ISO/IEC 17025 Accredited Legal Entity, UKAS Accredited Testing Laboratory No. 4279
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4279

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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
15th - 16th December 2015

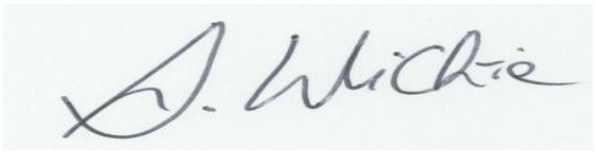
Job Reference Number
CEK-1970

Report Written by
Stephen Dick Team Leader MCERTS Level 2 MM 10 1061 TE1 TE2 TE3 TE4

Report Approved by
Iain Wilkie Team Leader MCERTS Level 2 MM 04 492 TE1 TE2 TE3 TE4

Report Date
30th December 2015

Version
Version 1

Signature of Report Approver


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Opinions and interpretations expressed herein are outside the scope of Exova Catalyst's ISO 17025 accreditation.

MONITORING OBJECTIVES

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack
15th - 16th December 2015

Overall Aim of the Monitoring Campaign

Exova Catalyst 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

MONITORING RESULTS

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack
15th - 16th December 2015

where MU = Measurement Uncertainty associated with the Result

	Concentration				Mass Emission			
Parameter	**Units**	**Result**	**MU +/-**	**Limit**	**Units**	**Result**	**MU +/-**	**Limit**
Total Particulate Matter [1]	mg/m³	8.6	0.48	100	g/hr	959	102	-
Hydrogen Fluoride [1]	mg/m³	1.0	0.07	10	g/hr	113	12.9	-
Water Vapour	% v/v	2.8	0.13					
Stack Gas Temperature	°C	23.0						
Stack Gas Velocity	m/s	7.4	0.58					
Volumetric Flow Rate (ACTUAL)	m³/hr	123688	11215					
Volumetric Flow Rate (REF) [1]	m³/hr	111904	10146					

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.

MONITORING DATE(S) & TIMES

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack
15th - 16th December 2015

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m³	4.7	g/hr	522	15/12/2015	11:40 - 14:40	180
Total Particulate Matter	R2	mg/m³	4.2	g/hr	470	15/12/2015	14:50 - 17:50	180
Total Particulate Matter	R3	mg/m³	16.8	g/hr	1885	16/12/2015	09:22 - 12:22	180
Hydrogen Fluoride(ISO)	R1	mg/m³	0.24	g/hr	26.3	15/12/2015	11:40 - 14:40	180
Hydrogen Fluoride(ISO)	R2	mg/m³	0.48	g/hr	53.9	15/12/2015	14:50 - 17:50	180
Hydrogen Fluoride (non Iso)	R3	mg/m³	0.69	g/hr	77.6	15/12/2015	18:00 - 00:00	360
Hydrogen Fluoride (non Iso)	R4	mg/m³	1.3	g/hr	150	16/12/2015	00:10 - 09:10	540
Hydrogen Fluoride(ISO)	R5	mg/m³	2.3	g/hr	257	16/12/2015	09:22 - 12:22	180
Velocity & Volumetric Flow Rate	R1					15/12/2015	11:25 - 11:40	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack
15th - 16th December 2015

Standard Operating Conditions

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

Executive Summary

MONITORING & ANALYTICAL METHODS

Furness Brick and Tile Company Ltd, Askam-in-Furness
Main Kiln Stack
15th - 16th December 2015

	Monitoring				Analysis					
Parameter	**Standard**	**Technical Procedure**	**ISO 17025 Testing**	**Testing Lab**	**Analytical Procedure**	**Analytical Technique**	**ISO 17025 Analysis**	**Analysis Lab**	**MCERTS Testing**	**LOD (Average)**
Total Particulate Matter	EN 13284-1	CAT-TP-01	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.06 mg/m³
Hydrogen Fluoride	BS ISO 15713	CAT-TP-10	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.013 mg/m³
Water Vapour	EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.1 % v/v
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

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.

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	87.0
Orientation of Duct	-	Horizontal
Sample Port Size	-	3" BSP

Location of Sampling Platform

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

Platform Details

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

Sampling Location / Platform Improvement Recommendations

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.

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	38.2		> 5 Pa	Yes
Mean Velocity	m/s	7.37		-	-
Lowest Gas Velocity	m/s	6.80		-	-
Highest Gas Velocity	m/s	7.94		-	-
Ratio of Above	: 1	1.17		< 3 : 1	Yes
Maximum Angle of Swirl	°	10.0		< 15°	Yes
No Local Negative Flow	-	Yes		-	Yes

PLANT PHOTOS

Photo 1

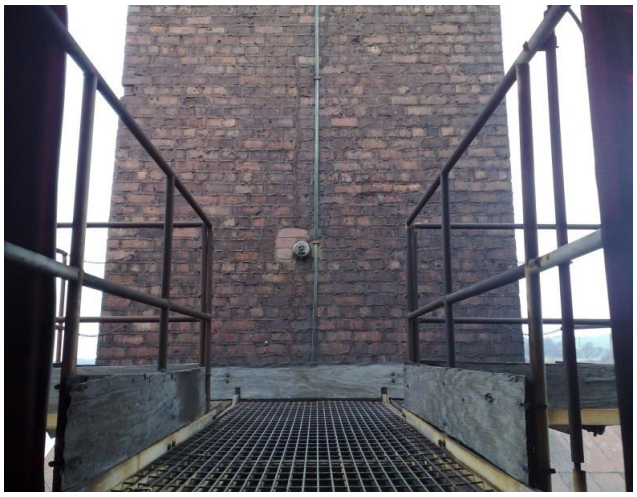
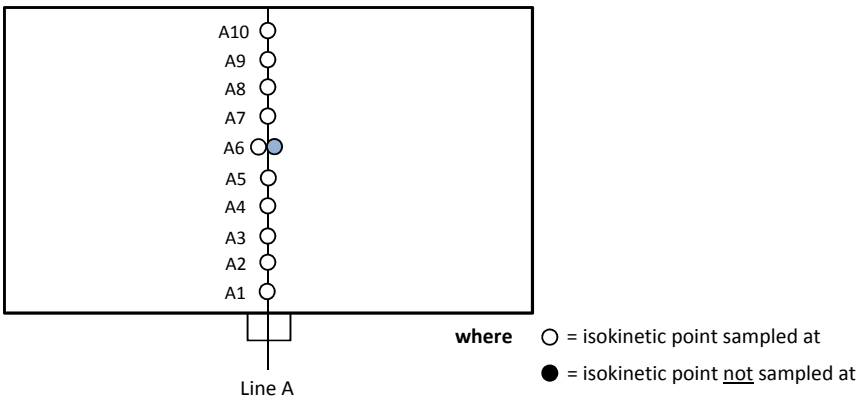


Photo 2

SAMPLE POINTS



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

APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Stephen Dick	MCERTS Level 2	MM 10 1061	TE1 TE2 TE3 TE4
Technician	Graham Grant	MCERTS Level 1	MM 11 1142	None

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	CAT 7.38
Control Box DGM (2)	-
Box Thermocouples (1)	CAT 3.57
Box Thermocouples (2)	-
Umbilical (1)	CAT 3.57
Umbilical (2)	-
Oven Box (1)	CAT 12.963
Oven Box (2)	-
Heated Probe (1)	CAT 5.4
Heated Probe (2)	CAT 5.8
Heated Probe (3)	CAT 5.11
S-Pitot (1)	CAT 21S.4 / 21S.28
S-Pitot (2)	CAT 21S.26 / 21P.33
L-Pitot	CAT 21L.4
500g Check Weight	CAT 17.4
1Kg Check Weight	CAT 17.4
Last Impinger Arm	AT 4.22 / 4.24 / 4.99
Callipers	CAT 23.22
Tubes Kit Thermocouple	CAT 4.217

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250	CAT 9.10
Horiba PG-250 SRM	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Servomex 5200MP	-
JCT JCC P1 Cooler	CAT 4.206
Gasmet DX4000	-
Gasmet Sampling System	-
Bernath 3006 FID	-
Ankersmid APP100	CAT 12.72
Mass Flow Controller (1)	CAT 6.11
Mass Flow Controller (2)	CAT 6.12
Mass View (1)	CAT 25.3
Mass View (2)	CAT 25.4
Easylogger EN-EL-12 Bit	CAT 11.19
Easylogger EN-EL-12 Bit	CAT 11.6
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.54
Digital Manometer (2)	CAT 3.54
Digital Temperature Meter	CAT 3.54
Stopwatch	CAT 14.4 / 14.53
Barometer	CAT 13.24
Stack Thermocouple (1)	CAT 4.240
Stack Thermocouple (2)	CAT 4.573
Stack Thermocouple (3)	CAT 4.585 / 4.702
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	CAT 20.4
15m Heated Line (1)	-
20m Heated Line (1)	CAT 20.8
20m Heated Line (2)	-
Dual Channel Heater Controller	CAT 3.15
Single Channel Heater Controller	-
Laboratory Balance	CAT 1.18 / 1.18a
Tape Measure	CAT 16.3

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	CAT-TP-01
Hydrogen Fluoride	BS ISO 15713	CAT-TP-10
Water Vapour	EN 14790	CAT-TP-05
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	1.57
Stack Width, W	m	2.97
Stack Area, A	m^2	4.66
Average Stack Gas Temperature, T_a	°C	23.0
Average Stack Gas Pressure	mmH_2O	4.6
Average Stack Static Pressure, P_{static}	kPa	0.077
Average Barometric Pressure, P_b	kPa	99.3
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/m³ p	Conc kg/m³ p_i
CO_2 (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O_2 (Estimated)	-	20.80	20.21	0.2080	32.00	1.4277	0.29696
N_2	-	79.14	76.89	0.7914	28.01	1.2498	0.98913
Moisture (H_2O)	-	-	2.85	0.0285	18.02	0.8037	0.02289

Where: p = M / 22.41

p_i = r x p

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m³	1.287
Wet Density (STP), P_{STW}	kg/m³	1.273
Dry Density (Actual), P_{Actual}	kg/m³	1.165
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	1.152

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

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

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

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

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Units	Actual	REF [1]
Temperature	°C	23.0	0.0
Total Pressure	kPa	99.4	101.3
Moisture	%	2.85	2.85

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	123688
Gas Volumetric Flowrate (STP, Wet)	m³/hr	111904
Gas Volumetric Flowrate (STP, Dry)	m³/hr	108718
Gas Volumetric Flowrate REF [1]	m³/hr	111904

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	15/12/2015
Time of Survey	-	11:25 - 11:40
Atmospheric Pressure	kPa	99.3
Average Stack Static Pressure	Pa	77
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 200 (500Pa)	

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

Sampling Line A

Traverse Point	Depth m	ΔP mmH_2O	Temp °C	Wet Density kg/m^3	Velocity m/s	Swirl °
STATIC (Units: Pa)		*77.0*				
Mean		**4.6**	**23.0**	**1.152**	**7.37**	
1	0.08	3.9	22.8	1.153	6.80	5.0
2	0.24	4.2	22.9	1.153	7.06	6.0
3	0.39	4.4	23.0	1.152	7.23	7.0
4	0.55	4.6	23.0	1.152	7.39	9.0
5	0.71	5.1	23.0	1.152	7.78	8.0
6	0.86	4.5	23.1	1.152	7.31	7.0
7	1.02	4.2	23.1	1.152	7.06	9.0
8	1.18	5.3	23.1	1.152	7.94	10.0
9	1.33	4.7	23.1	1.152	7.47	9.0
10	1.49	4.9	23.1	1.152	7.63	8.0

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(Δpi)	1.149	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	0.210	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	0.025	
- Overall corrections to dynamic measurements	u(Cf)	0.320	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.208	
- $\varphi CO_2,w$	-	0.058	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.145	
- Oxygen, wet	u(ϕO_2,w)	0.619	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.510	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.696	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	1.149	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00622	-
Standard uncertainty associated with the local velocities	u(vi)	0.928	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.295	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.579	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	7.86	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	11214.5	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00214	
- $u^2(qV,w)$	-	32737673	
- u(qV,w)	-	5721.7	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	9.07	%

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/m³	4.7	4.2	16.8		8.6
Uncertainty	±mg/m³	0.29	0.28	0.86		0.48
Mass Emission	g/hr	522	470	1885		959
Uncertainty	±g/hr	57.6	53.0	196		102

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	3.0	3.1	2.5		2.9
Uncertainty	±% v/v	0.15	0.16	0.13		0.14

NOTE: Where water droplets are present (See the Quality Assurance page), the Water Vapour concentration as found in Annex A of EN 14790 has been reported instead of the calculated value.

Blank Runs

Parameter	Units	Blank 1	Blank 2		Maximum
Concentration	mg/m³	0.14	0.13		0.14

General Sampling Information

Parameter	Value	
Standard	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 Quartz Fibre	
Number of Sampling Lines Used	1 / 3	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.

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	744.8	744.8	744.8	
Stack static pressure, P_{static}	mmH_2O	7.9	7.9	7.9	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	745.3	745.3	745.3	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	25.5	46.5	38.1	
Total mass collected in impingers (silica trap)	g	37.8	17.0	3.3	
Total mass of liquid collected, V_{lc}	g	63.3	63.5	41.4	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0789	0.0791	0.0516	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m^3	2.3479	2.2656	2.0479	
Gas meter correction factor, Y_d	-	1.0580	1.0580	1.0580	
Average dry gas meter temperature, T_m	°C	20.6	23.0	18.6	
Average pressure drop across orifice, ΔH	mmH_2O	19.7	18.6	15.7	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	2.2681	2.1703	1.9906	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0336	0.0352	0.0253	
B_{wo} as a percentage	% v/v	3.36	3.52	2.53	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	2.96	3.14	2.53	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	2.3373	2.2407	2.0421	
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	28.52	28.50	28.57	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.85	0.85	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	5.30	4.88	4.23	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	2.30	2.21	2.06	
Average stack gas temperature, T_s	°C	23.5	24.8	28.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	8.10	7.79	7.28	
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	2266.0	2180.5	2037.2	
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	2045.9	1960.3	1811.9	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	1985.3	1898.8	1766.1	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	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	6.05	6.05	6.05	
Nozzle area, A_n	mm^2	28.72	28.72	28.72	
Total sampling time, q	min	180	180	180	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.0	103.1	101.7	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	11:40 - 14:40	14:50 - 17:50	09:22 - 12:22	
Sampling Dates	-	15/12/2015	15/12/2015	16/12/2015	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m^3	2.3373	2.2407	2.0421	
Filter I.D. Number	-	90-4656	47-28632	47-29669	
Start Filter Mass	g	0.52571	0.13786	0.14700	
End Filter Mass	g	0.53017	0.14149	0.14887	
Total Mass on Filter	g	0.00446	0.00363	0.00187	
Probe Rinse I.D. Number	-	PR-90-4656	PR-47-28632	PR-47-29669	
Start Probe Rinse Mass	g	2.99616	3.06594	3.07137	
End Probe Rinse Mass	g	3.00260	3.07173	3.10389	
Total Mass in Probe Rinse	g	0.00644	0.00579	0.03252	
Total Mass Collected	mg	10.90	9.42	34.39	
Calculated Concentration	mg/m^3	4.66	4.20	16.84	
Balance Uncertainty / LOD	mg/m^3	0.06	0.06	0.06	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	Blank 2	
Blank Dates	-	15/12/2015	16/12/2015	
Average Volume Sampled (REF)	m^3	2.2067	2.2067	
Filter I.D. Number	-	47-30204	47-29692	
Start Filter Mass	g	0.14856	0.14533	
End Filter Mass	g	0.14861	0.14541	
Total Mass on Filter	g	0.00005	0.00008	
Probe Rinse I.D. Number	-	PR-47-30204	PR-47-29692	
Start Probe Rinse Mass	g	3.08844	3.04260	
End Probe Rinse Mass	g	3.08869	3.04280	
Total Mass in Probe Rinse	g	0.00025	0.00020	
Total Mass Collected	mg	0.30	0.28	
Calculated Concentration	mg/m^3	0.14	0.13	
Balance Uncertainty / LOD	mg/m^3	0.06	0.06	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3	
Mean Sampling Rate	l/min	13.80	13.32	12.04	
Pre-Sampling Leak Rate	l/min	0.06	0.15	0.09	
Post-Sampling Leak Rate	l/min	0.14	0.11	0.14	
Allowable Leak Rate	l/min	0.28	0.27	0.24	
Leak Test Acceptable	-	Yes	Yes	Yes	

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

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3	
Measurement Uncertainty (MU)	%	5.0	5.0	5.1	
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	%	103.0	103.1	101.7	
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/m³	0.10	0.11	0.12	
ELV [Daily ELV for IED]	mg/m³	100.00	100.00	100.00	
Allowable Weighing Uncertainty	mg/m³	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	24	25	28	

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

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

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Blank Runs

Leak Test Results	Units	Blank 1	Blank 2	
Expected Sampling Rate	l/min	15.00	15.00	
Pre-Sampling Leak Rate	l/min	0.09	0.11	
Post-Sampling Leak Rate	l/min	0.13	0.15	
Allowable Leak Rate	l/min	0.30	0.30	
Leak Test Acceptable	-	Yes	Yes	

Validity of Blank vs ELV	Units	Blank 1	Blank 2	
Allowable Blank	mg/m^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 (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 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.	x	x	x	

TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value					Standard uncertainty					
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**		**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	
Sampled Volume (Actual)	V_m	2.3479	2.2656	2.0479		uV_m	m^3	0.0470	0.0453	0.0410	
Sampled Gas Temperature	T_m	293.6	296.0	291.6		uT_m	K	2.0	2.0	2.0	
Sampled Gas Pressure	ρ_m	99.4	99.4	99.4		$u\rho_m$	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	1.01	0.83	1.16		uL	%	-	-	-	
Mass of Particulate	m	10.90	9.42	34.39		um	mg	0.13	0.13	0.13	
Uncollected Mass	UCM	0.30	0.30	0.30		uUCM	mg	-	-	-	

	Uncertainty as a Percentage					
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	2.00	2.00		≤2%
Sampled Gas Temperature	%	0.68	0.68	0.69		≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50		≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00		≤1%
Leak	%	1.01	0.83	1.16		≤2%
Mass of Particulate	%	0.06	0.06	0.06		<5% of ELV
Uncollected Mass	%	-	-	-		-

	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	2.2681	2.1703	1.9906		2.06	1.94	8.46	
Leak	L	mg/m^3	0.027	0.020	0.113		1.00	1.00	1.00	
Mass of Particulate	L_r	mg	10.900	9.420	34.393		0.43	0.45	0.49	
Uncollected Mass	UCM	mg	0.17	0.17	0.17		0.43	0.45	0.49	

	Uncertainty in Result				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	
Sampled Volume (STP)	mg/m^3	0.114	0.104	0.411	
Leak	mg/m^3	0.0273	0.0200	0.1131	
Mass of Particulate	mg/m^3	0.0556	0.0580	0.0637	
Uncollected Mass	mg/m^3	0.0741	0.0773	0.0848	

	Oxygen Correction Part of MU Budget				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	
O_2 Correction Factor	-	N/A	N/A	N/A	
Stack Gas O_2 Content	% v/v	N/A	N/A	N/A	
MU for O_2 Correction	-	N/A	N/A	N/A	
Overall MU For O_2 Measurement	%	N/A	N/A	N/A	

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**	
Combined uncertainty	mg/m^3	0.15	0.14	0.44	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.29	0.28	0.86	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.29	0.28	0.86	
Reported Uncertainty	mg/m^3	0.29	0.28	0.86	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	6.3	6.7	5.1	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	6.3	6.7	5.1	
Reported Uncertainty	%	6.3	6.7	5.1	

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/m³	0.24	0.48	2.3		1.0
Uncertainty	±mg/m³	0.02	0.03	0.17		0.07
Mass Emission	g/hr	26.3	53.9	257		113
Uncertainty	±g/hr	3.0	6.2	29.8		13.0

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	3.0	3.1	2.5		2.9
Uncertainty	±% v/v	0.15	0.16	0.13		0.14

NOTE: Where water droplets are present (See the Quality Assurance page), the Water Vapour concentration as found in Annex A of EN 14790 has been reported instead of the calculated value.

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 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-01	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	30/12/2015	
Probe Material	Monel	
Filter Housing Material	Monel	
Impinger Material	Polyethylene	
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 / 3	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.

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	744.8	744.8	744.8	
Stack static pressure, P_{static}	mmH_2O	7.9	7.9	7.9	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	745.3	745.3	745.3	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	25.5	46.5	38.1	
Total mass collected in impingers (silica trap)	g	37.8	17.0	3.3	
Total mass of liquid collected, V_{lc}	g	63.3	63.5	41.4	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0789	0.0791	0.0516	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m^3	2.3479	2.2656	2.0479	
Gas meter correction factor, Y_d	-	1.0580	1.0580	1.0580	
Average dry gas meter temperature, T_m	°C	20.6	23.0	18.6	
Average pressure drop across orifice, ΔH	mmH_2O	19.7	18.6	15.7	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	2.2681	2.1703	1.9906	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0336	0.0352	0.0253	
B_{wo} as a percentage	% v/v	3.36	3.52	2.53	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	2.96	3.14	2.53	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	2.3373	2.2407	2.0421	
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	28.52	28.50	28.57	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.85	0.85	0.85	
Average of velocity heads, ΔP_{avg}	mmH_2O	5.30	4.88	4.23	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	2.30	2.21	2.06	
Average stack gas temperature, T_s	°C	23.5	24.8	28.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	8.10	7.79	7.28	
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	2266.0	2180.5	2037.2	
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	2045.9	1960.3	1811.9	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	1985.3	1898.8	1766.1	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	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	6.05	6.05	6.05	
Nozzle area, A_n	mm^2	28.72	28.72	28.72	
Total sampling time, q	min	180	180	180	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.0	103.1	101.7	

HYDROGEN FLUORIDE(ISO): SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	11:40 - 14:40	14:50 - 17:50	09:22 - 12:22	
Sampling Dates	-	15/12/2015	15/12/2015	16/12/2015	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m^3	2.3373	2.2407	2.0421	
Laboratory Result for Front Impingers	µg/ml	1.06	2.12	9.12	
Laboratory Result for Back Impinger	µg/ml	0.05			
Volume in Front Impingers	ml	507.6	509.2	515.0	
Volume in Back Impinger	ml	232.7			
Mass in Front Impingers	µg	538.1	1079.5	4696.8	
Mass in Back Impinger	µg	< 11.6			
Total Mass Collected	µg	549.7	1079.5	4696.8	
Calculated Concentration	mg/m^3	0.24	0.48	2.30	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	15/12/2015	
Average Volume Sampled (REF)	m^3	2.2067	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	427.3	
Total Mass Collected	µg	< 21.4	
Calculated Concentration	mg/m^3	< 0.01	

HYDROGEN FLUORIDE(ISO): QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3	
Mean Sampling Rate	l/min	13.80	13.32	12.04	
Pre-Sampling Leak Rate	l/min	0.06	0.15	0.09	
Post-Sampling Leak Rate	l/min	0.14	0.11	0.14	
Allowable Leak Rate	l/min	0.28	0.27	0.24	
Leak Test Acceptable	-	Yes	Yes	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	100.0	
Allowable Absorption Efficiency	%	N/A	
Absorption Efficiency Acceptable	-	N/A	

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	-	Yes	Yes	No	

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3	
Measurement Uncertainty (MU)	%	5.0	5.0	5.1	
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	%	103.0	103.1	101.7	
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	24	25	28	

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

HYDROGEN FLUORIDE(ISO): QUALITY ASSURANCE

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Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	15.00	
Pre-Sampling Leak Rate	l/min	0.09	
Post-Sampling Leak Rate	l/min	0.13	
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			
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3	
There are no deviations associated with the sampling employed.	wx	wx	wx	

HYDROGEN FLUORIDE(ISO): MEASUREMENT UNCERTAINTY CALCULATIONS

	Value					Standard uncertainty					
Measured Quantities	**Symbol**	**Run 1**	**Run 2**	**Run 3**		**Symbol**	**Units**	**Run 1**	**Run 2**	**Run 3**	
Sampled Volume (Actual)	V_m	2.3479	2.2656	2.0479		uV_m	m^3	0.0470	0.0453	0.0410	
Sampled Gas Temperature	T_m	293.6	296.0	291.6		uT_m	K	2.0	2.0	2.0	
Sampled Gas Pressure	ρ_m	99.4	99.4	99.4		$u\rho_m$	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	1.01	0.83	1.16		uL	%	-	-	-	
Laboratory Result	L_r	2.65	2.65	2.65		uL_r	%	-	-	-	

	Uncertainty as a Percentage					
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	2.00	2.00		≤2%
Sampled Gas Temperature	%	0.68	0.68	0.69		≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50		≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00		≤1%
Leak	%	1.01	0.83	1.16		≤2%
Laboratory Result	%	2.65	2.65	2.65		No Requirement

	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	2.2681	2.1703	1.9906		0.10	0.22	1.16	
Leak	L	mg/m^3	0.0014	0.0023	0.0154		1.00	1.00	1.00	
Laboratory Result	L_r	mg/m^3	0.006	0.013	0.061		1.00	1.00	1.00	

	Uncertainty in Result				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	
Sampled Volume (STP)	mg/m^3	0.0058	0.0119	0.0561	
Leak	mg/m^3	0.001	0.002	0.015	
Laboratory Result	mg/m^3	0.006	0.013	0.061	

	Oxygen Correction Part of MU Budget				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	
O_2 Correction Factor	-	N/A	N/A	N/A	
Stack Gas O_2 Content	% v/v	N/A	N/A	N/A	
MU for O_2 Correction	-	N/A	N/A	N/A	
Overall MU For O_2 Measurement	%	N/A	N/A	N/A	

Parameter	**Units**	**Run 1**	**Run 2**	**Run 3**	
Combined uncertainty	mg/m^3	0.01	0.02	0.08	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.02	0.03	0.17	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.02	0.03	0.17	
Reported Uncertainty	mg/m^3	0.02	0.03	0.17	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	7.2	7.2	7.2	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	7.2	7.2	7.2	
Reported Uncertainty	%	7.2	7.2	7.2	

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/m³	0.69	1.3		1.0
Uncertainty	±mg/m³	0.05	0.09		0.07
Mass Emission	g/hr	77.6	150		114
Uncertainty	±g/hr	8.7	16.8		12.7

Parameter	Units	Run 1	Run 2		Mean
Water Vapour	% v/v	2.7	2.9		2.8
Uncertainty	±% v/v	0.11	0.12		0.11

General Sampling Information

Parameter	Value	
Standard	ISO 15713	
Technical Procedure	CAT-TP-10	
Name of Analytical Laboratory	CAT	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	30/12/2015	
Probe Material	Monel	
Filter Housing Material	Monel	
Impinger Material	Polyethylene	
Absorption Solution	0.1 mol/l Sodium Hydroxide	
Positioning of Filter	Out 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	A6	

Reference Conditions

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

HYDROGEN FLUORIDE (NON ISO): SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	
Sampling Times	-	18:00 - 00:00	00:10 - 09:10	
Sampling Dates	-	15/12/2015	16/12/2015	
Sampling Device	-	MFC / MV	MFC / MV	
Duration	mins	360	540	
Volume Sampled (STP, Dry)	m^3	3.6455	3.9534	
Volume Sampled (STP, Wet)	m^3	3.7476	4.0696	
Volume Sampled (REF)	m^3	3.7476	4.0696	
Sample Flow Rate	l/min	10.12	7.32	
Laboratory Result for Front Impingers	µg/ml	4.57	9.64	
Laboratory Result for Back Impinger	µg/ml	0.05		
Volume in Front Impingers	ml	567.3	565.7	
Volume in Back Impinger	ml	149.3		
Mass in Front Impingers	µg	2592.6	5453.3	
Mass in Back Impinger	µg	< 7.5		
Total Mass Collected	µg	2600.0	5453.3	
Calculated Concentration	mg/m^3	0.69	1.34	
Liquid Trap Start Mass	g	1814.0	1829.6	
Liquid Trap End Mass	g	1877.2	1915.0	
Silica Trap Start Mass	g	1035.7	1039.6	
Silica Trap End Mass	g	1054.5	1047.5	
Total Mass Of Water Vapour	g	82.0	93.3	
Calculated Water Vapour	% v/v	2.73	2.86	

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

HYDROGEN FLUORIDE (NON ISO): QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	
Mean Sampling Rate	l/min	10.12	7.32	
Pre-Sampling Leak Rate	l/min	0.05	0.05	
Post-Sampling Leak Rate	l/min	0.00	0.04	
Allowable Leak Rate	l/min	0.20	0.15	
Leak Test Acceptable	-	Yes	Yes	

Absorption Efficiency	Units	Run 1	
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)	%	4.0	4.1	
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	

Method Deviations

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

HYDROGEN FLUORIDE (NON ISO): MEASUREMENT UNCERTAINTY CALCULATIONS

	Value				Standard uncertainty				
Measured Quantities	**Symbol**	**Run 1**	**Run 2**		**Symbol**	**Units**	**Run 1**	**Run 2**	
Sampled Volume (STP)	V_m	3.6455	3.9534		uV_m	m^3	0.0729	0.0791	
Leak	L	0.00	0.55		uL	%	-	-	
Laboratory Result	L_r	2.65	2.65		uL_r	%	-	-	

	Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**		**Requirement of Standard**
Sampled Volume (STP)	%	2.00	2.00		≤2%
Leak	%	0.00	0.55		≤2%
Laboratory Result	%	2.65	2.65		No Requirement

	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	3.6455	3.9534		0.19	0.34	
Leak	L	mg/m^3	0.000	0.004		1.00	1.00	
Laboratory Result	L_r	mg/m^3	0.018	0.036		1.00	1.00	

	Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	
Sampled Volume (STP)	mg/m^3	0.0139	0.0268	
Leak	mg/m^3	0.0000	0.0042	
Laboratory Result	mg/m^3	0.0184	0.0355	

	Oxygen Correction Part of MU Budget			
Measured Quantities	**Units**	**Run 1**	**Run 2**	
O_2 Correction Factor	-	N/A	N/A	
Stack Gas O_2 Content	% v/v	N/A	N/A	
MU for O_2 Correction	-	N/A	N/A	
Overall MU For O_2 Measurement	%	N/A	N/A	

Parameter	**Units**	**Run 1**	**Run 2**	
Combined uncertainty	mg/m^3	0.02	0.04	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.05	0.09	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.05	0.09	
Reported Uncertainty	mg/m^3	0.05	0.09	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	6.5	6.5	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	6.5	6.5	
Reported Uncertainty	%	6.5	6.5	