

Appendix 14A

Summary of Air Quality Criteria

Table 1 – Summary of Air Quality Criteria

Application	Parameter	Limit Value	Reference
Annoyance	Deposited dust	200mg/m ² per day	“Custom and practice (England and Wales)” quoted in Environment Agency Technical Guidance Document (Monitoring) M17 Monitoring of particulate matter in ambient air around waste facilities.
		Open country: 100mg/m ² /day complaints possible, 140mg/m ² /day complaints likely. Residential areas and outskirts of town: 150mg/m ² /day complaints possible, 200mg/m ² /day complaints likely.	Vallack, H. W. & Shillito, D. E. (1998), “Suggested guidelines for deposited ambient dust”, Atmospheric Environment, Vol.32, pp.2737-2744.
	Soiling (by dust slide)	25 soiling units (SU) per week	“Custom and practice” quoted in Environment Agency M17.
	Soiling (by sticky pad)	0.5% effective area coverage (EAC) per day in rural summer time; public response: possible complaints. 0.2% EAC/day – noticeable, 0.7% EAC/day – objectionable, 2% EAC/day – probable complaints, 5% EAC/day – serious complaints.	Beaman, A.L. & Kingsbury, R.W.S.M. (1981), “Assessment of nuisance from deposited dust particulates using a simple and inexpensive measuring system”, Clean Air, Vol.11, No.2, pp.77-81.
	Soiling (by DustScan method)	Source significance: Very High if >25 %EAC/week or 100 for 45° %AAC/week Very Low if <2.5 %EAC/week or <80 %AAC/week, where AAC = absolute area coverage.	Datson, H., Birch, W.J. (2006), “The development of a novel method for directional dust monitoring”, Environmental Monitoring and Assessment, Vol.124(1-3), pp.301-308.
Air quality management and environmental protection	Suspended particulates	24 hour average PM10 concentration not to exceed 50ug/m ³ more than 35 times per year, annual average PM10 concentration not to exceed 40ug/m ³ .	EU limit and National Air Quality Strategy objective
Worker protection	Hazardous substances	Occupational Exposure Limits (OELs) for the UK, the following being potentially relevant to inert landfill: Silica, long-term exposure limits (8-hr TWA reference period): - respirable crystalline 0.1 mg/m ³ - amorphous inhalable dust 6mg/m ³ - respirable dust 2.4mg/m ³	HSE Guidance Note EH40

Appendix 14B
Wind and Rain Data for Plymouth, United Kingdom

Wind and Rain Data For Plymouth, United Kingdom (source <https://weatherspark.com/averages/28715/Plymouth-England-United-Kingdom>)

This report describes the typical weather at the Plymouth City Airport (Plymouth, United Kingdom) weather station over the course of an average year. It is based on the historical records from 1995 to 2011. Earlier records are either unavailable or unreliable.

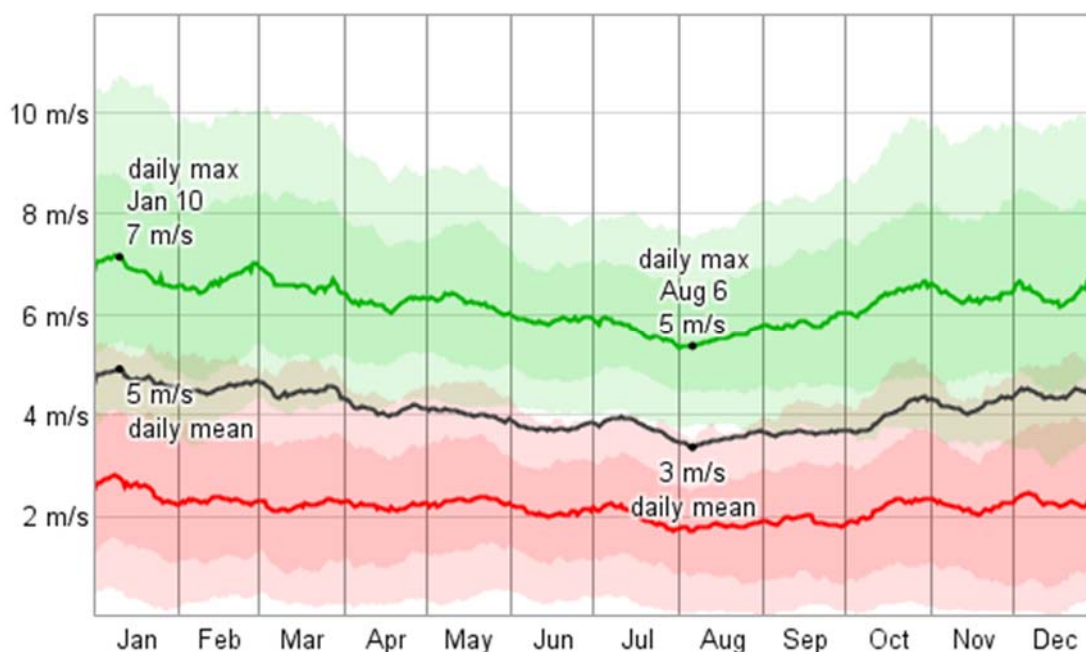
Wind

Over the course of the year typical wind speeds vary from 2 m/s to 7 m/s (light breeze to moderate breeze), rarely exceeding 11 m/s (strong breeze).

The highest average wind speed of 5 m/s (gentle breeze) occurs around January 10, at which time the average daily maximum wind speed is 7 m/s (moderate breeze).

The lowest average wind speed of 3 m/s (light breeze) occurs around August 6, at which time the average daily maximum wind speed is 5 m/s (gentle breeze).

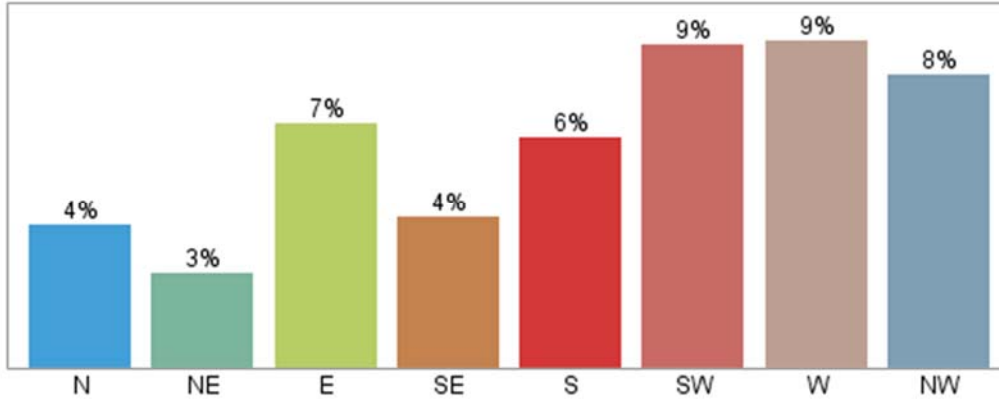
Wind Speed



The average daily minimum (red), maximum (green), and average (black) wind speed with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile).

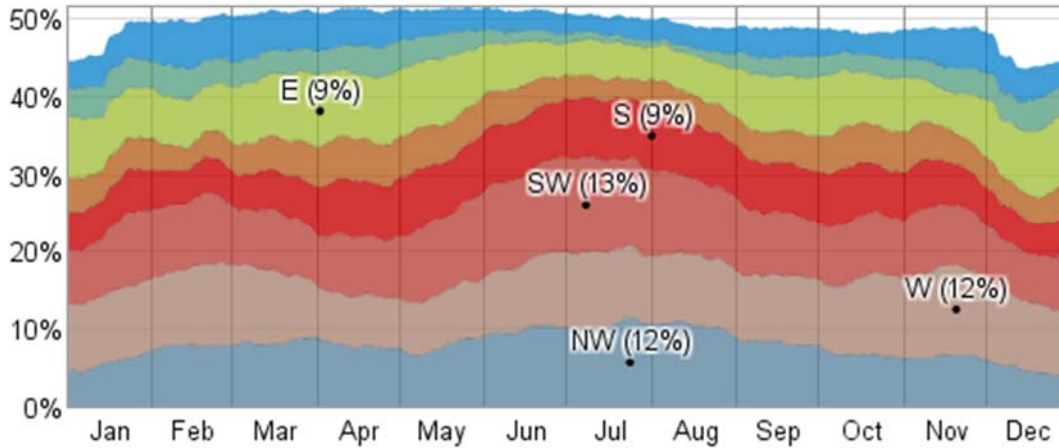
The wind direction is highly variable and is not predominantly from any single direction. The wind is least often out of the north east (3% of the time), north (4% of the time), and south east (4% of the time).

Wind Directions Over the Entire Year



The fraction of time spent with the wind blowing from the various directions over the entire year. Values do not sum to 100% because the wind direction is undefined when the wind speed is zero.

Fraction of Time Spent with Various Wind Directions

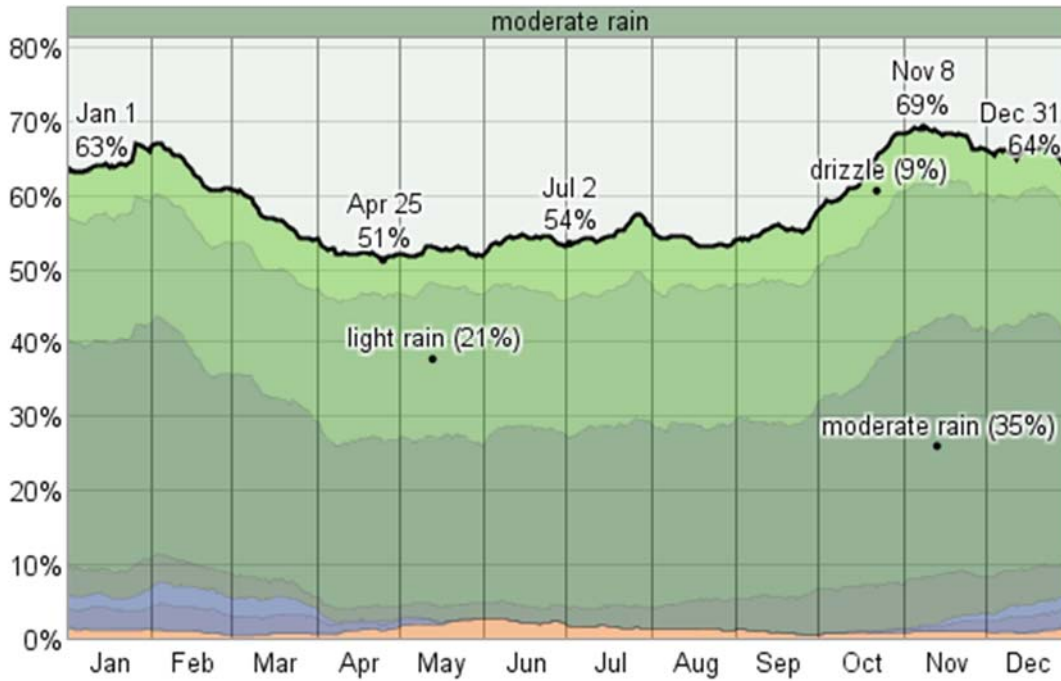


The fraction of time spent with the wind blowing from the various directions on a daily basis. Stacked values do not always sum to 100% because the wind direction is undefined when the wind speed is zero.

Precipitation

The probability that precipitation will be observed at this location varies throughout the year. Precipitation is most likely around November 8, occurring in 69% of days. Precipitation is least likely around April 25, occurring in 51% of days.

Probability of Precipitation at Some Point in the Day



The fraction of days in which various types of precipitation are observed. If more than one type of precipitation is reported in a given day, the more severe precipitation is counted. For example, if light rain is observed in the same day as a thunderstorm, that day counts towards the thunderstorm totals. The order of severity is from the top down in this graph, with the most severe at the bottom.

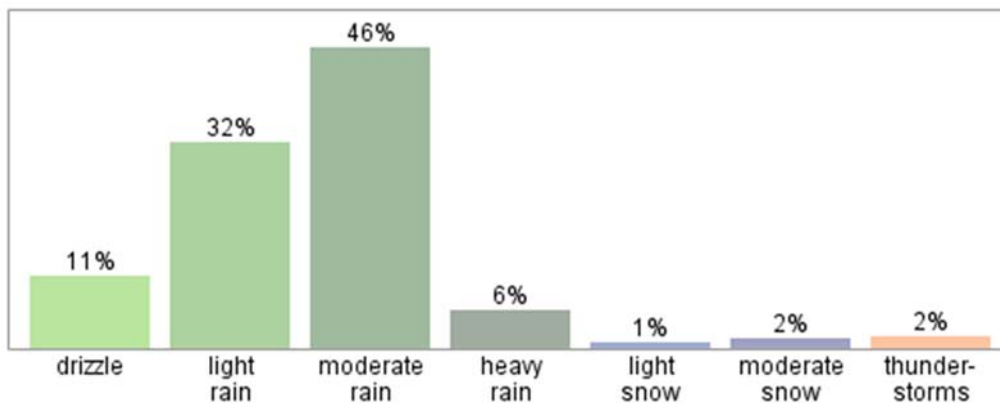
Over the entire year, the most common forms of precipitation are moderate rain, light rain, and drizzle.

Moderate rain is the most severe precipitation observed during 46% of those days with precipitation. It is most likely around November 13, when it is observed during 35% of all days.

Light rain is the most severe precipitation observed during 32% of those days with precipitation. It is most likely around May 13, when it is observed during 21% of all days.

Drizzle is the most severe precipitation observed during 11% of those days with precipitation. It is most likely around October 22, when it is observed during 9% of all days.

Types of Precipitation Throughout the Year

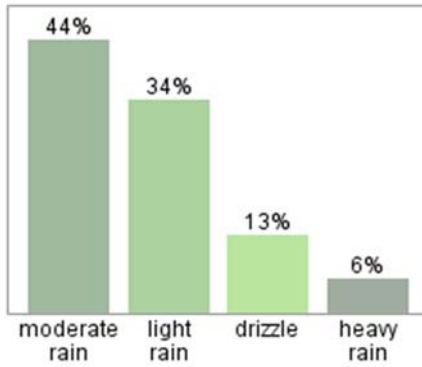


Relative frequency of various types of precipitation over the course of a typical year.

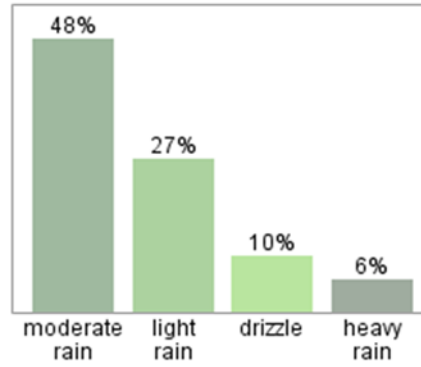
During the *warm season*, which lasts from June 14 to September 16, there is a 54% average chance that precipitation will be observed at some point during a given day. When precipitation does occur it is most often in the form of moderate rain (44% of days with precipitation have at worst moderate rain), light rain (34%), drizzle (13%), and heavy rain (6%).

During the *cold season*, which lasts from November 24 to March 15, there is a 64% average chance that precipitation will be observed at some point during a given day. When precipitation does occur it is most often in the form of moderate rain (48% of days with precipitation have at worst moderate rain), light rain (27%), drizzle (10%), and heavy rain (6%).

Warm Season Precipitation



Cold Season Precipitation



Relative frequency of various types of precipitation during the warm and cold seasons respectively.

Appendix 14C

Stack Emission Test Results for 2014 and 2015

Environmental Protection Act
Pollution Prevention & Control

**PARTICULATE EMISSION TEST
(BS ISO 9096:2003)**

on

**LINHAY HILL QUARRY ROADSTONE COATING PLANT
BAG FILTER EXHAUST**

for

**E & JW GLENDINNING LTD
GLENTOR
ASHBURTON
NEWTON ABBOT
TQ13 7LF**

Tested By:



Date Of Test : 23.06.14

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

Report No : 976

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 - 4.9 Comments
- 5. SAMPLING RECORDS**

SUMMARY INFORMATION

Determined	Units	Results	Limit
Particulate Concentration (STP)	mg/m ³	3.7	50
Mass Emission (STP)	kg/hr	0.14	-
Stack Temperature	°C	83	-
Gas Velocity	m/s	11.88	-
Stack Volume Flow Rate (Actual)	m ³ /hr	51639	-
Stack Volume Flow Rate (STP)	m ³ /hr	39888	-

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

1. INTRODUCTION

Particulate emission testing was undertaken by Yelland Environmental Services, on the roadstone coating plant exhaust at E & JW Glendinning Ltd, Linhay Hill Quarry.

The purpose of the emission testing was to ensure compliance with the requirements of the permit issued by enforcing body 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 Regulatory Body 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 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 MCERTS 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 ISO 9096:2003 - Stationary source emissions. Manual Determination of mass concentration of particulate matter.

- * 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 ISO9096:2003.

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.

4. 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.

4.3 Sampling equipment

The test equipment is inspected prior to use and its 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 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°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 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 ISO 9096. 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

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 ISO 9096.

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/m³.

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 test was 32 minutes.

At the time of sampling, a particulate matter of 3.71mg/m³ 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 1.3529mg/m³ was obtained together with an existing calibration factor of 1.0000. It can be concluded that the monitor would benefit from an adjustment of the current calibration factor to 2.7425.

Full test data demonstrating procedural compliance with BS ISO 9096 for total particulate monitoring is provided in following sections.

Due to limited production on the day of sampling one sample run was able to be carried out in accordance with BS ISO 9096:2003. If production allows repeat samples are taken to achieve a greater degree of accuracy on the emission mean.

5. SAMPLING RECORDS

5.1 Process Conditions

Arrestment Plant:	Bag filter
Particulate Type:	Aggregate
Plant Loading:	Continuous - 20mm base @ 100tph.
Appearance of plume:	Steam

5.2 Sampling Results

	Test Run No. 1.
Time of Test:	08.10 - 08.42
Sampling Duration: (mins)	32
Gas Temperature (°C)	82
Mean Velocity at Sampling Points: (m/s)	11.59
Gas Flow Rate at STP (1): (m ³ /min)	630.9
Particulate Loading at STP (1): (mg/m ³)	3.71
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% O₂, etc).

5.3 - Calculations Sample Run No. 1

On-site measurements

$$\begin{aligned} \text{O}_2 &= 17.4 \% & \text{CO}_2 &= 1.9 \% & \text{N}_2 &= 80.7 \% \\ \text{Bws} &= 0.03 & \text{Ps} &= 101.9 \text{ kPa} & \text{Ts} &= 355.4 \text{ K} \end{aligned}$$

$$\begin{aligned} \text{Md} &= \text{Molecular weight of gas at DGM (g/g mole)} \\ \text{Md} &= (0.44 \times \% \text{CO}_2) + (0.32 \times \% \text{O}_2) + (0.28 \times \% \text{N}_2) \\ &= 29.00 \text{ g/g mole} \end{aligned}$$

$$\begin{aligned} \text{Ms} &= \text{Molecular weight of gas wet (g/g mole)} \\ &= 28.67 \text{ g/g mole} \end{aligned}$$

Stack gas velocity at sample points

$$\begin{aligned} V &= K_p \times C_p \times \sqrt{(T_s \cdot \Delta P / P_s \cdot M_s)} & K_p &= 4.07 \\ &= 11.59 \text{ m/s} & \Delta P &= 67.1 \text{ av. } \Delta p \text{ at sample plane} \\ & & C_p &= 1.00 \text{ pitot tube coefficient} \end{aligned}$$

Stack gas volume at sample points

$$\begin{aligned} Q &= V \times A \times 60 & A &= 1.21 \text{ area of stack m}^2 \\ &= 840.1 \text{ m}^3/\text{min} \end{aligned}$$

Volume of water vapour collected, standard conditions (m³)

$$\begin{aligned} V_{wstd} &= 0.00124 \times V_{lc} & V_{lc} &= 15 \text{ ml} \\ &= 0.019 \text{ m}^3 \end{aligned}$$

Volume of gas metered, standard conditions (m³)

$$\begin{aligned} V_{mstd} &= \frac{2.695 \times V_m \times (P_a + (\Delta H/102)) \times Y_d}{(T + T_m)} & T_m &= 19 \text{ }^\circ\text{C} \\ & & V_m &= 0.6338 \text{ m}^3 \\ & & P_a &= 101.9 \text{ kPa} \\ & & \Delta H &= 42.8 \text{ mm H}_2\text{O} \\ & & Y_d &= 1.090 \\ &= 0.6524 \text{ m}^3 \end{aligned}$$

Moisture content

$$\begin{aligned} B_{wo} &= V_{wstd} / (V_{wstd} + V_{mstd}) \\ &= 0.0283 \end{aligned}$$

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

$$\begin{aligned} Q_{std} &= \frac{Q \times P_s (2.695)(1 - B_{wo})}{T_s + 273} & T_s &= 82.4 \text{ }^\circ\text{C} \\ & & P_s &= 101.9 \text{ kPa} \\ &= 631 \text{ m}^3/\text{min} \end{aligned}$$

Percent isokinetic

$$\begin{aligned} \%I &= \frac{(6.184 \times 10^5)(T_s + 273) \times V_{mstd}}{P_s \times V \times A_a \times t \times (1 - B_{wo})} & A_a &= 38.5 \text{ area of nozzle m}^2 \\ &= 101.4 \% \end{aligned}$$

5.3 - Calculations Sample Run No. 1 Cont.

Filter & rinsing weights sample no. 1

weight gain on filters = 2.42 mg
weight of acetone wash = mg
total weight gain (M) = 2.42 mg

Particulate concentration (mg/m³)

$$C = M/V_{mstd} \qquad M = 2.42 \text{ mg}$$
$$= 3.71 \text{ mg/m}^3$$

Particulate emission rate (kg/hr)

$$E = (C \times Q_{std} \times 60)/1000000$$
$$= 0.14 \text{ kg/hr}$$

5.4 - Calculations Sample Run No.1 Cont.

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 = 0.00005 mg

weight of acetone wash = mg

total weight gain (M) = 0.00005 mg

Particulate concentration (mg/m³)

$$C = M/V_{mstd}$$

$$= 0.08 \text{ mg/m}^3$$

$$M = 0.05 \text{ mg}$$

5.5 - On Site Velocity and Flow Data

Company	E & JW GLENDINNING LTD	Stack Diameter	1.24	m
Site	GLENTOR	Area	1.21	m ²
Location	LINHAY HILL QUARRY ROADSTONE	Barometric Pressure	101.9	kPa
Job No	976	Stack Pressure	0.01	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	64	82	63	83
2	70	82	69	84
3	72	82	72	84
4	75	82	73	83
5	74	82	75	83
6	72	83	76	83
7	71	83	74	83
8	68	82	72	82
9	66	82	69	82
10	60	82	66	82

av temp (K)=((average temp traverse A+average temp traverse B)/2)+273	356
av press (Pa)=((average press traverse A+average press traverse B)/2)	70

Suitability of sampling positions & Required No. of sample points	Actual Stack Conditions
Permitted highest to lowest pressure range = 9:1	1.3 : 1
Negative pressure	Not permitted
Differential pressure minimum > 5 Pa	60
No. of sampling points	8

5.6 - Sampling Conditions

Sample Run No. 1			
Sample Position	Stack Temp °C	Velocity Pressure ΔP (Pa)	Nozzle Area mm ²
0.065D	82	64	38.5
0.25D	82	72	38.5
0.75D	82	68	38.5
0.935D	82	60	38.5
0.065D	83	63	38.5
0.25D	84	72	38.5
0.935D	82	72	38.5
0.935D	82	66	38.5

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	22	0.05974	0.06216	0.00242	4.0	4.1%
Acetone						
Total weight = 0.00242						
Sample Blank	Ref No.	Weight gms			Sample time at each point (mins)	% weight gain
		Before	After	Collected		
Filter	23	0.06009	0.06014	0.00005	n/a	0.1%
Acetone						
Total weight = 0.00005						

5.8 - 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 $\pm 10^\circ$	*	
	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.

Environmental Protection Act
Pollution Prevention & Control

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

on

**LINHAY HILL QUARRY ROADSTONE COATING PLANT
BAG FILTER EXHAUST**

for

**E & JW GLENDINNING LTD
GLENTOR
ASHBURTON
NEWTON ABBOT
TQ13 7LF**

Tested By:



Date Of Test : 29.06.15

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

Report No : 2152

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- 5. SAMPLING RECORDS**

SUMMARY INFORMATION

Determined	Units	Results	Limit
Particulate Concentration (STP)	mg/m ³	1.3	50
Mass Emission (STP)	kg/hr	0.05	-
Stack Temperature	°C	50	-
Gas Velocity	m/s	11.49	-
Stack Volume Flow Rate (Actual)	m ³ /hr	49954	-
Stack Volume Flow Rate (STP)	m ³ /hr	42685	-

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

1. INTRODUCTION

Particulate emission testing was undertaken by Yelland Environmental Services, on the roadstone coating plant dust collector exhaust at E & JW Glendinning Ltd., Linhay Hill Quarry.

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.

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* Process Guidance Note PG3/15(12) Secretary of State's Guidance for Roadstone Coating Processes.

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. 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.

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 its 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 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°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 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

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/m³.

4.8 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 1.33mg/m³ 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 DT990 continuous emission monitor was interrogated and the average results, which were recorded during the measurement period, noted. A level of 0.64mg/m³ was obtained together with an existing calibration factor of 3.54. It can be concluded that the monitor would benefit from an adjustment of the current calibration factor to 7.3566.

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 - 20mm base @ 100tph.
Appearance of plume:	No visible discharge.

5.2 Sampling Results

	Test Run No. 1.	Test Run No. 2.	Average
Time of Test:	08.16 - 08.48	08.53 - 09.25	
Sampling Duration: (mins)	32	32	
Gas Temperature (°C)	50	49	50
Mean Velocity at Sampling Points: (m/s)	11.21	11.08	11.15
Gas Flow Rate at STP (1): (m ³ /min)	668.4	662.4	665.4
Particulate Loading at STP (1): (mg/m ³)	1.49	1.17	1.33
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% O₂, etc).

5.3 - Calculations Sample Run No. 1

On-site measurements

$$\begin{array}{lll} \text{O}_2 = & 17.6 \% & \text{CO}_2 = 1.8 \% & \text{N}_2 = 80.6 \% \\ \text{Bws} = & 0.03 & \text{Ps} = 102.4 \text{ kPa} & \text{Ts} = 322.9 \text{ K} \end{array}$$

$$\begin{aligned} \text{Md} &= \text{Molecular weight of gas at DGM (g/g mole)} \\ \text{Md} &= (0.44 \times \% \text{CO}_2) + (0.32 \times \% \text{O}_2) + (0.28 \times \% \text{N}_2) \\ &= 28.99 \text{ g/g mole} \end{aligned}$$

$$\begin{aligned} \text{Ms} &= \text{Molecular weight of gas wet (g/g mole)} \\ &= 28.66 \text{ g/g mole} \end{aligned}$$

Stack gas velocity at sample points

$$\begin{aligned} V &= K_p \times C_p \times \sqrt{(T_s \cdot \Delta P / P_s \cdot M_s)} \\ &= 11.21 \text{ m/s} \end{aligned}$$
$$\begin{array}{ll} K_p = & 4.07 \\ \Delta P = & 69.4 \text{ av. } \Delta p \text{ at sample plane} \\ C_p = & 1.00 \text{ pitot tube coefficient} \end{array}$$

Stack gas volume at sample points

$$\begin{aligned} Q &= V \times A \times 60 \\ &= 812.2 \text{ m}^3/\text{min} \end{aligned}$$
$$A = 1.21 \text{ area of stack m}^2$$

Volume of water vapour collected, standard conditions (m³)

$$\begin{aligned} V_{wstd} &= 0.00124 \times V_{lc} \\ &= 0.02 \text{ m}^3 \end{aligned}$$
$$V_{lc} = 16 \text{ ml}$$

Volume of gas metered, standard conditions (m³)

$$\begin{aligned} V_{mstd} &= \frac{2.695 \times V_m \times (P_a + (\Delta H / 102)) \times Y_d}{(T + T_m)} \\ &= 0.5155 \text{ m}^3 \end{aligned}$$
$$\begin{array}{ll} T_m = & 23 \text{ }^\circ\text{C} \\ V_m = & 0.5703 \text{ m}^3 \\ P_a = & 102.4 \text{ kPa} \\ \Delta H = & 27.3 \text{ mm H}_2\text{O} \\ Y_d = & 0.967 \end{array}$$

Moisture content

$$\begin{aligned} B_{wo} &= V_{wstd} / (V_{wstd} + V_{mstd}) \\ &= 0.0373 \end{aligned}$$

5.3 - Calculations Sample Run No. 1 Cont.

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

$$\begin{aligned} Q_{std} &= \frac{Q \times P_s(2.695)(1 - B_{wo})}{T_s + 273} & T_s &= 49.9 \text{ }^\circ\text{C} \\ & & P_s &= 102.4 \text{ kPa} \\ &= 668 \text{ m}^3/\text{min} \end{aligned}$$

Percent isokinetic

$$\begin{aligned} \%I &= \frac{(6.184 \times 10^5)(T_s + 273) \times V_{mstd}}{P_s \times V \times A_a \times t \times (1 - B_{wo})} & A_a &= 28.3 \text{ area of nozzle m}^2 \\ &= 102.9 \% \end{aligned}$$

Filter & rinsing weights sample no. 1

$$\begin{aligned} \text{weight gain on filters} &= 0.77 \text{ mg} \\ \text{weight of acetone wash} &= \text{mg} \\ \text{total weight gain (M)} &= 0.77 \text{ mg} \end{aligned}$$

Particulate concentration (mg/m³)

$$\begin{aligned} C &= M/V_{mstd} & M &= 0.77 \text{ mg} \\ &= 1.49 \text{ mg/m}^3 \end{aligned}$$

Particulate emission rate (kg/hr)

$$\begin{aligned} E &= (C \times Q_{std} \times 60)/1000000 \\ &= 0.06 \text{ kg/hr} \end{aligned}$$

5.3 - Calculations Sample Run No. 2

On-site measurements

$$\begin{array}{lll} \text{O}_2 = & 17.7 \% & \text{CO}_2 = 1.7 \% & \text{N}_2 = 80.6 \% \\ \text{Bws} = & 0.04 & \text{Ps} = 102.4 \text{ kPa} & \text{Ts} = 322.1 \text{ K} \end{array}$$

$$\begin{aligned} \text{Md} &= \text{Molecular weight of gas at DGM (g/g mole)} \\ \text{Md} &= (0.44 \times \% \text{CO}_2) + (0.32 \times \% \text{O}_2) + (0.28 \times \% \text{N}_2) \\ &= 28.98 \text{ g/g mole} \end{aligned}$$

$$\begin{aligned} \text{Ms} &= \text{Molecular weight of gas wet (g/g mole)} \\ &= 28.57 \text{ g/g mole} \end{aligned}$$

Stack gas velocity at sample points

$$\begin{aligned} V &= K_p \times C_p \times \sqrt{(T_s \cdot \Delta P / P_s \cdot M_s)} & K_p &= 4.07 \\ &= 11.08 \text{ m/s} & \Delta P &= 67.8 \text{ av. } \Delta p \text{ at sample plane} \\ & & C_p &= 1.00 \text{ pitot tube coefficient} \end{aligned}$$

Stack gas volume at sample points

$$\begin{aligned} Q &= V \times A \times 60 & A &= 1.21 \text{ area of stack m}^2 \\ &= 803.0 \text{ m}^3/\text{min} \end{aligned}$$

Volume of water vapour collected, standard conditions (m³)

$$\begin{aligned} V_{wstd} &= 0.00124 \times V_{lc} & V_{lc} &= 16 \text{ ml} \\ &= 0.0196 \text{ m}^3 \end{aligned}$$

Volume of gas metered, standard conditions (m³)

$$\begin{aligned} V_{mstd} &= \frac{2.695 \times V_m \times (P_a + (\Delta H / 102)) \times Y_d}{(T + T_m)} & T_m &= 24 \text{ }^\circ\text{C} \\ & & V_m &= 0.5620 \text{ m}^3 \\ & & P_a &= 102.4 \text{ kPa} \\ & & \Delta H &= 27 \text{ mm H}_2\text{O} \\ & & Y_d &= 0.967 \\ &= 0.5063 \text{ m}^3 \end{aligned}$$

Moisture content

$$\begin{aligned} B_{wo} &= V_{wstd} / (V_{wstd} + V_{mstd}) \\ &= 0.0373 \end{aligned}$$

5.3 - Calculations Sample Run No. 2 Cont.

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

$$Q_{std} = \frac{Q \times P_s(2.695)(1 - B_{wo})}{T_s + 273}$$
$$= 662.4 \text{ m}^3/\text{min}$$

$$T_s = 49.1 \text{ }^\circ\text{C}$$
$$P_s = 102.4 \text{ kPa}$$

Percent isokinetic

$$\%I = \frac{(6.184 \times 10^5)(T_s + 273) \times V_{mstd}}{P_s \times V \times A_a \times t \times (1 - B_{wo})}$$
$$= 102.0 \%$$

$$A_a = 28.3 \text{ area of nozzle m}^2$$

Filter & rinsing weights sample no. 2

$$\begin{aligned} \text{weight gain on filters} &= 0.59 \text{ mg} \\ \text{weight of acetone wash} &= \text{mg} \\ \text{total weight gain (M)} &= 0.59 \text{ mg} \end{aligned}$$

Particulate concentration (mg/m³)

$$C = M/V_{mstd}$$
$$= 1.17 \text{ mg/m}^3$$

$$M = 0.59 \text{ mg}$$

Particulate emission rate (kg/hr)

$$E = (C \times Q_{std} \times 60)/1000000$$
$$= 0.05 \text{ kg/hr}$$

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/m³)

$$C = M/V_{mstd}$$

$$= 0.06 \text{ mg/m}^3$$

$$M = 0.03 \text{ mg}$$

5.5 - On Site Velocity and Flow Data

Company	E & JW GLENDINNING LTD	Stack Diameter	1.24	m
Site	GLENTOR	Area	1.21	m ²
Location	LINHAY HILL QUARRY ROADSTONE	Barometric Pressure	102.4	kPa
Job No	2152	Stack Pressure	0.01	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	68	51	65	49
2	73	51	72	50
3	75	51	74	50
4	76	51	74	50
5	78	51	75	50
6	75	50	77	50
7	73	50	76	49
8	70	50	73	49
9	67	49	72	50
10	62	49	68	50

av temp (K)=((average temp traverse A+average temp traverse B)/2)+273	323
av press (Pa)=((average press traverse A+average press traverse B)/2)	72

Suitability of sampling positions & Required No. of sample points	Actual Stack Conditions
Permitted highest to lowest pressure range = 9:1	1.3 : 1
Negative pressure	Not permitted
Differential pressure minimum > 5 Pa	62
No. of sampling points	8

5.6 - Sampling Conditions

Sample Position	Sample Run No. 1			Sample Run No. 2		
	Stack Temp °C	Velocity Pressure ΔP (Pa)	Nozzle Area mm ²	Stack Temp °C	Velocity Pressure ΔP (Pa)	Nozzle Area mm ²
0.065D	51	68	28.3	49	66	28.3
0.25D	51	75	28.3	50	74	28.3
0.75D	50	70	28.3	49	68	28.3
0.935D	49	62	28.3	49	63	28.3
0.065D	49	65	28.3	50	62	28.3
0.25D	50	74	28.3	49	71	28.3
0.935D	49	73	28.3	48	72	28.3
0.935D	50	68	28.3	49	66	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	1	0.05941	0.06018	0.00077	4.0	1.3%
Acetone						
Total weight = 0.00077						
Sample Run No.2.	Ref No.	Weight gms			Sample time at each point (mins)	
		Before	After	Collected		
Filter	2	0.05920	0.05979	0.00059	4.0	1.0%
Acetone						
Total weight = 0.00059						
Sample Blank	Ref No.	Weight gms			Sample time at each point (mins)	
		Before	After	Collected		
Filter	3	0.05907	0.05910	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 $\pm 10^\circ$	*	
	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.

Appendix 14D

Dust Deposition Monitoring