ADVANCE
ENVIRONMENTAL

PARTICULATE EMISSION MONITORING
AGGREGATE INDUSTRIES UK LIMITED
DOYLE DRIVE
COVENTRY
WEST MIDLANDS

REPORT ON PARTICULATE EMISSION MONITORING

to

DETERMINE THE LEVELS OF PARTICULATE EMISSION

from the

ROADSTONE COATING PLANT

at

AGGREGATE INDUSTRIES UK LIMITED
DOYLE DRIVE
COVENTRY
WEST MIDLANDS
CV6 6NW

Report Submitted To:

AGGREGATE INDUSTRIES UK LIMITED
DOYLE DRIVE
COVENTRY
WEST MIDLANDS
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Date: 20.12.17

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SUMMARY INFORMATION

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Determined	Units	Results	Uncertainty +/-	Limit
Particulate Concentration (STP)	mg/m^3	3.03	0.10	50
Mass Emission	kg/hr	0.12	0.00	-
Stack Temperature	ºC	86	-	-
Gas Velocity	m/s	16.63	-	-
Stack Volume Flow Rate (Actual)	m^3/hr	38081.45	-	-
Stack Volume Flow Rate (STP)	m^3/hr	28492.37	-	-

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

1. INTRODUCTION

On 20 December 2017, particulate emission testing was undertaken by Advance Environmental, on the roadstone coating plant exhaust at Aggregate Industries UK Limited, Coventry depot.

The purpose of the emission testing was to ensure compliance with the requirements of the permit issued by the Local Authority 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 PG3/15(12) Secretary of State's Guidance for Roadstone Coating Processes.

3.   MONITORING CONTRACTOR

The emission monitoring was co-ordinated by Mr K Gough, Advance Environmental Consulting Limited. Mr Gough has 24 years experience of undertaking particulate emission testing on plant used in the quarrying and allied industries.

The lead engineer managing the on site testing is MCERTS Level 2 accredited.

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. Determination 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.

4.3   MONITORING PROTOCOL CONT.

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.

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 calliper 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 efficiency 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 $180^{\circ}C$ for a period of at least one hour and then placed to cool in a desiccator 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 diameter 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° 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.

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 EN13284-1.

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.

4.8   Sampling Results

A particulate test was carried out, under continuous operating conditions, to assess the emission concentration in the exhaust gases. The sample time of the first test was 32 minutes, with the second test being reduced in time to 24 minutes due to limited production.

At the time of sampling, a particulate matter of 3.03mg/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.

4.9   Comments

On the completion of sampling, the data from the PCME DT 990 continuous emission monitor was interrogated and the average results, which were recorded during the measurement period, noted. A level of 3.2103mg/m3 was obtained together with an existing scaling factor of 6.2806. It can be concluded that the monitor would benefit from an adjustment of the current calibration factor to 1.5282.

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

5. SAMPLING RECORDS

5.1 Process Conditions

Arrestment Plant:	Bag Filter
Particulate Type:	Aggregate
Plant Loading:	Continuous - various grades @ 40tph.
Appearance of plume:	No visible discharge

5.2 Sampling Results

	Test Run No. 1.	Test Run No. 2.	Average
Time of Test:	09.07 - 09.39	10.02 - 10.26	
Sampling Duration: (mins)	32	24	
Gas Temperature (°C)	87	84	86
Mean Velocity at Sampling Points: (m/s)	16.63	16.69	16.66
Gas Flow Rate at STP (1): (m^3/min)	455.1	455.6	455.4
Particulate Loading at STP (1): (mg/m^3)	2.81	3.25	3.03
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 =	18.3 %	CO2 =	1.5 %	N2 =	80.2 %
Bws =	0.04	Ps =	99.9 kPa	Ts =	360.0 K

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

$$Md = (0.44 \times \%CO_2) + (0.32 \times \%O_2) + (0.28 \times \%N_2)$$
$$= 28.97 \text{ g/g mole}$$

Ms = Molecular weight of gas wet (g/g mole)
$$= 28.53 \text{ g/g mole}$$

Stack gas velocity at sample points

$$V = Kp \times Cp \times \ddot{O}(Ts.DP/Ps.Ms)$$

$$= 16.63 \text{ m/s}$$

Kp = 4.07
DP = 133.0 av. Dp at sample plane
Cp = 1.00 pitot tube coefficient

Stack gas volume at sample points

$$Q = V \times A \times 60$$

$$= 634.7 \text{ m}^3/\text{min}$$

A = 0.64 area of stack m^2

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

$$Vwstd = 0.00124 \times Vlc$$

$$= 0.0284 \text{ m}^3$$

Vlc = 23 ml

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

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

$$= 0.6574 \text{ m}^3$$

Tm = 10 ^{o}C
Vm = 0.7352 m^3
Pa = 99.9 kPa
DH = 43.1 mm H$_2$O
Yd = 0.936

Moisture content

$$Bwo = Vwstd/(Vwstd + Vmstd)$$

$$= 0.0414$$

5.3 - Calculations Sample Run No. 1 Cont.

Dry total flow of stack gas, standard conditions (m³/min)

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

$Ts = $ 87.0 °C

$Ps = $ 99.9 kPa

$$= \text{ 455 m}^3/\text{min}$$

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 m²

$$= \text{ 101.6 \%}$$

Filter & rinsing weights sample no. 1

weight gain on filters =   1.85 mg
weight of acetone wash =   mg
total weight gain (M) =   1.85 mg

Particulate concentration (mg/m³)

$$C = M/Vmstd$$

$M = $ 1.85 mg

$$= \text{ 2.81 mg/m}^3$$

Particulate emission rate (kg/hr)

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

$$= \text{ 0.11 kg/hr}$$

5.4 - Calculations Sample Run No. 2

On-site measurements

O2 =	18.2 %	CO2 =	1.6 %	N2 =	80.2 %
Bws =	0.04	Ps =	99.9 kPa	Ts =	357.3 K

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

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

= 28.98 g/g mole

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

= 28.53 g/g mole

Stack gas velocity at sample points

$V = Kp \times Cp \times Ö(Ts.DP/Ps.Ms)$ Kp = 4.07

= 16.69 m/s   DP = 135.0 av. Dp at sample plane

     Cp = 1.00 pitot tube coefficient

Stack gas volume at sample points

$Q = V \times A \times 60$ A = 0.64 area of stack m^2

= 637.1 m^3/min

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

$Vwstd = 0.00124 \times Vlc$ Vlc = 21 ml

= 0.0265 m^3

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

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

Tm = 10 $^{\circ}$C

Vm = 0.5500 m^3

Pa = 99.9 kPa

= 0.4919 m^3 DH = 44 mm H$_2$O

Yd = 0.936

Moisture content

$Bwo = Vwstd/(Vwstd + Vmstd)$

= 0.0512

5.4 - Calculations Sample Run No. 2 Cont.

Dry total flow of stack gas, standard conditions (m³/min)

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

$$= 455.6 \text{ m}^3/\text{min}$$

$Ts = $ 84.3 °C
$Ps = $ 99.9 kPa

Percent isokinetic

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

$$= 101.2 \text{ \%}$$

$Aa = $ 28.3 area of nozzle m²

Filter & rinsing weights sample no. 2

weight gain on filters =   1.6 mg
weight of acetone wash =   mg
total weight gain (M) =   1.60 mg

Particulate concentration (mg/m³)

$$C = M/Vmstd$$

$$= 3.25 \text{ mg/m}^3$$

$M = $ 1.6 mg

Particulate emission rate (kg/hr)

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

$$= 0.12 \text{ kg/hr}$$

5.5 - 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 dispersion of results related to the whole procedure.

weight gain on filters =   0.00001 mg

weight of acetone wash =   mg

total weight gain (M) =   0.00001 mg

Particulate concentration (mg/m^3)

$C = M/Vmstd$ $M =$ 0.01 mg

$=$ 0.02 mg/m^3

5.6 - On Site Velocity and Flow Data

Company	AGGREGATE INDUSTRIES UK LIMIT	Stack Diameter	0.90	m
Site	DOYLE DRIVE	Area	0.64	m²
Location	ROADSTONE COATING PLANT	Barometric Pressure	99.9	kPa
Job No	2747	Stack Pressure	0.02	kPa
Operators	AJY/MJR	Pitot Tube Coefficient	0.997	

Preliminary readings taken before sampling				
			Pitot Traverse B	
Pitot Settings	D P pa	Temp ºC	D P pa	Temp ºC
1	124	88	126	86
2	132	88	129	86
3	136	88	137	86
4	138	88	138	86
5	140	87	141	86
6	141	87	143	87
7	139	87	144	87
8	137	87	140	87
9	135	87	136	87
10	127	86	128	87

av temp (K)=((average temp traverse A+average temp traverse B)/2)+273	360
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	1.2 : 1
Negative pressure	Not permitted
Differential pressure minimum > 5 Pa	124
No. of sampling points	4

5.7 - Sampling Conditions

	Sample Run No. 1			Sample Run No. 2		
Sample Position	Stack Temp °C	Velocity Pressure DP (Pa)	Nozzle Area mm²	Stack Temp °C	Velocity Pressure DP (Pa)	Nozzle Area mm²
0.15D	88	132	28.3	84	134	28.3
0.85D	87	135	28.3	85	138	28.3
0.15D	86	129	28.3	85	130	28.3
0.85D	87	136	28.3	83	138	28.3

5.8 - 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 Before	After	Collected	Sample time at each point (mins)	% weight gain
Filter	10	0.05625	0.05810	0.00185	8.0	3.3%
Acetone						
Total weight = 0.00185						

Sample Run No.2.	Ref No.	Weight gms Before	After	Collected	Sample time at each point (mins)	
Filter	11	0.05599	0.05759	0.00160	6.0	2.9%
Acetone						
Total weight = 0.00160						

Sample Blank	Ref No.	Weight gms Before	After	Collected	Sample time at each point (mins)	
Filter	12	0.05608	0.05609	0.00001	n/a	0.0%
Acetone						
Total weight = 0.00001						

5.9 - 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

	Pass	Fail
Sampling plane was correctly positioned	*	
Sampling centroids of equal area	*	
Nozzle was facing upstream to within $\pm$ 10°	*	
Leak check performed	*	
Constant 'at' during cumulative sampling	*	

Post Sampling Operations

	Pass	Fail
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

| Limit value | 50 | mg.m^{-3} | O2 Ref | 21 | % |
| Measured conc. | 2.81 | mg.m^{-3} | | | |

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

Measured Quantities	Symbol	Value	Standard uncertain		Units	Uncertainty %		Requirement of std
Sampled Volume	V_m	0.7352	uV_m	0.001	m^3	0.14		<=2%
Sampled gas Tem	T_m	283.0	uTm	2	k	0.71		<=1%
Sampled gas Pressure	ρ_m	99.9	$u\rho_m$	0.1	kPa	0.10		<=1%
Sampled gas Humidity	H_m	4.14	uH_m	1	% by vol	0.24		<=1%
Oxygen content	$O_{2,m}$	18.3	$uO_{2,m}$	0.1	% by vol	0.55		<=5%
Mass particulate	m	1.85	um	0.01	mg	1	0.03	<5% of limit val

Note - Sampled gas humidity, temperature and pressure are values at the gas meter

Leak	L	2			%	2.00		<=2%
Uncollected Mass	UCM	0.01			mg	0.54		<=10%
(Instack filter - no rinse)								

Intermediate calculations

Factor for std conds	fs		0.89			
uncertainty components	symbol	sensitivity coeff		u (in units of fs)		
	ρ_m	0.009		0.001		
	H_m	0.009		0.009		
	T_m	0.003		0.006		
	ufs			0.011		1.26
Corrected volume	V		0.66	uV	0.008 m^3	1.27

$$f_s = \frac{(100 - H_m)}{100} \frac{273}{T_m} \frac{\rho_m}{101.3}$$

$$V = V_m f_s$$

Factor for O2 correction	fc	1.00	
uncertainty components	symbol	sensitivity coeff	u
	$O_{2,m}$	0.37	0.037
Factor for O2 Corr	ufc	1.00	0.037

$$f_c = \frac{21 - O_{2,ref}}{21 - O_{2,m}}$$

3.70

Parameter	Uncertainty	Value	Units	Sens coef	Uncertainty in Result		Uncertainty as %
Volume(stp)	V	0.66	m^3	4.28	0.04	mg.m^{-3}	1.27 %
Mass	m	1.85	mg	1.52	0.02	mg.m^{-3}	0.54 %
Factor for O2 Correction	fc	1.00		0.00	0.00	mg.m^{-3}	0.00 %
Leak	L	0.03	mg.m^{-3}	1.00	0.03	mg.m^{-3}	
Uncollected mass	UCM	0.01	mg	1.52	0.01	mg.m^{-3}	
Combined uncertainty					**0.05**	mg.m^{-3}	

Expanded uncertainty expressed with a level of confidence of 95% | 3.66 | %

Expanded uncertainty expressed with a level of confidence of 95% | 0.10 | mg.m^{-3}