STACK EMISSIONS MONITORING REPORT

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Operator & Address:
Tarmac Lafarge Cliff Quay Dock Cliff Road Ipswich Suffolk IP3 0BG

Permit:
EPR Permit: RP1/VPA/06/11

Release Point:
Main Stack

Sampling Date(s):
7th November 2013

ESG Job Number:	LCH 00660
Report Date:	15th November 2013
Version:	1
Report By:	Chris Houston
MCERTS Number:	MM 11 1135
MCERTS Level:	MCERTS Level 1 - Technician
Technical Endorsements:	
Report Approved By:	Nik Agopian
MCERTS Number:	MM 08 902
Business Title:	MCERTS Level 2 - Team Leader
Technical Endorsements:	1, 2, 3 & 4
Signature:	

UKAS TESTING 1015

mCERTS THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

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EXECUTIVE SUMMARY

Stack Emissions Monitoring Objectives

Tarmac Lafarge operates a mineral drying and roadstone coating process at Ipswich which is subject to EPR Permit RP1/VPA/06/11, under the Environmental Permitting Regulations 2010.

Environmental Scientifics Group Limited were commissioned by Tarmac Lafarge to carry out stack emissions monitoring to determine the release of prescribed pollutants from the following Plant under normal operating conditions.

The results of these tests shall be used to demonstrate compliance with a set of emission limit values for prescribed pollutants as specified in the Plant's EPR Permit, RP1/VPA/06/11.

Plant

Main Stack

Operator

Tarmac Lafarge
Cliff Quay Dock
Cliff Road
Ipswich
Suffolk
IP3 0BG

EPR Permit: RP1/VPA/06/11

Stack Emissions Monitoring Test House

Environmental Scientifics Group Limited - Mitcheldean Laboratory
Acacia Building
Vantage Point Business Village
Mitcheldean
GL17 0DD
UKAS and MCERTS Accreditation Number: 1015

Opinions and interpretations expressed herein are outside the scope of UKAS accreditation.
MCERTS accredited results will only be claimed where both the sampling and analytical stages are UKAS accredited.

EXECUTIVE SUMMARY

Emissions Summary

Parameter	Units	Result	Calculated Uncertainty +/-	Limit	MCERTS accredited result
Total Particulate Matter	mg/m³	16	1.7	50	✓
Particulate Emission Rate	g/hr	794	89	-	
Moisture	%	9.8	0.28	-	✓
Stack Gas Temperature	°C	81.6	-	-	
Stack Gas Velocity	m/s	16.9	-	-	
Gas Volumetric Flow Rate (Actual)	m³/hr	68707	-	-	✓
Gas Volumetric Flow Rate (STP, Wet)	m³/hr	52139	-	-	
Gas Volumetric Flow Rate (STP, Dry)	m³/hr	47018	-	-	
Gas Volumetric Flow Rate at Reference Conditions	m³/hr	52139	-	-	

ND = None Detected,
Results at or below the limit of detection are highlighted by bold italic text.
The above volumetric flow rate is calculated using data from the preliminary survey. Mass emissions for non isokinetic tests are calculated using these values. For all isokinetic testing the mass emission is calculated using test specific flow data and not the above values.
Reference conditions are 273K, 101.3kPa without correction for water vapour

EXECUTIVE SUMMARY

Monitoring Times

Parameter	Sampling Date(s)	Sampling Times	Sampling Duration
Total Particulate Matter Run 1	07 November 2013	09:57 - 10:29	32 minutes
Stack Gas Flow Rate & Temperature Run 1	07 November 2013	09:25	-

EXECUTIVE SUMMARY

Process Details

Parameter	Process Details
Description of process	Mineral Drying and Roadstone Coating
Continuous or batch	Continuous
Product Details	50% Rap, 15 & 20 mm Hot Roll
Part of batch to be monitored (if applicable)	N/A
Normal load, throughput or continuous rating	100 T / H
Fuel used during monitoring	GT
Abatement	Bag Filter
Plume Appearance	None Visible

EXECUTIVE SUMMARY

Monitoring Methods

The selection of standard reference / alternative methods employed by Environmental Scientifics Group Limited is determined, wherever possible by the hierarchy of method selection outlined in Environment Agency Technical Guidance Note (Monitoring) M2. i.e. CEN, ISO, BS, US EPA etc.

MONITORING METHODS						
Species	**Method** Standard Reference Method / Alternative Method	**ESG Technical Procedure**	**UKAS Lab Number**	**MCERTS Accredited Method**	**Limit of Detection (LOD)**	**Calculated MU +/- %**
TPM	SRM - BS EN 13284-1	AE 104	1015	Yes	0.84 mg/m³	11.2 %
H_2O	SRM - BS EN 14790	AE 105	1015	Yes	0.02%	2.81%
Flow Rate / Temp.	SRM - BS EN 13284-1	AE 122	1015	Yes	5 Pa	-

EXECUTIVE SUMMARY

Analytical Methods

The following tables list the analytical methods employed together with the custody and archiving details:

SAMPLING METHODS WITH SUBSEQUENT ANALYSIS							
Species	**Analytical Technique**	**Analytical Procedure**	**UKAS Lab Number**	**UKAS Accredited Lab Analysis**	**Analysis Lab (ESG or Subcontract)**	**Sample Archive Location**	**Archive Period**
TPM	Gravimetric	AE 106	1015	Yes	ESG Mitcheldean	ESG Mitcheldean	3 months

ON-SITE TESTING							
Species	**Analytical Technique**	**Analytical Procedure**	**UKAS Lab Number**	**MCERTS Accredited Analysis**	**Laboratory**	**Data Archive Location**	**Archive Period**
H_2O	Gravimetric	AE 105	1015	Yes	ESG Mitcheldean	-	-

EXECUTIVE SUMMARY

Sampling Location

Sampling Plane Validation Criteria	Value	Units	Requirement	Compliant	Method
Lowest Differential Pressure	216	Pa	>= 5 Pa	Yes	BS EN 13284-1
Lowest Gas Velocity	16.57	m/s	-	-	-
Highest Gas Velocity	17.47	m/s	-	-	-
Ratio of Gas Velocities	1.05	: 1	< 3 : 1	Yes	BS EN 13284-1
Mean Velocity	16.87	m/s	-	-	-
Maximum angle of flow with regard to duct axis	0	^{o}	< 15^{o}	Yes	BS EN 13284-1
No local negative flow	Yes	-	-	Yes	BS EN 13284-1

Duct Characteristics

	Value	Units
Shape	Circular	-
Depth	1.20	m
Width	-	m
Area	1.13	m^2
Port Depth	90	mm

Sampling Lines & Sample Points

	Isokinetic (CEN Methods)	Isokinetic (ISO Methods)	Non-Iso & Gases
Sample port size	5.5" BSP	-	-
Number of lines used	1	-	-
Number of points / line	8	-	-
Duct orientation	Horizontal	-	-
Filtration for TPM	In Stack	-	-

Sampling Platform

General Platform Information	
Permanent / Temporary Platform / Ground level / Floor Level / Roof	Permanent
Inside / Outside	Outside

M1 Platform requirements	
Is there a sufficient working area so work can be performed in a compliant manner	Yes
Platform has 2 levels of handrails (approximately 0.5 m & 1.0 m high)	Yes
Platform has vertical base boards (approximately 0.25 m high)	Yes
Platform has removable chains / self closing gates at the top of ladders	Yes
Handrail / obstructions do not hamper insertion of sampling equipment	Yes
Depth of Platform = Minimum of 2m or Probe Length + 1m	Yes

Sampling Platform Improvement Recommendations (if applicable)

The sampling location meets all the requirements as specified in EA Guidance Note M1.

EXECUTIVE SUMMARY

Sampling & Analytical Method Deviations

Sample Line

Port cap stuck on line B. Therefore only one sample line was used, however the number of sample points on that line were doubled to compensate for this.

APPENDICES

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APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

APPENDIX 3 - Measurement Uncertainty Budget Calculations

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

MONITORING SCHEDULE

Species	Method Standard Reference Method / Alternative Method	ESG Technical Procedure	UKAS Lab Number	MCERTS Accredited Method	Number of Samples
TPM	SRM - BS EN 13284-1	AE 104	1015	Yes	1
H_2O	SRM - BS EN 14790	AE 105	1015	Yes	1
Flow Rate / Temp.	SRM - BS EN 13284-1	AE 122	1015	Yes	1

APPENDIX 1 - Monitoring Schedule, Calibration Checklist & Monitoring Team

CALIBRATEABLE EQUIPMENT CHECKLIST

Extractive Sampling		Instrumental Analyser/s		Miscellaneous	
Equipment	**Equipment I.D.**	**Equipment**	**Equipment I.D.**	**Equipment**	**Equipment I.D.**
Control Box DGM	P1760	Horiba PG-250 Analyser	-	Laboratory Balance	-
Box Thermocouples	P1760	FT-IR	-	Tape Measure	-
Meter In Thermocouple	P1760	FT-IR Oven Box	-	Stopwatch	-
Meter Out Thermocouple	P1760	Bernath 3006 FID	-	Protractor	-
Control Box Timer	P1760	Signal 3030 FID	-	Barometer	-
Oven Box	-	Servomex	-	Digital Micromanometer	-
Probe	-	JCT Heated Head Filter	-	Digital Temperature Meter	-
Probe Thermocouple	-	Thermo FID	-	Stack Thermocouple	-
Probe	-	Stackmaster	-	Mass Flow Controller	-
Probe Thermocouple	-	FTIR Heater Box for Heated Line	-	MFC Display module	-
S-Pitot	-	Anemometer	-	1m Heated Line (1)	-
L-Pitot	-	Ecophysics NOx Analyser	-	1m Heated Line (2)	-
Site Balance	P1951	Chiller (JCT/MAK 10)	-	1m Heated Line (3)	-
Last Impinger Arm	-		-	5m Heated Line (1)	-
Dioxins Cond. Thermocouple	-		-	10m Heated Line (1)	-
Callipers	-		-	10m Heated Line (2)	-
Small DGM	-		-	15m Heated Line (1)	-
Heater Controller	-		-	20m Heated Line (1)	-
Inclinometer (Swirl Device)	-		-	20m Heated Line (2)	-

NOTE: If the equipment I.D is represented by a dash (-), then this piece of equipment has not been used for this test.

-	-	-	-	-	-

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
$P_s = \frac{P_b + (P_{static})}{13.6}$	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	^oC	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/m³	15.530
$C_{dry} = \frac{M_n}{V_{mstd}}$	mg/m³	17.222
$C_{dry@X\%O2} = \frac{M_n}{V_{mstd@X\%oxygen}}$	mg/m³	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/m^3	Daily Emission Limit Value mg/m^3	Acceptable Blank Value mg/m^3	Overall Blank Acceptable mg/m^3
Blank 1	0.84	50	5.0	Yes

Filters

Run	Filter Material	Filter Size mm	Max Filtration Temperature ℃	Pre-use Filter Conditioning Temperature ℃	Post-use Filter Conditioning Temperature ℃
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	^oC
Stack static pressure	0.05	kPa
Barometric Pressure	99.8	kPa
Pitot tube calibration coefficient, K_{pt}	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 p*i* = r x 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)	ΔP pt mmH_2O	ΔP pt 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)	ΔP pt mmH_2O	ΔP pt 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	^{o}	< 15^{o}	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	^{o}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

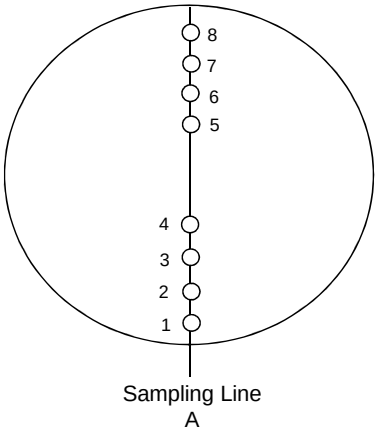
STACK DIAGRAM

	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

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - TOTAL PARTICULATE MATTER

Run	Sampled Volume	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Limit of Detection	Leak	Uncollected Mass
	m^3	K	kPa	% by volume	% by volume	% by mass	%	mg
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 5% of ELV**	**≤ 2%**	**≤ 10% of ELV**
Run 1	0.001	2	0.5	1	N/A	0.5000	-	-
as a %	0.17	0.70	0.50	1.00	N/A	1.68807	0.68	0.001
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**	**Yes**

Run	Volume (STP)	Mass of particulate	O_2 Correction	Leak	Uncollected Mass	Combined uncertainty
	m^3	mg	-	mg/m^3	mg	
Run 1	0.56	9.2000	1.00	0.061	0.0003	-
MU as mg/m^3	0.21	0.8440	-	0.061	0.0005	**0.87**
MU as %	1.33	5.4348	-	0.391	0.0031	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**1.74**	**mg/m^3**	**11.22**	**%**

(k is a coverage factor which gives a 95% confidence in the quoted figures)

Developed for the STA by R Robinson, NPL

APPENDIX 3 - Measurement Uncertainty Budget Calculations

MEASUREMENT UNCERTAINTY BUDGET - MOISTURE

Run	Sampled Volume	Sampled Gas Temp	Sampled Gas Pressure	Sampled Gas Humidity	Oxygen Content	Leak
	m^3	K	kPa	% by volume	% by volume	%
MU required	**≤ 2%**	**≤ 2%**	**≤ 1%**	**≤ 1%**	**≤ 10%**	**≤ 2%**
Run 1	0.001	2	0.5	1	N/A	-
as a %	0.17	0.70	0.50	1.00	N/A	0.68
compliant?	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**

Run	Volume (STP)	Mass Gained	O_2 Correction	Leak	Uncollected Mass	Combined uncertainty
	m^3	mg	-	mg/m^3	mg	
Run 1	0.56	46700.00	1.00	308.14	57.74	-
MU as % v/v	0.13	0.02	-	0.04	0.012	**0.14**
MU as %	1.33	0.21	-	0.39	0.12	-

R1 - Uncertainty expressed at a 95% confidence level (where k = 2)	**0.28**	**% v/v**	**2.81**	**%**

END OF REPORT