APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

STACK EMISSIONS MONITORING TEAM

Team Leader	Nik Agopian MCERTS Level 2, Technical Endorsements 1, 2, 3 & 4 MM 08 902 MCERTS Expiry Date - Mar 2014 H&S Expiry Date - Feb 2018
Technician	Chris Houston MCERTS Level 1 MM 11 1135 MCERTS Expiry Date - Oct 2016 H&S Expiry Date - Oct 2016

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER SUMMARY

Parameter	Sampling Times	Concentration mg/m³	Uncertainty mg/m³	Limit mg/m³	Emission Rate g/hr
Run 1	09:57 - 10:29 07 November 2013	15.5	1.74	50	794
Blank	-	0.84	-	-	-

Reference conditions are 273K, 101.3kPa without correction for water vapour

Acetone Blank Value mg/l	Acceptable Value mg/l
2.0	10

FILTER INFORMATION

Samples

Test	Filter & Probe Rinse Number	Filter Start Weight g	Filter End Weight g	Mass Gained on Filter g	Probe Rinse Start Weight g	Probe Rinse End Weight g	Mass Gained on Probe g	Combined Total Mass Gained g
Run 1	115513.00	0.14630	0.14880	0.00250	71.02480	71.03150	0.00670	0.00920

If total mass gained is less than the LOD then the LOD is reported

Blanks

Test	Filter & Probe Number	Filter Start Weight g	Filter End Weight g	Mass Gained Filter g	Probe Start Weight g	Probe End Weight g	Mass Gained Probe g	Combined Total Mass Gained g
Run 1	115512	0.14740	0.14760	0.00020	72.45820	72.45830	0.00010	0.00050

If total mass gained is less than the LOD then the LOD is reported

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

ISOKINETIC SAMPLING EQUATIONS - RUN 1 — TPM

Absolute pressure of stack gas, P_s		
Barometric pressure, P_b	mm Hg	751.51
Stack static pressure, P_{static}	mm H_2O	5.10
$P_s = P_b + \frac{(P_{static})}{13.6}$	mm Hg	751.88
Vol. of water vapour collected, V_{wstd}		
Moisture trap weight increase, Vlc	g	46.7
$V_{wstd} = (0.001246)(V_{lc})$	m^3	0.0581882
Volume of gas metered dry, V_{mstd}		
Volume of gas sample through gas meter, V_m		0.527
Gas meter correction factor, Y_d		1.0766
Mean dry gas meter temperature, T_m		14.625
Mean pressure drop across orifice, ΔH	mmH_2O	36.092
$V_{mstd} = \frac{(0.3592)(V_m)(P_b+(\Delta H/13.6))(Y_d)}{T_m + 273}$		0.534
Volume of gas metered wet, V_{mstw}		
$V_{mstw} = V_{mstd} + V_{wstd}$	m^3	0.5924
Vol. of gas metered at O_2 Ref. Cond., $V_{mstd@X\%O2}$		
Is the process burning hazardous waste? *(If yes, no favourable oxygen correction)*		No
% oxygen measured in gas stream, act%O_2		21.0
% oxygen reference condition		21
O_2 Reference Factor $O_2\ Ref = \frac{21.0 - act\%O_2}{21.0 - ref\%O_2}$		No O2 Ref
$V_{mstd@X\%oxygen} = (V_{mstd})\ (O_{2\ Ref})$	m^3	No O2 Ref
Moisture content, B_{wo}		
$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$		0.0982
	%	9.82
Moisture by FTIR	%	-
Velocity of stack gas, V_s		
Pitot tube velocity constant, K_p		34.97
Velocity pressure coefficient, C_p		0.84
Mean of velocity heads, ΔP_{avg}	mm H_2O	20.13
Mean square root of velocity heads, $\sqrt{\Delta P}$		4.49
Mean stack gas temperature, T_s	°C	83
$V_s = \frac{(K_p)(C_p)(\sqrt{\Delta P})(\sqrt{(T_s + 273)})}{(M_s)(P_s)}$	m/s	16.55

Molecular weight of dry gas, M_d		
CO_2	%	15.50
O_2	%	21.00
Total	%	36.50
N_2 (100 -Total)	%	63.50
$M_d = 0.44(\%CO_2)+0.32(\%O_2)+0.28(\%N_2)$		31.32
Molecular weight of wet gas, M_s		
$M_s = M_d(1 - B_{wo}) + 18(B_{wo})$	g/gmol	30.01
Actual flow of stack gas, Q_a		
Area of stack, A_s	m^2	1.13
$Q_a = (60)(A_s)(V_s)$	m^3/min	1122.9
Total flow of stack gas, Q		
Conversion factor (K/mm.Hg)		0.3592
$Q_{std} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})}{(T_s) +273}$	Dry	768.8
$Q_{stdO2} = \frac{(Q_a)P_s(0.3592)(1-B_{wo})(O_2REF)}{(T_s) +273}$	@O_2ref	No O2 Ref
$Q_{stw} = \frac{(Q_a)P_s(0.3592)}{(T_s) +273}$	Wet	852.50
Percent isokinetic, %I		
Nozzle diameter, D_n	mm	5.35
Nozzle area, A_n	mm^2	22.48
Total sampling time, θ	min	32
$\%I = \frac{(4.6398E6)(T_s+273)(V_{mstd})}{(P_s)(V_s)(A_n)(\theta)(1-B_{wo})}$	%	109.2
Acceptable isokinetic range 95% to 115%		Yes
Particulate Concentration, C		
Mass collected on filter, M_f	g	0.00250
Mass collected in probe, M_p	g	0.00670
Total mass collected, M_n	g	0.00920
$C_{wet} = \frac{M_n}{V_{mstw}}$	mg/m^3	15.530
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m^3	17.222
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m^3	No O2 Ref
Particulate Emission Rates, E		
$E = [(C_{wet})(Q_{stw})(60)] / 1000$		794.38

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

TOTAL PARTICULATE MATTER QUALITY ASSURANCE CHECKLIST

Leak Rate

Run	Mean Sampling Rate litre/min	Pre-sampling Leak Rate litre/min	Post-sampling Leak Rate litre/min	Maximum Vacuum mm Hg	Acceptable Leak Rate litre/min	Leak Tests Acceptable?
Run 1	17.72	0.11	0.12	-279.4	0.35	Yes

Isokineticity

Run	Isokinetic Variation %	Acceptable Isokineticity *
Run 1	109.25	Yes

Acceptable isokinetic range 95% to 115%

Balance Uncertainty

Run	Result mg/m³	5% ELV mg/m³	LOD < 5% ELV
Run 1	0.84	2.5	Yes

The above is based on both the Filter and rinse uncertainty

Blank Value

Run	Overall Blank Value mg/m³	Daily Emission Limit Value mg/m³	Acceptable Blank Value mg/m³	Overall Blank Acceptable mg/m³
Blank 1	0.84	50	5.0	Yes

Filters

Run	Filter Material	Filter Size mm	Max Filtration Temperature °C	Pre-use Filter Conditioning Temperature °C	Post-use Filter Conditioning Temperature °C
Run 1	QF	47	84	180	160

GF = Glass Fibre

QF = Quartz Fibre

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

MOISTURE CALCULATIONS

Moisture Determination - Isokinetic

Test Number	Sampling Time and Date	Start Weight kg	End Weight kg	Total gain kg	Concentration %	LOD %	Uncertainty %
Run 1	09:57 - 10:29 07 November 2013	4.0207	4.0674	0.0467	9.8226	0.021	2.8

Moisture Quality Assurance

Test Number	Sampling Duration mins	Total Volume Sampled l	Sampling Rate l/min	Start Leak Rate l/min	End Leak Rate l/min	Acceptable Leak Rate l/min	Leak Tests Acceptable?
Run 1	32	592	17.7249	0.1100	0.1200	0.3545	Yes

PRELIMINARY STACK SURVEY

Stack Characteristics

Stack Diameter / Depth, D	1.20	m
Stack Width, W	-	m
Stack Area, A	1.13	m^2
Average stack gas temperature	82	°C
Stack static pressure	0.05	kPa
Barometric Pressure	99.8	kPa
Pitot tube calibration coefficient, K_{pi}	0.82	-

Stack Gas Composition & Molecular Weights

Component	Molar Mass M	Density kg/m^3 p	Conc Dry % Vol	Dry Volume Fraction r	Dry Conc kg/m^3 pi	Conc Wet % Vol	Wet Volume Fraction r	Wet Conc kg/m^3 pi
CO_2	44	1.963059	15.500000	0.155000	0.304274	13.977500	0.139775	0.274387
O_2	32	1.427679	21.000000	0.210000	0.299813	18.937258	0.189373	0.270363
N_2	28	1.249219	63.500000	0.635000	0.793254	57.262660	0.572627	0.715336
H_2O	18	0.803070	-	-	-	9.822582	0.098226	0.078882

Where: p = M / 22.41 $pi = r \times p$

Calculation of Stack Gas Densities

Determinand	Result	Units
Dry Density (STP), P_{STD}	1.3973	kg/m^3
Wet Density (STP), P_{STW}	1.3390	kg/m^3
Dry Density (Actual), P_{Actual}	1.0604	kg/m^3
Average Wet Density (Actual), $P_{ActualW}$	1.016	kg/m^3

Where:

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

$P_{STW} = (P_{STD} + pi \text{ of } H_2O) / (1 + (pi \text{ of } H_2O / 0.8036))$

$P_{Actual} = P_{STD} \times (Ts / Ps) \times (Pa / Ta)$

$P_{ActualW} = P_{STW} \times (Ts / Ps) \times (Pa / Ta)$

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY

TRAVERSE 1

Date of Survey	07 November 2013
Time of Survey	09:25
Velocity Measurement Device:	S-Type

Sampling Line A

Traverse Point	Distance into duct (m)	ΔPpt mmH_2O	ΔPpt Pa	Temp °C	Velocity m/s	O_2 % Vol	Angle of Swirl °
1	0.06	23.0	225	82	16.92	-	0
2	0.18	22.0	216	84	16.60	-	0
3	0.30	22.5	221	81	16.71	-	0
4	0.42	23.5	230	80	17.06	-	0
5	0.54	22.0	216	83	16.57	-	0
6	0.66	24.0	235	81	17.26	-	0
7	0.78	24.5	240	82	17.47	-	0
8	0.90	22.5	221	80	16.69	-	0
9	1.02	22.0	216	83	16.57	-	0
10	1.14	23.0	225	80	16.87	-	0
Mean	-	22.9	224	82	16.87	-	

Sampling Line B

Traverse Point	Distance into duct (m)	ΔPpt mmH_2O	ΔPpt Pa	Temp °C	Velocity m/s	O_2 % Vol	Angle of Swirl °
1	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
Mean	-	-	-	-	-	-	

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

PRELIMINARY STACK SURVEY (CONTINUED)

Sampling Plane Validation Criteria

EA Technical Guidance Note (Monitoring) M1	Result	Units	Requirement	Compliant
Lowest Differential Pressure	215.6	Pa	>= 5 Pa	Yes
Lowest Gas Velocity	16.57	m/s	-	-
Highest Gas Velocity	17.47	m/s	-	-
Ratio of Gas Velocities	1.05	-	< 3 : 1	Yes
Maximum angle of flow with regard to duct axis	0	°	< 15°	Yes
No local negative flow	Yes	-	-	Yes

Other Sampling Method Criteria	Result	Units	Requirement	Compliant
Mean Velocity	16.87	m/s	-	-
Standard Deviation of Velocity from Mean	1.82	%	< 10%	Yes
Mean Oxygen	-	%	-	-
Standard Deviation of Oxygen from Mean	-	%	< 15%	-
Homogeneous flow stream / gas velocity	-	-	-	Yes

Calculation of Stack Gas Velocity, V

Velocity at Traverse Point, $V = K_{pt} \times (1-\varepsilon) * \sqrt{(2 * \Delta P_{pt} / P_{ActualW})}$

Where:

K_{pt} = Pitot tube calibration coefficient

$(1-\varepsilon)$ = Compressibility correction factor, assumed at a constant 0.998

Average Stack Gas Velocity, Va	16.87		m/s

Calculation of Stack Gas Volumetric Flowrate, Q

Duct gas flow conditions	Actual	Reference	Units
Temperature	82	0	°C
Total Pressure	99.85	101.3	kPa
Oxygen	21.0	21	%
Moisture	9.82	9.82	%

Gas Volumetric Flowrate	Result	Units
Average Stack Gas Velocity (Va)	16.87	m/s
Stack Area (A)	1.13	m^2
Gas Volumetric Flowrate (Actual), Q_{Actual}	68707	m^3/hr
Gas Volumetric Flowrate (STP, Wet), Q_{STP}	52139	m^3/hr
Gas Volumetric Flowrate (STP, Dry), $Q_{STP,Dry}$	47018	m^3/hr
Gas Volumetric Flowrate (REF), Q_{Ref}	52139	m^3/hr

Where:

Q_{Actual} = Va x A x 3600

Q_{STP} = Q (Actual) x (Ts / Ta) x (Pa / Ps) x 3600

$Q_{STP,Dry}$ = Q (STP) / (100 - (100 / Ma)) x 3600

Q_{Ref} = Q (STP) x ((100 - Ma) / (100 - Ms)) x ((20.9 - O_2a) / (20.9 - O_2s))

Nomenclature:

Ts = Absolute Temperature, Standard Conditions, 273 K

Ps = Absolute Pressure, Standard Conditions, 101.3 kPa

Ta = Absolute Temperature, Actual Conditions, K

Pa = Absolute Pressure, Actual Conditions, kPa

Ma = Water vapour, Actual Conditions, % Vol

Ms = Water vapour, Reference Conditions, % Vol

O_2a = Oxygen, Actual Conditions, % Vol

O_2s = Oxygen, Reference Conditions, % Vol

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

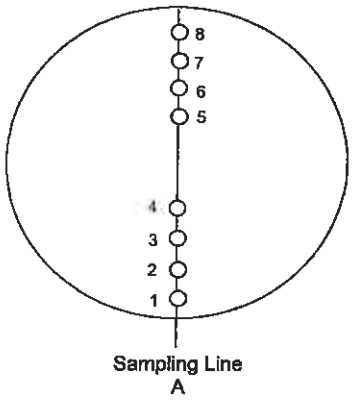
STACK DIAGRAM

	Value	Units
Stack Depth	1.20	m
Stack Width	-	m
Area	1.13	m^2

Non-Isokinetic Sampling

Sampling Point	Distance (% of Depth)	Distance into Stack	Units
-	-	-	-

Circular 1 Line 8 Points



- ○ Isokinetic sampling point
- ● Isokinetic sampling points not used
- ○ Non Isokinetic/Gases sampling point

Isokinetic Sampling CEN Methods

Sampling Point	Distance (% of Depth)	Distance into Stack (m)	Swirl °
1	4.2	0.05	0
2	10.5	0.13	0
3	19.4	0.23	0
4	32.3	0.39	0
5	67.7	0.81	0
6	80.6	0.97	0
7	89.5	1.07	0
8	95.8	1.15	0
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

SAMPLING LOCATION