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Emissions Test on
Sand Reclamation Filter
at
Hytec Castings Ltd, Coventry

Report No EM3370

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1. Introduction

The above site was visited on the 16th December 2003 in order to carry out tests to quantify the levels of emissions from the filter serving the sand reclamation unit. The emissions were sampled for particulate and VOCs. These tests are required as a condition of authorisation of the process and the results should be forwarded to the local authority within eight weeks of completion of testing.

Sampling was carried out by T N Blackman MIM CEng

2. Methods of Test

The particulate tests were carried out in accordance with BS3405:1983, as far as conditions allowed, using a BSC design sampling probe. The particulates were collected onto glass wool depth filters that have a nominal container weight of 25g, the mass collected was determined gravimetrically after drying at 140°C. The use of relatively heavy depth filters means that at low emission concentrations it is unlikely that sufficient mass of particulates will be collected to satisfy the requirements of BS3405. (minimum of 0.3% of the container mass). However, the resolution of the balance is greater than that required of the standard and reproducibility of the weighings is shown to be good. The use of depth filters will have no effect on the accuracy of the test. Depth filters are the preferred option when sampling ducts where the discharge is likely to comprise granular particulates, often these do not adhere to filter papers and may be lost during handling and transport which can result in an underestimation of emission levels.

Airflow and velocity measurements in the ducts were determined using an ellipsoidal pitot-static tube and electronic manometer. Temperature measurements were made using a K-type thermocouple and electronic thermometer. The manometer, thermometer and balance all have calibrations traceable to NPL standards.

The levels of VOCs (volatile organic compounds) in the extraction ducts were measured continuously using a model 3010 Minifid Total Hydrocarbon Analyser supplied by Signal Instruments. The 3010 Minifid is a direct reading flame ionisation detector with an integral heated sample line. This detects volatile organic compounds in the airstream, including any compounds that are liquid at ambient temperatures. The instrument is calibrated against a standard methane concentration and gives a readout in ppm Methane Equivalence. VOC levels were measured over a 30 minute period during a time of peak emissions, the concentration range and the mean concentration being reported.

All results are reported under standard conditions of 0°C, 101.3 kPa, uncorrected for water vapour. A full sampling protocol is included in the Appendix.

3. Results

Particulate Emissions

Full results of the particulate emission tests and conditions in the ducts are given in the tables at the end of this report. A summary of the main findings is produced below.

Run No.	Time min	Vol. lt.	Wt collected mg	Concentration mg/m ³
1	30	505	3.0	5.9
2	30	507	2.4	4.7

VOCs

	Range.	15 minute mean	
	ppm methane	ppm methane	mg/m ³ carbon
No sand being processed	212-340	237	127
Sand throughput 8kg/h, Temperature 630-650°C	222-320	258	138

4. Compliance with BS3405:1983

The conditions of the particulate emission test fully conformed to BS3405.

5. Comments

The results of the test show that particulate emissions were around 5 mg/m³, well within the limit of 50 mg/m³.

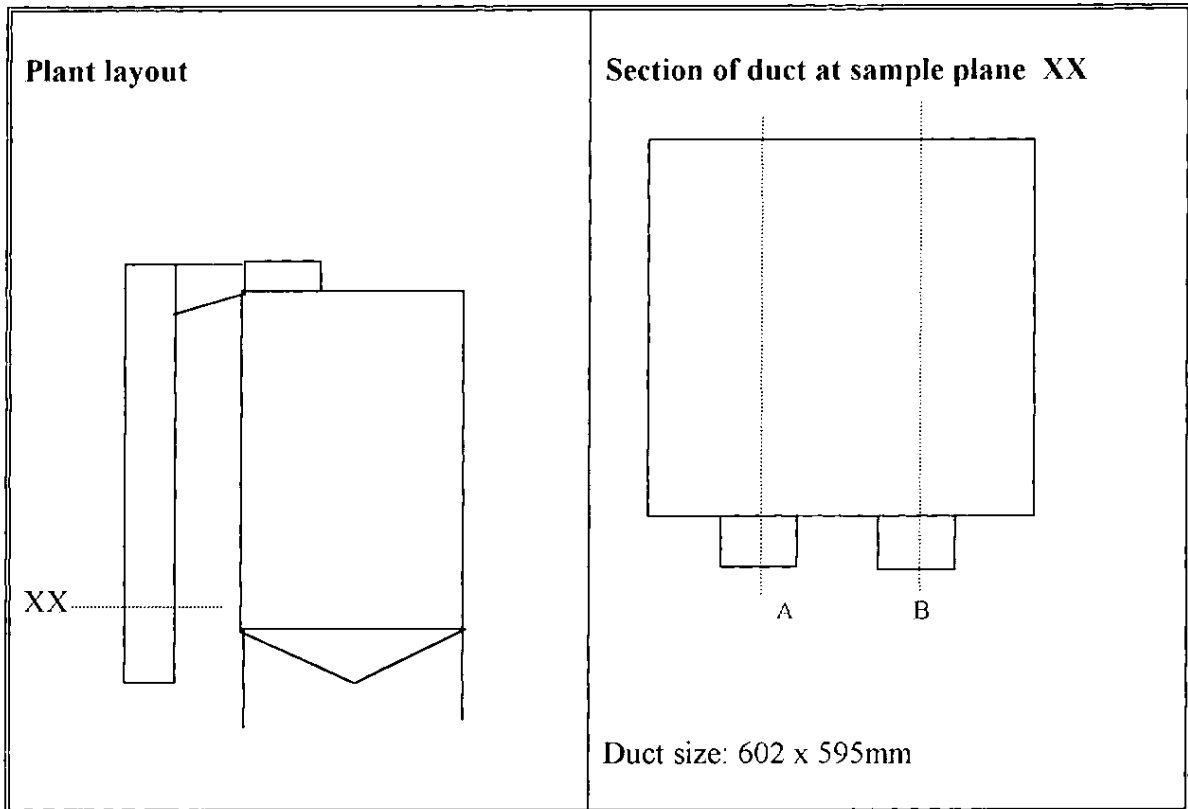
The limit for VOCs is 50mg Carbon/m³. Emissions were around 2.5 times this level. There was no significant difference in the levels of VOCs discharged whether or not sand was being processed. This would indicate that most of the VOC is unburned methane from the gas burners and, without adjustment/modification to the burners, it is highly unlikely that the unit will be able to comply with the limit for VOCs,



pp T N Blackman MIM. C.Eng.

Particulate emission test to BS3405:1983

Hytec Castings Ltd
Sand Reclamation filter
16/12/03



Process/test conditions

Arrestment type	Pulse Jet
Particulate type	Sand/dust
Appearance of plume	Non visible

Sample ports located vertical discharge duct approximately 600 mm before discharge.

Moulds were being knocked-out through out sampling period, attrition unit and fluidised bed both operating throughout. Sand was processed through the thermal reclamation unit for the second sample run.

Conformance

Test fully conformed.

Sand Reclamation filter

Duct size	0.602 m x 0.595 m
Duct temperature	35 °C
Atmospheric pressure	100.8 kPa
Static pressure in duct	0.9 "wg 224.1 Pa
Mean velocity in duct	10.14 m/s
Gas flow rate	10660 Nm ³ /hr

Preliminary Survey

Pitot-static pressures ("wg)

Position (xD)	0.065	0.125	0.25	0.375	0.50	0.625	0.75	0.875	0.935
Traverse A	0.25	0.26	0.26	0.26	0.27	0.25	0.25	0.25	0.20
Traverse B	0.28	0.25	0.23	0.23	0.23	0.23	0.24	0.22	0.21

Ratio of highest to lowest pitot-static reading: (Max 9:1) 1.40 :1

Sampling details

Nozzle size: 1/4" Number of sample points: 4

Position	0.25A	0.75A	0.25B	0.75B
Run 1				
Velocity pressure "wg	0.26	0.25	0.25	0.21
Flow rate l/min	19	19	19	17
Pump temp °C	29	37	35	35
Run 2				
Velocity pressure "wg	0.25	0.25	0.25	0.20
Flow rate l/min	19	19	19	17
Pump temp °C	30	33	32	33
velocity pressure end	0.25	0.24	0.25	0.20

Pump correction factor: Run 1: 0.910 Run 2: 0.913

Variation in sum of velocity pressures during test: (Max 10%)

Run 1 -2.06 % Run 2 -1.05 %

Results

	Run 1	Run 2
Filter No.	D1	D2
Duration. min	30	30
Condensate. mls	0	0
Volume sampled.lt	505	507
Weight collected. mg	3.0	2.4
Concentration mg/m ³	5.94	4.74

Ratio of final emission concentrations: (Max 1.5:1) 1.25 :1

APPENDIX

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Isokinetic Sampling To BS3405:1983

Particulate sampling is carried out using either the Enviro-Met isokinetic sampler, based on a BSC design or a Zambelli ZB2 sampler, the design of which complies with BS 3405. The equipment consists of an in-stack filter, water-cooled condenser (for hot applications), sample pump and flow measurement device. Pressure, air velocity and flow rates are measured using an ellipsoidal pitot-static tube and electronic manometer. Temperature measurements are made using a k-type thermocouple and electronic thermometer.

The tests are carried out adopting the following protocol:

A Preparation

- 1 Verify sampling ports are fitted and in accordance with the requirements of BS3405. Ensure there is safe access and platform at the sampling position and that power will be available locally. Check whether there are any potential hazard such as dangerous gases.
- 2 Establish the likely levels of emissions and whether there may be cyclical variations in the process. Determine sampling times and duration accordingly. Minimum sample times of 60 minutes are normally used.
- 3 Check isokinetic sampler and measuring equipment is working correctly.
- 4 Pack depth filters with a tightly packed layer of ultrafine glass fibre followed by a loosely packed layer of fine glass fibre. Dry depth filters in an oven at 120°C overnight and cool in a desiccator. Weigh to a constant weight using a four figure balance weighing to 0.1mg.
- 5 Leave GFA filter papers to equilibrate for 24hrs in the weighing room before weighing to a constant weight on a five figure balance to 0.01mg. Weigh two blanks per batch to compensate for any humidity or temperature changes.

B On site

Preliminary

- 1 Ensure access and sample position is safe. Carry out a risk assessment prior to commencement of sampling. If any risk is considered "high" do not commence sampling until measures to reduce the risk have been taken.
- 2 Agree on notification and emergency evacuation procedures.
- 3 Determine that the plant is operating under normal conditions. Arrange for notification in the event of any stoppages or abnormal conditions.

Sampling Procedure

- 1 Carry out preliminary survey at ten points across both traverses of the duct for pitot-static pressure. Velocity pressure across the duct should not vary by more than a factor of 9:1
- 2 Note the extent of any swirl, the direction of flow should not be more than 20° to axis of the duct.
- 3 Measure the duct static pressure and record any variation in temperature across the duct. Record the atmospheric pressure.

- 4 Calculate ratio of highest to lowest pitot static measurements and assess whether sampling can be carried out in accordance with BS3405 and if so whether 4 or 8 point sampling is necessary.
- 5 Select a suitable nozzle and calculate the flow rate to achieve isokinetic sampling. For cumulative sampling the product of sample time and nozzle area must remain constant.
- 6 Assemble sampling equipment train and check for leaks.
- 7 Load a clean filter into the sample head and locate the sample probe at the first sample point with the nozzle facing upstream, start the pump and stopwatch simultaneously. Adjust the flowrate so the calculated sample rate is shown on the rotameter.
- 8 Record the temperature of the exhaust gas during the test.
- 9 At the end of the required sample time move the sample head to the next position and adjust the flow rate to maintain isokinetic sampling conditions.
- 10 When all points have been sampled transfer the sample filter to a clean dry transport container. In order to remove any particulate adhering to the nozzle, brush through the nozzle and sample head surfaces into the transport container.
- 11 Re-measure the pitot static pressures at the points sampled. Variation in the sum of the measurements should not exceed 10%.

C Processing

- 1 Dry depth filters overnight at 120°C, re weigh after cooling in a desiccator.
- 2 Filter papers are dried and weighed following the same procedure as during the preparation stage. Any difference in the weight of the blank is taken into account when determining the mass collected

D Metal analysis

- 1 Where determination of emissions concentrations of specific metals, such as lead copper etc. are required, the filters used for the particulate test will be sent to a NAMAS accredited laboratory for analysis.
- 2 The analysis method is chosen by the laboratory as being the one most suitable for the metal and the media it is presented on.
- 3 The most popular method is an in-house method based on NIOSH 7300, acid dissolution followed by determination by inductively coupled plasma (ICP) analysis.

E Reporting

The report will include the following:

Description of plant and process operation

Activity level during the period of test

Method of sampling and standard to which sampling is carried out.

Physical conditions in duct.

Gas temperature

Velocity profiles

Mean velocity

Mean volume flow

Results of the emission test

Discussion and interpretation of the results, including details of compliance with any stated emission limit, comments on the effectiveness of abatement equipment along with recommendations where appropriate.

Statement of conformity and identification of any deviation from the stated standard.

The flow rates in the duct and the final emission concentration results are calculated using the following equations.

Mean gas velocity

$$v_{(\text{mean})} = \sqrt{(2/\rho) \cdot h}$$
$$= \text{m/s}$$

ρ = density of air
 h = mean velocity pressure (Pa)

Mean gas flowrate (Q)

$$Q = v \cdot A \cdot (273/T + 273)(DP/101.3)$$
$$= \text{Nm}^3/\text{s}$$

A = area of duct (m^2)
 T = duct gas temp ($^{\circ}\text{C}$)
 DP = duct pressure (static pressure + atmospheric pressure)

Sample volume (at 0°C)

$$V = \sum(f\phi)\omega$$
$$= \text{lt}$$

$f\phi$ = product of flowrate and sample duration at each point
 ω = temp. correction factor.

Concentration of particulates (at 0°C)

$$C = m \cdot 1000/V$$
$$= \text{mg}/\text{m}^3$$

m = mass collected on filter

F. Calibration of Continuous Monitors

Where continuous monitors are installed at the sample points and these are fitted with a data logging facility, then the units may be calibrated using the results of the particulate emission test.

The exact time of the start and finish of each sample run is noted and the data logger can later be interrogated to find the response over that same time period. The actual emission concentration determined from the particulate test can then be compared with the response of the continuous monitor and if there is a difference than the calibration factor of the instrument can be re-calculated and altered as necessary.

Some instruments do not have a simple means of interrogation at a later date, or the calibration mode overwrites, and in these cases the calibration mode of the instrument must be started and stopped at the same time as the particulate emission test run in order to determine the instrument readings over the time period.

Non-isokinetic sampling

Certain collectors do not have ducted emissions, in these situations it is only possible to carry out an indicative test by non-isokinetic sampling just inside the discharge grille. It is not possible to guarantee the accuracy of this test although it can serve to demonstrate that the filter is working correctly and to show compliance with the emission limits of 50 or 100mg/m³.

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Procedures for VOC Monitoring

VOCs are prescribed substances for several processes, as defined in the Environmental Protection (Prescribed Processes and Substances) Regulations 1991. Individual Guidance Notes set out the emission concentrations that should apply to releases from contained sources, although for Part B processes the local authority under whose control the process falls, may set different limits as it sees fit.

The levels of VOCs (volatile organic compounds) in the extraction ducts are measured continuously using a Signal 3010 Mini FID Total Hydrocarbon Monitor. VOC levels are measured during a period of peak emissions; the concentration range and a 15 or 30 minute mean concentration are reported, depending on process. Sampling is normally carried out in a straight section of the final discharge duct after the fan to ensure the gases are well mixed.

The Signal 3010 Mini FID analyser is a direct reading instrument based on a flame ionisation detector, both the sample line and the instrument are heated to 190°C. The instrument has a organic filter for zeroing and the span is calibrated against a known concentration of methane (typically 500ppm). The instrument gives a readout in ppm, methane equivalent. Readings from the instrument are periodically noted throughout the measurement period. After the test and the average and maximum and minimum emission concentration are noted.

The method of reporting VOCs will depend on the actual process and the nature of the organic compounds released. Where there is a simple mixture or a single compound released, (such as from paint processes) then the emission concentration of actual compound in the discharge can also be calculated, based on the known, experimental response of the instrument. Where there is a complex mixture of organics, such as from thermal breakdown, then the results can only be quoted as the methane equivalent. In each case the concentration of VOCs is reported as carbon, as specified in the process guidance notes.

A Preparation

1. Verify that holes of at least 9mm diameter are available for sampling. Where possible, these should be positioned after the fan to ensure good mixing of the gases. Isokinetic sampling is not required for sampling gaseous emissions.
2. Establish the major solvent or organic compounds used, or released during the process.
3. Establish the process operating cycle time.

B On site

Preliminary

1. Verify safe access to the sample position.
2. Determine that the plant is operating under normal conditions. Arrange for notification in the event of any stoppages or abnormal conditions.
3. If the process is cyclic try to arrange that sampling starts at the same time as the process cycle begins.

Sampling Procedure

1. Assemble the sample lines and probe, ensure there are no leaks.
2. Switch on and allow the instrument to heat up to operational temperature (190°C).
3. Open the gas supplies and ignite the flame, allow to stabilise for a 10-15 minutes.
4. Zero the instrument using a source of clean air.
5. Set the *span* against a known concentration of methane.
6. Select sample mode on the instrument.
7. Insert sample probe into centre of the duct and record the VOC concentration every 30 seconds. If a datalogger is used, start the datalogger at the same time. The datalogger will switch itself off after the sample period is complete.
8. At end of monitoring check span gas reading and zero.

C Processing

1. Interrogate the datalogger to obtain the average response and the maximum and minimum value over the sample period, or manually calculate the average from the periodic recordings.
2. Calculate the emission concentration of the specific organic compound, relative to methane, using experimentally derived relative response factors.
3. Express the results as mgC/m³ at standard temperature and pressure.

D Reporting

The report will include

Description of plant and process operation

Activity level during the period of testing.

Sampling method.

Results (corrected to standard conditions of 0°C and 101.3kPa.)

Discussion and interpretation of the results, including details of compliance with any stated emission limits, comments on the effectiveness of any abatement equipment and any appropriate recommendations.