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1994: Odour Control at Food Plant. Over 20 streams of up to 75,000 odour units are successfully treated in a venturi scrubber, and achieve a stack outlet odour concentration of 440 odour units

Control of Air Emissions From Food Manufacturing Plant

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1. Abstract.

A manufacturer of breakfast cereals located in the middle of a built up city area was the subject of many complaints from neighbours who were experiencing particulate fallout and objectionable odours on a regular basis. Under the terms of the Resource Management Act, the manufacturer was required to control these emissions.

Investigation work done by the manufacturer's consultants identified over 20 individual discharges with a diverse range of contaminants. One small air stream had an odour concentration of 75,000 odour units per cubic metre. Other air streams contained particulate up to 70 mg/cu.m. The temperatures varied from ambient to 90 degrees C. The majority of the streams contained high levels of moisture.

Pilot plant work was done on some of the highest odour streams and confirmed that wet scrubbing could reduce the odour to satisfactory levels. Pilot plant work also showed that water scrubbing alone was quite effective.

A wet scrubbing system based on water alone was installed to combine the air streams and remove the particulate in a venturi scrubber. Allowance was made in the design to install a wet packed tower for odour control if it was found to be necessary at a later date. Results since commissioning have found that combining of the air streams and scrubbing with water have been very effective. The treated air discharge has an odour concentration of 440 odour units per cubic metre and a particulate concentration of less than 5 mg per cubic metre. It is not expected to result in complaints from neighbours.

It is concluded that water scrubbing alone has been effective because the odour molecules tend to associate themselves with particles. The odour molecules are volatile organic compounds and can be physically or electrostatically attached to the solid particles. Thus collecting the solid particles in a wet scrubber can also collect a considerable amount of the odour molecules.

2. Background.

A manufacturer of breakfast cereals located in the middle of a built up city area was the subject of many complaints from neighbours who were experiencing particulate fallout and objectionable odours. The complaints ranged from objectionable odour events on a regular basis, to their vehicles being "covered in gunk" when parked adjacent to the plant. The neighbouring business is an up market recording studio and visitors often arrived in late model sports cars with the top down. When they went to leave the seats of their car would have collected a range of breakfast cereal dust!

The local Regional Council served an abatement notice under the terms of the Resource Management Act 1991 requiring the manufacturer to control these emissions. Some of the neighbours even called for the entire plant to be relocated.

The manufacturer began the control project by employing a consulting company to quantify the various air emissions and recommend the most appropriate control method and equipment.

3. Quantifying the Air Emissions

Investigation work done by the manufacturer's consultants (ref 1) identified over 20 individual discharges with a diverse range of contaminants. For each individual discharge they measured the air flow rate, odour intensity by dynamic olfactometry (forced choice method), and temperature. The unit of odour intensity is odour units per cubic metre (OU/m^3), and is defined as the number of dilutions required to reduce the odour to the threshold value, i.e. when it can just be detected.

One small air stream had an odour concentration of 75,000 OU/ m^3. Other air streams contained particulate up to 70 mg/ m^3. The temperatures varied from ambient to 90 degrees C. The majority of the streams contained high levels of moisture. A few of the streams were highly intermittent discharging only when a batch cooking vessel was emptied. The following table summarises the findings.

Table 1: Air Emissions from Food Manufacturing Plant

Emission	Flow cu.m./s	Temp ºC	OU/ m^3	OU/second
Heating Lines	1.86	88	14,996	27,893
Cooling Lines	0.30	70	558	167
Toasters	2.37	80	1184	2,806
Spill Air	2.90	67	7,664	22,226
Cookers	0.72	75	75,324	54,233
Roaster	2.45	80	3,000	7,350
Steam Vent	0.10	90	10,000	1,000
Misc	0.75	85	3,067	2,300
TOTALS	11.45	Average 75	Average 10,303	117,975

Given the multitude of emissions and the range of contaminants it was concluded early in the study that the most practical control system would be to aggregate the emissions into one large stream. This would have the effect of averaging out the temperature, odour intensity and particulate concentrations.

To obtain no objectionable odours at the plant boundary, it was agreed that the odour concentration needed to be reduced to between 2 and 5 OU/ m^3. By definition, 1 odour unit is the odour concentration when an odour can just be detected. Generally an odour intensity below 2 OU/ m^3 has not been found to be objectionable, particularly from a food manufacturing plant, and short excursions to 5 OU/ m^3 would probably not result in complaints from neighbours. Assuming a well designed stack giving optimum dispersion could achieve an odour dilution of 800 to 1 under worst case atmospheric conditions, and the need to achieve 2 OU/ m^3 at the plant boundary, then the odour concentration in the stack needed to be limited to 1600 OU/ m^3. This meant that the odour control method selected needed to be able to collect the particulate plus remove over 85% of all the odours.

Bag house filters would clog and blind with the high levels of moisture in the streams, and would not necessarily collect sufficient of the odour. A biofilter would need a large area of land that was not readily available, it would need a particulate filter ahead of it plus the temperature is above the level ideal for microbial action.

Wet scrubbing of the combined air streams was considered by the manufacturer's consultants to be the most appropriate control method as it could collect both the particulate and odour at the same time, and they recommended to the manufacturer that they proceed to investigate this further.

4. Wet Scrubber Pilot Plant Studies

Before the food manufacturer would commit to a large wet scrubbing installation, they wanted to know that it would work effectively given the diverse nature of the various emissions. It was agreed that pilot plant work would be done to confirm or otherwise that wet scrubbing would be an effective solution.

The first pilot plant trial involved using a venturi scrubber and a vertical counter-current packed bed scrubber in series on one of the more odour intense air streams. Particulate was effectively removed at only a small venturi pressure drop indicating that the particulate was all relatively large in size and probably all over 10 microns in size. Odour was reduced by 72% from an inlet odour concentration of 23,071 down to 5,177 OU/ m^3 measured by olfactometry. This odour reduction was achieved using the venturi scrubber with water only and the packed bed scrubber with water only as the scrubbing liquid. Trials with caustic and acid scrubbing liquids did not make significant improvements in the odour scrubbing efficiency.

An electronic "odour meter" with a metal oxide sensor and a response that approximates the human nose was used to monitor some of the pilot plant trials. The electronic odour meter is a relative instrument only but has been found useful in giving a fast and continuous evaluation of a pilot plant scrubbing trial. The meter basically sums all compounds in the air stream, and does not differentiate between a highly odorous compound and a compound that has little odour. By contrast, olfactometry is a time consuming and costly way of monitoring a pilot plant, but does give a measurement that is more meaningful and applicable.

Trials were done using the electronic odour meter to measure the effectiveness of scrubbing. A trial with a scrubbing liquid dosed with sodium hypochlorite was done. A small scale trial was done with a filter of activated carbon before the odour meter. The electronic odour meter gave the following results (ref. 2).

Table 2: Electronic Odour Meter Results of Pilot Plant Testing

	Odour Meter Figure	Comments
Background at site	200	Relative measurement
At inlet to pilot plant	925 to 1180	Varied considerably
After venturi scrubber	730	
After packed bed scrubber	850	Hypo added to odour
After carbon filter	130	Less odour than background

The wet scrubbing dosed with sodium hypochlorite appeared to improve the scrubbing efficiency but changed the odour profile in the exhaust air due to residual sodium hypochlorite in the exit gas. The carbon filter trial demonstrated that a significant odour reduction could be achieved using activated carbon.

The pilot plant studies gave sufficient confidence to all parties that wet scrubbing would be effective in controlling emissions of particulate and odours from site. It was not clear how many stages of scrubbing would be required, so a staged approach that could be added to as necessary was decided upon.

5. Staged Wet Scrubbing System

The staged approach agreed upon was as follows:

- **Stage 1:** Aggregate all vents and scrub with low pressure drop venturi to remove over 90% of particulate and some odours before discharging up stack. The scrubbing liquid would be water only. Duct sprays would be used to increase scrubbing efficiency.
- **Stage 2:** If necessary, a vertical counter-current packed bed scrubber would be installed after the venturi, again using water only as the scrubbing liquid. Note this scrubber requires particulate to be removed before it, so the venturi scrubber is an essential pre-treatment stage.
- **Stage 3:** If necessary improve the odour removal of the packed bed scrubber by retrofitting the Odorgard™ process to the wet scrubber. This process catalytically enhances the wet scrubbing action and is proven at removing VOC (volatile organic compounds) from air streams such as this (ref. 3). It requires chemical additions of sodium hydroxide and sodium hypochlorite. The wet scrubber in stage 2 would be designed to accept this retrofit.
- **Stage 4:** If necessary install activated carbon filters on the most odorous air streams to reduce the odour going to the wet scrubbing system.

This staged approach allowed the manufacturing plant to minimise their capital expenditure by not installing equipment that may not be required. It was widely accepted that the first two stages would be needed. This approach also gave the plant flexibility in that future processes may involve more intense odour emissions, and the wet scrubbing plant could be expanded to suit.

6. Results After Stage 1 Installed

The stage 1 system involved collecting the discharges of over 16 vents into a single system with an air flow rate of 10 cubic metre per second. Duct sprays were installed in many of the streams to enhance the scrubbing action of the system, and the combined air stream was passed through a low pressure drop venturi. In order to minimise the energy consumption of the system a multiple throat venturi using rods was selected and installed with the air stream moving horizontally rather than the normal vertical direction.

The ventilating fan was installed immediately after the mist eliminator associated with the venturi scrubber. Room was left for a vertical packed bed scrubber to be installed after the fan is required at some time in the future. A silencer was installed after the fan and before the stack to reduce in duct noise emissions from the fan.

Results since commissioning have found that combining of the air streams and scrubbing with water in a low pressure drop venturi have been very effective. The treated air discharge had an odour concentration of 440 OU/ m^3 during one test sampled over 15 minutes and measured by dynamic olfactometry (forced choice) and a particulate concentration of less than 5 mg per cubic metre (ref. 2). The odour concentration at the inlet to the venturi scrubber was measured by olfactometry at 754 OU/ m^3 indicating that the duct sprays and the dilution effect of combining air streams is significantly reducing odour levels.

Due to the intermittent nature of the batch processes involved, the odour intensity is not expected to ever be constant. Using results of a single measurement like this may be somewhat misleading. However the news is really positive for the food manufacturer and the air discharge from the scrubbing system is not expected to result in complaints from neighbours. Some neighbours have already expressed delight in that objectionable odour events have been eliminated and there is no particulate matter on their vehicles.

As a result stage 2 of the scrubbing system has been put on hold thus minimising capital expenditure by the plant.

7. Discussion on Results

The odour concentration in the air discharged from the stack was expected to be in the order of 5,000 OU/ m^3. This was based on an expected inlet concentration of 10,000 odour units and a 50% reduction using water only as the scrubbing liquid. The measured scrubber exit concentration of 440 OU/ m^3 is much less than this. Possible reasons for this are as follows.

- The initial odour unit measurements were all done at times of very high odour emissions. This is especially applicable on a vent where the odour emission may only be for a 5 minute period every hour.
- The combining of all the air streams causes cooling and of the hot air streams and possibly some condensation of water and odorous volatile organic compounds.
- The duct sprays ahead of the venturi effect considerable scrubbing action.
- The blow down of the scrubbing liquid had recently been increased and this is typically accompanied by an increase in scrubbing efficiency.
- The measurement of 440 OU/ m^3 after the scrubber was done at a time of low odour emissions by the plant.
- The measurement of 440 OU/ m^3 after the scrubber may have been done when the scrubbing system had been freshly charged with water. As the scrubbing liquor becomes dirty, scrubbing efficiency would decline.
- Odour molecules tend to associate themselves with particles. The odour molecules are volatile organic compounds and can be physically or electrostatically attached to the solid particles. Thus collecting the solid particles in a wet scrubber can also collect a considerable amount of the odour molecules.

There is no one answer to the unexpectedly good result but it is believed that collecting the particulate goes a long way to reducing odour emissions. Any particulate that deposits and accumulates in a neighbour's property will tend to keep giving off odours. If the particulate is wetted, more of these compounds will be given off. This will continue until all the volatile organic compounds held by the particles are exhausted. The result of this may be an odour that a neighbour may find objectionable.

We conclude that stopping particulate emissions has greatly assisted in reducing odour emissions.

8. Acknowledgements

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9. References

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