DJB

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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 & GASEOUS EMISSION SURVEY

on

COATING PLANT
BAG FILTER EXHAUST

for

HANSON AGGREGATES
ST. IVES WORKS
MEADOW LANE
ST. IVES
CAMBRIDGESHIRE PE27 4LG

Tested By: A Yelland

Date Of Test : 21.09.10

A. Yelland, MCERTS Level 2

Report No : 031

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/Standard	Concentration		Limit
	kg/hr	mg/m^3	mg/m^3
Particulate matter	39.8	39.8	50
Chloride (expressed as HCL)	0.54	9.4	100
Fluoride (expressed as HF)	0.08	1.3	5
Lead	0.005	0.089	5
Cadmium	0.003	0.053	0.5
Nickel	0.005	0.080	1
Chromium	0.008	0.141	1.5
Copper	0.009	0.153	inc. 'above
Vanadium	0.007	0.118	inc. 'above

All results are reported at reference conditions of 273K, 101.3kPa, wet gas.
Total organic compounds (TOCs) are expressed as total carbon mass concentrations.

Measured	Units	Results
Stack Temperature	°C	86
Stack efflux Velocity	m/s	14.3
Stack Volume Flow Rate (Actual)	m^3/hr	74780
Stack Volume Flow Rate (STP)	m^3/hr	57294

1 - Laboratory Results

Element	Units	Results
Lead	µg	54
Cadmium	µg	32
Nickel	µg	49
Chromium	µg	86
Copper	µg	93
Vanadium	µg	72
Chloride (expressed as HCL)	mg/m^3	9.40
Fluoride (expressed as HF)	mg/m^3	1.32

Following the calculation of the particulate loading the samples sent are off to be analysed by a UKAS accredited laboratory for their heavy meatal content. The results obtained are then corrected to for temperature and pressure.

Heavy metals were analysed by an ion-chromatoghraphy/mass spectroscopy method.
Gases were analysed by a high performance liquid chromatoghraphy with an ECD detector.

2 - Method (Particulate)

The work carried out was, as far as was reasonably practical, in accordance with BS ISO 9096.

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 ISO 9096. 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 ISO 9096. 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°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 ISO 9096. 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° 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°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.

2 - Method (Heavy Metals)

Sampling for heavy metals was carrried out in accordance with BS EN 14385:2005 using APEX Instruments sampling equipment.
A sample of the stack gas was removed and passed, via a stainless steal nozzle and glass lined probe through a heated quartz filter contained in an oven compartment. The filter used had a pore size of 0.45microns, capable of attaining a >99.5% efficiency of smoke particulate as stipulated in BS EN 14385:2005. The hot gas stream then passed through into an impinger train.
The impinger train was seated in a water bath to cool the gas stream and condense out less volatile gases and water vapour. The first two impingers encountered by the gas stream each contained 100ml of 5% nitric acid (NHO_3)/10% hydrogen peroxide H_2O_2 solution. The third impinger was left empty to condense out any excess moisture in the gas stream. The fourth impinger contained anhydrous silica gel which was used to dry the gas stream before passing through the dry gas meter which measured the volume of gas sampled.
The volume of liquid in the first two impingers and the weight of the silica gel trap was measured before the sample run. This was used to calculate the moisture off the gas stream in the stack.
Upon completion of sampling, the filter was removed to its original container and sealed. The liquid volumes in the impingers was re-measured in order to determine the mass of water trapped by the impinger train. The probe and glassware up to the filter were rinsed with acetone and the washings collected in a container.
The contents of the first two impingers and appopriate solutions were combined and transferred to a separate container and the total volume recorded.
The filter and probe was are acid digested and the metals determined on the solution using inductively coupled plasma spectroscopy (ICP). The nitric/peroxide solution was boiled to low volume and this solution directly aspirated onto the ICP. A total mass of metals in micrograms was determined from the sum of the particulate and vapour phases.

2 - Method (Hydrogen Chloride)

The work carried out was, as far as was reasonably practical, in accordance with BS EN 1911. To determine the gaseous chloride content of a gas within a stack or duct, a metered sample of gas is drawn through a heated sampling probe and into an sampling train. Gaseous chlorides are absorbed in a series of impingers containing a distilled/deionised water. The moisture content, oxygen concentration, temperature and relative pressure of the gas sample before the gas meter are measured, along with the atmospheric pressure during the test to enable the results to be normalised.

Flue gases are sampled at a rate of between 2.0 and 4.0 litres/min with a total gas sample volume measured by a calibrated dry gas meter.

The resulting solution and washings of all tubing and impingers are then analysed to determine the chloride ion concentration. A Dionex 2000I ion chromatograph fitted with an HPIC-AS4A anion exchange separator column, with a carbonate/bicarbonate buffer eluant is used. Detection is by conductivity with chemical eluant suppression. Reference standards are prepared from analytical grade reagents in solution, and identification of the fluoride peak confirmed by spiking with a reference standard solution. Total chloride concentration is then calculated from the volume of gas sampled.

Samples of all reagents and solutions used were also taken to act as blank values for the calculation of background chloride concentrations and the results adjusted accordingly.

3 - Process Conditions

Table A

Arrestment Plant:	Bag Filter
Particulate Type:	Aggregate
Plant Loading:	Continuous - 6mm dense @ 110tph.
Appearance of plume:	Light visible discharge.

4 - Sampling Results

Table B

	Test Run No. 1.	Test Run No. 2.	Average
Time of Test:	12.01 - 12.33		
Sampling Duration: (mins)	32	n/a	
Gas Temperature (°C)	86	n/a	86
Mean Velocity at Sampling Points: (m/s)	14.51	n/a	14.51
Gas Flow Rate at STP (1): (m^3/min)	931.0	n/a	931.0
Particulate Loading at STP (1): (mg/m^3)	39.83	n/a	39.83
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 - Calculations Sample Run No. 1

On-site measurements

O2 =	18.5 %	CO2 =	1.4 %	N2 =	80.1 %
Bws =	0.05	Ps =	102.0 kPa	Ts =	358.8 K

Md = Molecular weight of gas at DGM (g/g mole)
Md = $(0.44 \times \%CO_2) + (0.32 \times \%O_2) + (0.28 \times \%N_2)$
= 28.96 g/g mole

Ms = Molecular weight of gas wet (g/g mole)
= 28.42 g/g mole

Stack gas velocity at sample points

$V = Kp \times Cp \times \sqrt{(Ts.\Delta P/Ps.Ms)}$
= 14.51 m/s

Kp = 4.07
ΔP = 103.4 average Δp at sample plane
Cp = 1.00 pitot tube coefficient

Stack gas volume at sample points

$Q = V \times A \times 60$
= 1265.0 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
= 0.0252 m^3

Vlc = 20 ml

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

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

= 0.6095 m^3

Tm = 22 °C
Vm = 0.6387 m^3
Pa = 102 kPa
ΔH = 42.0 mm H_2O
Yd = 1.020

Moisture content

Bwo = Vwstd/(Vwstd +Vmstd)
= 0.0397

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

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

= 931 m^3/min

Ts = 85.8 °C
Ps = 102.0 kPa

Percent isokinetic

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

= 105.1 %

Aa = 28.3 area of nozzle m^2

5 - Calculations Sample Run No. 1 Cont.

Filter & rinsing weights sample no. 1

weight gain on filters = 24.28 mg
weight of acetone wash = mg
total weight gain (M) = 24.28 mg

Particulate concentration (mg/m^3)

C = M/Vmstd M = 24.28 mg
= 39.83 mg/m^3

Particulate emission rate (kg/hr)

E = (C x Qstd x 60)/1000
= 2.23 kg/hr

6 - 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° 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)

$C = M/Vmstd$ $\qquad M =$ 0.07 mg

$= \quad 0.11 \ mg/m^3$

7 - On Site Velocity and Flow Data

Company	HANSON AGGREGATES	Stack Diameter	1.36	m
Site	ST. IVES WORKS	Area	1.45	m^2
Location	COATING PLANT	Barometric Pressure	102	kPa
Job No	031	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 °C	Δ P pa	Temp °C
1	133	85	130	86
2	137	85	141	86
3	130	85	134	87
4	119	85	113	87
5	100	86	104	87
6	90	86	86	86
7	86	86	83	86
8	76	87	82	85
9	77	86	76	85
10	71	86	71	85

av temp (K)=((average temp traverse A+average temp traverse B)/2)+273	359
av press (Pa)=((average press traverse A+average press traverse B)/2)	102

Suitability of sampling positions & Required No. of sample points	Actual Stack Conditions
Permitted highest to lowest pressure range = 9:1	2.0 : 1
Negative pressure	Not permitted
Differential pressure minimum > 5 Pa	71
No. of sampling points	8

8 - Sampling Conditions

	Sample Run No. 1			Sample Run No. 2		
Sample Position	Stack Temp °C	Velocity Pressure ΔP (Pa)	Nozzle Area mm^2	Stack Temp °C	Velocity Pressure ΔP (Pa)	Nozzle Area mm^2
0.065D	85	133	28.3			
0.25D	85	130	28.3			
0.75D	87	76	28.3			
0.935D	86	71	28.3			
0.065D	86	130	28.3			
0.25D	87	134	28.3			
0.935D	85	82	28.3			
0.935D	85	71	28.3			

9 - 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	12	0.05759	0.08187	0.02428	4.0	42.2%
Acetone						
Total weight = 0.02428						
Sample Run No.2.	Ref No.	Weight gms			Sample time at each point (mins)	
		Before	After	Collected		
Filter						
Acetone						
Total weight = 0.00000						
Sample Blank	Ref No.	Weight gms			Sample time at each point (mins)	
		Before	After	Collected		
Filter	13	0.05672	0.05679	0.00007	n/a	0.1%
Acetone						
Total weight = 0.00007						

10 - Main conditions for compliance with BS ISO 9096:2003

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 ISO 9096:2003. 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.