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Stack Emissions Testing Report Commissioned by
Brierley British Crystal

Installation Name & Address
Brierley British Crystal
Unit 24
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
29th November 2017

Job Reference Number
CAT-3854

Report Written by
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Report Date
15th December 2017

Version
Version 1

Signature of Report Approver



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Executive Summary

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MONITORING OBJECTIVES

Brierley British Crystal, West Midlands

Wet Arrestor

29th November 2017

Overall Aim of the Monitoring Campaign

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

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

MONITORING RESULTS

Brierley British Crystal, West Midlands

Wet Arrestor

29th November 2017

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration				Mass Emission			
	Units	Result	MU +/-	Limit	Units	Result	MU +/-	Limit
Total Particulate Matter	¹ mg/m ³	1.4	0.30	20	g/hr	5.6	1.2	-
Lead	¹ mg/m ³	0.24	0.03	5	g/hr	0.92	0.14	-
Water Vapour	% v/v	2.0	0.10					
Stack Gas Temperature	°C	12.6						
Stack Gas Velocity	m/s	3.5	0.19					
Volumetric Flow Rate (ACTUAL)	m ³ /hr	4127	290					
Volumetric Flow Rate (REF)	¹ m ³ /hr	3920	275					

NOTE: VOLUMETRIC FLOW RATE & VELOCITY 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

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MONITORING DATE(S) & TIMES

Brierley British Crystal, West Midlands

Wet Arrestor

29th November 2017

Parameter	Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1 mg/m ³	1.4	g/hr	5.6	29/11/2017	11:08 - 12:08	60
Lead	R1 mg/m ³	0.24	g/hr	0.92	29/11/2017	12:30 - 13:30	60
Velocity & Volumetric Flow Rate	R1				29/11/2017	09:20 - 09:26	

All results are expressed at the respective reference conditions.

Executive Summary

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PROCESS DETAILS

Brierley British Crystal, West Midlands

Wet Arrestor

29th November 2017

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	Full Extaction
Continuous or Batch Process	Contuous
Feedstock (if applicable)	Glass Cut Offs
Abatement System	Water Trough
Abatement System Running Status	On
Fuel	N/A
Plume Appearance	No Visible Plume

MONITORING & ANALYTICAL METHODS

Brierley British Crystal, West Midlands

Wet Arrestor

29th November 2017

Parameter	Monitoring				Analysis				MCERTS Testing	LOD (Average)
	Standard	Technical Procedure	ISO 17025 Testing	Testing Lab	Analytical Procedure	Analytical Technique	ISO 17025 Analysis	Analysis Lab		
Total Particulate Matter	EN 13284-1	CAT-TP-01	Yes	CAT	CAT-TP-03	Gravimetric	Yes	CAT	Yes	0.14 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
Total Particulate Matter & Lead	All Runs	One out of two sampling lines was used due to sampling location restrictions, however the number of sample points used on the available line were increased to the minimum required by the Standard

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
Number of Ports	-	2
Sample Port Size	-	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	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)

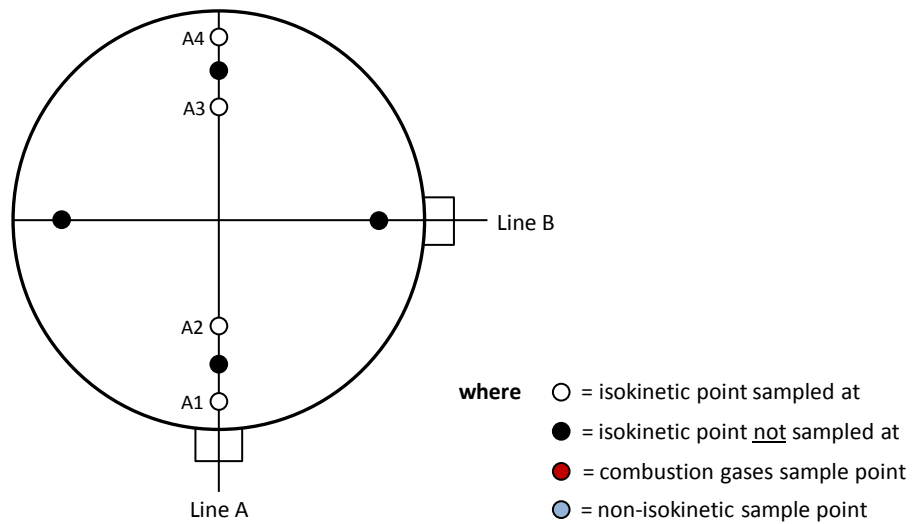
Criteria in EN 15259	Units	Traverse 1	Required	Compliant
Lowest Differential Pressure	Pa	8.5	> 5 Pa	Yes
Mean Velocity	m/s	6.88	-	-
Lowest Gas Velocity	m/s	3.40	-	-
Highest Gas Velocity	m/s	10.28	-	-
Ratio of Above	: 1	3.02	< 3 : 1	No
Maximum Angle of Swirl	°	2	< 15°	Yes
No Local Negative Flow	-	Yes	-	Yes

PLANT PHOTOS

Photo 1



SAMPLE POINTS





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	Andrew Shipley	MCERTS Level 2	MM13 1243	TE1 TE2 TE3 TE4
Trainee	Michael Biagioni	MCERTS Trainee	MM17 1444	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 7.60	Horiba PG-250	-	Digital Manometer (1)	CAT 3.86
Control Box DGM (2)	-	Horiba PG-250	-	Digital Manometer (2)	-
Box Thermocouples (1)	CAT 3.159	Servomex 4900	-	Digital Temperature Meter	CAT 3.86
Box Thermocouples (2)	-	Eco Physics CLD 822Mh	-	Stopwatch	CAT 15.53
Umbilical (1)	CAT 7.60	ABB AO2020-URAS26	-	Barometer	CAT 13.43
Umbilical (2)	-	Testo 350 XL	-	Stack Thermocouple (1)	CAT 4.876
Oven Box (1)	CAT 21.113	JCT JCC P1 Cooler	-	Stack Thermocouple (2)	CAT 4.877
Oven Box (2)	-	Gasmet DX4000	-	Stack Thermocouple (3)	-
Heated Probe (1)	CAT 5.136	Gasmet Sampling System	-	1m Heated Line (1)	-
Heated Probe (2)	-	Bernath 3006 FID	-	1m Heated Line (2)	-
Heated Probe (3)	-	Ankersmid APP100	-	1m Heated Line (3)	-
S-Pitot (1)	CAT 219.44	Mass Flow Controller (1)	-	5m Heated Line (1)	-
S-Pitot (2)	CAT 21S.59	Mass Flow Controller (2)	-	15m Heated Line (1)	-
L-Pitot	-	Mass View (1)	-	20m Heated Line (1)	-
Site Balance	CAT 17.36	Mass View (2)	-	20m Heated Line (2)	-
500g / 1Kg Check Weights	CAT 17.36	Easylogger EN-EL-12 Bit	-	Dual Channel Heater Controller	-
Last Impinger Arm	-	Easylogger EN-EL-12 Bit	-	Single Channel Heater Controller	-
Callipers	CAT 23.42	Bioaerosols Temperature Logger	-	Laboratory Balance	CAT 1.18 / 1.18a
Tubes Kit Thermocouple	-	Electronic Refrigerator	-	Tape Measure	CAT 40.3

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	11.5
Average Stack Gas Pressure	Pa	10.2
Average Stack Static Pressure, P _{static}	kPa	-0.01
Average Barometric Pressure, P _b	kPa	100.7
Average Pitot Tube Calibration Coefficient, C _p	-	0.85

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	20.39	0.2080	32.00	1.4277	0.2970
N ₂	-	79.14	77.59	0.7914	28.01	1.2498	0.9891
Moisture (H ₂ O)	-	-	1.96	0.0196	18.02	0.8037	0.0158

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	1.2873
Wet Density (STP), P _{STW}	kg/m ³	1.2778
Dry Density (Actual), P _{Actual}	kg/m ³	1.2277
Average Wet Density (Actual), P _{ActualW}	kg/m ³	1.2187

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	11.5	0.00
Total Pressure	kPa	100.7	101.3
Moisture	%	1.96	1.96

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m ³ /hr	8215
Gas Volumetric Flowrate (STP, Wet)	m ³ /hr	7835
Gas Volumetric Flowrate (STP, Dry)	m ³ /hr	7681
Gas Volumetric Flowrate REF ¹	m ³ /hr	7835

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	29/11/2017
Time of Survey	-	09:20 - 09:26
Atmospheric Pressure	kPa	100.7
Average Stack Static Pressure	Pa	-6
Result of Pitot Stagnation Test	-	Pass
Are Water Droplets Present?	-	No
Device Used	S-Type Pitot with KIMO MP 200 (500Pa)	

Parameter	Units	Value
Initial Pitot Leak Check	-	Pass
Final Pitot Leak Check	-	Pass
Orientation of Duct	-	Vertical
Pitot Tube, C_p	-	0.85
Number of Lines Available	-	1
Number of Lines Used	-	1

Sampling Line A										
Traverse Point	Depth m	ΔP Pa	Temp °C	Wet Density kg/m^3	Velocity m/s	Swirl °				
<i>STATIC (Units: Pa)</i>		-5.5					-6.2			
Mean		11.6	11.3	1.220	3.67		8.9	11.8	1.218	10.08
1	0.09	13.3	11.0	1.221	3.94	0.0	9.2	11.7	1.218	10.28
2	0.56	9.9	11.5	1.219	3.40	0.0	8.5	11.9	1.217	9.88

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	$u(\Delta p_i)$	1.047	Pa
- Resolution	$u(res)$	0.00087	
- Calibration	$u(cal)$	0.011	
- Drift	$u(drift)$	0.083	
- Lack of Fit	$u(fit)$	0.001	
- Overall corrections to dynamic measurements	$u(C_f)$	0.096	
Standard uncertainty associated with the molar mass of the gas	$u(M)$	0.00003	-
- $\phi_{O_2,w}$	-	20.392	
- $\phi_{CO_2,w}$	-	0.059	
- Oxygen, dry	$u(\phi_{O_2,d})$	0.637	
- Carbon Dioxide, dry	$u(\phi_{CO_2,d})$	0.002	
- Water Vapour	$u(\phi_{H_2O})$	0.100	
- Oxygen, wet	$u(\phi_{O_2,w})$	0.625	
- Carbon Dioxide, wet	$u(\phi_{CO_2,w})$	0.002	
Standard uncertainty associated with the stack temperature	$u(T_c)$	1.452	K
Standard uncertainty associated with the absolute pressure in the duct	$u(p_c)$	175.695	Pa
- Atmospheric Pressure	$u(p_{atm})$	175.692	
- Static Pressure	$u(p_{stat})$	1.047	
Standard uncertainty associated with the density in the duct	$u(\rho)$	0.00657	-
Standard uncertainty associated with the local velocities	$u(v_i)$	0.386	Pa
Standard uncertainty associated with the mean velocity	$u(\bar{v})$	0.188	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	$U_c(v)$	0.369	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	$U_{c,rel}(v)$	5.36	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	$U_c(qV,w)$	576.4	m ³ /hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00128	
- $u^2(qV,w)$	-	86495	
- $u(qV,w)$	-	294.1	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	$U_{c,rel}(qV,w)$	7.02	%

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Brierley British Crystal, West Midlands
Wet Arrestor

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	1.4	1.4
Uncertainty	±mg/m ³	0.30	0.30
Mass Emission	g/hr	5.6	5.6
Uncertainty	±g/hr	1.2	1.2

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	2.85	2.85
Uncertainty	±% v/v	0.15	0.15

Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m ³	0.14	0.14

NOTE: Where the Balance Uncertainty / Limit of Detection is higher than the Blank concentration, the Balance Uncertainty / Limit of Detection concentration has been reported.

General Sampling Information

Parameter	Value
Standard	EN 13284-1
Technical Procedure	CAT-TP-01
Probe Material	Titanium
Filter Housing Material	Titanium
Positioning of Filter	In Stack
Filter Size and Material	47mm Glass Fibre
Number of Sampling Lines Used	1 / 2
Number of Sampling Points Used	4 / 4
Sample Point I.D.'s	A1 - A4

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, 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	755.3	
Stack static pressure, P _{static}	mmH ₂ O	-0.6	
P _s = (P _b + (P _{static} / 13.6))	mmHg	755.2	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	17.1	
Total mass collected in impingers (silica trap)	g	6.2	
Total mass of liquid collected, V _{lc}	g	23.3	
V _{wstd} = (0.001246)(V _{lc})	m ³	0.0290	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V _m	m ³	1.0457	
Gas meter correction factor, Y _d	-	0.9720	
Average dry gas meter temperature, T _m	°C	7.0	
Average pressure drop across orifice, ΔH	mmH ₂ O	29.0	
V _{mstd} = ((0.3592)(V _m)(P _b + (ΔH/13.6))(Y _d)) / (T _m + 273)	m ³	0.9876	
Moisture content, B_{w0} & R_{wv}			
B _{w0} = V _{wstd} / (V _{mstd} + V _{wstd})	m ³	0.0286	
B _{w0} as a percentage	% v/v	2.86	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	2.85	
Volume of gas metered wet, V_{mstw}			
V _{mstw} = (V _{mstd})(100/(100 - R _{wv}))	m ³	1.0166	
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	20.80	
Total	% v/v	20.86	
N ₂	% v/v	79.14	
M _d = 0.44(%CO ₂)+0.32(%O ₂)+0.28(%N ₂)	g/gmol	28.84	
Molecular weight of stack gas (wet), M_s			
M _s = M _d (1 - (R _{wv} /100)) + 18(R _{wv} /100)	g/gmol	28.53	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K _p	-	34.97	
Velocity pressure coefficient, C _p	-	0.85	
Average of velocity heads, ΔP _{avg}	mmH ₂ O	1.03	
Average square root of velocity heads, √ΔP	√mmH ₂ O	1.02	
Average stack gas temperature, T _s	°C	12.7	
V _s = ((K _p)(C _p)(√ΔP)(√T _s + 273)) / (√(M _s)(P _s))	m/s	3.46	
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	68.9	
Conversion factor (K/mm.Hg), C _f	-	0.3592	
Q _{stw} = ((Q _a)(P _s)(C _f)) / ((T _s + 273)	m ³ /min	65.4	
Q _{std} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s + 273)	m ³ /min	63.5	
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	9.96	
Nozzle area, A _n	mm ²	77.87	
Total sampling time, q	min	60	
%I = (4.6398E ⁹)(T _s +273)(V _{mstd}) / (P _s)(V _s)(A _n)(q)(1 - (R _{wv} /100))	%	110.4	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	11:08 - 12:08	
Sampling Dates	-	29/11/2017	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	1.0169	
Filter I.D. Number	-	47-47339	
Start Filter Mass	g	0.14722	
End Filter Mass	g	0.14835	
Total Mass on Filter	g	0.00113	
Probe Rinse I.D. Number	-	PR-47-47339	
Start Probe Rinse Mass	g	3.03381	
End Probe Rinse Mass	g	3.03415	
Total Mass in Probe Rinse	g	0.00034	
Total Mass Collected	mg	1.46	
Calculated Concentration	mg/m ³	1.44	
Balance Uncertainty / LOD	mg/m ³	0.14	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	29/11/2017	
Average Volume Sampled (REF)	m ³	1.0169	
Filter I.D. Number	-	47-47338	
Start Filter Mass	g	0.16475	
End Filter Mass	g	0.16476	
Total Mass on Filter	g	0.00001	
Probe Rinse I.D. Number	-	PR-47-47338	
Start Probe Rinse Mass	g	2.99356	
End Probe Rinse Mass	g	2.99364	
Total Mass in Probe Rinse	g	0.00008	
Total Mass Collected	mg	0.09	
Calculated Concentration	mg/m ³	0.09	
Balance Uncertainty / LOD	mg/m ³	0.14	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

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Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	16.9	
Pre-Sampling Leak Rate	l/min	0.06	
Post-Sampling Leak Rate	l/min	0.09	
Allowable Leak Rate	l/min	0.34	
Leak Test Acceptable	-	Yes	
Water Droplets			
Are Water Droplets Present	-	No	
MU (Concurrent Water Vapour)			
Measurement Uncertainty (MU)	%	5.1	
Allowable MU	%	20	
MU Acceptable	%	Yes	
Silica Gel (Concurrent Water Vapour)			
Less than 50% Faded	%	Yes	
Isokinetic Criterion Compliance			
Isokinetic Variation	%	110.4	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	
Weighing Uncertainty Criteria			
Overall Weighing Uncertainty	± mg	0.25	
Overall Weighing Uncertainty	± mg/m ³	0.25	
ELV [Daily ELV for IED]	mg/m ³	20.0	
Allowable Weighing Uncertainty	mg/m ³	1.00	
Weighing Uncertainty Acceptable	-	Yes	
Filter Temperatures			
Pre-Conditioning Temperature	°C	180	
Post-Conditioning Temperature	°C	160	
Maximum Filter Temperature	°C	13	
Test Conditions			
Ambient Temperature Recorded?	-	No	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	20.0	
Pre-Sampling Leak Rate	l/min	0.02	
Post-Sampling Leak Rate	l/min	0.02	
Allowable Leak Rate	l/min	0.40	
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
One out of two sampling lines was used due to sampling location restrictions, however the number of sample points used on the available line were increased to the minimum required by the Standard	x

TOTAL PARTICULATE MATTER: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	1.05		uV _m	m ³	0.02	
Sampled Gas Temperature	T _m	280.0		uT _m	K	2.00	
Sampled Gas Pressure	p _m	100.7		uρ _m	kPa	0.50	
Sampled Gas Humidity	H _m	0.00		uH _m	% v/v	1.00	
Leak	L	0.53		uL	%	-	
Mass of Particulate	m	1.46		um	mg	0.14	
Uncollected Mass	UCM	0.09		uUCM	mg	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.71		≤1%
Sampled Gas Pressure	%	0.50		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.53		≤2%
Mass of Particulate	%	0.69		<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	0.99		1.46	
Leak	L	mg/m ³	0.00		1.00	
Mass of Particulate	L _r	mg	1.46		0.98	
Uncollected Mass	UCM	mg	0.05		0.98	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.04	
Leak	mg/m ³	0.00	
Mass of Particulate	mg/m ³	0.14	
Uncollected Mass	mg/m ³	0.05	

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	0.15	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.30	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.30	
Reported Uncertainty	mg/m ³	0.30	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	20.6	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.6	
Reported Uncertainty	%	20.6	

LEAD: RESULTS SUMMARY

Brierley British Crystal, West Midlands
Wet Arrestor

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	0.24	0.24
Uncertainty	±mg/m ³	0.03	0.03
Mass Emission	g/hr	0.92	0.92
Uncertainty	±g/hr	0.14	0.14

Parameter	Units	Run 1	Mean
Water Vapour	% v/v	1.07	1.07
Uncertainty	±% v/v	0.06	0.06

Blank Runs

Parameter	Units	Blank 1	Maximum
Concentration	mg/m ³	< 0.0006	< 0.0006

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	13/12/2017
Probe Material	Titanium
Filter Housing Material	Titanium
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	1 / 2
Number of Sampling Points Used	4 / 4
Sample Point I.D.'s	A1 - A4

FORMAT: Number Used / Number Required

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, 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	755.3	
Stack static pressure, P _{static}	mmH ₂ O	-0.6	
P _s = (P _b + (P _{static} / 13.6))	mmHg	755.2	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	6.0	
Total mass collected in impingers (silica trap)	g	2.1	
Total mass of liquid collected, V _{lc}	g	8.1	
V _{wstd} = (0.001246)(V _{lc})	m ³	0.0101	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V _m	m ³	0.9990	
Gas meter correction factor, Y _d	-	0.9720	
Average dry gas meter temperature, T _m	°C	9.8	
Average pressure drop across orifice, ΔH	mmH ₂ O	29.4	
V _{mstd} = ((0.3592)(V _m)(P _b + (ΔH/13.6))(Y _d)) / (T _m + 273)	m ³	0.9343	
Moisture content, B_{w0} & R_{wv}			
B _{w0} = V _{wstd} / (V _{mstd} + V _{wstd})	m ³	0.0107	
B _{w0} as a percentage	% v/v	1.07	
Reported Water Vapour, checked with Tables in EN 14790, R _{wv}	% v/v	1.07	
Volume of gas metered wet, V_{mstw}			
V _{mstw} = (V _{mstd})(100/(100 - R _{wv}))	m ³	0.9444	
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	20.80	
Total	% v/v	20.86	
N ₂	% v/v	79.14	
M _d = 0.44(%CO ₂)+0.32(%O ₂)+0.28(%N ₂)	g/gmol	28.84	
Molecular weight of stack gas (wet), M_s			
M _s = M _d (1 - (R _{wv} /100)) + 18(R _{wv} /100)	g/gmol	28.73	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K _p	-	34.97	
Velocity pressure coefficient, C _p	-	0.85	
Average of velocity heads, ΔP _{avg}	mmH ₂ O	1.03	
Average square root of velocity heads, √ΔP	√mmH ₂ O	1.02	
Average stack gas temperature, T _s	°C	12.4	
V _s = ((K _p)(C _p)(√ΔP)(√T _s + 273)) / (√(M _s)(P _s))	m/s	3.45	
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	68.7	
Conversion factor (K/mm.Hg), C _f	-	0.3592	
Q _{stw} = ((Q _a)(P _s)(C _f)) / ((T _s + 273)	m ³ /min	65.3	
Q _{std} = ((Q _a)(P _s)(C _f)(1 - (R _{wv} /100))) / ((T _s + 273)	m ³ /min	64.6	
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	9.96	
Nozzle area, A _n	mm ²	77.87	
Total sampling time, q	min	60	
%I = (4.6398E ⁶)(T _s +273)(V _{mstd}) / (P _s)(V _s)(A _n)(q)(1 - (R _{wv} /100))	%	102.8	

LEAD: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	12:30 - 13:30	
Sampling Dates	-	29/11/2017	
Sampling Device	-	ISO	
Volume Sampled (REF)	m ³	0.9444	
Mass on Filter / in Rinse	µg	219.00	
Mass in Front Impingers	µg	1.85	
Mass in Back Impinger	µg	1.26	
Total Mass Collected	µg	222.11	
Calculated Concentration	mg/m ³	0.2352	
Reported Concentration	mg/m ³	0.2352	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	29/11/2017	
Average Volume Sampled (REF)	m ³	0.9444	
Mass on Filter / in Rinse	µg	< 0.50	
Mass in Front Impingers	µg	< 0.04	
Mass in Back Impinger	µg	< 0.02	
Total Mass Collected	µg	< 0.56	
Calculated Concentration	mg/m ³	< 0.0006	
Reported Concentration	mg/m ³	< 0.0006	

LEAD: QUALITY ASSURANCE

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Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	16.2	
Pre-Sampling Leak Rate	l/min	0.02	
Post-Sampling Leak Rate	l/min	0.11	
Allowable Leak Rate	l/min	0.32	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	99.4	
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	Units	Run 1	
Detection Limit	µg/m ³	0.60	
Allowable Detection Limit	µg/m ³	5.0	
Detection Limit Acceptable	-	Yes	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.9	
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	%	102.8	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	180	

Impingers Exit Temperature	Units	Run 1	
Maximum Temperature Recorded	°C	14	
Maximum Allowable Temperature	°C	30	
Exit Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	



LEAD: QUALITY ASSURANCE

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Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	20.0	
Pre-Sampling Leak Rate	l/min	0.09	
Post-Sampling Leak Rate	l/min	0.09	
Allowable Leak Rate	l/min	0.40	
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
One out of two sampling lines was used due to sampling location restrictions, however the number of sample points used on the available line were increased to the minimum required by the Standard	wx	

LEAD: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (Actual)	V _m	1.00		uV _m	m ³	0.02	
Sampled Gas Temperature	T _m	282.8		uT _m	K	2.00	
Sampled Gas Pressure	p _m	100.7		uρ _m	kPa	0.50	
Sampled Gas Humidity	H _m	0.00		uH _m	% v/v	1.00	
Leak	L	0.68		uL	%	-	
Laboratory Result	L _r	6.50		uL _r	%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.71		≤1%
Sampled Gas Pressure	%	0.50		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.68		≤2%
Laboratory Result	%	6.50		No Requirement

Measured Quantities	Uncertainty in Measurement Units			Sensitivity Coefficient	
	Symbol	Units	Run 1	Run 1	
Sampled Volume (STP)	V _m	m ³	0.93	0.25	
Leak	L	mg/m ³	0.001	1.00	
Laboratory Result	L _r	mg/m ³	0.02	1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.01	
Leak	mg/m ³	0.001	
Laboratory Result	mg/m ³	0.02	

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	0.02	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m ³	0.03	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m ³	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.03	
Reported Uncertainty	mg/m ³	0.03	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	13.7	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	13.7	
Reported Uncertainty	%	13.7	