/A	N/A	
Molecular weight of dry gas stream, M_d					
CO ₂ (Estimated)	% v/v		2.00	2.00	
O ₂ (Estimated)	% v/v		18.00	18.00	
Total	% v/v		20.00	20.00	
N ₂	% v/v		80.00	80.00	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol		29.04	29.04	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol		28.94	28.90	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-		34.97	34.97	
Velocity pressure coefficient, C_p	-		0.83	0.83	
Average of velocity heads, ΔP_{avg}	mmH ₂ O		4.67	4.64	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O		2.16	2.15	
Average stack gas temperature, T_s	°C		38.5	38.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s		7.52	7.47	
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		4.66	4.66	
$Q_a = (60)(A_s)(V_s)$	m ³ /min		2104.5	2088.6	
Conversion factor (K/mm.Hg), C_f	-		0.3592	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m ³ /min		1803.1	1806.8	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min		1786.9	1783.6	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)(O_{2REFw})$	m ³ /min		N/A	N/A	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)(O_{2REFd})$	m ³ /min		N/A	N/A	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm		8.95	8.95	
Nozzle area, A_n	mm ²		62.87	62.87	
Total sampling time, q	min		50	100	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%		104.5	105.2	

APPENDIX 2

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units		Run 1	Run 2	
Sampling Times	-		22:35 - 23:25	09:35 - 11:15	
Sampling Dates	-		08/12/2011	09/12/2011	
Sampling Device	-		ISO	ISO	
Volume Sampled (REF)	m ³		1.2704	2.5639	
Filter I.D. Number	-		47-7599	47-7497	
Start Filter Mass	g		0.15457	0.15704	
End Filter Mass	g		0.16432	0.28835	
Total Mass on Filter	g		0.00975	0.13131	
Probe Rinse I.D. Number	-		PR-47-7599	PR-47-7497	
Start Probe Rinse Mass	g		2.89451	2.84912	
End Probe Rinse Mass	g		2.89900	2.86452	
Total Mass in Probe Rinse	g		0.00449	0.01540	
Total Mass Collected	mg		14.24	146.71	
Calculated Concentration	mg/m ³		11.21	57.22	
Balance Uncertainty / LOD	mg/m ³		0.09	0.05	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	08/12/2011	
Average Volume Sampled (REF)	m ³	3.7481	
Filter I.D. Number	-	47-7419	
Start Filter Mass	g	0.15173	
End Filter Mass	g	0.15178	
Total Mass on Filter	g	0.00005	
Probe Rinse I.D. Number	-	PR-47-7419	
Start Probe Rinse Mass	g	3.13042	
End Probe Rinse Mass	g	3.13076	
Total Mass in Probe Rinse	g	0.00034	
Total Mass Collected	mg	0.39	
Calculated Concentration	mg/m ³	0.10	
Balance Uncertainty / LOD	mg/m ³	0.03	

APPENDIX 2

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units		Run 1	Run 2	
Mean Sampling Rate	l/min		26.97	27.39	
Pre-Sampling Leak Rate	l/min		0.23	0.19	
Post-Sampling Leak Rate	l/min		0.22	0.13	
Allowable Leak Rate	l/min		0.54	0.55	
Leak Test Acceptable	-		Yes	Yes	
Water Droplets	Units		Run 1	Run 2	
Are Water Droplets Present	-		No	No	
MU (Concurrent Water Vapour)	Units		Run 1	Run 2	
Measurement Uncertainty (MU)	%		6.3	5.3	
Allowable MU	%		20	20	
MU Acceptable	%		Yes	Yes	
Silica Gel (Concurrent Water Vapour)	Units		Run 1	Run 2	
Less than 50% Faded	%		Yes	Yes	
Isokinetic Criterion Compliance	Units		Run 1	Run 2	
Isokinetic Variation	%		104.5	105.2	
Allowable Isokinetic Range	%		95 - 115	95 - 115	
Isokineticity Acceptable	-		Yes	Yes	
Balance Uncertainty Criteria (1)	Units		Run 1	Run 2	
Balance Uncertainty	± mg		0.12	0.12	
Balance Uncertainty	± mg/m ³		0.09	0.05	
Daily ELV	mg/m ³		100.00	100.00	
Allowable Balance Uncertainty	± mg/m ³		5.00	5.00	
Balance Uncertainty Acceptable	-		Yes	Yes	
Balance Uncertainty Criteria (2)	Units		Run 1	Run 2	
Balance Uncertainty	± mg		0.12	0.12	
20 x Balance Uncertainty	mg		2.40	2.40	
Mass Collected	mg		14.24	146.71	
Sample Time	mins		50	100	
Balance Uncertainty Acceptable	-		N/A	N/A	
Filter Temperatures	Units		Run 1	Run 2	
Pre-Conditioning Temperature	°C		180	180	
Post-Conditioning Temperature	°C		160	160	
Maximum Filter Temperature	°C		39	38	
Test Conditions	Units		Run 1	Run 2	
Ambient Temperature Recorded?	-		Yes	Yes	

APPENDIX 2

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	20.00	
Pre-Sampling Leak Rate	l/min	0.21	
Post-Sampling Leak Rate	l/min	0.14	
Allowable Leak Rate	l/min	0.40	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	10.0	
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		
	2	3	
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)			
Only one sampling line was installed on the stack, however the number of sample points used on the available line were increased to meet the requirements of the Standard.	wx	wx	

APPENDIX 2

TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty					
	Symbol		Run 1	Run 2		Symbol	Units		Run 1	Run 2
Sampled Volume (Actual)	V _m		1.3649	2.7727		uV _m	m ³		0.0273	0.0555
Sampled Gas Temperature	T _m		288.0	293.4		uT _m	K		2.0	2.0
Sampled Gas Pressure	p _m		99.1	99.9		up _m	kPa		0.5	0.5
Sampled Gas Humidity	H _m		0.0	0.0		uH _m	% v/v		1.0	1.0
Leak	L		0.82	0.47		uL	%		-	-
Mass of Particulate	m		14.24	146.71		um	mg		0.12	0.12
Oxygen Content	O _{2,m}		N/A	N/A		uO _{2,m}	% v/v		N/A	N/A
Uncollected Mass	UCM		0.39	0.39		uUCM	mg		-	-

Uncertainty as a Percentage					
Measured Quantities	Units		Run 1	Run 2	Requirement of Standard
Sampled Volume (Actual)	%		2.00	2.00	≤2%
Sampled Gas Temperature	%		0.69	0.68	≤1%
Sampled Gas Pressure	%		0.50	0.50	≤1%
Sampled Gas Humidity	%		1.00	1.00	≤1%
Leak	%		0.82	0.47	≤2%
Mass of Particulate	%		0.09	0.05	<5% of ELV
Oxygen Content	%		N/A	N/A	≤5%
Uncollected Mass	%		-	-	-

Uncertainty in Measurement Units						Sensitivity Coefficient			
Measured Quantities	Symbol	Units		Run 1	Run 2		Run 1	Run 2	
Sampled Volume (STP)	V _m	m ³		1.2590	2.5309		8.90	22.61	
Leak	L	mg/m ³		0.053	0.157		1.00	1.00	
Mass of Particulate	L _r	mg		14.240	147		0.79	0.39	
Factor for O ₂ Correction	O _{2,m}	% v/v		N/A	N/A		N/A	N/A	
Uncollected Mass	UCM	mg		0.23	0.23		0.79	0.39	

Uncertainty in Result				
Measured Quantities	Units		Run 1	Run 2
Sampled Volume (STP)	mg/m ³		0.284	1.461
Leak	mg/m ³		0.0528	0.1568
Mass of Particulate	mg/m ³		0.0945	0.0468
Factor for O ₂ Correction	mg/m ³		N/A	N/A
Uncollected Mass	mg/m ³		0.1772	0.0878

Parameter	Units		Run 1	Run 2	
Combined uncertainty	mg/m ³		0.35	1.47	
Expanded uncertainty (95% confidence)	mg/m ³		0.69	2.89	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³		0.69	2.89	
Reported Uncertainty	mg/m ³		0.69	2.89	
Expanded uncertainty (95% confidence)	%		6.2	5.0	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%		6.2	5.0	
Reported Uncertainty	%		6.2	5.0	

APPENDIX 2

HYDROGEN FLUORIDE: RESULTS SUMMARY

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m ³	1.00	0.78	0.62		0.80
Uncertainty	±mg/m ³	0.15	0.12	0.09		0.12
Mass Emission	g/hr	86.8	67.9	53.9		69.5
Uncertainty	±g/hr	12.8	10.0	7.9		10.2

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	1.25	0.90	1.29		1.09
Uncertainty	±% v/v	0.06	0.06	0.07		0.06

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	< 0.005		< 0.005

General Sampling Information

Parameter	Value	
Standard	BS ISO 15713	
Technical Procedure	CAT-TP-10	
Name of Analytical Laboratory	CAT	
Analytical Laboratory's Procedure	CAT-AP-01	
UKAS Accredited Analysis?	Yes	
Date of Sample Analysis	22/12/2011	
Probe Material	Monel	
Filter Housing Material	Monel	
Impinger Material	Borosilicate Glass	
Absorption Solution	0.1 mol/l Sodium Hydroxide	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	10 / 10	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, A3, A4, A5, A6, A7, A8, A9 & A10	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

APPENDIX 2

HYDROGEN FLUORIDE: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg	740.3	743.3	749.3	
Stack static pressure, P_{static}	mmH ₂ O	-3.5	-3.5	-3.5	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	740.0	743.0	749.0	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	22.6	5.6	21.4	
Total mass collected in impingers (silica trap)	g	51.5	3.6	5.1	
Total mass of liquid collected, V_{lc}	g	22.6	9.2	26.5	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.0282	0.0114	0.0330	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m ³	8.0507	1.3649	2.7727	
Gas meter correction factor, Y_d	-	0.9880	0.9880	0.9880	
Average dry gas meter temperature, T_m	°C	18.1	15.0	20.4	
Average pressure drop across orifice, ΔH	mmH ₂ O	70.5	71.9	74.1	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	7.3176	1.2590	2.5309	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.0038	0.0090	0.0129	
B_{wo} as a percentage	% v/v	0.38	0.90	1.29	
Reported Water Vapour, checked with Tables in BS EN 14790, R_{wv}	% v/v	1.25	0.90	1.29	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m ³	7.4100	1.2704	2.5639	
Volume of gas metered at Oxygen Reference Conditions, $V_{mstd@X\%O_2}$ & $V_{mstw@X\%O_2}$					
WID & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	No	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	N/A	N/A	N/A	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	N/A	N/A	N/A	
% oxygen reference condition, REF%O ₂	% v/v	N/A	N/A	N/A	
O ₂ Reference Factor wet ($O_{2REFw} = (21 - REF\%O_2) / (21 - ACT\%O_{2w})$)	-	N/A	N/A	N/A	
O ₂ Reference Factor dry ($O_{2REFd} = (21 - REF\%O_2) / (21 - ACT\%O_{2d})$)	-	N/A	N/A	N/A	
$V_{mstw@X\%oxygen} = (V_{mstw}) / (O_{2REFw})$	m ³	N/A	N/A	N/A	
$V_{mstd@X\%oxygen} = (V_{mstd}) / (O_{2REFd})$	m ³	N/A	N/A	N/A	
Molecular weight of dry gas stream, M_d					
CO ₂ (Estimated)	% v/v	2.00	2.00	2.00	
O ₂ (Estimated)	% v/v	18.00	18.00	18.00	
Total	% v/v	20.00	20.00	20.00	
N ₂	% v/v	80.00	80.00	80.00	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	29.04	29.04	29.04	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.90	28.94	28.90	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.83	0.83	0.83	
Average of velocity heads, ΔP_{avg}	mmH ₂ O	4.55	4.67	4.64	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	2.13	2.16	2.15	
Average stack gas temperature, T_s	°C	41.5	38.5	38.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s + 273})) / (\sqrt{M_s}(P_s))$	m/s	7.48	7.52	7.47	
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	4.66	4.66	4.66	
$Q_a = (60)(A_s)(V_s)$	m ³ /min	2093.3	2104.5	2088.6	
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	1769.5	1803.1	1806.8	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	1747.4	1786.9	1783.6	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)(O_{2REFw})$	m ³ /min	N/A	N/A	N/A	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)(O_{2REFd})$	m ³ /min	N/A	N/A	N/A	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm	8.95	8.95	8.95	
Nozzle area, A_n	mm ²	62.87	62.87	62.87	
Total sampling time, q	min	300	50	100	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.5	104.5	105.2	

APPENDIX 2

HYDROGEN FLUORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	11:11 - 16:11	22:35 - 23:25	09:35 - 11:15	
Sampling Dates	-	08/12/2011	08/12/2011	09/12/2011	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m ³	7.4100	1.2704	2.5639	
Laboratory Result for Front Impingers	µg/ml	23.43	1.91	3.02	
Laboratory Result for Back Impinger	µg/ml	0.49			
Volume in Front Impingers	ml	312.7	520.0	526.2	
Volume in Back Impinger	ml	163.0			
Mass in Front Impingers	µg	7326.6	993.2	1589.1	
Mass in Back Impinger	µg	79.9			
Total Mass Collected	µg	7406.4	993.2	1589.1	
Calculated Concentration	mg/m ³	1.00	0.78	0.62	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	08/12/2011	
Average Volume Sampled (REF)	m ³	3.7481	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	348.5	
Total Mass Collected	µg	< 17.4	
Calculated Concentration	mg/m ³	< 0.00	

APPENDIX 2

HYDROGEN FLUORIDE: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3	
Mean Sampling Rate	l/min	26.51	26.97	27.39	
Pre-Sampling Leak Rate	l/min	0.13	0.23	0.19	
Post-Sampling Leak Rate	l/min	0.19	0.22	0.13	
Allowable Leak Rate	l/min	0.53	0.54	0.55	
Leak Test Acceptable	-	Yes	Yes	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	98.9	
Allowable Absorption Efficiency	%	N/A ²	
Absorption Efficiency Acceptable	-	N/A ²	

² The concentration is less than 30% of the ELV, therefore no assessment against an allowable efficiency is required.

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)	%	5.2	6.3	5.3	
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	%	0.0	104.5	105.2	
Allowable Isokinetic Range	%	95 - 115	95 - 115	95 - 115	
Isokineticity Acceptable	-	No	Yes	Yes	

Filter Temperatures	Units	Run 1	Run 2	Run 3	
Maximum Filter Temperature	°C	41	39	38	

Test Conditions	Units	Run 1	Run 2	Run 3	
Ambient Temperature Recorded?	-	No	Yes	Yes	

APPENDIX 2

HYDROGEN FLUORIDE: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	20.00	
Pre-Sampling Leak Rate	l/min	0.21	
Post-Sampling Leak Rate	l/min	0.14	
Allowable Leak Rate	l/min	0.40	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	1.0	
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	

APPENDIX 2

HYDROGEN FLUORIDE: 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_m	8.0507	1.3649	2.7727		uV_m	m^3	0.1610	0.0273	0.0555	
Sampled Gas Temperature	T_m	291.1	288.0	293.4		uT_m	K	2.0	2.0	2.0	
Sampled Gas Pressure	p_m	98.7	99.1	99.9		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	0.72	0.82	0.47		uL	%	-	-	-	
Laboratory Result	L_r	7.05	7.05	7.05		uL_r	%	-	-	-	
Oxygen Content	$O_{2,m}$	N/A	N/A	N/A		$uO_{2,m}$	% v/v	N/A	N/A	N/A	

Uncertainty as a Percentage						Requirement of Standard
Measured Quantities	Units	Run 1	Run 2	Run 3		
Sampled Volume (Actual)	%	2.00	2.00	2.00		≤2%
Sampled Gas Temperature	%	0.69	0.69	0.68		≤1%
Sampled Gas Pressure	%	0.51	0.50	0.50		≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00		≤1%
Leak	%	0.72	0.82	0.47		≤2%
Laboratory Result	%	7.05	7.05	7.05		No Requirement
Oxygen Content	%	N/A	N/A	N/A		≤5%

Uncertainty in Measurement Units						Sensitivity Coefficient			
Measured Quantities	Symbol	Units	Run 1	Run 2	Run 3		Run 1	Run 2	Run 3
Sampled Volume (STP)	V_m	m^3	7.3176	1.2590	2.5309		0.14	0.62	0.24
Leak	L	mg/ m^3	0.0041	0.0037	0.0017		1.00	1.00	1.00
Laboratory Result	L_r	mg/ m^3	0.070	0.055	0.044		1.00	1.00	1.00
Factor for O ₂ Correction	$O_{2,m}$	% v/v	N/A	N/A	N/A		N/A	N/A	N/A

Uncertainty in Result				
Measured Quantities	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/ m^3	0.0256	0.0198	0.0158
Leak	mg/ m^3	0.004	0.004	0.002
Laboratory Result	mg/ m^3	0.070	0.055	0.044
Factor for O ₂ Correction	mg/ m^3	N/A	N/A	N/A

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	mg/ m^3	0.08	0.06	0.05
Expanded uncertainty (95% confidence)	mg/ m^3	0.15	0.12	0.09
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/ m^3	0.15	0.12	0.09
Reported Uncertainty	mg/ m^3	0.15	0.12	0.09
Expanded uncertainty (95% confidence)	%	14.7	14.7	14.7
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	14.7	14.7	14.7
Reported Uncertainty	%	14.7	14.7	14.7

APPENDIX 2

HYDROGEN FLUORIDE: RESULTS SUMMARY

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack

Sample Runs

Parameter	Units	Run 1	Run 2		Mean
Concentration	mg/m ³	0.53	0.35		0.44
Uncertainty	±mg/m ³	0.08	0.05		0.07
Mass Emission	g/hr	45.9	30.8		38.4
Uncertainty	±g/hr	6.78	4.54		5.66

Parameter	Units	Run 1	Run 2		Mean
Water Vapour	% v/v	1.36	1.04		1.20
Uncertainty	±% v/v	0.07	0.05		0.06

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	< 0.00		< 0.00

General Sampling Information

Parameter	Value	
Standard	BS ISO 15713	
Technical Procedure	CAT-TP-10	
Name of Analytical Laboratory	CAT	
Analytical Laboratory's Procedure	CAT-AP-01	
UKAS Accredited Analysis?	Yes	
Date of Sample Analysis	22/12/2011	
Probe Material	Monel	
Filter Housing Material	Monel	
Impinger Material	Quartz Glass	
Absorption Solution	0.1 mol/l Sodium Hydroxide	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
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, without correction for water vapour content.

APPENDIX 2

HYDROGEN FLUORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	
Sampling Times	-	16:23 - 22:23	23:37 - 09:27	
Sampling Dates	-	08/12/2011	08-09/12/2011	
Sampling Device	-	DGM	DGM	
Duration	mins	360	550	
DGM Start Volume	m ³	6.0212	1.9872	
DGM End Volume	m ³	10.4814	8.8425	
DGM Start Temperature	°C	20.0	20.0	
DGM End Temperature	°C	19.0	22.0	
Start ΔH	mmH ₂ O	10.0	10.0	
End ΔH	mmH ₂ O	11.3	8.0	
DGM Y _d	-	0.9880	0.9880	
Barometric Pressure	kPa	98.7	99.1	
Volume Sampled (STP, Dry)	m ³	4.0101	6.1559	
Volume Sampled (STP, Wet)	m ³	4.0655	6.2205	
Volume Sampled (REF)	m ³	4.0655	6.2205	
Sample Flow Rate	l/min	12.24	12.31	
Laboratory Result for Front Impingers	µg/ml	4.51	4.06	
Laboratory Result for Back Impinger	µg/ml	0.00		
Volume in Front Impingers	ml	476.6	543.4	
Volume in Back Impinger	ml	0.0		
Mass in Front Impingers	µg	2149.5	2206.2	
Mass in Back Impinger	µg	0.0		
Total Mass Collected	µg	2149.5	2206.2	
Calculated Concentration	mg/m ³	0.53	0.35	
Liquid Trap Start Mass	g	1924.0	1930.5	
Liquid Trap End Mass	g	1951.1	1967.4	
Silica Trap Start Mass	g	800.5	817.8	
Silica Trap End Mass	g	817.8	832.7	
Total Mass Of Water Vapour	g	44.4	51.8	
Calculated Water Vapour	% v/v	1.36	1.04	

Where: DGM stands for Dry Gas Meter

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	08/12/2011	
Average Volume Sampled (REF)	m ³	5.1430	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	348.5	
Total Mass Collected	µg	< 17.4	
Calculated Concentration	mg/m ³	< 0.00	

APPENDIX 2

HYDROGEN FLUORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	
Mean Sampling Rate	l/min	12.24	12.31	
Pre-Sampling Leak Rate	l/min	0.13	0.11	
Post-Sampling Leak Rate	l/min	0.13	0.09	
Allowable Leak Rate	l/min	0.24	0.25	
Leak Test Acceptable	-	Yes	Yes	
Absorption Efficiency	Units	Run 1	Run 2	
Absorption Efficiency	%	100.0		
Allowable Absorption Efficiency	%	N/A ²		
Absorption Efficiency Acceptable	-	N/A ²		
² The concentration is less than 30% of the ELV, therefore no assessment against an allowable efficiency is required.				
Water Droplets	Units	Run 1	Run 2	
Are Water Droplets Present	-	No	No	
MU (Concurrent Water Vapour)	Units	Run 1	Run 2	
Measurement Uncertainty (MU)	%	5.3	5.3	
Allowable MU	%	20	20	
MU Acceptable	%	Yes	Yes	
Silica Gel (Concurrent Water Vapour)	Units	Run 1	Run 2	
Less than 50% Faded	%	Yes	Yes	
Test Conditions	Units	Run 1	Run 2	
Ambient Temperature Recorded?	-	Yes	Yes	

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	20.00	
Pre-Sampling Leak Rate	l/min	0.21	
Post-Sampling Leak Rate	l/min	0.14	
Allowable Leak Rate	l/min	0.40	
Leak Test Acceptable	-	Yes	
Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	1.0	
Blank Acceptable	-	Yes	

Method Deviations

Nature of Deviation	Run Number	
	1	2
(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

APPENDIX 2

HYDROGEN FLUORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2		Symbol	Units	Run 1	Run 2	
Sampled Volume (Actual)	V_m	4.4602	6.8553		uV_m	m^3	0.0892	0.1371	
Sampled Gas Temperature	T_m	292.5	294.0		uT_m	K	2.0	2.0	
Sampled Gas Pressure	p_m	98.7	99.1		up_m	kPa	0.5	0.5	
Sampled Gas Humidity	H_m	0.0	0.0		uH_m	% v/v	1.0	1.0	
Leak	L	1.06	0.73		uL	%	-	-	
Laboratory Result	L_r	7.05	7.05		uL_r	%	-	-	
Oxygen Content	$O_{2,m}$	N/A	N/A		$uO_{2,m}$	% v/v	N/A	N/A	

Uncertainty as a Percentage					
Measured Quantities	Units	Run 1	Run 2		Requirement of Standard
Sampled Volume (Actual)	%	2.00	2.00		$\leq 2\%$
Sampled Gas Temperature	%	0.68	0.68		$\leq 1\%$
Sampled Gas Pressure	%	0.51	0.50		$\leq 1\%$
Sampled Gas Humidity	%	1.00	1.00		$\leq 1\%$
Leak	%	1.06	0.73		$\leq 2\%$
Laboratory Result	%	7.05	7.05		No Requirement
Oxygen Content	%	N/A	N/A		$\leq 5\%$

Uncertainty in Measurement Units						Sensitivity Coefficient		
Measured Quantities	Symbol	Units	Run 1	Run 2		Run 1	Run 2	
Sampled Volume (STP)	V_m	m^3	4.0101	6.1559		0.13	0.06	
Leak	L	mg/ m^3	0.003	0.001		1.00	1.00	
Laboratory Result	L_r	mg/ m^3	0.037	0.025		1.00	1.00	
Factor for O ₂ Correction	$O_{2,m}$	% v/v	N/A	N/A		N/A	N/A	

Uncertainty in Result				
Measured Quantities	Units	Run 1	Run 2	
Sampled Volume (STP)	mg/ m^3	0.014	0.009	
Leak	mg/ m^3	0.0032	0.0015	
Laboratory Result	mg/ m^3	0.0373	0.0250	
Factor for O ₂ Correction	mg/ m^3	N/A	N/A	

Parameter	Units	Run 1	Run 2	
Combined uncertainty	mg/ m^3	0.04	0.03	
Expanded uncertainty (95% confidence)	mg/ m^3	0.08	0.05	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/ m^3	0.08	0.05	
Reported Uncertainty	mg/ m^3	0.08	0.05	
Expanded uncertainty (95% confidence)	%	14.8	14.7	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	14.8	14.7	
Reported Uncertainty	%	14.8	14.7	