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Stack Emissions Testing Report Commissioned by
British Crystal Ltd

Installation Name & Address
British Crystal Ltd
Unit 14
Pedmore Road Industrial Estate
Brierley Hill
West Midlands
DY5 1TJ

PPC Permit: PB 98 Variation 200839393

Stack Reference
Wet Arrestor

Dates of the Monitoring Campaign
6th September 2016

Job Reference Number
CAT-2917

Report Written by
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Report Date
5th October 2016

Version
Version 1

Signature of Report Approver

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Executive Summary

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MONITORING OBJECTIVES

British Crystal Ltd, Brierley Hill

Wet Arrestor

6th September 2016

Overall Aim of the Monitoring Campaign

Exova Catalyst were commissioned by British Crystal Ltd to carry out stack emissions testing on the Wet Arrestor at Brierley Hill.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Permit.

Special Requirements

There were no special requirements.

Target Parameters

Total Particulate Matter | Lead |

Executive Summary

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MONITORING RESULTS

British Crystal Ltd, Brierley Hill

Wet Arrestor

6th September 2016

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	1.3	0.95	20	g/hr	7.2	5.4	-
Lead	¹ mg/m ³	0.02	0.003	5	g/hr	0.12	0.02	-
Water Vapour	% v/v	0.41	0.04					
Stack Gas Temperature	°C	27.2						
Stack Gas Velocity	m/s	5.3	0.15					
Volumetric Flow Rate (ACTUAL)	m ³ /hr	6278	337					
Volumetric Flow Rate (REF)	¹ m ³ /hr	5730	307					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY 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

British Crystal Ltd, Brierley Hill

Wet Arrestor

6th September 2016

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m ³	1.3	g/hr	7.2	06/09/2016	12:42 - 12:58, 13:01 - 13:17	32
Lead	R1	mg/m ³	0.02	g/hr	0.12	06/09/2016	11:46 - 12:02, 12:06 - 12:22	32
Velocity & Volumetric Flow Rate	R1					06/09/2016	11:08 - 11:18	

All results are expressed at the respective reference conditions.

Executive Summary

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PROCESS DETAILS

British Crystal Ltd, Brierley Hill

Wet Arrestor

6th September 2016

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	Full Extraction
Continuous or Batch Process	Continuous
Feedstock (if applicable)	Glass Cut Offs
Abatement System	N/A
Abatement System Running Status	N/A
Fuel	N/A
Plume Appearance	None Visible

Executive Summary

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MONITORING & ANALYTICAL METHODS

British Crystal Ltd, Brierley Hill

Wet Arrestor

6th September 2016

Parameter	Monitoring				Analysis				MCERTS Testing	LOD (Average)
	Standard	Technical Procedure	ISO 17025 Testing	Testing Lab	Analytical Procedure	Analytical Technique	ISO 17025 Analysis	Analysis Lab		
Total Particulate Matter	EN 13284-1	CAT-TP-01	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.16 mg/m ³
Lead	EN 14385	CAT-TP-06	Yes	CAT	M31	ICP-MS	Yes	RPS	Yes	0.001 mg/m ³
Water Vapour	EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.10 % 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
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All Parameters	All Runs	There are no deviations associated with the sampling employed.

Executive Summary

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SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.65
Width	m	-
Area	m ²	0.33
Port Depth	cm	0
Orientation of Duct	-	Vertical
Sample Port Size	-	4" Hole

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Temporary
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	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 EN 15259, and therefore there are no improvement recommendations.

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	16.0	> 5 Pa	Yes
Mean Velocity	m/s	5.26	-	-
Lowest Gas Velocity	m/s	4.37	-	-
Highest Gas Velocity	m/s	6.65	-	-
Ratio of Above	: 1	1.52	< 3 : 1	Yes
Maximum Angle of Swirl	°	3	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

Executive Summary

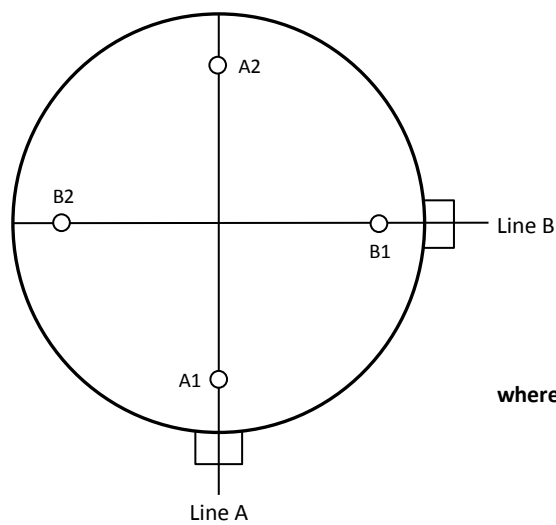
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PLANT PHOTOS

Photo 1



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

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Harpreet Badwal	MCERTS Level 2	MM 03 149	TE1 TE2 TE3 TE4
Trainee	Aaron Nagha	MCERTS Trainee	MM 16 1392	None

LIST OF EQUIPMENT

Extractive Sampling		Instrumental Analysers		Miscellaneous Items	
Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.
Control Box DGM (1)	CAT 7.57	Horiba PG-350E	-	Digital Manometer (1)	CAT 3.142
Control Box DGM (2)	-	Horiba PG-250	-	Digital Manometer (2)	CAT 3.144
Box Thermocouples (1)	CAT 3.146	Servomex 4900	-	Digital Temperature Meter	-
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 14.84
Umbilical (1)	CAT 3.146	ABB AO2020-URAS26	-	Barometer	CAT 13.40
Umbilical (2)	-	Servomex 5200MP	-	Stack Thermocouple (1)	CAT 4.844
Oven Box (1)	CAT 12.109	Ankersmid APS 313	-	Stack Thermocouple (2)	CAT 4.789
Oven Box (2)	-	Gasmet DX4000	-	Stack Thermocouple (3)	CAT 4.013
Heated Probe (1)	CAT 5.126	Gasmet Sampling System	-	1m Heated Line (1)	-
Heated Probe (2)	CAT 5.127	Bernath 3006 FID	-	1m Heated Line (2)	-
Heated Probe (3)	CAT 5.128	M&C PSS	-	1m Heated Line (3)	-
S-Pitot (1)	CAT 21S.57	Mass Flow Controller (1)	-	5m Heated Line (1)	-
S-Pitot (2)	CAT 21P.38	Mass Flow Controller (2)	-	15m Heated Line (1)	-
L-Pitot	-	Mass View (1)	-	20m Heated Line (1)	-
Site Balance	CAT 17.33	Mass View (2)	-	20m Heated Line (2)	-
500g / 1Kg Check Weights	CAT 17.33a & b	Hioki 5043 (V)	-	Dual Channel Heater Controller	-
Last Impinger Arm	CAT 4.844	Easylogger EN-EL-12 Bit	-	Single Channel Heater Controller	-
Callipers	CAT 23.40	Bioaerosols Temperature Logger	-	Laboratory Balance	CAT 1.18 / 1.18a
Tubes Kit Thermocouple	-	Electronic Refrigerator	-	Tape Measure	CAT 16.45

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	CAT-TP-01
Lead	EN 14385	CAT-TP-06
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	0.65
Stack Width, W	m	-
Stack Area, A	m ²	0.33
Average Stack Gas Temperature, T _a	°C	25.3
Average Stack Gas Pressure	Pa	23.8
Average Stack Static Pressure, P _{static}	kPa	0.020
Average Barometric Pressure, P _b	kPa	101.0
Average Pitot Tube Calibration Coefficient, C _p	-	0.84

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m ³ ρ	Conc kg/m ³ ρ _i
CO ₂ (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.0012
O ₂ (Estimated)	-	20.80	20.71	0.2080	32.00	1.4277	0.2970
N ₂	-	79.14	78.82	0.7914	28.01	1.2498	0.9891
Moisture (H ₂ O)	-	-	0.41	0.0041	18.02	0.8037	0.0033

Where: $\rho = M / 22.41$

$\rho_i = r \times \rho$

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	1.285
Dry Density (Actual), P _{Actual}	kg/m ³	1.175
Average Wet Density (Actual), P _{ActualW}	kg/m ³	1.173

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	25.3	0.00
Total Pressure	kPa	101.0	101.3
Moisture	%	0.41	0.41

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m ³ /hr	6278
Gas Volumetric Flowrate (STP, Wet)	m ³ /hr	5730
Gas Volumetric Flowrate (STP, Dry)	m ³ /hr	5706
Gas Volumetric Flowrate REF ¹	m ³ /hr	5730

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	06/09/2016
Time of Survey	-	11:08 - 11:18
Atmospheric Pressure	kPa	101.0
Average Stack Static Pressure	Pa	20
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 210 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C _p	-	0.84
Number of Lines Available	-	2
Number of Lines Used	-	2

Traverse Point	Depth m	Sampling Line A					Sampling Line B				
		ΔP Pa	Temp °C	Wet Density kg/m ³	Velocity m/s	Swirl °	ΔP Pa	Temp °C	Wet Density kg/m ³	Velocity m/s	Swirl °
<i>STATIC (Units: Pa)</i>		21.0					18.0				
Mean		21.0	25.2	1.173	5.00		26.5	25.5	1.172	5.51	
1	0.09	24.0	25.3	1.173	5.36	2.0	16.0	25.4	1.173	4.37	3.0
2	0.56	18.0	25.1	1.174	4.64	3.0	37.0	25.5	1.172	6.65	3.0

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

(1 of 1)

Performance characteristics (Uncertainty Components)	Uncertainty	Value	Units
Standard Uncertainty on the coefficient of the Pitot Tube	$u(k)$	0.005	-
Standard Uncertainty associated with the mean local dynamic pressures	$u(\Delta p_i)$	1.075	Pa
- Resolution	$u(res)$	0.00087	
- Calibration	$u(cal)$	0.059	
- Drift	$u(drift)$	0.083	
- Lack of Fit	$u(fit)$	0.013	
- Overall corrections to dynamic measurements	$u(C_f)$	0.156	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00003	-
- $\phi_{O_2,w}$	-	20.715	
- $\phi_{CO_2,w}$	-	0.060	
- Oxygen, dry	$u(\phi_{O_2,d})$	0.637	
- Carbon Dioxide, dry	$u(\phi_{CO_2,d})$	0.002	
- Water Vapour	$u(\phi_{H_2O})$	0.021	
- Oxygen, wet	$u(\phi_{O_2,w})$	0.634	
- Carbon Dioxide, wet	$u(\phi_{CO_2,w})$	0.002	
Standard uncertainty associated with the stack temperature	$u(T_c)$	1.522	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.694	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	0.760	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00632	-
Standard uncertainty associated with the local velocities	$u(v_i)$	0.134	Pa
Standard uncertainty associated with the mean velocity	$u(\bar{v})$	0.077	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	0.151	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	2.87	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV,w)$	336.6	m ³ /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00075	
- $u^2(qV,w)$	-	29496	
- $u(qV,w)$	-	171.7	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV,w)$	5.36	%

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

British Crystal Ltd, Brierley Hill
Wet Arrestor

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	1.3	1.3
Uncertainty	±mg/m ³	0.95	0.95
Mass Emission	g/hr	7.2	7.2
Uncertainty	±g/hr	5.4	5.4

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	0.56	0.56
Uncertainty	±% v/v	0.04	0.04

Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m ³	0.79	0.79

General Sampling Information

Parameter	Value
Standard	EN 13284-1
Technical Procedure	CAT-TP-01
Probe Material	Titanium
Filter Housing Material	Titanium
Positioning of Filter	In Stack
Filter Size and Material	47mm Glass Fibre
Number of Sampling Lines Used	2 / 2
Number of Sampling Points Used	4 / 4
Sample Point I.D.'s	A1, A2, B1 & B2

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

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

TOTAL PARTICULATE MATTER: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P _b	mmHg	757.5	
Stack static pressure, P _{static}	mmH ₂ O	2.1	
P _s = (P _b + (P _{static} / 13.6))	mmHg	757.7	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	-2.5	
Total mass collected in impingers (silica trap)	g	6.4	
Total mass of liquid collected, V _{lc}	g	3.9	
V _{wstd} = (0.001246)(V _{lc})	m ³	0.0049	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V _m	m ³	0.9572	
Gas meter correction factor, Y _d	-	0.9920	
Average dry gas meter temperature, T _m	°C	31.0	
Average pressure drop across orifice, ΔH	mmH ₂ O	86.7	
V _{mstd} = ((0.3592)(V _m)(P _b + (ΔH/13.6))(Y _d)) / (T _m + 273)	m ³	0.8570	
Moisture content, B_{w0} & R_{wv}			
B _{w0} = V _{wstd} / (V _{mstd} + V _{wstd})	m ³	0.0056	
B _{w0} as a percentage	% v/v	0.56	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	0.56	
Volume of gas metered wet, V_{mstw}			
V _{mstw} = (V _{mstd})(100/(100 - R _{wv}))	m ³	0.8619	
Volume of gas metered at Oxygen Reference Conditions, V_{mstd@X%O₂} & V_{mstw@X%O₂}			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	N/A	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	N/A	
% oxygen reference condition, REF%O ₂	% v/v	N/A	
O ₂ Reference Factor wet (O _{2REFw}) = (21 - REF%O ₂) / (21 - ACT%O _{2w})	-	N/A	
O ₂ Reference Factor dry (O _{2REFd}) = (21 - REF%O ₂) / (21 - ACT%O _{2d})	-	N/A	
V _{mstw@X%oxygen} = (V _{mstw}) / (O _{2REFw})	m ³	N/A	
V _{mstd@X%oxygen} = (V _{mstd}) / (O _{2REFd})	m ³	N/A	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	0.06	
O ₂ (Estimated)	% v/v	20.60	
Total	% v/v	20.66	
N ₂	% v/v	79.34	
M _d = 0.44(%CO ₂)+0.32(%O ₂)+0.28(%N ₂)	g/gmol	28.83	
Molecular weight of stack gas (wet), M_s			
M _s = M _d (1 - (R _{wv} /100)) + 18(R _{wv} /100)	g/gmol	28.77	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K _p	-	34.97	
Velocity pressure coefficient, C _p	-	0.84	
Average of velocity heads, ΔP _{avg}	mmH ₂ O	3.00	
Average square root of velocity heads, √ΔP	√mmH ₂ O	1.73	
Average stack gas temperature, T _s	°C	27.4	
V _s = ((K _p)(C _p)(√ΔP)(√T _s + 273)) / (√(M _s)(P _s))	m/s	5.99	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO₂}), Dry@O_{2REF} (Q_{stdO₂})			
Area of stack, A _s	m ²	0.33	
Q _a = (60)(A _s)(V _s)	m ³ /min	119.2	
Conversion factor (K/mm.Hg), C _f	-	0.3592	
Q _{stw} = ((Q _a)(P _s)(C _f)) / ((T _s + 273)	m ³ /min	108.0	
Q _{std} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s + 273)	m ³ /min	107.4	
Q _{stwO₂} = ((Q _a)(P _s)(C _f)) / ((T _s + 273) / (O _{2REFw}))	m ³ /min	N/A	
Q _{stdO₂} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s + 273) / (O _{2REFd}))	m ³ /min	N/A	
Percent isokinetic, %I			
Nozzle diameter, D _n	mm	9.99	
Nozzle area, A _n	mm ²	78.39	
Total sampling time, q	min	32	
%I = (4.6398E ⁹)(T _s +273)(V _{mstd}) / (P _s)(V _s)(A _n)(q)(1 - (R _{wv} /100))	%	105.6	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	12:42 - 12:58, 13:01 - 13:17	
Sampling Dates	-	06/09/2016	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	0.8619	
Filter I.D. Number	-	47-35459	
Start Filter Mass	g	0.13953	
End Filter Mass	g	0.14039	
Total Mass on Filter	g	0.00086	
Probe Rinse I.D. Number	-	PR-47-35459	
Start Probe Rinse Mass	g	3.16685	
End Probe Rinse Mass	g	3.16708	
Total Mass in Probe Rinse	g	0.00022	
Total Mass Collected	mg	1.08	
Calculated Concentration	mg/m ³	1.25	
Balance Uncertainty / LOD	mg/m ³	0.16	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	06/09/2016	
Average Volume Sampled (REF)	m ³	0.8619	
Filter I.D. Number	-	47-35452	
Start Filter Mass	g	0.14075	
End Filter Mass	g	0.14142	
Total Mass on Filter	g	0.00067	
Probe Rinse I.D. Number	-	PR-47-35452	
Start Probe Rinse Mass	g	2.99104	
End Probe Rinse Mass	g	2.99104	
Total Mass in Probe Rinse	g	0.00000	
Total Mass Collected	mg	0.68	
Calculated Concentration	mg/m ³	0.79	
Balance Uncertainty / LOD	mg/m ³	0.16	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	29.7	
Pre-Sampling Leak Rate	l/min	0.09	
Post-Sampling Leak Rate	l/min	0.09	
Allowable Leak Rate	l/min	0.59	
Leak Test Acceptable	-	Yes	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	7.6	
Allowable MU	%	20	
MU Acceptable	%	Yes	

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

Isokinetic Criterion Compliance	Units	Run 1	
Isokinetic Variation	%	105.6	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

Weighing Uncertainty Criteria	Units	Run 1	
Overall Weighing Uncertainty	± mg	0.27	
Overall Weighing Uncertainty	± mg/m ³	0.31	
ELV [Daily ELV for IED]	mg/m ³	20.0	
Allowable Weighing Uncertainty	mg/m ³	1.00	
Weighing Uncertainty Acceptable	-	Yes	

Filter Temperatures	Units	Run 1	
Pre-Conditioning Temperature	°C	180	
Post-Conditioning Temperature	°C	160	
Maximum Filter Temperature	°C	28	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

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Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	18.0	
Pre-Sampling Leak Rate	l/min	0.08	
Post-Sampling Leak Rate	l/min	0.06	
Allowable Leak Rate	l/min	0.36	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	2.0	
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
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1
There are no deviations associated with the sampling employed.	wx

TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	0.96		uV _m	m ³	0.02	
Sampled Gas Temperature	T _m	304.0		uT _m	K	2.00	
Sampled Gas Pressure	p _m	101.0		uρ _m	kPa	0.50	
Sampled Gas Humidity	H _m	0.00		uH _m	% v/v	1.00	
Leak	L	0.30		uL	%	-	
Mass of Particulate	m	1.08		um	mg	0.14	
Uncollected Mass	UCM	0.68		uUCM	mg	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.66		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.30		≤2%
Mass of Particulate	%	0.81		<5% of ELV
Uncollected Mass	%	-		-

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	0.86		1.46	
Leak	L	mg/m ³	0.00		1.00	
Mass of Particulate	L _r	mg	1.08		1.16	
Uncollected Mass	UCM	mg	0.39		1.16	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.03	
Leak	mg/m ³	0.00	
Mass of Particulate	mg/m ³	0.16	
Uncollected Mass	mg/m ³	0.45	

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

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	0.48	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.95	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.95	
Reported Uncertainty	mg/m ³	0.95	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	75.5	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	75.5	
Reported Uncertainty	%	75.5	

LEAD: RESULTS SUMMARY

British Crystal Ltd, Brierley Hill
Wet Arrestor

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	0.02	0.02
Uncertainty	±mg/m ³	0.003	0.003
Mass Emission	g/hr	0.12	0.12
Uncertainty	±g/hr	0.02	0.02

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	0.26	0.26
Uncertainty	±% v/v	0.04	0.04

Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m ³	< 0.0008	< 0.0008

General Sampling Information

Parameter	Value
Standard	EN 14385
Technical Procedure	CAT-TP-06
Name of Analytical Laboratory	RPS
Analytical Laboratory's Procedure	M31
ISO 17025 Accredited Analysis?	Yes
Date of Sample Analysis	20/09/2016
Probe Material	Titanium
Filter Housing Material	Borosilicate Glass
Impinger Material	Borosilicate Glass
Absorption Solution	Nitric Peroxide
Positioning of Filter	Out Stack
Filter Size and Material	47mm Quartz Fibre
Number of Sampling Lines Used	2 / 2
Number of Sampling Points Used	4 / 4
Sample Point I.D.'s	A1, A2, B1 & B2

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

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

LEAD: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P _b	mmHg	757.5	
Stack static pressure, P _{static}	mmH ₂ O	2.1	
P _s = (P _b + (P _{static} / 13.6))	mmHg	757.7	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	-2.9	
Total mass collected in impingers (silica trap)	g	4.4	
Total mass of liquid collected, V _{lc}	g	1.5	
V _{wstd} = (0.001246)(V _{lc})	m ³	0.0019	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V _m	m ³	0.8048	
Gas meter correction factor, Y _d	-	0.9920	
Average dry gas meter temperature, T _m	°C	27.1	
Average pressure drop across orifice, ΔH	mmH ₂ O	62.8	
V _{mstd} = ((0.3592)(V _m)(P _b + (ΔH/13.6))(Y _d)) / (T _m + 273)	m ³	0.7282	
Moisture content, B_{w0} & R_{wv}			
B _{w0} = V _{wstd} / (V _{mstd} + V _{wstd})	m ³	0.0026	
B _{w0} as a percentage	% v/v	0.26	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	0.26	
Volume of gas metered wet, V_{mstw}			
V _{mstw} = (V _{mstd})(100/(100 - R _{wv}))	m ³	0.7301	
Volume of gas metered at Oxygen Reference Conditions, V_{mstd@X%O₂} & V_{mstw@X%O₂}			
IED & Incinerates Hazardous Material? (Yes = no positive O ₂ correction)	-	No	
% wet oxygen measured in gas stream, ACT%O _{2w}	% v/v	N/A	
% dry oxygen measured in gas stream, ACT%O _{2d}	% v/v	N/A	
% oxygen reference condition, REF%O ₂	% v/v	N/A	
O ₂ Reference Factor wet (O _{2REFw}) = (21 - REF%O ₂) / (21 - ACT%O _{2w})	-	N/A	
O ₂ Reference Factor dry (O _{2REFd}) = (21 - REF%O ₂) / (21 - ACT%O _{2d})	-	N/A	
V _{mstw@X%oxygen} = (V _{mstw}) / (O _{2REFw})	m ³	N/A	
V _{mstd@X%oxygen} = (V _{mstd}) / (O _{2REFd})	m ³	N/A	
Molecular weight of dry gas stream, M_d			
CO ₂ (Estimated)	% v/v	0.06	
O ₂ (Estimated)	% v/v	20.60	
Total	% v/v	20.66	
N ₂	% v/v	79.34	
M _d = 0.44(%CO ₂)+0.32(%O ₂)+0.28(%N ₂)	g/gmol	28.83	
Molecular weight of stack gas (wet), M_s			
M _s = M _d (1 - (R _{wv} /100)) + 18(R _{wv} /100)	g/gmol	28.81	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K _p	-	34.97	
Velocity pressure coefficient, C _p	-	0.84	
Average of velocity heads, ΔP _{avg}	mmH ₂ O	2.20	
Average square root of velocity heads, √ΔP	√mmH ₂ O	1.48	
Average stack gas temperature, T _s	°C	27.0	
V _s = ((K _p)(C _p)(√ΔP)(√T _s + 273)) / (√(M _s)(P _s))	m/s	5.12	
Total flow of stack gas: Actual (Q_a), Wet (Q_{stw}), Dry (Q_{std}), Wet@O_{2REF} (Q_{stwO₂}), Dry@O_{2REF} (Q_{stdO₂})			
Area of stack, A _s	m ²	0.33	
Q _a = (60)(A _s)(V _s)	m ³ /min	102.0	
Conversion factor (K/mm.Hg), C _f	-	0.3592	
Q _{stw} = ((Q _a)(P _s)(C _f)) / ((T _s + 273)	m ³ /min	92.5	
Q _{std} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s + 273)	m ³ /min	92.3	
Q _{stwO₂} = ((Q _a)(P _s)(C _f)) / ((T _s + 273) / (O _{2REFw}))	m ³ /min	N/A	
Q _{stdO₂} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s + 273) / (O _{2REFd}))	m ³ /min	N/A	
Percent isokinetic, %I			
Nozzle diameter, D _n	mm	9.99	
Nozzle area, A _n	mm ²	78.39	
Total sampling time, q	min	32	
%I = (4.6398E ⁶)(T _s +273)(V _{mstd}) / (P _s)(V _s)(A _n)(q)(1 - (R _{wv} /100))	%	104.4	

LEAD: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	11:46 - 12:02, 12:06 - 12:22	
Sampling Dates	-	06/09/2016	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	0.7301	
Mass on Filter / in Rinse	µg	13.00	
Mass in Front Impingers	µg	1.39	
Mass in Back Impinger	µg	0.47	
Total Mass Collected	µg	14.86	
Calculated Concentration	mg/m ³	0.0204	
Reported Concentration	mg/m ³	0.0204	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	06/09/2016	
Average Volume Sampled (REF)	m ³	0.7301	
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.05	
Mass in Back Impinger	µg	< 0.02	
Total Mass Collected	µg	< 0.57	
Calculated Concentration	mg/m ³	< 0.0008	
Reported Concentration	mg/m ³	< 0.0008	

LEAD: QUALITY ASSURANCE

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Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	24.9	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.08	
Allowable Leak Rate	l/min	0.50	
Leak Test Acceptable	-	Yes	
Absorption Efficiency			
Absorption Efficiency	%	96.8	
Allowable Absorption Efficiency	%	N/A	
Absorption Efficiency Acceptable	-	N/A	
Where the emissions are < 30% of the ELV, MID 14385 does not require the 90% absorption efficiency requirement to be applied			
Detection Limit			
Detection Limit	µg/m ³	0.8	
Allowable Detection Limit	µg/m ³	5	
Detection Limit Acceptable	-	Yes	
Water Droplets			
Are Water Droplets Present	-	No	
MU (Concurrent Water Vapour)			
Measurement Uncertainty (MU)	%	15.3	
Allowable MU	%	20	
MU Acceptable	%	Yes	
Silica Gel (Concurrent Water Vapour)			
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance			
Isokinetic Variation	%	104.4	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	
Filter Temperatures			
Maximum Filter Temperature	°C	160	
Impingers Exit Temperature			
Maximum Temperature Recorded	°C	16	
Maximum Allowable Temperature	°C	30	
Exit Temperature Acceptable	-	Yes	
Test Conditions			
Ambient Temperature Recorded?	-	Yes	

APPENDIX 2

LEAD: QUALITY ASSURANCE

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Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	18.0	
Pre-Sampling Leak Rate	l/min	0.08	
Post-Sampling Leak Rate	l/min	0.09	
Allowable Leak Rate	l/min	0.36	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m ³	0.50	
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
There are no deviations associated with the sampling employed.	wx	

LEAD: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	0.80		uV _m	m ³	0.02	
Sampled Gas Temperature	T _m	300.1		uT _m	K	2.00	
Sampled Gas Pressure	p _m	101.0		uρ _m	kPa	0.50	
Sampled Gas Humidity	H _m	0.00		uH _m	% v/v	1.00	
Leak	L	0.32		uL	%	-	
Laboratory Result	L _r	7.50		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.67		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.32		≤2%
Laboratory Result	%	7.50		No Requirement

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	0.73		0.03	
Leak	L	mg/m ³	0.00004		1.00	
Laboratory Result	L _r	mg/m ³	0.0015		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.0005	
Leak	mg/m ³	0.00004	
Laboratory Result	mg/m ³	0.0015	

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

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	0.0016	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.0032	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.0032	
Reported Uncertainty	mg/m ³	0.0032	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	15.5	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	15.5	
Reported Uncertainty	%	15.5	