Yelland
Environmental
Services

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Measurement of Particulate Emissions
Respirable Dust Monitoring
L.E.V.E. Plant Test and Inspection
Noise Surveys

MCERTS
THE ENVIRONMENT AGENCY'S
MONITORING CERTIFICATION SCHEME

Environmental Protection Act
Pollution Prevention & Control

PARTICULATE EMISSION TEST
(BS EN 13284-1:2002)

on

COATING PLANT
BAG FILTER EXHAUST

for

MIDLAND QUARRY PRODUCTS
ST. IVES WORKS
MEADOW LANE
ST. IVES
CAMBRIDGESHIRE PE27 4LG

Tested By: A. Yelland

Date Of Test : 10.05.17

A. Yelland
MCERTS Level 2 Team Leader (MM 02 130)

Report No : 2589

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SUMMARY INFORMATION

Determined	Units	Results	Uncertainty +/-	Limit
Particulate Concentration (STP)	mg/m^3	45.83	1.35	50
Mass Emission (STP)	kg/hr	3.02	0.09	-
Stack Temperature	°C	75	-	-
Gas Velocity	m/s	16.30	-	-
Stack Volume Flow Rate (Actual)	m^3/hr	85245	-	-
Stack Volume Flow Rate (STP)	m^3/hr	66605	-	-

All results are reported at reference conditions of 273K, 101.3kPa, wet gas.

Sampling Results

Two particulate tests were carried out, under continuous operating conditions, to assess the emission concentration in the exhaust gases. The sample time of each test was 32 minutes.

At the time of sampling, a particulate matter of 45.8mg/m^3 at reference conditions was measured. It can be concluded, therefore, that the emission from this plant was found to comply with the emission limit currently imposed.

Comments

Full test data demonstrating procedural compliance with BS EN 13284-1 for total particulate monitoring is provided in following sections.

1. INTRODUCTION

Particulate emission testing was undertaken by Yelland Environmental Services, on the roadstone coating plant dust collector exhaust at Midland Quarry Products, St Ives site.

The purpose of the emission testing was to ensure compliance with the requirements of the permit issued by the Local Authorithy under The Environmental Permitting (England and Wales) Regulations 2010.

2. BACKGROUND INFORMATION

The Environmental Permitting (England and Wales) Regulations 2010 (EPR), came into force on 6 April 2010. The regulations combine Pollution Prevention and Control and Waste Management Licensing.

Environmental Permits automatically replaced previously issued Pollution Prevention and Control permits (PPC) permits with effect from April 2010. As with PPC permits, to continue operations, all sites operating scheduled processes must obtain an EPA permit from their Local Authority and comply with the conditions contain therein. The conditions will include a requirement to monitor emissions to air both periodically and continuously in accordance with relevant clauses of following process guidance note:-

* Process Guidance Note PG3/8 (12) Secretary of State's Guidance for Quarry Processess.

3. MONITORING CONTRACTOR

The emission monitoring was carried out by Mr A Yelland, Company Principal, Yelland Environmental Services. Mr Yelland has 20 years experience of undertaking particulate emission testing on plant used in the quarrying and allied industries and has held level 2 MCERTS Team Leader accreditation since its conception.

4. MONITORING PROTOCOL

4.1 Test Method and references

Isokinetic sampling of the contained emission sources was undertaken using the APEX Instruments Inc Method Five isokinetic sampling apparatus in accordance with the main procedural requirements within the following British Standards and Technical Guidance Notes:-

* BS EN 13284-1:2002 - Stationary source emissions. Dertermination of low range mass concentration of dust.

* Environment Agency - Technical Guidance Document (Monitoring) M1 Sampling requirements for monitoring stack emissions to air from industrial installations; and

* Environment Agency - Technical Guidance Document (Monitoring) M2 Monitoring of Stack Emissions to Air.

4.2 Sampling Procedure

The work carried out was, as far as was reasonably practical, in accordance with BS EN 13284-1:2002.

Isokinetic flow means that sample gases laden with particulates are drawn off at the same velocity as the free stream velocity in the flue. Isokinetic sampling thus avoids possible inertial effects of particulates approaching the vicinity of the inlet nozzle which may result in significant error.

The Apex Instruments test equipment was designed to meet the sampling requirements of US EPA Method 5 and with a modified nozzle design, meets the sampling requirements of BS EN 13284-1.

The principle of the standard is to draw a known volume of dust laden gas isokinetically through a filter. The weight gain on the filter, after sampling, divided by the gas sample volume equates to the particulate concentration, which in turn can be used to calculate a mass emission.

4.3 Sampling equipment

The test equipment is inspected prior to use and it's calibration status observed. This includes:-

* *Pitot Tube* - All pitot tubes are checked for damage, alignment and that there are no blockages;

* *Manometer* - Check of oil levels, connectors and orientation level;

* *Thermocouple* - Temperature is measured using k type thermocouples. Each thermocouple is inspected for calibration and damage. Digital temperature meters are used in conjunction with k type thermocouples which are also checked for calibration dates;

* Gas meter - The calibration of the gas meter is checked before and after sampling using a critical orifice.

* *Nozzles* - All nozzles used have been constructed in accordance with BS EN 13284-1. Each nozzle is checked for damaged and measured using a vernier caliper on at least 3 planes. Non conforming nozzles will be rejected.

* *Balance* - A Mettler Toledo balance is used to weigh filters. It is calibrated yearly by the manufacturer and checked daily by in-house weights.

* *Filters* - Pall quartz membrane filters with a collection efficieny of >99.5% at 0.3microns.

4.4 Preparation for sampling

4.4.1 Filter Preparation

Filters are pre-conditioned before arrival on site. The filters are dried in an oven at 180°C for a period of at least one hour and then placed to cool in a dessicator for at least four hours. The filters are then weighed on a five figure balance and placed in individual transport containers. Spare Filters are prepared to obtain blank values.

4.4.2 Sampling Location

No site visit was undertaken prior to undertaking the sampling procedure, as monitoring had previously been undertaken at the site, during which time the sampling position, working platform, sampling ports, access and safety precautions were found to be satisfactory.

The internal dimension of the flue was known from previous monitoring undertaken. However, further measurements were taken to check that the internal diamerter had not changed.

Prior to sampling a pressure and temperature survey, using a pitot static tube, a micromanometer, a digital thermometer and a nickel-chromium/nickel-aluminium thermocouple, is carried out to check whether the flow conditions meet with the requirements of BS EN 13284-1. From this initial survey sample locations, isokinetic flow rates, nozzle size, and sample period can be worked out.

4.5 Sample Collection

A leak check is carried out before and after sampling to confirm all the suction is drawn through the nozzle.

With the required isokinetic flow rates known the sample probe is inserted into the stack at 90^o to the gas flow, this is to stop any particulate matter impinging on the filter before sampling.

The filter head and probe were allowed to obtain the stack gas temperature.

The initial gas meter reading was noted and the suction device and timer started. The correct flow rate for isokinetic sampling was set and the nozzle positioned to face parallel to the gas flow.

Sampling was then carried out for the planned duration and number of sample points, recording all the necessary data for final calculations. On completion, the suction device and timer were stopped and the final gas meter volume recorded.

The probe was removed from the process stack and a further leak test carried out prior to removal of the filter, which was subsequently removed and placed in a storage container.

Any residual particulates upstream of the filter was washed with acetone into an appropriate beaker.

Repeat all of the above procedures to obtain duplicate samples.

At all times during the sampling procedure the sampling technicians were in contact with the process operator to ensure that the plant was in full production and there were no changes in the process that might affect the representative nature of the samples collected.

4.6 Analysis of samples

On returning to the laboratory, the used filters were dried in an oven at 160°C for a minimum of one hour and then desiccated and weighed as before. The water/acetone washings are first evaporated, without boiling, then dried and weighed as above. The total particulate mass is the sum of the differential filter weight added to the differential water/acetone rinsings component.

4.7 Calculation of results

The calculations were made using the formula specified in BS EN 13284-1.

The recorded filter weights, velocity, temperature, sampling duration and internal flue dimensions were then used to calculate:-

- the mass rate of solids emission in kg/hr; and
- the solids concentration in mg/m^3.

5. SAMPLING RECORDS

5.1 Process Conditions

Arrestment Plant:	Bag Filter
Particulate Type:	Aggregate
Plant Loading:	Continuous - 20mm dense @ 85tph
Appearance of plume:	Visible discharge

5.2 Sampling Results

	Test Run No. 1.	Test Run No. 2.	Average
Time of Test:	07.27 - 07.59	08.05 - 08.37	
Sampling Duration: (mins)	32	32	
Gas Temperature (°C)	75	73	74
Mean Velocity at Sampling Points: (m/s)	16.86	16.66	16.76
Gas Flow Rate at STP (1): (m^3/min)	1102.1	1093.1	1097.6
Particulate Loading at STP (1): (mg/m^3)	47.27	44.38	45.83
Particulate at Normalised Conditions (2): (mg/m^3)	-----	-----	-----

(1) Particulate stated at 273K, 101.3kPa without correction for water vapour.

(2) State normalised conditions (eg 11% O_2, etc).

5.3 - Calculations Sample Run No. 1

On-site measurements

O2 = 16.9 %
CO2 = 2.2 %
N2 = 80.9 %
Bws = 0.05
Ps = 100.9 kPa
Ts = 347.9 K

Md = Molecular weight of gas at DGM (g/g mole)
Md = (0.44 x $\%CO_2$) + (0.32 x $\%O_2$) + (0.28 x $\%N_2$)
= 29.03 g/g mole

Ms = Molecular weight of gas wet (g/g mole)
= 28.48 g/g mole

Stack gas velocity at sample points

V = Kp x Cp x $\sqrt{(Ts.\Delta P/Ps.Ms)}$
= 16.86 m/s

Kp = 4.07
ΔP = 142.6 av. Δp at sample plane
Cp = 1.00 pitot tube coefficient

Stack gas volume at sample points

Q = V x A x 60
= 1469.5 m^3/min

A = 1.45 area of stack m^2

Volume of water vapour collected, standard conditions (m^3)

Vwstd = 0.00124 x Vlc
= 0.0299 m^3

Vlc = 24 ml

Volume of gas metered, standard conditions (m^3)

$$Vmstd = \frac{2.695 \times Vm \times (Pa + (\Delta H/102)) \times Yd}{(T + Tm)}$$

= 0.7031 m^3

Tm = 6 °C
Vm = 0.7673 m^3
Pa = 100.9 kPa
ΔH = 46.3 mm H_2O
Yd = 0.936

Moisture content

Bwo = Vwstd/(Vwstd +Vmstd)
= 0.0408

5.3 - Calculations Sample Run No. 1 Cont.

Dry total flow of stack gas, standard conditions (m^3/min)

$$Qstd = \frac{Q \times Ps(2.695)(1 - Bwo)}{Ts + 273}$$

Ts = 74.9 °C

Ps = 100.9 kPa

= 1102 m^3/min

Percent isokinetic

$$\%I = \frac{(6.184 \times 10^5)(Ts + 273) \times Vmstd}{Ps \times V \times Aa \times t \times (1 - Bwo)}$$

Aa = 28.3 area of nozzle m^2

= 102.4 %

Filter & rinsing weights sample no. 1

weight gain on filters =	33.24 mg
weight of acetone wash =	mg
total weight gain (M) =	33.24 mg

Particulate concentration (mg/m^3)

C = M/Vmstd

M = 33.24 mg

= 47.27 mg/m^3

Particulate emission rate (kg/hr)

E = (C x Qstd x 60)/1000000

= 3.13 kg/hr

5.3 - Calculations Sample Run No. 2

On-site measurements

O2 = 14.9 % CO2 = 3.4 % N2 = 81.7 %

Bws = 0.04 Ps = 100.9 kPa Ts = 346.3 K

Md = Molecular weight of gas at DGM (g/g mole)

Md = $(0.44 \times \%CO_2) + (0.32 \times \%O_2) + (0.28 \times \%N_2)$

= 29.14 g/g mole

Ms = Molecular weight of gas wet (g/g mole)

= 28.69 g/g mole

Stack gas velocity at sample points

V = Kp x Cp x $\sqrt{(Ts.\Delta P/Ps.Ms)}$

= 16.66 m/s

Kp = 4.07

ΔP = 140.9 av. Δp at sample plane

Cp = 1.00 pitot tube coefficient

Stack gas volume at sample points

Q = V x A x 60

= 1451.8 m^3/min

A = 1.45 area of stack m^2

Volume of water vapour collected, standard conditions (m^3)

Vwstd = 0.00124 x Vlc

= 0.0293 m^3

Vlc = 24 ml

Volume of gas metered, standard conditions (m^3)

$$Vmstd = \frac{2.695 \times Vm \times (Pa + (\Delta H/102)) \times Yd}{(T + Tm)}$$

= 0.676 m^3

Tm = 8 °C

Vm = 0.7426 m^3

Pa = 100.9 kPa

ΔH = 52 mm H_2O

Yd = 0.936

Moisture content

Bwo = Vwstd/(Vwstd +Vmstd)

= 0.0415

5.3 - Calculations Sample Run No. 2 Cont.

Dry total flow of stack gas, standard conditions (m^3/min)

$$Qstd = \frac{Q \times Ps(2.695)(1 - Bwo)}{Ts + 273}$$

$= 1093.1\ m^3/min$

$Ts = 73.3\ ^{o}C$

$Ps = 100.9$ kPa

Percent isokinetic

$$\%I = \frac{(6.184 \times 10^5)(Ts + 273) \times Vmstd}{Ps \times V \times Aa \times t \times (1 - Bwo)}$$

$= 99.3\ \%$

$Aa = 28.3$ area of nozzle m^2

Filter & rinsing weights sample no. 2

weight gain on filters = 30 mg
weight of acetone wash = mg
total weight gain (M) = 30.00 mg

Particulate concentration (mg/m^3)

$C = M/Vmstd$

$= 44.38\ mg/m^3$

$M = 30$ mg

Particulate emission rate (kg/hr)

$E = (C \times Qstd \times 60)/1000000$

$= 2.91$ kg/hr

5.4 - Sample Blank

An overall sample blank was taken after the measurement series, following the sampling procedure in the methodology without starting the suction device and keeping the blank in the duct for 15 minutes with the sampling nozzle 180o from the direction of flow. This leads to an estimation of the the dispersion of results related to the whole procedure.

weight gain on filters = 0.00003 mg

weight of acetone wash = mg

total weight gain (M) = 0.00003 mg

Particulate concentration (mg/m^3)

C = M/Vmstd M = 0.03 mg

= 0.04 mg/m^3

5.5 - On Site Velocity and Flow Data

Company	MIDLAND QUARRY PRODUCTS	Stack Diameter	1.36	m
Site	ST. IVES WORKS	Area	1.45	m^2
Location	COATING PLANT	Barometric Pressure	100.9	kPa
Job No	2589	Stack Pressure	0.02	kPa
Operators	AJY/MJR	Pitot Tube Coefficient	0.997	

Preliminary readings taken before sampling				
			Pitot Traverse B	
Pitot Settings	Δ P pa	Temp ºC	Δ P pa	Temp ºC
1	157	74	170	75
2	179	74	178	75
3	162	75	169	76
4	146	75	154	76
5	120	75	119	76
6	115	76	96	75
7	123	76	103	75
8	132	75	106	75
9	135	75	109	75
10	141	74	104	75

av temp (K)=((average temp traverse A+average temp traverse B)/2)+273	348
av press (Pa)=((average press traverse A+average press traverse B)/2)	136

Suitability of sampling positions & Required No. of sample points	Actual Stack Conditions
Permitted highest to lowest pressure range = 9:1	1.9 : 1
Negative pressure	Not permitted
Differential pressure minimum > 5 Pa	96
No. of sampling points	8

5.6 - Sampling Conditions

	Sample Run No. 1			Sample Run No. 2		
Sample Position	Stack Temp ^{o}C	Velocity Pressure ΔP (Pa)	Nozzle Area mm^{2}	Stack Temp ^{o}C	Velocity Pressure ΔP (Pa)	Nozzle Area mm^{2}
0.065D	74	157	28.3	73	155	28.3
0.25D	75	162	28.3	74	160	28.3
0.75D	75	132	28.3	73	129	28.3
0.935D	74	141	28.3	72	143	28.3
0.065D	75	170	28.3	73	167	28.3
0.25D	76	169	28.3	73	166	28.3
0.935D	75	106	28.3	74	103	28.3
0.935D	75	104	28.3	74	104	28.3

5.7 - Weighing Results

The below filters and acetone rinsings were weighed on a balance in a temperature controlled room with corrections made for differences in atmospheric pressure. Control parts and blank filters are used to confirm accuracy of weighings.

Sample Run No.1.	Ref No.	Weight gms			Sample time at each point (mins)	% weight gain
		Before	After	Collected		
Filter	10	0.05563	0.08887	0.03324	4.0	59.8%
Acetone						
			Total weight =	0.03324		
Sample Run No.2.	Ref No.	Weight gms			Sample time at each point (mins)	
		Before	After	Collected		
Filter	11	0.05547	0.08547	0.03000	4.0	54.1%
Acetone						
			Total weight =	0.03000		
Sample Blank	Ref No.	Weight gms			Sample time at each point (mins)	
		Before	After	Collected		
Filter	12	0.05529	0.05532	0.00003	n/a	0.1%
Acetone						
			Total weight =	0.00003		

5.8 - Main conditions for compliance with BS EN 13284-1:2002

The following requirements must be met:

Preliminary Velocity Survey

		Pass	Fail
	No negative flow at sampling points	*	
	Direction of gas flow within 15° of flue axis	*	
	Pitot-static pressure differential greater than 5 Pa (3m/s)	*	
	Ratio of highest to lowest pitot-static readings less than 9:1	*	

Sampling procedure

	Sampling plane was corectly positioned	*	
	Sampling centroids of equal area	*	
	Nozzle was facing upstream to within ± 10°	*	
	Leak check performed	*	
	Constant 'at' during cumulative sampling	*	

Post Sampling Operations

	Leak test performed	*	
	Isokinetic rate 95 % to 115 %	*	
	Samples achieved stable weights	*	

Note :

A single tick in the "fail" column indicates that this test does not comply with the full provisions of BS EN 13284-1:2002. Due to site/sampling locations it is not always practically possible for all the conditions to be met. Best practical means are employed to try and achieve a representative result.

Uncertainty calculation for EN 13284 Determination of low range mass concentration of dust, Manual Gravimetric Method

Measurement Equation

$$c = \frac{m}{V} f_c$$

Limit value	50	**mg.m^{-3}**	O2 Ref	21	**%**
Measured conc.	47.27	**mg.m^{-3}**			

Measured Quantities	**Symbol**	**Value**	**Standard uncertain**		**Units**	**Uncertainty %**		**Requirement of std**
Sampled Volume	V_m	0.7673	uV_m	0.001	**m^3**	0.13		<=2%
Sampled gas Tem	T_m	279.0	uTm	2	k	0.72		<=1%
Sampled gas Pressure	ρ_m	100.9	$u\rho_m$	0.5	**kPa**	0.50		<=1%
Sampled gas Humidity	H_m	4.08	uH_m	1	**% by vol**	0.25		<=1%
Oxygen content	$O_{2,m}$	16.9	$uO_{2,m}$	0.1	**% by vol**	0.59		<=5%
Mass particulate	m	33.24	um	0.1	**mg**	0	0.28	<5% of limit val
Note - Sampled gas humidity, temperature and pressure are values at the gas meter								
Leak	L	0.5			**%**	0.50		<=2%
Uncollected Mass	UCM	0.03			**mg**	0.09		<=10%
(Instack filter - no rinse)								

Intermediate calculations

Factor for std conds	fs	0.92					
uncertainty components	symbol	**sensitivity coeff**		**u (in units of fs)**			
	ρ_m	0.009		0.005		$f_s = \frac{(100 - H_m)}{100}\frac{273}{T_m}\frac{\rho_m}{101.3}$	
	H_m	0.010		0.010			
	T_m	0.003		0.007			
	ufs			0.012			1.36
Corrected volume	V	0.70	uV	0.010	m^3	$V = V_m f_s$	1.37
Factor for O2 correction	fc	1.00					
uncertainty components	symbol	**sensitivity coeff**		**u**		$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$	
	$O_{2,m}$	0.24		0.024			
Factor for O2 Corr	ufc	1.00		0.024			1.00

Parameter	**Uncertainty**	**Value**	**Units**	**ens coeff**	**Uncertainty in Resul**		**Uncertainty as %**	
Volume(stp)	V	0.70	m^3	67.23	0.65	mg.m^{-3}	1.37	%
Mass	m	33.24	mg	1.42	0.14	mg.m^{-3}	0.30	%
Factor for O2 Correction	fc	1.00		0.00	0.00	mg.m^{-3}	0.00	%
Leak	L	0.14	mg.m^{-3}	1.00	0.14	mg.m^{-3}		
Uncollected mass	UCM	0.02	mg	1.42	0.02	mg.m^{-3}		
Combined uncertainty					**0.68**	mg.m^{-3}		

Expanded uncertainty expressed with a level of confidence of 95% **2.86** **%**

Expanded uncertainty expressed with a level of confidence of 95% **1.35** **mg.m^{-3}**