Exova Catalyst, Unit 11, Aspen Close, Swindon, SN2 8AJ
T: 0800 328 1821 (or + 44 161 432 3286 from overseas)
E: stuart.davidson@exova.com
Your Exova Catalyst Contact: Stuart Davidson (07957 554 956)

Stack Emissions Testing Report Commissioned by
PCME Ltd

Installation Name & Address
Clark-Drain Ltd
Station Road
Yaxley
Peterbourough
Cambridgeshire
PE7 3EQ

PPC Permit: A12/92; Variation: PPC 20/09

Stack Reference
Galvanising Plant

Dates of the Monitoring Campaign
11th February 2016

Job Reference Number
CSW-2136

Report Written by
Aaron Purbrick Technician MCERTS Level 1 MM 14 1309 TE1 & TE4

Report Approved by
Paul Martin Deputy Regional Manager MCERTS Level 2 MM 04 503 TE1 TE2 TE3 TE4

Report Date
7th March 2016

Version
Version 1

Signature of Report Approver


CONTENTS

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

MONITORING OBJECTIVES

Clark-Drain Ltd, Yaxley
Galvanising Plant
11th February 2016

Overall Aim of the Monitoring Campaign

Exova Catalyst, in partnership with PCME Ltd, were commissioned to carry out stack emissions testing on the Galvanising Plant by Clark-Drain Ltd at Yaxley.

The aim of the monitoring campaign was to conduct stack emissions testing as part of PCME's calibration service in support of the PCME particulate monitor installed at the emissions point.

Special Requirements

Record the PCME Meter readings. These can be found on the back page of this Report.

Target Parameters

Total Particulate Matter, Lead, Hydrogen Chloride

Executive Summary

MONITORING RESULTS

Clark-Drain Ltd, Yaxley
Galvanising Plant
11th February 2016

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	6.5	0.71	15	g/hr	53	6.5	-
Lead [1]	mg/m³	0.0059	0.0015	-	g/hr	0.048	0.013	-
Hydrogen Chloride [1]	mg/m³	0.039	0.003	-	g/hr	0.32	0.03	-
Water Vapour	% v/v	2.1	0.10					
Stack Gas Temperature	°C	20.0						
Stack Gas Velocity	m/s	6.1	0.14					
Volumetric Flow Rate (ACTUAL)	m³/hr	8909	453					
Volumetric Flow Rate (REF) [1]	m³/hr	8197	417					

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

MONITORING DATE(S) & TIMES

Clark-Drain Ltd, Yaxley
Galvanising Plant
11th February 2016

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m³	6.7	g/hr	54.9	11/02/2016	11:05 - 12:05	60
Total Particulate Matter	R2	mg/m³	1.9	g/hr	15.8	11/02/2016	12:33 - 13:33	60
Total Particulate Matter	R3	mg/m³	10.8	g/hr	88.8	11/02/2016	14:00 - 15:00	60
Lead	R1	mg/m³	0.0059	g/hr	0.048	11/02/2016	15:36 - 16:36	60
Hydrogen Chloride	R1	mg/m³	0.039	g/hr	0.32	11/02/2016	14:00 - 15:00	60
Velocity & Volumetric Flow Rate	R1					11/02/2016	09:00 - 09:10	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Clark-Drain Ltd, Yaxley
Galvanising Plant
11th February 2016

Standard Operating Conditions

Parameter	Value
Process Status	Normal
Capacity (of 100%) and Tonnes / Hour	N/A
Continuous or Batch Process	Batch
Feedstock (if applicable)	Steel Components
Abatement System	Wet Scrubber
Abatement System Running Status	Normal
Fuel	N/A
Plume Appearance	None Visible

Executive Summary

MONITORING & ANALYTICAL METHODS

Clark-Drain Ltd, Yaxley
Galvanising Plant
11th February 2016

	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	0.11 mg/m³
Lead	EN 14385	CAT-TP-06	Yes	CAT	M31	ICP-MS	Yes	RPS	Yes	0.0004 mg/m³
Hydrogen Chloride	EN 1911	CAT-TP-11	Yes	CAT	CAT-AP-01	IC	Yes	CAT	Yes	0.023 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
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
Toal Particulate Matter, Lead	All	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 meet the requirements of the Standard.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.72
Width	m	-
Area	m²	0.41
Port Depth	cm	9
Orientation of Duct	-	Vertical
Sample Port Size	-	4" BSP

Location of Sampling Platform

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

Platform Details

EA Technical Guidance Note M1 / 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

All platforms should be designed in accordance with the requirements in the Environment Agency's Technical Guidance Note M1 and EN 15259.

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)

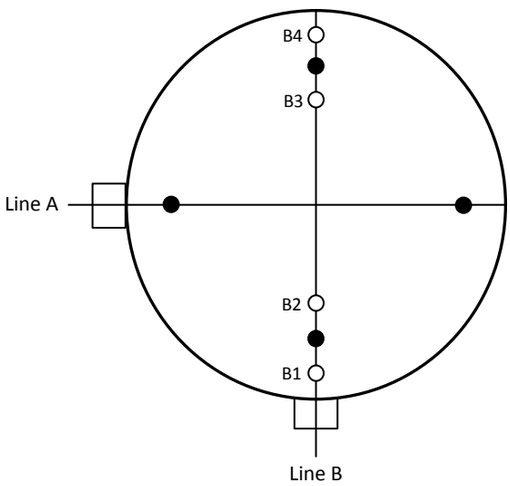
Criteria in EN 15259	Units	Traverse 1		Required	Compliant
Lowest Differential Pressure	Pa	21.0		> 5 Pa	Yes
Mean Velocity	m/s	6.08		-	-
Lowest Gas Velocity	m/s	5.01		-	-
Highest Gas Velocity	m/s	6.83		-	-
Ratio of Above	: 1	1.36		< 3 : 1	Yes
Maximum Angle of Swirl	°	5		< 15°	Yes
No Local Negative Flow	-	Yes		-	Yes

PLANT PHOTOS

Photo 1

Photo 2

SAMPLE POINTS



where ○ = isokinetic point sampled at

● = isokinetic point not sampled at

APPENDIX CONTENTS

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Neil Teixeira	MCERTS Level 2	MM 05 583	TE1 TE2 TE3 TE4
Team Leader	David Burns	MCERTS Level 2	MM 05 579	TE1 TE2 TE3 TE4

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	CAT 7.52
Control Box DGM (2)	-
Box Thermocouples (1)	CAT 3.128
Box Thermocouples (2)	-
Umbilical (1)	CAT 3.128
Umbilical (2)	-
Oven Box (1)	CAT 12.102
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	CAT 5.111
Heated Probe (3)	-
S-Pitot (1)	CAT 21P.43
S-Pitot (2)	CAT 21P.80
L-Pitot	-
500g Check Weight	CAT 17.25
1Kg Check Weight	CAT 17.25
Last Impinger Arm	CAT 4.82
Callipers	CAT 23.29
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
Horiba PG-250	-
Horiba PG-250	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Servomex 5200MP	-
Ankersmid APS 313	-
Gasmet DX4000	-
Gasmet Sampling System	-
Bernath 3006 FID	-
M&C PSS	-
Mass Flow Controller (1)	-
Mass Flow Controller (2)	-
Mass View (1)	-
Mass View (2)	-
Hioki 5043 (V)	-
Hioki 5043 (V)	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.12
Digital Manometer (2)	CAT 3.115
Digital Temperature Meter	CAT 3.12
Stopwatch	CAT 14.78
Barometer	CAT 13.37
Stack Thermocouple (1)	-
Stack Thermocouple (2)	CAT 4.78
Stack Thermocouple (3)	-
2m Heated Line (1) (P&G)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
10m Heated Line (1)	-
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	CAT 3.129
Single Channel Heater Controller	-
Laboratory Balance	CAT 1.18 / 1.18a
Tape Measure	CAT 16.9

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	CAT-TP-01
Lead	EN 14385	CAT-TP-06
Hydrogen Chloride	EN 1911	CAT-TP-11
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	0.72
Stack Width, W	m	-
Stack Area, A	m^2	0.41
Average Stack Gas Temperature, T_a	°C	20.0
Average Stack Gas Pressure	Pa	31.3
Average Stack Static Pressure, P_{static}	kPa	0.040
Average Barometric Pressure, P_b	kPa	100.0
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/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	20.36	0.2080	32.00	1.4277	0.29696
N_2	-	79.14	77.47	0.7914	28.01	1.2498	0.98913
Moisture (H_2O)	-	-	2.11	0.0211	18.02	0.8037	0.01698

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	1.277
Dry Density (Actual), P_{Actual}	kg/m³	1.184
Average Wet Density (Actual), $P_{ActualW}$	kg/m³	1.175

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	20.0	0.0
Total Pressure	kPa	100.0	101.3
Moisture	%	2.11	2.11

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m³/hr	8909
Gas Volumetric Flowrate (STP, Wet)	m³/hr	8197
Gas Volumetric Flowrate (STP, Dry)	m³/hr	8024
Gas Volumetric Flowrate REF [1]	m³/hr	8197

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	11/02/2016
Time of Survey	-	09:00 - 09:10
Atmospheric Pressure	kPa	100.0
Average Stack Static Pressure	Pa	40
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	-	0.84
Number of Lines Available	-	2
Number of Lines Used	-	1

		Sampling Line A - Restricted Access					Sampling Line B				
Traverse Point	**Depth m**	**ΔP**	**Temp °C**	**Wet Density kg/m³**	**Velocity m/s**	**Swirl °**	**ΔP Pa**	**Temp °C**	**Wet Density kg/m³**	**Velocity m/s**	**Swirl °**
STATIC (Units: Pa)							*40.0*				
Mean							**31.3**	**20.0**	**1.175**	**6.08**	
1	0.05						34.0	20.0	1.175	6.38	3.0
2	0.18						21.0	20.0	1.175	5.01	5.0
3	0.54						39.0	20.0	1.175	6.83	3.0
4	0.67						31.0	20.0	1.175	6.09	2.0

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)	1.095	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	0.102	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	0.012	
- Overall corrections to dynamic measurements	u(Cf)	0.198	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.360	
- $\varphi CO_2,w$	-	0.059	
- Oxygen, dry	u(ϕO_2,d)	0.637	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.108	
- Oxygen, wet	u(ϕO_2,w)	0.624	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.495	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.695	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	1.095	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00634	-
Standard uncertainty associated with the local velocities	u(vi)	0.119	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.072	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.141	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	2.31	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	452.9	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00067	
- $u^2(qV,w)$	-	53384	
- u(qV,w)	-	231.0	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	5.08	%

TOTAL PARTICULATE MATTER: RESULTS SUMMARY

Clark-Drain Ltd, Yaxley
Galvanising Plant

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3		Mean
Concentration	mg/m³	6.7	1.9	10.8		6.5
Uncertainty	±mg/m³	0.71	0.60	0.82		0.71
Mass Emission	g/hr	54.9	15.8	88.8		53.2
Uncertainty	±g/hr	6.5	5.0	8.1		6.5

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	2.6	1.7	1.8		2.0
Uncertainty	±% v/v	0.13	0.09	0.09		0.10

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.51		0.51

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	FORMAT: Number Used / Number Required
Number of Sampling Points Used	4 / 4	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B1, B2, B3, B4	

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	750.0	750.0	750.0	
Stack static pressure, P_{static}	mmH_2O	4.1	4.1	4.1	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	750.3	750.3	750.3	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	18.7	11.0	9.5	
Total mass collected in impingers (silica trap)	g	7.9	7.1	9.6	
Total mass of liquid collected, V_{lc}	g	26.6	18.1	19.1	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0331	0.0226	0.0238	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m^3	1.3620	1.4490	1.4010	
Gas meter correction factor, Y_d	-	0.9700	0.9700	0.9700	
Average dry gas meter temperature, T_m	°C	14.0	13.0	12.3	
Average pressure drop across orifice, ΔH	mmH_2O	50.3	55.9	55.1	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.2463	1.3310	1.2902	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0259	0.0167	0.0181	
B_{wo} as a percentage	% v/v	2.59	1.67	1.81	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	2.59	1.67	1.81	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.2794	1.3536	1.3140	
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	28.56	28.66	28.65	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.82	0.82	0.82	
Average of velocity heads, ΔP_{avg}	mmH_2O	3.24	3.61	3.56	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	1.80	1.90	1.89	
Average stack gas temperature, T_s	°C	20.0	20.0	20.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	6.06	6.38	6.34	
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	0.41	0.41	0.41	
$Q_a = (60)(A_s)(V_s)$	m^3/min	147.9	155.9	155.0	
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	136.1	143.4	142.5	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	132.6	141.0	140.0	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	N/A	N/A	N/A	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	N/A	N/A	N/A	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm	8.85	8.85	8.85	
Nozzle area, A_n	mm^2	61.52	61.52	61.52	
Total sampling time, q	min	60	60	60	
$\%I = (4.6398E^{6})(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.7	104.1	101.7	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	11:05 - 12:05	12:33 - 13:33	14:00 - 15:00	
Sampling Dates	-	11/02/2016	11/02/2016	11/02/2016	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m^3	1.2794	1.3536	1.3140	
Filter I.D. Number	-	47-30303	47-26956	47-26955	
Start Filter Mass	g	0.14710	0.14439	0.14610	
End Filter Mass	g	0.15516	0.14659	0.16005	
Total Mass on Filter	g	0.00806	0.00220	0.01395	
Probe Rinse I.D. Number	-	PR-47-30303	PR-47-26956	PR-47-26955	
Start Probe Rinse Mass	g	3.02576	3.19175	3.18539	
End Probe Rinse Mass	g	3.02627	3.19216	3.18567	
Total Mass in Probe Rinse	g	0.00051	0.00041	0.00028	
Total Mass Collected	mg	8.57	2.61	14.23	
Calculated Concentration	mg/m^3	6.70	1.93	10.83	
Balance Uncertainty / LOD	mg/m^3	0.11	0.10	0.11	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	11/02/2016	
Average Volume Sampled (REF)	m^3	1.3157	
Filter I.D. Number	-	47-30518	
Start Filter Mass	g	0.14501	
End Filter Mass	g	0.14529	
Total Mass on Filter	g	0.00028	
Probe Rinse I.D. Number	-	PR-47-30518	
Start Probe Rinse Mass	g	3.10884	
End Probe Rinse Mass	g	3.10923	
Total Mass in Probe Rinse	g	0.00039	
Total Mass Collected	mg	0.67	
Calculated Concentration	mg/m^3	0.51	
Balance Uncertainty / LOD	mg/m^3	0.11	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3	
Mean Sampling Rate	l/min	22.0	23.4	22.6	
Pre-Sampling Leak Rate	l/min	0.20	0.10	0.20	
Post-Sampling Leak Rate	l/min	0.10	0.20	0.20	
Allowable Leak Rate	l/min	0.44	0.47	0.45	
Leak Test Acceptable	-	Yes	Yes	Yes	

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

MU (Concurrent Water Vapour)	Units	Run 1	Run 2	Run 3	
Measurement Uncertainty (MU)	%	5.1	5.2	5.2	
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	%	103.7	104.1	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	0.27	0.27	0.27	
Overall Weighing Uncertainty	± mg/m³	0.21	0.20	0.21	
ELV [Daily ELV for IED]	mg/m³	15.0	15.0	15.0	
Allowable Weighing Uncertainty	mg/m³	0.75	0.75	0.75	
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	20	20	20	

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	
Expected Sampling Rate	l/min	15.0	
Pre-Sampling Leak Rate	l/min	0.20	
Post-Sampling Leak Rate	l/min	0.20	
Allowable Leak Rate	l/min	0.30	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m³	1.5	
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 (x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	Run Number 1	2	3	
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 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	1.3620	1.4490	1.4010		uV_m	m^3	0.0272	0.0290	0.0280	
Sampled Gas Temperature	T_m	287.0	286.0	285.3		uT_m	K	2.0	2.0	2.0	
Sampled Gas Pressure	ρ_m	100.0	100.0	100.0		$u\rho_m$	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	0.45	0.85	0.88		uL	%	-	-	-	
Mass of Particulate	m	8.57	2.61	14.23		um	mg	0.14	0.14	0.14	
Uncollected Mass	UCM	0.67	0.67	0.67		uUCM	mg	-	-	-	

		Uncertainty as a Percentage				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.0	2.0	2.0		≤2%
Sampled Gas Temperature	%	0.70	0.70	0.70		≤1%
Sampled Gas Pressure	%	0.50	0.50	0.50		≤1%
Sampled Gas Humidity	%	1.0	1.0	1.0		≤1%
Leak	%	0.45	0.85	0.88		≤2%
Mass of Particulate	%	0.73	0.69	0.71		<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	1.2463	1.3310	1.2902			5.37	1.45	8.39	
Leak	L	mg/m^3	0.018	0.010	0.055			1.00	1.00	1.00	
Mass of Particulate	L_r	mg	8.570	2.610	14.230			0.78	0.74	0.76	
Uncollected Mass	UCM	mg	0.39	0.39	0.39			0.78	0.74	0.76	

		Uncertainty in Result			
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	
Sampled Volume (STP)	mg/m^3	0.171	0.049	0.275	
Leak	mg/m^3	0.0176	0.0095	0.0552	
Mass of Particulate	mg/m^3	0.1094	0.1034	0.1065	
Uncollected Mass	mg/m^3	0.3023	0.2858	0.2944	

		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	0.36	0.31	0.42	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.71	0.60	0.82	
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	0.71	0.60	0.82	
Reported Uncertainty	mg/m^3	0.71	0.60	0.82	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	10.7	31.3	7.6	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	10.7	31.3	7.6	
Reported Uncertainty	%	10.7	31.3	7.6	

LEAD: RESULTS SUMMARY

Clark-Drain Ltd, Yaxley
Galvanising Plant

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	0.0059		0.0059
Uncertainty	±mg/m³	0.0015		0.0015
Mass Emission	g/hr	0.048		0.048
Uncertainty	±g/hr	0.013		0.013

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	2.2		2.2
Uncertainty	±% v/v	0.11		0.11

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.00039		< 0.00039

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	23/02/2016	
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	1 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	4 / 4	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B1, B2, B3, B4	

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	750.0	
Stack static pressure, P_{static}	mmH_2O	4.1	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	750.3	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	13.7	
Total mass collected in impingers (silica trap)	g	12.0	
Total mass of liquid collected, V_{lc}	g	25.7	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0320	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	1.5430	
Gas meter correction factor, Y_d	-	0.9700	
Average dry gas meter temperature, T_m	°C	12.5	
Average pressure drop across orifice, ΔH	mmH_2O	65.5	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.4212	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0220	
B_{wo} as a percentage	% v/v	2.20	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	2.20	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.4532	
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	
% 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	28.60	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.82	
Average of velocity heads, ΔP_{avg}	mmH_2O	4.23	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	2.06	
Average stack gas temperature, T_s	°C	20.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)}(P_s))$	m/s	6.92	
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	0.41	
$Q_a = (60)(A_s)(V_s)$	m^3/min	169.0	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	155.5	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	152.1	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	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	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	8.85	
Nozzle area, A_n	mm^2	61.52	
Total sampling time, q	min	60	
$\%I = (4.6398E^{6})(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	103.1	

LEAD: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	15:36 - 16:36	
Sampling Dates	-	11/02/2016	
Sampling Device	-	ISO	
Volume Sampled (REF)	m^3	1.4532	
Mass on Filter / in Rinse	µg	8.00	
Mass in Front Impingers	µg	0.44	
Mass in Back Impinger	µg	0.10	
Total Mass Collected	µg	8.54	
Calculated Concentration	mg/m^3	0.0059	
Reported Concentration	mg/m^3	0.0059	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	11/02/2016	
Average Volume Sampled (REF)	m^3	1.4532	
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	< 0.57	
Calculated Concentration	mg/m^3	< 0.00039	
Reported Concentration	mg/m^3	< 0.00039	

LEAD: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	24.9	
Pre-Sampling Leak Rate	l/min	0.20	
Post-Sampling Leak Rate	l/min	0.20	
Allowable Leak Rate	l/min	0.50	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	98.8	
Allowable Absorption Efficiency	%	90	
Absorption Efficiency Acceptable	-	Yes	

Detection Limit	Units	Run 1	
Detection Limit	µg/m³	0.4	
Allowable Detection Limit	µg/m³	5	
Detection Limit Acceptable	-	Yes	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.2	
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	%	103.1	
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	15	
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	15.0	
Pre-Sampling Leak Rate	l/min	0.20	
Post-Sampling Leak Rate	l/min	0.20	
Allowable Leak Rate	l/min	0.30	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m³	N/A	
Blank Acceptable	-	N/A	

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	
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 meet the requirements of the Standard.	x	

LEAD: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	1.5430		uV_m	m³	0.0309	
Sampled Gas Temperature	T_m	285.5		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	100.0		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.80		uL	%	-	
Laboratory Result	L_r	13.00		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.0		≤2%
Sampled Gas Temperature	%	0.70		≤1%
Sampled Gas Pressure	%	0.50		≤1%
Sampled Gas Humidity	%	1.0		≤1%
Leak	%	0.80		≤2%
Laboratory Result	%	13.0		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m³	1.4212		0.004	
Leak	L	mg/m³	0.00003		1.00	
Laboratory Result	L_r	mg/m³	0.0008		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m³	0.0001	
Leak	mg/m³	0.00003	
Laboratory Result	mg/m³	0.0008	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**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/m³	0.0008	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m³	0.0015	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m³	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m³	0.0015	
Reported Uncertainty	mg/m³	0.0015	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	26.0	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	26.0	
Reported Uncertainty	%	26.0	

HYDROGEN CHLORIDE: RESULTS SUMMARY

Clark-Drain Ltd, Yaxley
Galvanising Plant

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	0.039		0.039
Uncertainty	±mg/m³	0.003		0.003
Mass Emission	g/hr	0.32		0.32
Uncertainty	±g/hr	0.03		0.03

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	1.8		1.8
Uncertainty	±% v/v	0.09		0.09

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	< 0.012		< 0.012

General Sampling Information

Parameter	Value	
Standard	EN 1911	
Technical Procedure	CAT-TP-11	
Name of Analytical Laboratory	CAT	
Analytical Laboratory's Procedure	CAT-AP-01	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	18/02/2016	
Probe Material	Titanium	
Filter Housing Material	Titanium	
Impinger Material	Polyethylene	
Absorption Solution	HPLC Grade Water	
Positioning of Filter	In Stack	
Filter Size and Material	47mm Quartz Fibre	
Number of Sampling Lines Used	1 / 2	FORMAT: Number Used / Number Required
Number of Sampling Points Used	4 / 4	FORMAT: Number Used / Number Required
Sample Point I.D.'s	B1, B2, B3, B4	

Reference Conditions

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

HYDROGEN CHLORIDE: ISOKINETIC SAMPLING CALCULATIONS

Test	Units	Run 1	
Absolute pressure of stack gas, P_s			
Barometric pressure, P_b	mmHg	750.0	
Stack static pressure, P_{static}	mmH_2O	4.1	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	750.3	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	9.5	
Total mass collected in impingers (silica trap)	g	9.6	
Total mass of liquid collected, V_{lc}	g	19.1	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0238	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	1.4010	
Gas meter correction factor, Y_d	-	0.9700	
Average dry gas meter temperature, T_m	°C	12.3	
Average pressure drop across orifice, ΔH	mmH_2O	55.1	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	1.2902	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0181	
B_{wo} as a percentage	% v/v	1.81	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	1.81	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	1.3140	
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	
% 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	28.65	
Velocity of stack gas, V_s			
Pitot tube velocity constant, K_p	-	34.97	
Velocity pressure coefficient, C_p	-	0.82	
Average of velocity heads, ΔP_{avg}	mmH_2O	3.56	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	1.89	
Average stack gas temperature, T_s	°C	20.0	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)}(P_s))$	m/s	6.34	
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	0.41	
$Q_a = (60)(A_s)(V_s)$	m^3/min	155.0	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	142.5	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	140.0	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	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	
Percent isokinetic, %I			
Nozzle diameter, D_n	mm	8.85	
Nozzle area, A_n	mm^2	61.52	
Total sampling time, q	min	60	
$\%I = (4.6398E^{6})(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	101.7	

HYDROGEN CHLORIDE: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	14:00 - 15:00	
Sampling Dates	-	11/02/2016	
Sampling Device	-	ISO	
Volume Sampled (REF)	m^3	1.3140	
Laboratory Result for Front Impingers	µg/ml	0.10	
Laboratory Result for Back Impinger	µg/ml	0.05	
Volume in Front Impingers	ml	408.5	
Volume in Back Impinger	ml	206.7	
Mass in Front Impingers	µg	40.9	
Mass in Back Impinger	µg	< 10.3	
Total Mass Collected	µg	51.2	
Calculated Concentration	mg/m^3	0.04	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	11/02/2016	
Average Volume Sampled (REF)	m^3	1.3140	
Laboratory Result for Impingers	µg/ml	< 0.05	
Volume in Impingers	ml	320.4	
Total Mass Collected	µg	< 16.0	
Calculated Concentration	mg/m^3	< 0.012	

HYDROGEN CHLORIDE: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	22.6	
Pre-Sampling Leak Rate	l/min	0.20	
Post-Sampling Leak Rate	l/min	0.20	
Allowable Leak Rate	l/min	0.45	
Leak Test Acceptable	-	Yes	

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

[1] The concentration in the last absorber was less than 5 times the analytical detection limit.

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

MU (Concurrent Water Vapour)	Units	Run 1	
Measurement Uncertainty (MU)	%	5.2	
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	%	101.7	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	20	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

HYDROGEN CHLORIDE: QUALITY ASSURANCE

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Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	15.0	
Pre-Sampling Leak Rate	l/min	0.20	
Post-Sampling Leak Rate	l/min	0.20	
Allowable Leak Rate	l/min	0.30	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m³	N/A	
Blank Acceptable	-	N/A	

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	
There are no deviations associated with the sampling employed.	x	

HYDROGEN CHLORIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	1.4010		uV_m	m^3	0.028	
Sampled Gas Temperature	T_m	285.3		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	100.0		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.88		uL	%	-	
Laboratory Result	L_r	2.50		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.70		≤1%
Sampled Gas Pressure	%	0.50		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.88		≤2%
Laboratory Result	%	2.50		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	1.2902		0.03	
Leak	L	mg/m^3	0.0002		1.00	
Laboratory Result	L_r	mg/m^3	0.001		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	0.001	
Leak	mg/m^3	0.0002	
Laboratory Result	mg/m^3	0.0010	

	Oxygen Correction Part of MU Budget		
Measured Quantities	**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	0.0014	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0027	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0027	
Reported Uncertainty	mg/m^3	0.0027	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	7.1	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	7.1	
Reported Uncertainty	%	7.1	

PCME METER

Contract Details	
Test House Job Number	CSW-2136
Company	**Clark-Drain Ltd**
Site	Yaxley
Stack	Galvanising Plant
Sampling Date	11/02/2016
PCME Job Number	**26011600**

Stack Conditions	Value	Units
Stack Temperature	20.0	°C
Stack Humidity	2.0	% v/v
Stack Oxygen Content	N/A	% v/v
Stack Pressure	100.0	kPa

Current Instrument Settings	Type	Serial Number
Controller Type	IM	34304
Channel Type	DT373	34803
Channel Number	Stack 1	
Instrument Checks	Pass	
Current Calibration Factor	10.121	
Time on Display	11:47	
Time Difference - Meter v Actual	PCME meter 23 mins fast	
GMT / BST?	GMT	
Was Time Changed?	No	

Hardware Status	
Zero	23
Span	10042
S/C	10043
Contamination Ring	N/A
Comms Check	Pass

Summary of Test Data - Results of SRM vs CEM									
Run	**Start Time**	**Finish Time**	**Instrument Average**	**Instrument Maximum**	**TPM Conc. STP WET**	**TPM Conc. STP DRY**	**TPM Conc. STP WET, % O_2**	**TPM Conc. STP DRY, % O_2**	**TPM Conc. ACTUAL**
1	11:05	12:05	10.24	13.32	6.70	6.88	N/A	N/A	6.16
2	12:33	13:33	10.92	21.92	1.93	1.96	N/A	N/A	1.77
3	14:00	15:00	12.51	33.78	10.83	11.03	N/A	N/A	9.96
Mean			**11.22**		**6.49**	**6.62**	**N/A**	**N/A**	**5.97**

For all matters relating to the function, performance and calibration of the PCME Meter, please speak directly to PCME on 01480 468 200.

Times listed in the table above relate to the actual time of the tests, and not the times as read by the PCME meter.