DEVELOPING AN ODOUR MANAGEMENT PLAN – A CASE STUDY APPLYING THE NEW EA GUIDANCE

Gibson, N.B. and Broomfield, M.
AEA Group, The Gemini Building, Harwell IBC, Didcot, OX11 0QR
Corresponding Author Tel. 0870 190 6478 Email nigel.gibson@aeat.co.uk

Abstract

Odour management plans offer a structured way of understanding and managing odour problems, and is the approach adopted by the Environment Agency in the new draft H4 guidance on odour.

Odour management plans can be tailored to suit the requirement of individual installations. This paper outlines the type of information that should be included in an odour management plan.

The application of the odour management planning process is demonstrated through a case study based on a Part A1 regulated site. The case study shows how (i) a simple screening risk assessment can be used to identify significant sources, (ii) odour measurement and dispersion modelling can be used to set performance targets, (iii) BAT for odour control can be established (iv) odour and pollutant measurement can be used to validate odour control plant and (v) management and reporting aspects of odour management are established.

Keywords

BAT, dispersion modelling, odour control, Odour management plan, olfactometry, pilot trials, risk assessment.

Introduction

Odour regulation and odour management planning

Many agricultural, industrial and waste related activities give rise to odour emissions. Where those odour emissions are a problem, finding an effective solution can be costly, in terms of time, money and goodwill. In many instances it is not always clear exactly where the odours of most concern are emitted from, what causes those emissions and when they are emitted. Without a good understanding of the cause and scale of the emission it is difficult to identify suitable odour mitigation options – can the odour problems be resolved through improved management practice or is active abatement required? It is for this reason that a structured odour management planning (OMP) approach is now the recommended practice for dealing with odour issues.

The Environment Agency has published guidance on managing odours from Agency regulated installations [Environment Agency, 2009]. This guidance places great emphasis on the odour management planning process as a vehicle for an operator to demonstrate whether and to what extent odour needs to be mitigated. Where odour mitigation is considered necessary the OMP will need to be submitted for approval to demonstrate how the risk of odour problems will be dealt with. Once approved the OMP can be viewed as defining **B**est **A**vailable **T**echnique for the process and will need to be adhered to. In extreme situations, failure to comply with the OMP could be considered to be a breach of a permit condition.

Steps to develop an odour management plan

There are various steps that should be taken when developing a comprehensive odour management plan, these being:

- A screening review of the entire process to identify and prioritise the potential sources of emission both under normal and abnormal conditions;
- An assessment of the risks of odour problems, from normal and abnormal situations, including worst case scenarios, for example of weather, temperature, or process breakdowns, as well as accident scenarios;
- The appropriate controls (both physical and management) needed to manage those risks;
- Specification of emission limits where appropriate;
- Suitable monitoring;
- Actions, contingencies and responsibilities when problems arise, including the procedures to be followed when complaints are received and
- Regular review of the effectiveness of your odour control measures.

This paper provides a practical application of the odour management process applied to a waste handling operation regulated as a Part A1 activity under Environmental Permitting. The odour management plan was required in response to an Improvement Condition that arose following odour complaints.

Case study site

The permitted installation is a waste handling facility that deals with solid waste through a series of dewatering and drying stages to generate a stable waste for final disposal. The waste to be treated comprises mainly of contaminated water, protein matter and a natural inert substrate. A schematic diagram of the process is shown in Figure 1. In brief, the process includes the following basic stages:

- The delivery and storage tanks of waste;
- Various dewatering and drying activities to condition and sterilise waste according to current regulation and
- Skips storage for treated product waiting for export.

The original odour control system installed at the facility was designed around a single stage fluidised bed caustic (NaOH)- hypochlorite (NaOCl) scrubber treating the two extraction air flows on site. The air flows comprise a local exhaust ventilation (LEV) system extracting at a rate of

15,900 m^3/hr for storage tanks and a process air flow from the dewatering and drying activities with a flow rate of 1,100 m^3/hr.

The treated scrubber exhaust air is discharged through a single tall stack, whose height was limited by planning restrictions in the area.

The installation was located close to both industrial and residential areas.

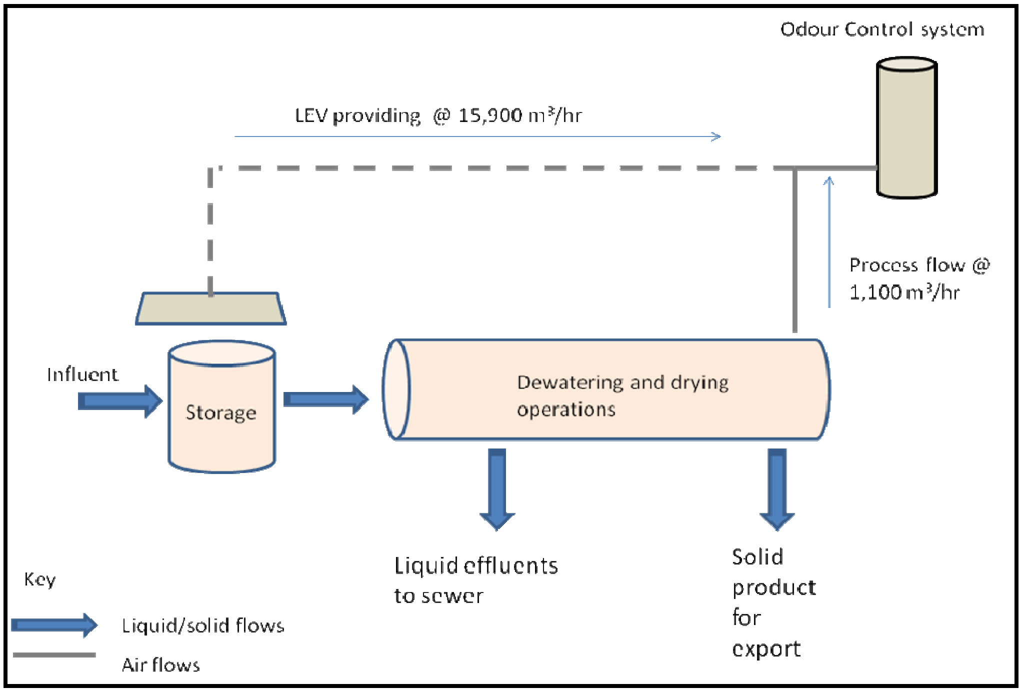

Figure 1: **Schematic diagram of the process**

Application of the odour management process

This section describes how an odour management plan is typically developed for an operational industrial facility. Each site will apply these steps as appropriate for its individual circumstances.

Step 1 – Screening of process to identify potential sources

A screening assessment of all process activities and operations associated with the facility needs to be carried out. The objective is to summarise emissions in terms of:

- What is emitted - the type of odorants;
- How much is emitted - the mass flow of odour and/or odorants;
- Where it is emitted from – location;
- How it is emitted – area, stack surface source etc and
- Under what conditions do the emissions arise – do the emissions arise as a result specific events etc.

Step 2 – Assessment of the risk of odour problems

Having established the nature and extent of the emission, a risk assessment needs to be carried out to identify (i) sources that can be adequately controlled through improved site and management practices and (ii) sources that require active odour control.

Table 1: Categorisation of odour risk

Category	Risk rating	characteristic of source and emissions
1	low or medium	A **low** risk would be a remote location with no record of justified odour complaints. The risk could be **medium** if odour emissions are of sufficient mass that complaints would be received if receptors were closer, or if new land development encroaches on the installation boundary.
2	low or medium	Risk will be **low** if measures to contain odour are in place, or it is discharged without need for dispersion, treatment leaves no residual odour and discharge is at high or low level. Odour stream may be fed into and consumed within a further process. Risk may be **medium** if the above apply but there is risk of failure of control method.
3	low, medium or high	Measures to contain odour are in place or it is discharged with dispersion. Release is usually at high level, e.g. stack or roof vent. Treatment leaves a residual odour, or there may be no treatment. Risk may be **medium** in these cases. There is a reliance on adequate dispersion to prevent annoyance at receptors. Risk may be **high** if plume conditions are not well-characterised.
4	low, medium or high	Odour-producing activities take place in the open. Cannot be contained by virtue of the type of activity (e.g. effluent treatment plant which cannot be covered, landfilling of putrescible wastes, lagoons etc). Measures to contain rely on good management techniques and adherence to best practice to minimise odour generation.

Step 3 – Appropriate controls to manage odour risk

Having ranked the odour sources on the basis of risk it is necessary to define what methods are used to manage the risk of odour. The methods identified at this state may range from procedures covering the process, management of site or end of pipe abatement.

Step 4 – specification of emission limits where appropriate

In those situations where aspects of the process needs to be controlled to minimised odour emission and/or end of pipe abatement is applied it may be necessary to define emission limits that need to be applied to prevent emission of offensive odour passing the site boundary and/or causing unreasonable annoyance at receptor locations.

At this stage it may also be necessary to provide additional evidence to support the existing odour control strategy or, in certain circumstances, to identify what BAT is for the process and how BAT can be applied to the process.

Step 5 – Monitoring requirement

Having established the control requirements for the process, be they through process management or through end of pipe abatement it is necessary to define what monitoring will be carried out to demonstrate compliance with the emission limits. This may involve monitoring an odour sensitive process parameter (for example oxygen level within compost) or process dependent parameter within the end of pipe abatement (for example pH within a chemical scrubber).

On more sensitive sites this may also involve daily boundary fence olfactory tests and annual olfactometry testing to assess odour concentrations leaving the site.

Step 6 – Action plans and management responsibilities

The OMP needs to describe:

- The action and investigations that will be carried out in the event of extreme operating condition (i.e. complete process or abatement failure). This will include investigating the causes of any odour complaints and in extreme situations how material can be diverted away from the site in the event of catastrophic failure.
- The that site operators will be given training to perform any duty that could influence odour generation or emission
- The management structure in place for dealing with odour. The OMP needs to identify specific staff positions that are responsible for liaising with the regulator and members of the public, and who has the authority to initiate action in the event of catastrophic failure.

Step 7 – review of effectiveness of OMP

The OMP as described above is a living document that will evolve. The OMP should identify the situations under which the status of OMP will be re viewed, which may include:

- An annual review;
- Its adequacy following any changes to the operation of the site and
- Its adequacy following receipt of odour complaints;

The OMP development process applied to the case study site

Steps 1 and 2 - Initial Screening of potential sources and risk assessment

Screening of all process activities and operations associated with the facility was carried out. On the case study site this was done using a simple set of metrics to compare individual process activities on a consistent basis:

- Under normal operation:
  - What are the critical control points/process parameters that influence odour;
  - What monitoring procedures are used;

- How is monitoring carried out and
- What operating/management procedures are applied.

- Foreseeable emergency/abnormal events, for example what happens in the event of:
    - loss of power to site;
    - Equipment failure;
    - Steam supply failure;
    - Water or chemical supply failure and
    - Loss of computer control system.

A summary of the findings of the screening assessment is presented in Table 2. Through the screening process of the entire waste handling process the main pathways by which odour could be emitted were identified. The review focused attention on the primary emission – the process emission stack, but also highlighted the need to ensure good housekeeping and site management.

Table 2: Example of the output from the initial screen process

Odour source	*Receptor*	*Risk management / BAT for odour control*	*Risk and category*	*Consequence*	*What is the overall risk?*
Process emission stack	Industrial and residential in the vicinity of the site	Good process management Control using a bespoke odour abatement plant	Low/high [3]	Odour annoyance without adequate abatement	Not significant with effective controls in place
Excursion through doors louvers etc	Impact within site boundary	Air extraction Good process management Good housekeeping	Low [2]	Small impact within site boundary	Not significant
Tanks, skips and skip handling area	Impact within site boundary	Good process management Good housekeeping	Low [2]	Small impact within site boundary	Not significant
Yard sumps	Impact within site boundary	Good process management Good housekeeping	Low [2]	Small impact within site boundary	Not significant

Step 3 Summary of controls to manage odour risk

A full review of all operating instructions and procedures relevant to odour generation, control and monitoring was carried. As a result the OMP listed procedures for the following activities:

- Maintenance Appraisal Procedure;
- Calibration of Instruments;
- Operation & control of the waste treatment area;
- Operation of the process control system for the waste treatment area;
- Operation of the Effluent Treatment Area – Dryers;
- Operation of abatement plant within waste treatment area;
- Operation of the waste Treatment Area Local Exhaust Ventilation and Caustic Scrubber System;
- Chemical Delivery and Usage within the waste Treatment Area;
- Waste Treatment Area Critical Process Conditions and Contingency Plan;
- External Notifications procedure;
- Accident and Incident investigation procedure;
- Waste Management Procedure;
- Operation of the Waste Process Stream and
- Effluent treatment Area Odour Monitoring and Analysis.

Inclusion of these procedures within in the OMP implies that these procedures form an integral part of the control/management process and must be followed to ensure compliance with the requirements of the OMP.

Step 4 - Assessment of odour control system performance and setting control requirements

Where an active odour control system is employed it may be necessary to determine whether the current performance is adequate given the location of the operation and if not, it is necessary to determine what the acceptable level of odour emission would be to avoid odour annoyance beyond the plant boundary.

For the purpose of assessing the current and future odour control requirements the following techniques are routinely employed:

- Odour measurement using olfactometry carried out in accordance with BS EN 13725 [BS EN, 2003] to assess the removal performance of the OCS. Odour concentration is expressed in terms of dilution to detection threshold (odour unit) and is useful when comparing against odour exposure criteria. As the odour concentration term is derived from a measurement based on a physiological response to odour rather than a physically measureable quantity, it cannot readily be used for the chemical engineering design aspects of abatement equipment.
- Pollutant measurement, for example by GC-MS or colorimetric tubes, to assess the performance of the OCS in terms of the removal of individual chemical substances. This

can be important as the chemical engineering aspects of plant designs needs to target the chemicals present.

- Air dispersion modelling to predict the odour impact beyond the installation boundary. Annoyance criteria for odour have been published by the Environment Agency [Environment Agency, 2009]. Air dispersion modelling should not be used as a means of demonstrating the absence of odour, especially if justifiable complaints have been received.

These approaches were applied to the case study site. Table 3 summarises the results from the assessment of the performance of the OCS in terms of odour and odorant removal. The tests showed that, although the OCS had the capability to remove 70 to 85% of the odour, there was a significant residual odour emission. Overall odour removal performance of the scrubber based OCS was found to be below expectation for a chemical scrubber [UKWIR 2003].

The results of the GC-MS analysis showed that the OCS was effective at removing some acidic organic sulphur compounds. The OCS was not effective at removing the alkaline organic compounds containing oxygen and nitrogen. This finding was not surprising considering the alkaline media used in the OCS. With hindsight this is a factor that should have been taken into account when the OCS was initially designed. This type of oversight is not uncommon and can often lead to inappropriately designed abatement plant.

Table 3a: Odour measurements (ou_E/m^3)

Compound	*Process outlet*	*LEV*	*OCS Inlet*	*OCS outlet*	*% removal*
Odour Test 1	2,877,875		82,110	12,002	85
Odour Test 2	4,262,200	7, 000	181,245	53,480	70
Odour Test 3	5,629,624		303,909	44,695	85

Table 3b: Pollutant measurements (mg/m^3)

Compound	*Process outlet*	*OCS outlet*	*Odour threshold*
Methyl mercaptan	1.10	0.00	0.0021
Trimethylamine	56.00	3.10	0.0059
Ethanol	18.00	1.40	55
Isopropanol	5.30	0.40	26
1-propanol	1.40	0.19	6
2-methyl propanal	3.20	0.36	27
3-methyl butananal	5.60	0.37	0.0081
2-methylbutanal	5.40	0.59	0.0054
Dimethl disulphide	0.67	0.12	0.048
Nonanal	1.10	0.09	85

The initial test data established the performance of the OCS and the amount of residual odour emission from the main process stack. The next step was to establish whether the measured residual odour could be emitted without causing unreasonable annoyance. This can be achieved by means of a dispersion modelling study. This was carried out using the dispersion model

ADMS 4.2, meteorological data representative of the area and various inputs to describe the characteristics of the discharge.

Figure 2 shows the concentration contours expressed as 98 percentile of 1 hour averages. The results of dispersion modelling have been extracted to (i) show the odour emission rate required to comply with the 1.5 ou_E/m^3 98^{th}%ile at the closest complainant and (ii) to comply with the same criterion where an Environment Agency officer could observe the odour beyond the boundary fence. These results are shown in Table 4.

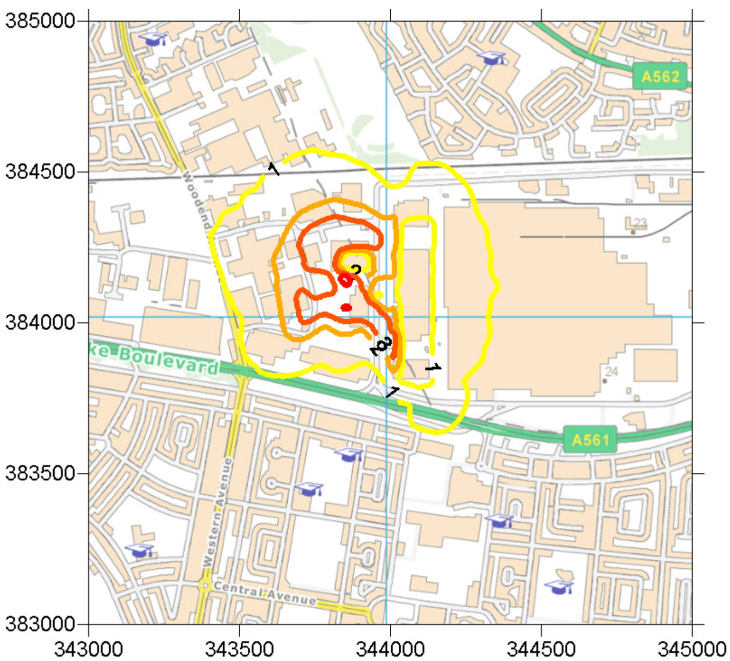

Figure 2: **Modelled odour levels around the installation based on an arbitrary emission rate.**

Table 4: **Targets obtained from the dispersion modelling study**

=	*Nearest receptor complainant*	*Maximum location*
Target odour exposure criterion:	1.5 ou_E/ m^3	1.5 ou_E/ m^3
Based on odour emission	100000ou_E/s	29032 ou_E/s
Based on odour concentration	18086 ou_E/ m^3	5251 ou_E/ m^3

The results presented in Table 4 show that the emissions from the main stack could exceed the odour exposure criterion at the nearest complainant location from time to time and would almost certainly exceed the odour exposure criterion where the Environment Agency officer would have access.

Following discussion with the Environment Agency, it was agreed that BAT for odour control would need to reduce the residual odour emission to below 5,250 ou_E/m^3.

Step 3 - Selection of odour abatement option(s)

Wherever there is a need to improve the level of odour control the first step must be to consider whether the process can be improved to minimise the generation of odour. Once this has been exhausted should attention move to active odour control.

On the case study site a full review of the management of the process was carried out. A number of process operations which exacerbated odour generation were identified and remedial measures identified, for example:

- Prevention of pipe blocking to give more consistent operation.
- Optimising dewatering options to reduce drying times and temperature.
- Better management of pH and optimized residence time of waste during storage.
- Better control of the process temperature profile and setting a maximum operating temperature.
- Better condensate droplet removal.
- Optimising condenser operation by reducing operating temperature

The benefit of these process management techniques was that they could be implemented cheaply and easily and had knock-on benefits for other aspects of the process, eg product quality, reducing down time, reduced operating costs. Figure 3 shows the reduction in the mass of odour (ou_E/s) achieved by careful management of the process. Unfortunately, in this case the management techniques alone were insufficient to reduce the odour level required to meet the odour reduction target.

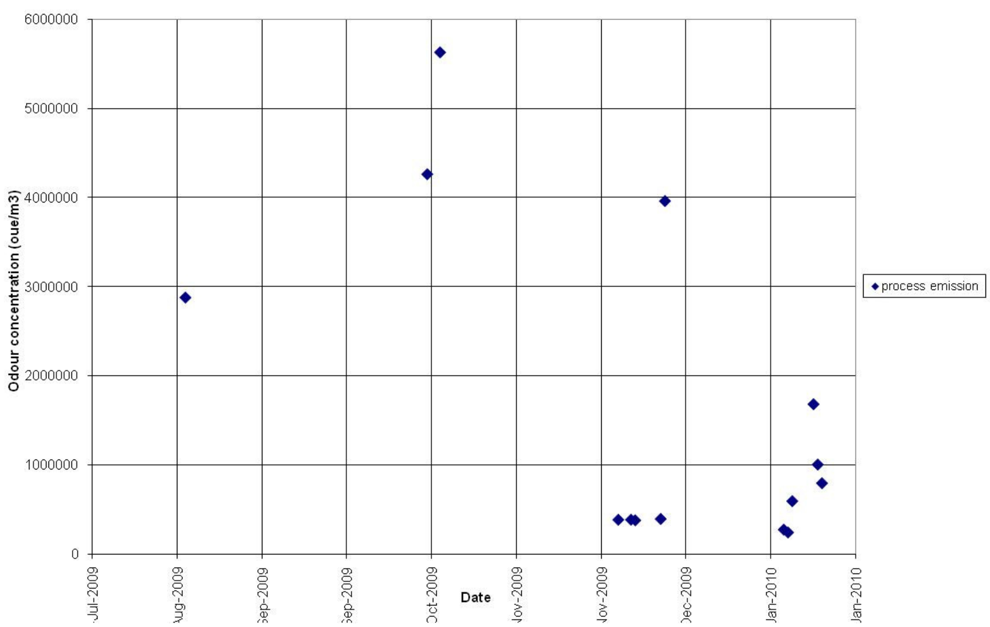

Figure 3: Odour strength of emissions from the process

A comprehensive review of active odour abatement options was carried out using the following selection criteria:

- Ability to abate amines and oxygenated compounds (e.g. aldehydes, ketones etc) and reduced sulphur compounds (e.g. H_2S, mercaptans, organic sulphides);
- Ability to achieve the odour control target;
- Capital costs;
- Running cost and the amount of raw materials to be used (chemicals, energy etc.);
- Ease of implementation within the context of the plant area layout and
- Potential secondary environmental issues that may arise (e.g. waste, contribution to local air pollution, energy use).

Table 5: Summary of the process to select active abatement

	Ability to control odour as required	*Cost (CAPEX/OPEX)*	*Secondary environmental issues*
Thermal incineration as a stand alone process;	✓✓✓	Very high	• Air quality issues
Thermal incineration using steam raising boilers	✓✓	high	• No spare capacity on site • Need to run for extended period • Air quality issues
Biofiltration;	✓✓	moderate	• Large area • Additional bioaersols
Carbon filtration as a stand alone process	✓✓	Very high if all air treated	• Disposal of waste • Odour breakthrough
Chemical scrubbing as a stand alone process	✓✓	high if all air treated	• Disposal of waste • Chemical storage
Combination of chemical scrubbing and carbon filtration	✓✓✓	Moderate if targeted	As above
UV/Ozone as a stand alone process	✓?	Moderate	• None but no track record

In light of the presence of the original caustic scrubbing system, the favoured option was to supplement the existing system with a combination of acid scrubbing and carbon filtration on the low volume process air flow. It was expected that this would be sufficient to pre-treat the odour before the caustic scrubbing stage.

Step 4 – validation of selected abatement options

At the case study site the Environment Agency sought verification that the chosen abatement option would achieve the necessary level of odour control.

A formal validation exercise was carried out using a pilot rig to deal with 20% of the process air flow. The performance of the overall abatement scheme was tested using both olfactometry and chemical analysis. The key findings of the pilot trial were:

- Removal of odour (see Table 6). The combined effect of the odour abatement strategy reduced the odour concentration by more than 98.5%. The combined effect reduced the residual concentration to below the 5,250 ou_E/m^3 needed to comply with the odour assessment criterion.

- Removal of amines (see Table 7)– the acid scrubber was able to remove more than 98.6% of the amines present.
- Removal of specific odorants (see Table 7) – the combined effect of the odour abatement strategy reduced odorant concentrations by over 98.6%.

Table 6: Olfactometry results from 6 separate tests of the chosen abatement strategy

Date	***05/01***	***06/01***	***07/01***	***12/01***	***13/01***	***14/01***	
Sample location							**Ave.**
ex Condenser	273,444	241,422	593,085	1,680,916	1,003,769	794,310	611,865
ex Acid Scrubber	216,215	181,608	370,305	1,775,640	357,523	334,947	381,683
ex Carbon	7,741	3,975	317,683	215,012	38,659	20,126	34,324
Abatement %	97.2	98.4	46.4[1]	87.2	96.1	97.5	94.4
Make-up air	4,700	694	2,067	2,093	924	3,459	1,887
Caustic Scrubber In	8,073	3,257	6,859	4,070	1,008	4,245	3,827
ex Caustic Scrubber	3,966	2,021	3,460	3,320	488	1,403	1,995
Abatement %	98.5	99.2	99.4	99.8	99.9	99.8	99.6

Table 7: Pollutant concentrations ($\mu g/m^3$) and removal efficiency

	Methyl mercaptan	***Dimethyl sulphide***	***2-Methyl propanal***	***3-Methyl butanal***	***2-Methyl butanal***	***Pentanal***	***Dimethyl disulphide***	***Hexanal***	***Octanal***	***Nonanal***	***Amine (ppm***
Condenser Out	441.2	0.5	11.8	6.2	5.8	18.8	11.9	29.2	15.5	17.0	>>70
Acid Scrubber Out	391.7	0.2	5.5	4.2	4.0	11.8	5.6	17.5	8.5	13.0	1
Carbon Out	26.6	0.1	1.1	0.6	0.5	2.1	1.4	3.7	1.2	2.0	nd
Removal efficiency	94%	84%	91%	90%	92%	89%	88%	87%	93%	88%	nd
Caustic Scrubber In	0.6	0.01	0.1	0.02	0.02	0.1	0.05	0.1	0.1	0.3	nd
Caustic Scrubber Out	0.4	0.003	0.1	0.01	0.01	0.1	0.03	0.1	0.1	0.2	nd
Removal efficiency	99.9%	99.5%	99.5%	99.8%	99.8%	99.7%	99.7%	99.7%	99.4%	98.6%	>98.6%
Make-up air	0.1	0.000	0.02	0.02	0.01	0.04	0.04	0.1	0.04	0.1	0.5

The findings of the pilot trial proved that the revised odour abatement scheme could reduce the odour concentration to the level required to achieve BAT. The plans to implement the abatement scheme on the full scale were put into effect.

Step 5 – Management and monitoring aspects

The OMP needs to reflect the current state of site operation and must cover all aspects of design, operation and maintenance. On the case study site the OMP included:

- Management roles and responsibilities. This identified who is responsible to overseeing the implementation of the OMP on site, for liaising with stakeholders and making decisions about diversion of waste from the site in the case of catastrophic plant failure.
- Detailed site operating procedures covering all aspects of the site that could give rise to odour.
- Monitoring requirement to demonstrate the on-going performance. On the case study site this included:
    - On-going monitoring of odour critical parameters such as pH, temperature, carbon filter pressure drop etc.
    - Daily olfactory observations to be made at agreed location.
    - A formal olfactometry test was required on an annual basis to demonstrate that the residual odour concentration remains below 5,250 ou_E/m^3.
- The OMP included a contingency planning process whereby following catastrophic failure of the plant the waste would be diverted to an alternative site for processing.
- The OMP included a review process. On the case study site a formal review of the whole OMP was required on an annual basis. In addition the OMP had to be reviewed following changes to the site or following any odour events.
- The OMP included a training element to make sure that all staff are aware of their obligations under the plan. On the case study site training covered the following aspects:
    - Awareness of the regulatory implications of the permit;
    - Awareness of all potential environmental impacts under normal and abnormal circumstances;
    - Awareness of the procedures for dealing with a breach of the permit conditions;
    - Prevention of accidental emissions and action to be taken when accidental emissions occur and
    - Awareness of all operating procedures.
- The OMP included a requirement that formal training records should be maintained.
- The OMP included a requirement to notify the regulator in the event of:
    - any malfunction, breakdown or failure of equipment or techniques, accident, or
    - any fugitive emission which has caused, is causing or may cause significant odour pollution or
    - any significant adverse odour impact attributed to the site operation.

Conclusion

The OMP process offers a structured way of dealing with odour. The successful implementation of the OMP process requires that the OMP is implemented and maintained. The structured approach can be modified to suit the complexity of the individual process.

The example case study described here shows the steps that need to be taken to develop an OMP to the satisfaction of the Environment Agency for a complex waste process. The structured approach was robust enough to identify problems such as inappropriately designed abatement plant, and to contribute to the business case for investment in improved controls.

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