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Environmental Protection Act
Pollution Prevention & Control

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

on

AGGREGATE DRYING PLANT
BAG FILTER EXHAUST

for

CPI MORTARS LTD
29 MEAD PARK
RIVERWAY
HARLOW
ESSEX CM20 2SE

Tested By: A. Yelland

Date Of Test : 22.03.16

A. Yelland, MCERTS Level 2
MM 02 130

Report No : 2320

NOTE: The level of emission is specific to the date and times noted in this report. This does not guarantee that the pollutant level from the process equipment will not exceed that measured outside the stated sampling period.

Contents

1 - Summary of Results

Determined	Units	Results	Limit
Particulate Concentration (STP)	mg/m^3	19.9	50
Mass Emission (STP)	kg/hr	0.62	-
Stack Temperature	°C	71	-
Gas Velocity	m/s	16.86	-
Stack Volume Flow Rate (Actual)	m^3/hr	38615	-
Stack Volume Flow Rate (STP)	m^3/hr	30775	-

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

2 - Comments

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. The mean particulate loading was 19.9 mg/m^3 at reference conditions. This value is below the specified emission limit of 50 mg/m^3.

The tests were performed in accordance with BS EN 13284-1:2002, Stationary source emissions - Determination of low range mass concentration of dust - Manual gravimetric method.

Full test data demonstrating procedural compliance with BS EN 13284-1 for total particulate monitoring is provided in section 11.

3 - Method

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

Monitoring of total particulates involved isokinetic sampling using the Apex Instruments test equipment.

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.

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.

Filter Preparation

Filters are pre-conditioned before arrival on site. The filters are dried in an oven at 180^{o}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.

Sampling Location

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.

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

Sampling

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. Allow the filter head and probe to obtain the stack gas temperature. Note initial gas meter volume, start the suction device and timer and set the correct flowrate for isokinetic sampling with the nozzle now facing parallel to the gas flow. Sample for the planned duration and number of sample points, recording all the necessary data for final calculations. Switch off suction device, timer and record final gas meter volume. Remove the probe from stack, carry out leak test then remove filter and place in storage container. Wash any residual particulates upstream of the filter with water and acetone into an appropriate beaker.
Repeat all of the above procedures to obtain duplicate samples.

Sample Weighing

The used filters are dried in an oven at $160^{o}C$ for at least one hour and then desicated 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 weight.

4 - Process Conditions

Table A

Arrestment Plant:	Bag filter
Particulate Type:	Sand
Plant Loading:	Continuous - Sand @ 35tph.
Appearance of plume:	Steam

5 - Sampling Results

Table B

	Test Run No. 1.	Test Run No. 2.	Average
Time of Test:	13.26 - 13.58	14.04 - 14.36	
Sampling Duration: (mins)	32	32	
Gas Temperature (°C)	71	72	71
Mean Velocity at Sampling Points: (m/s)	17.82	17.93	17.87
Gas Flow Rate at STP (1): (m^3/min)	522.0	525.4	523.7
Particulate Loading at STP (1): (mg/m^3)	17.90	21.85	19.87
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).

6 - Calculations Sample Run No. 1

On-site measurements

O2 =	18.8 %	CO2 =	1.2 %	N2 =	80.0 %
Bws =	0.04	Ps =	101.7 kPa	Ts =	344.0 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)

= 28.94 g/g mole

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

= 28.51 g/g mole

Stack gas velocity at sample points

V = Kp x Cp x √(Ts.ΔP/Ps.Ms) Kp = 4.07

= 17.82 m/s ΔP = 162.5 average Δp at sample plane

Cp = 1.00 pitot tube coefficient

Stack gas volume at sample points

Q = V x A x 60 A = 0.64 area of stack m^2

= 680.0 m^3/min

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

Vwstd = 0.00124 x Vlc Vlc = 16 ml

= 0.02 m^3

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

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

= 0.5208 m^3

Tm = 20 °C

Vm = 0.5932 m^3

Pa = 101.7 kPa

ΔH = 27.5 mm H_2O

Yd = 0.936

Moisture content

Bwo = Vwstd/(Vwstd +Vmstd)

= 0.0369

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

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

= 522 m^3/min

Ts = 71.0 °C

Ps = 101.7 kPa

Percent isokinetic

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

= 101.0 %

Aa = 19.6 area of nozzle m^2

6 - Calculations Sample Run No. 1 Cont.

Filter & rinsing weights sample no. 1

weight gain on filters = 9.32 mg
weight of acetone wash = mg
total weight gain (M) = 9.32 mg

Particulate concentration (mg/m^3)

C = M/Vmstd M = 9.32 mg
= 17.90 mg/m^3

Particulate emission rate (kg/hr)

E = (C x Qstd x 60)/1000
= 0.56 kg/hr

6 - Calculations Sample Run No. 2

On-site measurements

O2 =	18.8 %	CO2 =	1.2 %	N2 =	80.0 %
Bws =	0.04	Ps =	101.7 kPa	Ts =	344.5 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)

= 28.94 g/g mole

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

= 28.54 g/g mole

Stack gas velocity at sample points

V = Kp x Cp x √(Ts.ΔP/Ps.Ms)

= 17.93 m/s

Kp = 4.07

ΔP = 164.5 average Δp at sample plane

Cp = 1.00 pitot tube coefficient

Stack gas volume at sample points

Q = V x A x 60

= 684.3 m^3/min

A = 0.64 area of stack m^2

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

Vwstd = 0.00124 x Vlc

= 0.0195 m^3

Vlc = 16 ml

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

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

= 0.5327 m^3

Tm = 20 °C

Vm = 0.6068 m^3

Pa = 101.7 kPa

ΔH = 28 mm H_2O

Yd = 0.936

Moisture content

Bwo = Vwstd/(Vwstd +Vmstd)

= 0.0353

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

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

= 525.4 m^3/min

Ts = 71.5 °C

Ps = 101.7 kPa

Percent isokinetic

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

= 102.7 %

Aa = 19.6 area of nozzle m^2

6 - Calculations Sample Run No. 2 Cont.

Filter & rinsing weights sample no. 2

weight gain on filters = 11.64 mg
weight of acetone wash = mg
total weight gain (M) = 11.64 mg

Particulate concentration (mg/m^3)

C = M/Vmstd M = 11.64 mg
= 21.85 mg/m^3

Particulate emission rate (kg/hr)

E = (C x Qstd x 60)/1000
= 0.69 kg/hr

7 - 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 180^o from the direction of flow. This leads to an estimation of the dispersion of results related to the whole procedure.

weight gain on filters = 0.00007 mg
weight of acetone wash = mg
total weight gain (M) = 0.00007 mg

Particulate concentration (mg/m^3)

C = M/Vmstd M = 0.07 mg
= 0.13 mg/m^3

8 - On Site Velocity and Flow Data

Company	CPI MORTARS LTD	Stack Diameter	0.90	m
Site	29 MEAD PARK	Area	0.64	m^2
Location	AGGREGATE DRYING PLANT	Barometric Pressure	101.7	kPa
Job No	2320	Stack Pressure	0.03	kPa
Operators	AJY/MJR	Pitot Tube Coefficient	0.997	

Preliminary readings taken before sampling

			Pitot Traverse B	
Pitot Settings	Δ P pa	Temp °C	Δ P pa	Temp °C
1	168	71	117	71
2	164	71	126	71
3	136	71	134	71
4	127	71	127	71
5	114	71	116	71
6	117	71	138	71
7	132	71	156	71
8	145	71	175	71
9	176	71	184	71
10	185	71	201	71

av temp (K)=((average temp traverse A+average temp traverse B)/2)+273	344
av press (Pa)=((average press traverse A+average press traverse B)/2)	147

Suitability of sampling positions & Required No. of sample points	Actual Stack Conditions
Permitted highest to lowest pressure range = 9:1	1.8 : 1
Negative pressure	Not permitted
Differential pressure minimum > 5 Pa	114
No. of sampling points	4

9 - Sampling Conditions

	Sample Run No. 1			Sample Run No. 2		
Sample Position	Stack Temp ˚C	Velocity Pressure ΔP (Pa)	Nozzle Area mm˜	Stack Temp ˚C	Velocity Pressure ΔP (Pa)	Nozzle Area mm˜
0.15D	71	164	19.6	72	166	19.6
0.85D	71	176	19.6	72	178	19.6
0.15D	71	126	19.6	71	127	19.6
0.85D	71	184	19.6	71	187	19.6

10 - 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	8	0.05856	0.06788	0.00932	8.0	15.9%
Acetone						
Total weight =				0.00932		
Sample Run No.2.	Ref No.	Weight gms Before	After	Collected	Sample time at each point (mins)	
Filter	9	0.05831	0.06995	0.01164	8.0	20.0%
Acetone						
Total weight =				0.01164		
Sample Blank	Ref No.	Weight gms Before	After	Collected	Sample time at each point (mins)	
Filter	10	0.05849	0.05856	0.00007	n/a	0.1%
Acetone						
Total weight =				0.00007		

11 - 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^{o} 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 $\pm$ 10^{o}	*	
	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 13284-1:2023. 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.