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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

4th - 5th December 2013

Job Reference Number

CEK-1269

Report Written by

Nicholas Kane

Team Leader

MCERTS Level 2

MM 08 998

TE1 TE2 TE3 TE4

Report Approved by

John Healey

Deputy Regional Manager

MCERTS Level 2

MM 03 476

TE1 TE2 TE3 TE4

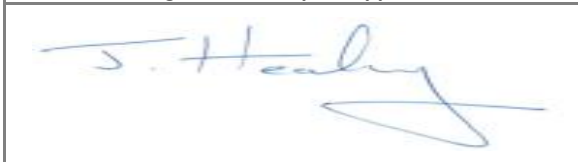
Report Date

16th December 2013

Version

Version 1

Signature of Report Approver

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CONTENTS

TITLE PAGE

CONTENTS 2

EXECUTIVE SUMMARY

Monitoring Objectives 3

Monitoring Results 4

Monitoring Dates & Times 5

Process Details 6

Monitoring & Analytical Methods 7

Summary of Method Deviations 7

Sampling Location 8

Plant Photos / Sample Points 9

APPENDIX 1 - Monitoring Personnel & List of Equipment

APPENDIX 2 - Raw Data, Sampling Equations & Charts

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Executive Summary

(Page 1 of 7)

MONITORING OBJECTIVES

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack
4th - 5th December 2013

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

(Page 2 of 7)

MONITORING RESULTS

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

Main Kiln Stack

4th - 5th December 2013

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	7.6	0.45	100	g/hr	537	31.5	-
Hydrogen Fluoride	¹ mg/m ³	1.4	0.24	10	g/hr	95.0	17.0	-
Water Vapour	% v/v	4.1	0.22					
Stack Gas Temperature	°C	39.3						
Stack Gas Velocity	m/s	4.9						
Volumetric Flow Rate (ACTUAL)	m ³ /hr	81964						
Volumetric Flow Rate (REF)	¹ m ³ /hr	70318						

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

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

Executive Summary

(Page 3 of 7)

MONITORING DATE(S) & TIMES

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

Main Kiln Stack

4th - 5th December 2013

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m ³	9.7	g/hr	682	04/12/2013	10:19 - 13:19	180
Total Particulate Matter	R2	mg/m ³	9.1	g/hr	643	04/12/2013	13:35 - 16:35	180
Total Particulate Matter	R3	mg/m ³	4.0	g/hr	284	05/12/2013	09:00 - 12:00	180
Hydrogen Fluoride (ISO)	R1	mg/m ³	2.1	g/hr	147	04/12/2013	10:19 - 13:19	180
Hydrogen Fluoride (ISO)	R2	mg/m ³	1.8	g/hr	125	04/12/2013	13:35 - 16:35	180
Hydrogen Fluoride (Non ISO)	R3	mg/m ³	1.0	g/hr	73.8	04/12/2013	16:50 - 22:50	360
Hydrogen Fluoride (Non ISO)	R4	mg/m ³	0.84	g/hr	59.2	04-05/12/2013	23:30 - 08:30	540
Hydrogen Fluoride (ISO)	R5	mg/m ³	1.0	g/hr	70.2	05/12/2013	09:00 - 12:00	180
Velocity & Volumetric Flow Rate	R1					04/12/2013	09:50 - 10:00	

All results are expressed at the respective reference conditions.

Executive Summary

(Page 4 of 7)

PROCESS DETAILS

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

Main Kiln Stack

4th - 5th December 2013

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	Not Visible

Executive Summary

(Page 5 of 7)

MONITORING & ANALYTICAL METHODS

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

Main Kiln Stack

4th - 5th December 2013

Parameter	Monitoring				Analysis				MCERTS Testing	LOD (Average)
	Standard	Technical Procedure	UKAS Testing	Testing Lab	Analytical Procedure	Analytical Technique	UKAS Analysis	Analysis Lab		
Total Particulate Matter	BS EN 13284-1	CAT-TP-01	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.05 mg/m ³
Hydrogen Fluoride	BS ISO 15713	CAT-TP-10	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.006 mg/m ³
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	All	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

(Page 6 of 7)

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	No
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

In the interest of improved Health and Safety, it would be advantageous to install some form of chain or self closing gate at the top of the sampling platform ladder.

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	11.8		> 5 Pa	Yes
Mean Velocity	m/s	4.77		-	-
Lowest Gas Velocity	m/s	3.85		-	-
Highest Gas Velocity	m/s	5.57		-	-
Ratio of Above	: 1	1.45		< 3 : 1	Yes
Maximum Angle of Swirl	°	6		< 15°	Yes
No Local Negative Flow	-	Yes		-	Yes

Executive Summary

(Page 7 of 7)

PLANT PHOTOS

Photo 1

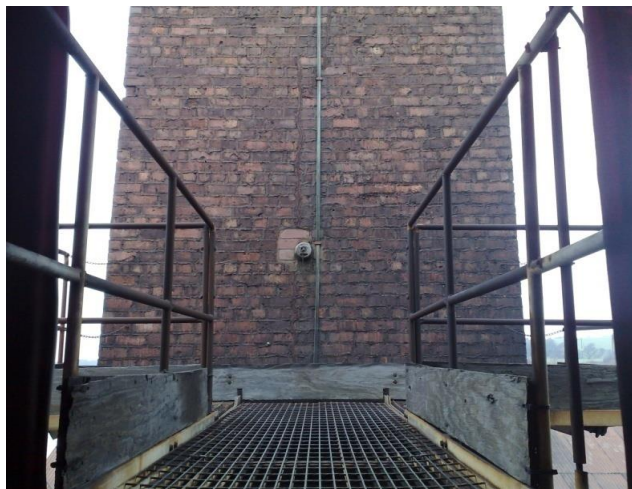
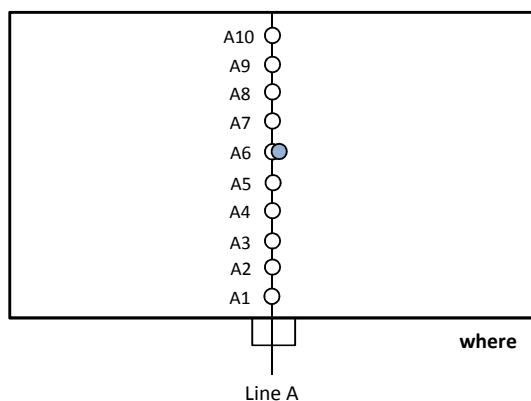


Photo 2



SAMPLE POINTS



where

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

APPENDICES

APPENDIX CONTENTS

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

APPENDIX 1

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Nicholas Kane	MCERTS Level 2	MM 08 998	TE1 TE2 TE3 TE4
Technician	Steve Royle	MCERTS Level 1	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 7.34	Horiba PG-250	-	Digital Manometer (1)	CAT 3.45
Box Thermocouples	CAT 3.37	Servomex 4900	-	Digital Manometer (2)	-
Umbilical	CAT 3.37	Eco Physics CLD 822Mh	-	Digital Temperature Meter	CAT 3.45
Oven Box	CAT 12.44	Testo 350 XL	-	Stopwatch	CAT 14.36/37
Probe	CAT 5.91/92/93	Servomex 5200MP	-	Barometer	CAT 13.10
S-Pitot (1)	CAT 21P.36/39	JCT JCC P1 Cooler	-	Stack Thermocouple (1)	CAT 4.343/189/246
S-Pitot (2)	CAT 21S.27	FT-IR	-	Stack Thermocouple (2)	CAT 4.154
L-Pitot	-	FT-IR Sampling System	-	1m Heated Line (1)	-
500g Check Weight	CAT 17.15	Bernath 3006 FID	-	1m Heated Line (2)	-
1Kg Check Weight	CAT 17.15	Heated Head Filter	-	1m Heated Line (3)	-
Last Impinger Arm	CAT 4.267/268	Mass Flow Controller (1)	-	5m Heated Line (1)	-
Callipers	CAT 23.17	Mass Flow Controller (2)	-	15m Heated Line (1)	-
Tubes Kit Thermocouple	-	Mass View (1)	CAT 25.39	15m Heated Line (2)	-
Laboratory Balance	CAT 1.18 / 1.18a	Mass View (2)	-	20m Heated Line (1)	-
Tape Measure	CAT 16.21	Easylogger EN-EL-12 Bit	-	Dual Channel Heater Controller	-

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	BS EN 13284-1	CAT-TP-01
Hydrogen Fluoride (ISO)	BS ISO 15713	CAT-TP-10
Hydrogen Fluoride (Non ISO)	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

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	41.6
Average Stack Gas Pressure	mmH ₂ O	1.9
Average Stack Static Pressure, P _{static}	kPa	0.123
Average Barometric Pressure, P _b	kPa	99.9
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)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O ₂ (Estimated)	-	20.80	19.95	0.2080	32.00	1.4277	0.29696
N ₂	-	79.14	75.91	0.7914	28.01	1.2498	0.98913
Moisture (H ₂ O)	-	-	4.08	0.0408	18.02	0.8037	0.03282

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	1.287
Wet Density (STP), P _{STW}	kg/m ³	1.268
Dry Density (Actual), P _{Actual}	kg/m ³	1.103
Average Wet Density (Actual), P _{ActualW}	kg/m ³	1.086

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	41.6	0.0
Total Pressure	kPa	100.0	101.3
Moisture	%	4.08	4.08

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m ³ /hr	80078
Gas Volumetric Flowrate (STP, Wet)	m ³ /hr	68611
Gas Volumetric Flowrate (STP, Dry)	m ³ /hr	65809
Gas Volumetric Flowrate REF ¹	m ³ /hr	68611

APPENDIX 2

PRELIMINARY STACK SURVEY: VELOCITY TRAVERSE

(1 of 1)

Parameter	Units	Value
Date of Survey	-	04/12/2013
Time of Survey	-	09:50 - 10:00
Atmospheric Pressure	kPa	99.9
Stack Static Pressure	Pa	123
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 (°)	5	6	4	5	6	5	3	4	5	6										

Sampling Line A					
Traverse Point	Depth m	ΔP mmH ₂ O	Temp °C	Wet Density kg/m ³	Velocity m/s
1	0.08	1.2	41.2	1.087	3.85
2	0.24	1.5	41.3	1.087	4.31
3	0.39	1.3	41.3	1.087	4.01
4	0.55	1.7	41.5	1.086	4.59
5	0.71	2.1	41.6	1.086	5.10
6	0.86	2.3	41.2	1.087	5.34
7	1.02	2.5	42.1	1.084	5.57
8	1.18	2.1	42.1	1.084	5.11
9	1.33	1.8	41.9	1.085	4.73
10	1.49	2.1	41.9	1.085	5.10
Mean		1.9	41.6	1.086	4.77

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	Run 3		Mean
Concentration	mg/m ³	9.7	9.1	4.0		7.6
Uncertainty	±mg/m ³	0.57	0.52	0.26		0.45
Mass Emission	g/hr	682	643	284		537
Uncertainty	±g/hr	39.8	36.6	18.3		31.5

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	7.7	3.6	3.2		4.8
Uncertainty	±% v/v	0.44	0.20	0.18		0.27

Blank Runs

Parameter	Units	Blank 1	Blank 2		Maximum
Concentration	mg/m ³	0.09	0.05		0.09

General Sampling Information

Parameter	Value	
Standard	BS EN 13284-1	
Technical Procedure	CAT-TP-01	
Probe Material	Monel	
Filter Housing Material	Monel	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Glass 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	Run 3	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg	749.3	749.3	736.5	
Stack static pressure, P_{static}	mmH ₂ O	12.5	12.5	12.5	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	750.2	750.2	737.4	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	122.6	48.8	46.6	
Total mass collected in impingers (silica trap)	g	16.3	18.0	18.2	
Total mass of liquid collected, V_{lc}	g	138.9	66.8	64.8	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.1731	0.0832	0.0807	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m ³	2.4372	2.6649	2.8980	
Gas meter correction factor, Y_d	-	0.9040	0.9040	0.9040	
Average dry gas meter temperature, T_m	°C	13.1	14.5	13.5	
Average pressure drop across orifice, ΔH	mmH ₂ O	18.6	19.7	21.5	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	2.0765	2.2595	2.4243	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.0769	0.0355	0.0322	
B_{wo} as a percentage	% v/v	7.69	3.55	3.22	
Reported Water Vapour, checked with Tables in BS EN 14790, R_{wv}	% v/v	7.69	3.55	3.22	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m ³	2.2495	2.3428	2.5050	
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 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	0.06	0.06	0.06	
O ₂ (Estimated)	% v/v	20.80	20.80	20.80	
Total	% v/v	20.86	20.86	20.86	
N ₂	% v/v	79.14	79.14	79.14	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	28.84	28.84	28.84	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.01	28.46	28.49	
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	1.80	1.89	2.06	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	1.34	1.37	1.44	
Average stack gas temperature, T_s	°C	41.1	39.4	37.4	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(T_s + 273)) / (V(M_s)(P_s))$	m/s	4.76	4.82	5.06	
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	1332.1	1349.6	1416.5	
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	1142.8	1164.1	1209.0	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	1054.9	1122.8	1170.0	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)(O_{2REFw})$	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	7.93	7.93	7.93	
Nozzle area, A_n	mm ²	49.44	49.44	49.44	
Total sampling time, q	min	180	180	180	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.1	105.4	108.6	

APPENDIX 2

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	10:19 - 13:19	13:35 - 16:35	09:00 - 12:00	
Sampling Dates	-	04/12/2013	04/12/2013	05/12/2013	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m ³	2.2503	2.3428	2.5057	
Filter I.D. Number	-	47-15180	47-15311	47-17029	
Start Filter Mass	g	0.14148	0.14196	0.14084	
End Filter Mass	g	0.15710	0.15572	0.14806	
Total Mass on Filter	g	0.01562	0.01376	0.00722	
Probe Rinse I.D. Number	-	PR-47-15180	PR-47-15311	PR-47-17029	
Start Probe Rinse Mass	g	3.02525	6.74726	3.17342	
End Probe Rinse Mass	g	3.03147	6.75493	3.17632	
Total Mass in Probe Rinse	g	0.00622	0.00767	0.00290	
Total Mass Collected	mg	21.84	21.43	10.12	
Calculated Concentration	mg/m ³	9.71	9.15	4.04	
Balance Uncertainty / LOD	mg/m ³	0.05	0.05	0.05	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	Blank 2	
Blank Dates	-	04/12/2012	05/12/2013	
Average Volume Sampled (REF)	m ³	2.3663	2.3663	
Filter I.D. Number	-	47-15309	47-17048	
Start Filter Mass	g	0.14115	3.04440	
End Filter Mass	g	0.14147	3.04432	
Total Mass on Filter	g	0.00032	-0.00008	
Probe Rinse I.D. Number	-	PR-47-15309	PR-47-17048	
Start Probe Rinse Mass	g	3.04856	0.14165	
End Probe Rinse Mass	g	3.04845	0.14186	
Total Mass in Probe Rinse	g	-0.00011	0.00021	
Total Mass Collected	mg	0.21	0.13	
Calculated Concentration	mg/m ³	0.09	0.05	
Balance Uncertainty / LOD	mg/m ³	0.05	0.05	

APPENDIX 2

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	12.24	13.38	14.55	
Pre-Sampling Leak Rate	l/min	0.24	0.18	0.18	
Post-Sampling Leak Rate	l/min	0.21	0.16	0.17	
Allowable Leak Rate	l/min	0.24	0.27	0.29	
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)	%	5.7	5.6	5.6	
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	%	103.1	105.4	108.6	
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	0.24	0.24	0.24	
Overall Weighing Uncertainty	± mg/m ³	0.11	0.10	0.10	
ELV [Daily ELV for IED]	mg/m ³	100.00	100.00	100.00	
Allowable Weighing Uncertainty	mg/m ³	5.00	5.00	5.00	
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	41	39	37	
Test Conditions	Units	Run 1	Run 2	Run 3	
Ambient Temperature Recorded?	-	Yes	Yes	Yes	

APPENDIX 2

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	Blank 2	
Expected Sampling Rate	l/min	15.00	13.00	
Pre-Sampling Leak Rate	l/min	0.16	0.14	
Post-Sampling Leak Rate	l/min	0.14	0.14	
Allowable Leak Rate	l/min	0.30	0.26	
Leak Test Acceptable	-	Yes	Yes	

Validity of Blank vs ELV	Units	Blank 1	Blank 2	
Allowable Blank	mg/m ³	10.0	10.0	
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)				
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.	x	x	x	

APPENDIX 2

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 _m	2.4372	2.6649	2.8980		uV _m	m ³	0.0487	0.0533	0.0580	
Sampled Gas Temperature	T _m	286.1	287.5	286.5		uT _m	K	2.0	2.0	2.0	
Sampled Gas Pressure	p _m	100.0	100.0	98.3		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	1.72	1.20	1.17		uL	%	-	-	-	
Mass of Particulate	m	21.84	21.43	10.12		um	mg	0.12	0.12	0.12	
Oxygen Content	O _{2,m}	N/A	N/A	N/A		uO _{2,m}	% v/v	N/A	N/A	N/A	
Uncollected Mass	UCM	0.21	0.21	0.21		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	%	0.70	0.70	0.70		≤1%
Sampled Gas Pressure	%	0.50	0.50	0.51		≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00		≤1%
Leak	%	1.72	1.20	1.17		≤2%
Mass of Particulate	%	0.05	0.05	0.05		<5% of ELV
Oxygen Content	%	N/A	N/A	N/A		≤5%
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 _m	m ³	2.0773	2.2595	2.4250		4.67	4.05	1.67	
Leak	L	mg/m ³	0.096	0.063	0.027		1.00	1.00	1.00	
Mass of Particulate	L _r	mg	21.840	21.427	10.120		0.44	0.43	0.40	
Factor for O ₂ Correction	O _{2,m}	% v/v	N/A	N/A	N/A		N/A	N/A	N/A	
Uncollected Mass	UCM	mg	0.12	0.12	0.12		0.44	0.43	0.40	

Measured Quantities	Uncertainty in Result				
	Units	Run 1	Run 2	Run 3	
Sampled Volume (STP)	mg/m ³	0.261	0.247	0.110	
Leak	mg/m ³	0.0961	0.0631	0.0272	
Mass of Particulate	mg/m ³	0.0533	0.0512	0.0479	
Factor for O ₂ Correction	mg/m ³	N/A	N/A	N/A	
Uncollected Mass	mg/m ³	0.0539	0.0518	0.0484	

Parameter	Units	Run 1	Run 2	Run 3	
Combined uncertainty	mg/m ³	0.29	0.27	0.13	
Expanded uncertainty (95% confidence)	mg/m ³	0.57	0.52	0.26	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.57	0.52	0.26	
Reported Uncertainty	mg/m ³	0.57	0.52	0.26	
Expanded uncertainty (95% confidence)	%	5.8	5.7	6.4	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	5.8	5.7	6.4	
Reported Uncertainty	%	5.8	5.7	6.4	

APPENDIX 2

HYDROGEN FLUORIDE (ISO): 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	2.1	1.8	1.0		1.6
Uncertainty	±mg/m ³	0.31	0.26	0.15		0.24
Mass Emission	g/hr	147	125	70		114
Uncertainty	±g/hr	21.9	18.6	10.4		17.0

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	7.7	3.6	3.2		4.8
Uncertainty	±% v/v	0.44	0.20	0.18		0.27

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	< 0.01		< 0.01

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-O1	
UKAS Accredited Analysis?	Yes	
Date of Sample Analysis	11/12/2013	
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 Glass 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 (ISO): ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	Run 2	Run 3	
Absolute pressure of stack gas, P_s					
Barometric pressure, P_b	mmHg	749.3	749.3	736.5	
Stack static pressure, P_{static}	mmH ₂ O	12.5	12.5	12.5	
$P_s = (P_b + (P_{static} / 13.6))$	mmHg	750.2	750.2	737.4	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	122.6	48.8	46.6	
Total mass collected in impingers (silica trap)	g	16.3	18.0	18.2	
Total mass of liquid collected, V_{lc}	g	138.9	66.8	64.8	
$V_{wstd} = (0.001246)(V_{lc})$	m ³	0.1731	0.0832	0.0807	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m ³	2.4372	2.6649	2.8980	
Gas meter correction factor, Y_d	-	0.9040	0.9040	0.9040	
Average dry gas meter temperature, T_m	°C	13.1	14.5	13.5	
Average pressure drop across orifice, ΔH	mmH ₂ O	18.6	19.7	21.5	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m ³	2.0765	2.2595	2.4243	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m ³	0.0769	0.0355	0.0322	
B_{wo} as a percentage	% v/v	7.69	3.55	3.22	
Reported Water Vapour, checked with Tables in BS EN 14790, R_{wv}	% v/v	7.69	3.55	3.22	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m ³	2.2495	2.3428	2.5050	
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 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	0.06	0.06	0.06	
O ₂ (Estimated)	% v/v	20.80	20.80	20.80	
Total	% v/v	20.86	20.86	20.86	
N ₂	% v/v	79.14	79.14	79.14	
$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$	g/gmol	28.84	28.84	28.84	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.01	28.46	28.49	
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	1.80	1.89	2.06	
Average square root of velocity heads, $\sqrt{\Delta P}$	√mmH ₂ O	1.34	1.37	1.44	
Average stack gas temperature, T_s	°C	41.1	39.4	37.4	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(T_s + 273)) / (V(M_s)(P_s))$	m/s	4.76	4.82	5.06	
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	1332.1	1349.6	1416.5	
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	1142.8	1164.1	1209.0	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m ³ /min	1054.9	1122.8	1170.0	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)(O_{2REFw})$	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	7.93	7.93	7.93	
Nozzle area, A_n	mm ²	49.44	49.44	49.44	
Total sampling time, q	min	180	180	180	
$\%I = (4.6398E^6)(T_s + 273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.1	105.4	108.6	

APPENDIX 2

HYDROGEN FLUORIDE (ISO): SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	10:19 - 13:19	13:35 - 16:35	09:00 - 12:00	
Sampling Dates	-	04/12/2013	04/12/2013	05/12/2013	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m ³	2.2503	2.3428	2.5057	
Laboratory Result for Front Impingers	µg/ml	13.90	10.09	5.01	
Laboratory Result for Back Impinger	µg/ml	0.05			
Volume in Front Impingers	ml	338.0	412.9	499.0	
Volume in Back Impinger	ml	169.0			
Mass in Front Impingers	µg	4698.2	4166.2	2500.0	
Mass in Back Impinger	µg	8.5			
Total Mass Collected	µg	4706.7	4166.2	2500.0	
Calculated Concentration	mg/m ³	2.09	1.78	1.00	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	04/12/2012	
Average Volume Sampled (REF)	m ³	2.3663	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	316.0	
Total Mass Collected	µg	< 15.8	
Calculated Concentration	mg/m ³	< 0.01	

APPENDIX 2

HYDROGEN FLUORIDE (ISO): QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3	
Mean Sampling Rate	l/min	12.24	13.38	14.55	
Pre-Sampling Leak Rate	l/min	0.24	0.18	0.18	
Post-Sampling Leak Rate	l/min	0.21	0.16	0.17	
Allowable Leak Rate	l/min	0.24	0.27	0.29	
Leak Test Acceptable	-	Yes	Yes	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	99.8	
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)	%	5.7	5.6	5.6	
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	%	103.1	105.4	108.6	
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	41	39	37	

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

APPENDIX 2

HYDROGEN FLUORIDE (ISO): 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	0.16	
Post-Sampling Leak Rate	l/min	0.14	
Allowable Leak Rate	l/min	0.30	
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.	x	x	x	

APPENDIX 2

HYDROGEN FLUORIDE (ISO): 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	2.4372	2.6649	2.8980	uV_m	m^3	0.0487	0.0533	0.0580
Sampled Gas Temperature	T_m	286.1	287.5	286.5	uT_m	K	2.0	2.0	2.0
Sampled Gas Pressure	p_m	100.0	100.0	98.3	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	1.72	1.20	1.17	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

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	%	0.70	0.70	0.70	≤1%
Sampled Gas Pressure	%	0.50	0.50	0.51	≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00	≤1%
Leak	%	1.72	1.20	1.17	≤2%
Laboratory Result	%	7.05	7.05	7.05	No Requirement
Oxygen Content	%	N/A	N/A	N/A	≤5%

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_m	m^3	2.0773	2.2595	2.4250	1.01	0.79	0.41	
Leak	L	mg/ m^3	0.0207	0.0123	0.0067	1.00	1.00	1.00	
Laboratory Result	L_r	mg/ m^3	0.147	0.125	0.070	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	

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	Run 3
Sampled Volume (STP)	mg/ m^3	0.0563	0.0480	0.0272
Leak	mg/ m^3	0.021	0.012	0.007
Laboratory Result	mg/ m^3	0.147	0.125	0.070
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	0.16	0.13	0.08
Expanded uncertainty (95% confidence)	mg/ m^3	0.31	0.26	0.15
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/ m^3	0.31	0.26	0.15
Reported Uncertainty	mg/ m^3	0.31	0.26	0.15
Expanded uncertainty (95% confidence)	%	14.9	14.9	14.9
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	14.9	14.9	14.9
Reported Uncertainty	%	14.9	14.9	14.9

APPENDIX 2

HYDROGEN FLUORIDE (NON ISO): 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	1.0	0.84		0.95
Uncertainty	±mg/m ³	0.15	0.12		0.14
Mass Emission	g/hr	73.8	59.2		66.5
Uncertainty	±g/hr	10.7	8.5		9.6

Parameter	Units	Run 1	Run 2		Mean
Water Vapour	% v/v	2.7	2.5		2.6
Uncertainty	±% v/v	0.12	0.11		0.11

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m ³	< 0.004		< 0.004

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	11/12/2013	
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 Glass 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	A6	

Reference Conditions

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

APPENDIX 2

HYDROGEN FLUORIDE (NON ISO): SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	
Sampling Times	-	16:50 - 22:50	23:30 - 08:30	
Sampling Dates	-	04/12/2013	04-05/12/2013	
Sampling Device	-	MFC / MV	MFC / MV	
Duration	mins	360	540	
Volume Sampled (STP, Dry)	m ³	3.4393	5.3338	
Volume Sampled (STP, Wet)	m ³	3.5338	5.4727	
Volume Sampled (REF)	m ³	3.5338	5.4727	
Sample Flow Rate	l/min	9.55	9.87	
Laboratory Result for Front Impingers	µg/ml	8.29	9.46	
Laboratory Result for Back Impinger	µg/ml	0.05	0.05	
Volume in Front Impingers	ml	446.5	486.0	
Volume in Back Impinger	ml	117.2	141.0	
Mass in Front Impingers	µg	3701.5	4597.6	
Mass in Back Impinger	µg	< 5.9	< 7.1	
Total Mass Collected	µg	3707.3	4604.6	
Calculated Concentration	mg/m ³	1.05	0.84	
Liquid Trap Start Mass	g	2546.2	2547.5	
Liquid Trap End Mass	g	2610.9	2648.5	
Silica Trap Start Mass	g	959.9	971.0	
Silica Trap End Mass	g	971.0	981.5	
Total Mass Of Water Vapour	g	75.8	111.5	
Calculated Water Vapour	% v/v	2.67	2.54	

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	04/12/2013	
Average Volume Sampled (REF)	m ³	4.5032	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	316.0	
Total Mass Collected	µg	< 15.8	
Calculated Concentration	mg/m ³	< 0.00	

APPENDIX 2

HYDROGEN FLUORIDE (NON ISO): QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	
Mean Sampling Rate	l/min	9.55	9.87	
Pre-Sampling Leak Rate	l/min	0.16	0.14	
Post-Sampling Leak Rate	l/min	0.17	0.12	
Allowable Leak Rate	l/min	0.19	0.20	
Leak Test Acceptable	-	Yes	Yes	
Absorption Efficiency	Units	Run 1	Run 2	
Absorption Efficiency	%	100	100	
Allowable Absorption Efficiency	%	N/A ²	N/A ²	
Absorption Efficiency Acceptable	-	N/A ²	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)	%	4.5	4.3	
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	9.50	
Pre-Sampling Leak Rate	l/min	0.18	
Post-Sampling Leak Rate	l/min	0.17	
Allowable Leak Rate	l/min	0.19	
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.	x	x	

APPENDIX 2

HYDROGEN FLUORIDE (NON ISO): MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value				Standard uncertainty				
	Symbol	Run 1	Run 2		Symbol	Units	Run 1	Run 2	
Sampled Volume (STP)	V _m	3.4393	5.3338		uV _m	m ³	0.0688	0.1067	
Leak	L	1.78	1.22		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	

Measured Quantities	Uncertainty as a Percentage				Requirement of Standard
	Units	Run 1	Run 2		
Sampled Volume (STP)	%	2.00	2.00		≤2%
Leak	%	1.78	1.22		≤2%
Laboratory Result	%	7.05	7.05		No Requirement
Oxygen Content	%	N/A	N/A		≤5%

Measured Quantities	Uncertainty in Measurement Units					Sensitivity Coefficient		
	Symbol	Units	Run 1	Run 2		Run 1	Run 2	
Sampled Volume (STP)	V _m	m ³	3.4393	5.3338		0.31	0.16	
Leak	L	mg/m ³	0.011	0.006		1.00	1.00	
Laboratory Result	L _r	mg/m ³	0.074	0.059		1.00	1.00	
Factor for O ₂ Correction	O _{2,m}	% v/v	N/A	N/A		N/A	N/A	

Measured Quantities	Uncertainty in Result			
	Units	Run 1	Run 2	
Sampled Volume (STP)	mg/m ³	0.0210	0.0168	
Leak	mg/m ³	0.0108	0.0059	
Laboratory Result	mg/m ³	0.0740	0.0593	
Factor for O ₂ Correction	mg/m ³	N/A	N/A	

Parameter	Units	Run 1	Run 2	
Combined uncertainty	mg/m ³	0.08	0.06	
Expanded uncertainty (95% confidence)	mg/m ³	0.15	0.12	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.15	0.12	
Reported Uncertainty	mg/m ³	0.15	0.12	
Expanded uncertainty (95% confidence)	%	14.5	14.4	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	14.5	14.4	
Reported Uncertainty	%	14.5	14.4	