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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
14th February 2017

Job Reference Number
CSW-2662

Report Written by
David Guy Team Leader MCERTS Level 2 MM 09 1044 TE1 TE2 TE3 TE4

Report Approved by
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Report Date
28th February 2017

Version
Version 1

Signature of Report Approver


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

MONITORING OBJECTIVES

Clark-Drain Ltd, Yaxley
Galvanising Plant
14th February 2017

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

Executive Summary

MONITORING RESULTS

Clark-Drain Ltd, Yaxley
Galvanising Plant
14th February 2017

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	5.9	0.46	15	g/hr	48.1	4.5	-
Lead	[1]	mg/m³	0.0046	0.0012	-	g/hr	0.038	0.010	-
Water Vapour		% v/v	2.2	0.12					
Stack Gas Temperature		°C	21.0						
Stack Gas Velocity		m/s	5.9	0.14					
Volumetric Flow Rate (ACTUAL)		m³/hr	8647	441					
Volumetric Flow Rate (REF)	[1]	m³/hr	8113	413					

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.

MONITORING DATE(S) & TIMES

Clark-Drain Ltd, Yaxley
Galvanising Plant
14th February 2017

Parameter		Units	Concentration	Units	Mass Emission	Sampling Date(s)	Sampling Times	Duration mins
Total Particulate Matter	R1	mg/m³	6.8	g/hr	55.2	14/02/3017	10:45 - 11:15; 11:16 - 11:46	60
Total Particulate Matter	R2	mg/m³	5.8	g/hr	46.8	14/02/2017	11:50 - 12:20; 12:21 - 12:51	60
Total Particulate Matter	R3	mg/m³	5.2	g/hr	42.3	14/02/2017	12:55 - 13:25; 13:26 - 13:56	60
Lead	R1	mg/m³	0.0046	g/hr	0.038	14/02/2017	14:06 - 14:36; 14:38 - 15:08	60
Velocity & Volumetric Flow Rate	R1					14/02/2017	10:00 - 10:20	

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Clark-Drain Ltd, Yaxley
Galvanising Plant
14th February 2017

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

MONITORING & ANALYTICAL METHODS

Clark-Drain Ltd, Yaxley
Galvanising Plant
14th February 2017

	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	0.15 mg/m³
Lead	EN 13211	CAT-TP-06	Yes	CAT	M31	ICP-MS	Yes	RPS	Yes	0.001 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
All	All	There are no deviations associated with the sampling employed.

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.72
Width	m	-
Area	m^2	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	25.0		> 5 Pa	Yes
Mean Velocity	m/s	5.90		-	-
Lowest Gas Velocity	m/s	5.42		-	-
Highest Gas Velocity	m/s	6.32		-	-
Ratio of Above	: 1	1.17		< 3 : 1	Yes
Maximum Angle of Swirl	°	4		< 15°	Yes
No Local Negative Flow	-	Yes		-	Yes

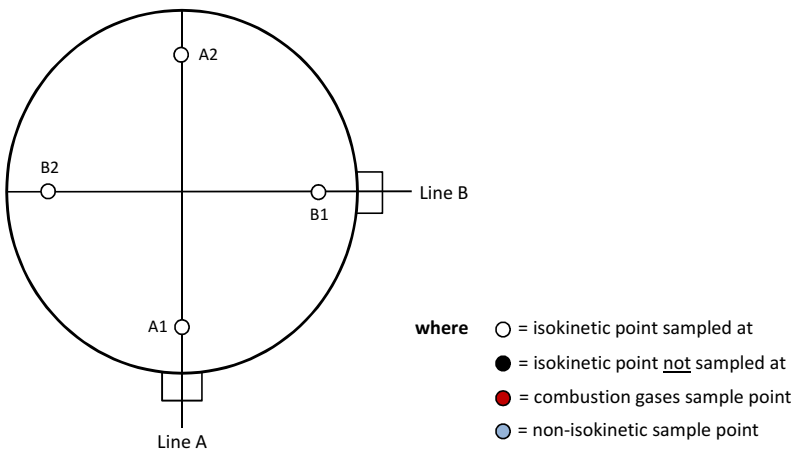
PLANT PHOTOS

Photo 1

Photo 2

Photo 3

SAMPLE POINTS



APPENDIX CONTENTS

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

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

APPENDIX 3 - PCME Meter

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	David Guy	MCERTS Level 2	MM 09 1044	TE1 TE2 TE3 TE4
Technician	Wayne Rossouw	MCERTS Level 1	MM 10 1083	TE1 TE2 TE3 TE4

LIST OF EQUIPMENT

Extractive Sampling	
Equipment Type	**Equipment I.D.**
Control Box DGM (1)	CAT 7.7
Control Box DGM (2)	-
Box Thermocouples (1)	CAT 3.20
Box Thermocouples (2)	-
Umbilical (1)	CAT 3.20
Umbilical (2)	-
Oven Box (1)	CAT 12.60
Oven Box (2)	-
Heated Probe (1)	-
Heated Probe (2)	CAT 5.69
Heated Probe (3)	CAT 5.70
S-Pitot (1)	CAT 21P.52
S-Pitot (2)	CAT 21P.64/21P.66
L-Pitot	-
Site Balance	CAT 17.3
500g / 1Kg Check Weights	CAT 17.3
Last Impinger Arm	CAT 4.81/4.82/4.893
Callipers	CAT 23.14
Tubes Kit Thermocouple	-

Instrumental Analysers	
Equipment Type	**Equipment I.D.**
SELECT Horiba Model (1)	-
SELECT Horiba Model (2)	-
Servomex 4900	-
Eco Physics CLD 822Mh	-
ABB AO2020-URAS26	-
Servomex 5200MP	-
SELECT Gas Conditioning	-
SELECT FTIR	-
Gasmet Sampling System	-
Bernath 3006 FID	-
SELECT Heated Head	-
Mass Flow Controller (1)	-
Mass Flow Controller (2)	-
Mass View (1)	-
Mass View (2)	-
SELECT Logger 1	-
SELECT Logger 2	-
Bioaerosols Temperature Logger	-
Electronic Refrigerator	-

Miscellaneous Items	
Equipment Type	**Equipment I.D.**
Digital Manometer (1)	CAT 3.55
Digital Manometer (2)	CAT 3.101
Digital Temperature Meter	CAT 3.55
Stopwatch	AT 14.12/14.14/14.5
Barometer	CAT 13.3
Stack Thermocouple (1)	-
Stack Thermocouple (2)	CAT 4.432 / 4.499
Stack Thermocouple (3)	-
1m Heated Line (1)	-
1m Heated Line (2)	-
1m Heated Line (3)	-
5m Heated Line (1)	-
15m Heated Line (1)	-
20m Heated Line (1)	-
20m Heated Line (2)	-
Dual Channel Heater Controller	-
Single Channel Heater Controller	-
Laboratory Balance	CAT 1.18 / 1.18a
Tape Measure	CAT 16.1 / 16.37

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Total Particulate Matter	EN 13284-1	CAT-TP-01
Lead	EN 13211	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	0.72
Stack Width, W	m	-
Stack Area, A	m^2	0.41
Average Stack Gas Temperature, T_a	°C	21.0
Average Stack Gas Pressure	Pa	29.8
Average Stack Static Pressure, P_{static}	kPa	0.055
Average Barometric Pressure, P_b	kPa	102.3
Average Pitot Tube Calibration Coefficient, C_p	-	0.84

Stack Gas Composition & Molecular Weights

Component	Conc ppm	Conc Dry % v/v	Conc Wet % v/v	Volume Fraction r	Molar Mass M	Density kg/m^3 p	Conc kg/m^3 p_i
CO_2 (Estimated)	-	0.06	0.06	0.0006	44.01	1.9635	0.00118
O_2 (Estimated)	-	20.90	20.43	0.2090	32.00	1.4277	0.29838
N_2	-	79.04	77.26	0.7904	28.01	1.2498	0.98788
Moisture (H_2O)	-	-	2.25	0.0225	18.02	0.8037	0.01806

Where: $p = M / 22.41$

$p_i = r \times p$

Calculation of Stack Gas Densities

Determinand	Units	Result
Dry Density (STP), P_{STD}	kg/m^3	1.287
Wet Density (STP), P_{STW}	kg/m^3	1.277
Dry Density (Actual), P_{Actual}	kg/m^3	1.208
Average Wet Density (Actual), $P_{ActualW}$	kg/m^3	1.198

Where: P_{STD} = sum of component concentrations, kg/m^3 (not including water vapour)

P_{STW} = sum of all wet concentrations / 100 x density, kg/m^3 (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	21.0	0.0
Total Pressure	kPa	102.4	101.3
Moisture	%	2.25	2.25

Gas Volumetric Flowrate (from Traverse)	Units	Result
Gas Volumetric Flowrate (Actual)	m^3/hr	8647
Gas Volumetric Flowrate (STP, Wet)	m^3/hr	8113
Gas Volumetric Flowrate (STP, Dry)	m^3/hr	7930
Gas Volumetric Flowrate REF [1]	m^3/hr	8113

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

(1 of 1)

Parameter	Units	Value
Date of Survey	-	14/02/2017
Time of Survey	-	10:00 - 10:20
Atmospheric Pressure	kPa	102.3
Average Stack Static Pressure	Pa	55
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	-	2

		Sampling Line A					Sampling Line B				
Traverse Point	Depth m	ΔP Pa	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)		*54.0*					*55.0*				
Mean		**33.0**	**21.0**	**1.198**	**6.22**		**26.5**	**21.0**	**1.198**	**5.57**	
1	0.11	32.0	21.0	1.198	6.13	4.0	28.0	21.0	1.198	5.73	4.0
2	0.61	34.0	21.0	1.198	6.32	4.0	25.0	21.0	1.198	5.42	4.0

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)	1.090	Pa
- Resolution	u(res)	0.00087	
- Calibration	u(cal)	0.092	
- Drift	u(drift)	0.083	
- Lack of Fit	u(fit)	0.011	
- Overall corrections to dynamic measurements	u(Cf)	0.187	
Standard uncertainty associated with the molar mass of the gas	u(M)	0.00003	-
- $\varphi O_2,w$	-	20.430	
- $\varphi CO_2,w$	-	0.059	
- Oxygen, dry	u(ϕO_2,d)	0.640	
- Carbon Dioxide, dry	u(ϕCO_2,d)	0.002	
- Water Vapour	u(ϕH_2O)	0.115	
- Oxygen, wet	u(ϕO_2,w)	0.626	
- Carbon Dioxide, wet	u(ϕCO_2,w)	0.002	
Standard uncertainty associated with the stack temperature	u(Tc)	1.500	K
Standard uncertainty associated with the absolute pressure in the duct	u(pc)	175.694	Pa
- Atmospheric Pressure	u(patm)	175.692	
- Static Pressure	u(pstat)	0.771	
Standard uncertainty associated with the density in the duct	u(ρ)	0.00645	-
Standard uncertainty associated with the local velocities	u(vi)	0.118	Pa
Standard uncertainty associated with the mean velocity	u(v)	0.070	m/s
Standard uncertainty associated with the mean velocity (95% Confidence)	Uc(v)	0.138	m/s
Standard uncertainty associated with the mean velocity (95% Confidence), relative	Uc,rel(v)	2.34	%
Standard uncertainty associated with the volume flow rate (95% Confidence)	Uc(qV,w)	440.7	m^3/hr
- $u^2(a)/a^2$	-	0.00053	
- $u^2(qV,w)/q^2V,w$	-	0.00068	
- $u^2(qV,w)$	-	50551	
- u(qV,w)	-	224.8	
Standard uncertainty associated with the volume flow rate (95% Confidence), relative	Uc,rel(qV,w)	5.10	%

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	6.8	5.8	5.2		5.9
Uncertainty	±mg/m³	0.49	0.44	0.46		0.46
Mass Emission	g/hr	55.2	46.8	42.3		48.1
Uncertainty	±g/hr	4.9	4.3	4.3		4.5

Parameter	Units	Run 1	Run 2	Run 3		Mean
Water Vapour	% v/v	2.0	2.0	1.6		1.9
Uncertainty	±% v/v	0.10	0.10	0.085		0.10

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.19		0.19

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	FORMAT: Number Used / Number Required
Number of Sampling Points Used	4 / 4	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, B1 & B2	

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	767.3	767.3	767.3	
Stack static pressure, P_{static}	mmH_2O	5.6	5.6	5.6	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	767.7	767.7	767.7	
Volume of water vapour collected, V_{wstd}					
Total mass collected in impingers (liquid trap)	g	5.7	9.1	7.6	
Total mass collected in impingers (silica trap)	g	9.8	6.8	4.0	
Total mass of liquid collected, V_{lc}	g	15.5	15.9	11.6	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0193	0.0198	0.0145	
Volume of gas metered dry, V_{mstd}					
Volume of gas sample through gas meter, V_m	m^3	0.9720	1.0470	0.9450	
Gas meter correction factor, Y_d	-	0.9910	0.9910	0.9910	
Average dry gas meter temperature, T_m	°C	12.9	16.8	17.8	
Average pressure drop across orifice, ΔH	mmH_2O	26.7	30.4	25.9	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	0.9309	0.9896	0.8896	
Moisture content, B_{wo} & R_{wv}					
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0203	0.0196	0.0160	
B_{wo} as a percentage	% v/v	2.03	1.96	1.60	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	2.03	1.96	1.60	
Volume of gas metered wet, V_{mstw}					
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	0.9502	1.0094	0.9041	
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	20.90	20.90	20.90	
Total	% v/v	20.96	20.96	20.96	
N_2	% v/v	79.04	79.04	79.04	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	28.85	28.85	28.85	
Molecular weight of stack gas (wet), M_s					
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.63	28.63	28.67	
Velocity of stack gas, V_s					
Pitot tube velocity constant, K_p	-	34.97	34.97	34.97	
Velocity pressure coefficient, C_p	-	0.84	0.84	0.84	
Average of velocity heads, ΔP_{avg}	mmH_2O	2.52	2.83	2.42	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	1.59	1.68	1.55	
Average stack gas temperature, T_s	°C	22.8	23.3	24.5	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	5.41	5.74	5.31	
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	132.2	140.2	129.7	
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	123.2	130.5	120.2	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	120.7	128.0	118.3	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	m^3/min	N/A	N/A	N/A	
$Q_{stdO_2} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273) / (O_{2REFd})$	m^3/min	N/A	N/A	N/A	
Percent isokinetic, %I					
Nozzle diameter, D_n	mm	7.95	7.95	7.95	
Nozzle area, A_n	mm^2	49.60	49.60	49.60	
Total sampling time, q	min	60	60	60	
$\%I = (4.6398E^6)(T_s+273)(V_{mstd}) / (P_s)(V_s)(A_n)(q)(1 - (R_{wv}/100))$	%	105.5	105.8	102.9	

TOTAL PARTICULATE MATTER: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	Run 2	Run 3	
Sampling Times	-	10:45 - 11:15; 11:16 - 11:46	11:50 - 12:20; 12:21 - 12:51	12:55 - 13:25; 13:26 - 13:56	
Sampling Dates	-	14/02/3017	14/02/2017	14/02/2017	
Sampling Device	-	ISO	ISO	ISO	
Volume Sampled (REF)	m^3	0.9502	1.0094	0.9041	
Filter I.D. Number	-	47-39179	47-39188	47-39189	
Start Filter Mass	g	0.14755	0.14741	0.14866	
End Filter Mass	g	0.15293	0.15206	0.15314	
Total Mass on Filter	g	0.00538	0.00464	0.00448	
Probe Rinse I.D. Number	-	PR-47-39179	PR-47-39188	PR-47-39189	
Start Probe Rinse Mass	g	2.87088	3.00084	2.82162	
End Probe Rinse Mass	g	2.87197	3.00201	2.82185	
Total Mass in Probe Rinse	g	0.00109	0.00118	0.00024	
Total Mass Collected	mg	6.47	5.82	4.72	
Calculated Concentration	mg/m^3	6.81	5.77	5.22	
Balance Uncertainty / LOD	mg/m^3	0.15	0.14	0.15	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	14/02/2017	
Average Volume Sampled (REF)	m^3	0.9546	
Filter I.D. Number	-	47-39178	
Start Filter Mass	g	0.14886	
End Filter Mass	g	0.14892	
Total Mass on Filter	g	0.00006	
Probe Rinse I.D. Number	-	PR-47-39178	
Start Probe Rinse Mass	g	2.91633	
End Probe Rinse Mass	g	2.91645	
Total Mass in Probe Rinse	g	0.00012	
Total Mass Collected	mg	0.18	
Calculated Concentration	mg/m^3	0.19	
Balance Uncertainty / LOD	mg/m^3	0.15	

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

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Sample Runs

Leak Test Results	Units	Run 1	Run 2	Run 3	
Mean Sampling Rate	l/min	16.05	17.29	15.61	
Pre-Sampling Leak Rate	l/min	0.12	0.07	0.12	
Post-Sampling Leak Rate	l/min	0.12	0.08	0.10	
Allowable Leak Rate	l/min	0.32	0.35	0.31	
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)	%	5.2	5.2	5.3	
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	%	105.5	105.8	102.9	
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	0.25	0.25	0.25	
Overall Weighing Uncertainty	± mg/m³	0.26	0.25	0.28	
ELV [Daily ELV for IED]	mg/m³	15.00	15.00	15.00	
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	24	24	25	

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

TOTAL PARTICULATE MATTER: QUALITY ASSURANCE

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	18.00	
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	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	Run Number			
(x = deviation applies to the associated run, wx = deviation also applies to the concurrent water vapour run)	1	2	3	
There are no deviations associated with the sampling employed.	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	0.9720	1.0470	0.9450		uV_m	m^3	0.0194	0.0209	0.0189	
Sampled Gas Temperature	T_m	285.9	289.8	290.8		uT_m	K	2.0	2.0	2.0	
Sampled Gas Pressure	ρ_m	102.4	102.4	102.4		$u\rho_m$	kPa	0.5	0.5	0.5	
Sampled Gas Humidity	H_m	0.0	0.0	0.0		uH_m	% v/v	1.0	1.0	1.0	
Leak	L	0.75	0.46	0.64		uL	%	-	-	-	
Mass of Particulate	m	6.47	5.82	4.72		um	mg	0.14	0.14	0.14	
Uncollected Mass	UCM	0.18	0.18	0.18		uUCM	mg	-	-	-	

	Uncertainty as a Percentage					
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.00	2.00	2.00		≤2%
Sampled Gas Temperature	%	0.70	0.69	0.69		≤1%
Sampled Gas Pressure	%	0.49	0.49	0.49		≤1%
Sampled Gas Humidity	%	1.00	1.00	1.00		≤1%
Leak	%	0.75	0.46	0.64		≤2%
Mass of Particulate	%	0.98	0.92	1.03		<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	0.9309	0.9896	0.8896		7.31	5.83	5.86	
Leak	L	mg/m^3	0.029	0.015	0.019		1.00	1.00	1.00	
Mass of Particulate	L_r	mg	6.470	5.820	4.717		1.05	0.99	1.11	
Uncollected Mass	UCM	mg	0.10	0.10	0.10		1.05	0.99	1.11	

	Uncertainty in Result				
Measured Quantities	**Units**	**Run 1**	**Run 2**	**Run 3**	
Sampled Volume (STP)	mg/m^3	0.168	0.143	0.130	
Leak	mg/m^3	0.0294	0.0154	0.0193	
Mass of Particulate	mg/m^3	0.1473	0.1387	0.1549	
Uncollected Mass	mg/m^3	0.1073	0.1010	0.1128	

	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	0.25	0.22	0.23	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.49	0.44	0.46	
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	0.49	0.44	0.46	
Reported Uncertainty	mg/m^3	0.49	0.44	0.46	
Expanded uncertainty (95% confidence), without Oxygen Correction	%	7.2	7.6	8.7	
Expanded uncertainty (95% confidence), with Oxygen Correction	%	N/A	N/A	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	7.2	7.6	8.7	
Reported Uncertainty	%	7.2	7.6	8.7	

LEAD: RESULTS SUMMARY

Clark-Drain Ltd, Yaxley
Galvanising Plant

Sample Runs

Parameter	Units	Run 1		Mean
Concentration	mg/m³	0.0046		0.0046
Uncertainty	±mg/m³	0.0012		0.0012
Mass Emission	g/hr	0.038		0.038
Uncertainty	±g/hr	0.0099		0.0099

Parameter	Units	Run 1		Mean
Water Vapour	% v/v	2.6		2.6
Uncertainty	±% v/v	0.14		0.14

Blank Runs

Parameter	Units	Blank 1		Maximum
Concentration	mg/m³	0.00076		0.00076

General Sampling Information

Parameter	Value	
Standard	EN 13211	
Technical Procedure	CAT-TP-06	
Name of Analytical Laboratory	RPS	
Analytical Laboratory's Procedure	M31	
ISO 17025 Accredited Analysis?	Yes	
Date of Sample Analysis	27/02/2017	
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	FORMAT: Number Used / Number Required
Number of Sampling Points Used	4 / 4	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1, A2, B1 & B2	

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	767.3	
Stack static pressure, P_{static}	mmH_2O	5.6	
$P_s = (P_b + (P_{static} / 13.6)$	mmHg	767.7	
Volume of water vapour collected, V_{wstd}			
Total mass collected in impingers (liquid trap)	g	13.5	
Total mass collected in impingers (silica trap)	g	5.3	
Total mass of liquid collected, V_{lc}	g	18.8	
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0234	
Volume of gas metered dry, V_{mstd}			
Volume of gas sample through gas meter, V_m	m^3	0.9220	
Gas meter correction factor, Y_d	-	0.9910	
Average dry gas meter temperature, T_m	°C	18.0	
Average pressure drop across orifice, ΔH	mmH_2O	25.7	
$V_{mstd} = ((0.3592)(V_m)(P_b + (\Delta H/13.6))(Y_d)) / (T_m + 273)$	m^3	0.8675	
Moisture content, B_{wo} & R_{wv}			
$B_{wo} = V_{wstd} / (V_{mstd} + V_{wstd})$	m^3	0.0263	
B_{wo} as a percentage	% v/v	2.63	
Reported Water Vapour, checked with Tables in EN 14790, Rwv	% v/v	2.63	
Volume of gas metered wet, V_{mstw}			
$V_{mstw} = (V_{mstd})(100/(100 - R_{wv}))$	m^3	0.8909	
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	20.90	
Total	% v/v	20.96	
N_2	% v/v	79.04	
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$	g/gmol	28.85	
Molecular weight of stack gas (wet), M_s			
$M_s = M_d(1 - (R_{wv}/100)) + 18(R_{wv}/100)$	g/gmol	28.56	
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_2O	2.40	
Average square root of velocity heads, √ΔP	$\sqrt{mmH_2O}$	1.55	
Average stack gas temperature, T_s	°C	24.7	
$V_s = ((K_p)(C_p)(\sqrt{\Delta P})(\sqrt{T_s} + 273)) / (\sqrt{(M_s)(P_s)})$	m/s	5.30	
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	129.4	
Conversion factor (K/mm.Hg), C_f	-	0.3592	
$Q_{stw} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273)$	m^3/min	119.9	
$Q_{std} = ((Q_a)(P_s)(C_f)(1 - (R_{wv}/100))) / ((T_s) + 273)$	m^3/min	116.8	
$Q_{stwO_2} = ((Q_a)(P_s)(C_f)) / ((T_s) + 273) / (O_{2REFw})$	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	7.95	
Nozzle area, A_n	mm^2	49.60	
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	

LEAD: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1	
Sampling Times	-	14:06 - 14:36; 14:38 - 15:08	
Sampling Dates	-	14/02/2017	
Sampling Device	-	ISO	
Volume Sampled (REF)	m^3	0.8909	
Mass on Filter / in Rinse	µg	4.00	
Mass in Front Impingers	µg	0.10	
Mass in Back Impinger	µg	0.03	
Total Mass Collected	µg	4.12	
Calculated Concentration	mg/m^3	0.0046	
Reported Concentration	mg/m^3	0.0046	

Where: ISO stands for Manual Isokinetic Sampling Train

Blank Runs

Parameter	Units	Blank 1	
Blank Dates	-	14/02/2017	
Average Volume Sampled (REF)	m^3	0.8909	
Mass on Filter / in Rinse	µg	0.60	
Mass in Front Impingers	µg	< 0.05	
Mass in Back Impinger	µg	< 0.03	
Total Mass Collected	µg	0.68	
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	15.23	
Pre-Sampling Leak Rate	l/min	0.10	
Post-Sampling Leak Rate	l/min	0.10	
Allowable Leak Rate	l/min	0.30	
Leak Test Acceptable	-	Yes	

Absorption Efficiency	Units	Run 1	
Absorption Efficiency	%	99.4	
Allowable Absorption Efficiency	%	90	
Absorption Efficiency Acceptable	-	Yes	

Detection Limit	Units	Run 1	
Detection Limit	µg/m³	0.7	
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	%	101.7	
Allowable Isokinetic Range	%	95 - 115	
Isokineticity Acceptable	-	Yes	

Filter Temperatures	Units	Run 1	
Maximum Filter Temperature	°C	184	

Impingers Exit Temperature	Units	Run 1	
Maximum Temperature Recorded	°C	18	
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	18.00	
Pre-Sampling Leak Rate	l/min	0.14	
Post-Sampling Leak Rate	l/min	0.13	
Allowable Leak Rate	l/min	0.36	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	
Allowable Blank	mg/m^3	N/A	
Blank Acceptable	-	N/A	

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.	x	

LEAD: MEASUREMENT UNCERTAINTY CALCULATIONS

	Value			Standard uncertainty			
Measured Quantities	**Symbol**	**Run 1**		**Symbol**	**Units**	**Run 1**	
Sampled Volume (Actual)	V_m	0.9220		uV_m	m^3	0.0184	
Sampled Gas Temperature	T_m	291.0		uT_m	K	2.0	
Sampled Gas Pressure	ρ_m	102.4		$u\rho_m$	kPa	0.5	
Sampled Gas Humidity	H_m	0.0		uH_m	% v/v	1.0	
Leak	L	0.66		uL	%	-	
Laboratory Result	L_r	13.00		uL_r	%	-	

	Uncertainty as a Percentage			
Measured Quantities	**Units**	**Run 1**		**Requirement of Standard**
Sampled Volume (Actual)	%	2.00		≤2%
Sampled Gas Temperature	%	0.69		≤1%
Sampled Gas Pressure	%	0.49		≤1%
Sampled Gas Humidity	%	1.00		≤1%
Leak	%	0.66		≤2%
Laboratory Result	%	13.00		No Requirement

	Uncertainty in Measurement Units				Sensitivity Coefficient	
Measured Quantities	**Symbol**	**Units**	**Run 1**		**Run 1**	
Sampled Volume (STP)	V_m	m^3	0.8675		0.005	
Leak	L	mg/m^3	0.00002		1.00	
Laboratory Result	L_r	mg/m^3	0.00060		1.00	

	Uncertainty in Result		
Measured Quantities	**Units**	**Run 1**	
Sampled Volume (STP)	mg/m^3	0.00012	
Leak	mg/m^3	0.00002	
Laboratory Result	mg/m^3	0.00060	

	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	0.0006	
Expanded uncertainty (95% confidence), without Oxygen Correction	mg/m^3	0.0012	
Expanded uncertainty (95% confidence), with Oxygen Correction	mg/m^3	N/A	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m^3	0.0012	
Reported Uncertainty	mg/m^3	0.0012	
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	

PCME METER

Contract Details	
Test House Job Number	CSW-2662
Company	**Clark-Drain Ltd**
Site	Yaxley
Stack	Galvanising Plant
Sampling Date	14/02/2017
PCME Job Number	**20020678**

Stack Conditions	Value	Units
Stack Temperature	23.5	°C
Stack Humidity	1.9	% v/v
Stack Oxygen Content	N/A	% v/v
Stack Pressure	102.3	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	1	
Time on Display	10:30	
Time Difference - Meter v Actual	PCME Meter 18 minutes fast	
GMT / BST?	GMT	
Was Time Changed?	No	

Hardware Status	
Zero	23
Span	10055
S/C	10038
Contamination Ring	-
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	10:45	11:46	3.9	6.4	6.8	7.0	N/A	N/A	6.3
2	11:50	12:51	4.1	8.3	5.8	5.9	N/A	N/A	5.4
3	12:55	13:56	4.1	7.0	5.2	5.3	N/A	N/A	4.9
Mean			**4.0**		**5.9**	**6.0**	**N/A**	**N/A**	**5.5**

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.