Technical Guidance Note
# IPPC H4

# Integrated Pollution Prevention and Control (IPPC)

# DRAFT
# Horizontal Guidance for Odour
# Part 1 – Regulation and Permitting

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**Note:**

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# Introduction

This guidance has been produced by the Environment Agency for England and Wales in collaboration with the Scottish Environment Protection Agency (SEPA) and the Northern Ireland Environment and Heritage Service (EHS). Together these are referred to as "the Agency" or "the Regulator" in this document.

This document has been released in the form of a working draft. Publication in final form will take place after wider consultation with industry, government departments, non-governmental organisations and other interested parties. Comments on this document and proposals for improved ways of working are particularly welcome during the consultation period.

**The field of odour measurement and control is very wide in scope and is continually developing. There are a number of areas where it would be desirable to have more data than is currently available, however this has been balanced against the need to provide guidance at this time. The best information available to the Agency has been used in compiling this document and some aspects have been necessarily simplified. Any additional data which is supplied to the Agency as part of this consultation which is constructive and relevant to the content and purpose of this guidance note will be most welcome and will be considered in the post-consultation review.**

***The aim and scope of this guidance***

This guidance aims to bring consistency to the overall approach to the regulation of odorous emissions by the Agency under IPPC. It brings together a number of aspects relating to the permitting and regulation of odour-generating activities and shows how these can be applied within the BAT framework of IPPC.

In England and Wales the Environment Agency will have regulatory responsibility for IPPC installations designated as A1 and Local Authorities will have responsibility for A2 activities. In Scotland and Northern Ireland there is no such distinction between A1 and A2 activities. Therefore SEPA will regulate all Part A installations in Scotland and, similarly, EHS will regulate all Part A installations in Northern Ireland. In both England & Wales and in Scotland legislation is in place to implement IPPC. In Northern Ireland the relevant legislation is in preparation and any queries should be directed to EHS.

In England and Wales guidance relating to odorous emissions from Part A2 and Part B activities can be found in the relevant Secretary of State's Process Guidance Notes or IPPC Sector Guidance Notes.

Guidance on odour control requirements which are specific to the **Waste Management Licensing** regime can be found in Reference 13. As an interim measure, the aforementioned reference should also be consulted with respect to those landfill operations which will be migrating to IPPC or PPC.

**Odour Management at IPPC Intensive Livestock Installations** describes the odour impact assessment requirements and odour management techniques for pig and poultry units (Reference 29).

This guidance consists of two parts:

**Part 1** - this document - outlines the main considerations relating to the **Permitting and Regulation** of odour-generating activities. It is aimed primarily at the information needs of Regulators, but also contains information which will be of use to Applicants. This Note:

- describes the information relating to odorous releases that is required from the Operator for the purpose of making an application for an IPPC Permit
- describes the process of determination as it relates to odour
- provides background information relating to the human response to odours
- outlines the tools available for the assessment of the environmental impact of odour.

**Part 2, "Odour Assessment & Control"**, is aimed equally at Regulators and Operators. It describes:

- a range of odour impact assessment methodologies
- the collection of odour samples
- the "measurement" of odour – using analytical and sensory techniques
- the control of odour by design, and by operational and management techniques
- the range of "end-of-pipe" odour abatement technologies available.

Part 2 forms a background to Part 1 and will assist in determining BAT for a given installation.

***This document provides an overview of the subject. It should be used in conjunction with the appropriate Sector Guidance Note to determine BAT and appropriate Permit conditions for a specific installation, taking local factors into account.***

# Summary of Permitting considerations

| ODOUR PRODUCING SCENARIOS *(references refer to Guidance Note H4: Part 1)* | | | | | |
|---|---|---|---|---|---|
| | | | | **Applicant** | **Regulator** |
| 1 | Are any activities on the installation potentially odorous? | YES Go to 2 | NO | Applicant provides simple justification. | If Regulator disagrees, go to 3. If Regulator agrees, reliance on implied BAT for permit conditions. **END** |
| 2 | Is this a proposed <u>new</u> plant which has the potential to release odour? | YES | NO Go to 3 | Applicant undertakes suitable odour impact assessment in consultation with the Regulator. *(Section 2.4(2), Appendices 3/4)* **Go to 7** | Regulator checks methodology and data inputs. *(Section 2.4(2), Appendices 3/4)* **Go to 7** |
| 3 | Is this an activity which is carried out largely in the open, containment of odour sources is not feasible? | YES | NO Go to 4 | Applicant undertakes impact assessment and proposes best management practice. **Go to 7** *(Section 2.4(2), Appendices 3/4)* If this is a landfill or transfer station refer to sector guidance or WML odour guidance. | Considers best practice proposals and checks assessment methodology. *(Section 2.4(2), Appendices 3/4)* **Go to 7.** |
| 4 | Is it an <u>existing</u> plant with potential to impact on receptors but is well controlled with no odour problems outstanding? | YES | NO Go to 5 | Applicant identifies sources and controls to prevent or reduce. **Go to 10** | If the Regulator agrees, appropriate Permit conditions are put in place to ensure plant remains under good control. **Go to 10** |
| 5 | Does the installation have potential to cause annoyance but does not only because it is remote from receptors? | YES | NO Go to 6 | Applicant identifies sources and controls to prevent or reduce. Applicant proposes improvements to meet BAT | If Regulator agrees, appropriate permit conditions and improvement conditions are put in place to meet BAT over an appropriate timescale. **END** |
| 6 | If none of the above, the activity is therefore an existing installation with an actual or potential odour problem | YES | **END** | A detailed odour impact assessment would normally be required. *(Section 2.4(2), Appendix 3)* **Go to 7** | Discuss detail required for odour impact assessment with Operator. What information is required and best represents the situation. *(Section 2.4(2), Appendix 3)* **Go to 7** |
| **ADDITIONAL CONSIDERATIONS FOR DETERMINING BAT & PERMIT CONDITIONS** | | | | | |
| | | | | **Applicant** | **Regulator** |
| 7 | Has an odour impact assessment been undertaken (and is it suitable)? | YES Go to 8 | NO | Carry out impact assessment using appropriate methodology Compare with benchmark where available/appropriate *(Section 2.4(2), Appendices 3, 4, 5, 6)* **Go to 8** | Regulator checks methodology and data input appropriate *(Section 2.4(2), Appendices 3, 4, 5, 6)* **Go to 8** |
| 8 | Is the impact acceptable? | YES Go to 9 | NO | Propose techniques to meet BAT/work towards the benchmark as far as BAT allows *(Part 2 of H4)* **Go to 9** | <u>New plant</u> should meet BAT from the outset. Put conditions in place to ensure that control is maintained. **END** <u>Existing plant</u>: conditions and improvement programme to meet BAT. **Go to 9** |
| 9 | Are the techniques and monitoring which need to be applied self evident and agreed? | YES | NO Read Part 2 of this Note | Existing plant: Applicant identifies, sources and proposes new controls *(Part 2 of H4)* **Go to 10** | <u>New plant</u> should meet BAT from the outset. Put conditions in place to ensure that control is maintained. **Go to 10** <u>Existing plant</u>: If the Regulator agrees with Operator's proposals appropriate process-related techniques might go in the Permit . **Go to 10** |
| 10 | Could events outside the operators control lead to a failure of techniques? | YES | NO **END** | Operator identifies the events/failures and actions which will be taken to minimise the impact. | If the Regulator agrees, the information supplied by the applicant may form the basis of an odour management plan or appropriate conditions can be put into the permit. **END** |
| 11 | Is odour still a problem? | YES | NO **END** | Check that: • best practice is being used at all times • containment is being maintained • materials have not changed • original risk assessment considered all relevant factors | Revisit improvement programme and Permit conditions on the basis of Operators revised information. |

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# 1 THE REGULATORY FRAMEWORK FOR CONTROL OF ODOUR

## 1.1 IPPC

***What is IPPC***

Integrated Pollution Prevention and Control (IPPC)[1] is a regulatory system that takes an integrated approach to control the environmental impacts of certain prescribed industrial activities. It involves determining the appropriate controls for industry to protect the environment through a single permitting process. To gain a Permit, Operators of prescribed activities will have to show that they have systematically developed proposals to apply the 'Best Available Techniques' (BAT) and meet certain other requirements, taking account of relevant local factors.

In England and Wales the Environment Agency is responsible for those IPPC installations designated as "A1". In Scotland SEPA is responsible for the regulatory control of all Part A IPPC installations. This is also the case in Northern Ireland. The legislation implementing IPPC has been put into place in England & Wales and in Scotland. In Northern Ireland, the legislation is in preparation and any queries should be directed to EHS

***The regulatory requirements of IPPC relating to odorous emissions***

The Pollution Prevention and Control (England & Wales) Regulations 2000 (the "PPC Regulations") define "pollution" as.[2]:

*"emissions as a result of human activity which may be harmful to human health or the quality of the environment, cause offence to any human senses, result in damage to material property, or impair or interfere with amenities and other legitimate uses of the environment.*

Regulation 12(1)(a)[3] requires that conditions are included in a Permit to ensure compliance with provisions in Regulation 12(2) to (8) relating to emission limit values:

- Regulation 12(2) states "….. a Permit shall include emission limit values for pollutants, in particular those listed in Schedule 5, likely to be emitted …. in significant quantities, having regard to their nature…"
- Regulation 12(6) states "….. the emission limit values required by paragraph (2) shall be based on the best available techniques for the description of installation…concerned but shall take account of the technical characteristics of the particular installation…, and, ……its geographical location and the local environmental conditions".
- Regulation 12(8) states "where appropriate, the emission limit values required by paragraph (2) may be supplemented or replaced by equivalent parameters or technical measures".

When determining the conditions of a Permit, the Regulator is required to take account of the general principles set out in Regulation 11(2) which state that an installation should be operated in such a way that:

(a) all the appropriate preventative measures are taken against pollution, in particular through application of the best available techniques; and

(b) no significant pollution is caused

In the generality of cases the Agency will aim to regulate odorous emissions by the imposition of emission limit values (ELVs), where this is feasible, or equivalent parameters and technical conditions, through the application of BAT, under Regulation 12(1)(a).

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[1] IPPC operates under the Pollution Prevention and Control (England and Wales) Regulations 2000 (Reference 2)and the Pollution Prevention and Control (Scotland) Regulations 2000 (Reference 3). These Regulations have been made under the Pollution Prevention and Control (PPC) Act 1999 and implement the EC Directive 96/61 on IPPC (References 4 and 5). Further information on the overall system of IPPC, together with Government policy and more detailed advice on the interpretation of the Regulations, can be found in the Department for Environment, Food and Rural Affairs (DEFRA) document "IPPC: A Practical Guide" (Reference 6) and the Scottish Executive/SEPA document "The Pollution Prevention and Control (Scotland) Regulations 2000 a practical guide" (Reference 7).

[2] The legislation for Scotland and also for Northern Ireland can be presumed to be the same as that given in this guidance for England and Wales, unless specifically stated otherwise.

[3] In Scotland, the Pollution Prevention and Control (Scotland) Regulations 2000 are numbered differently. The bullet points relating to Regulation 12 in E&W refer to Regulations 9(1)(a), 9(3), 9(7) and 9(9) respectively in Scotland

Regulation 12 (1)(b)(ii) requires the Regulator to impose such other conditions as appear to be appropriate for ensuring a high-level of protection for the environment as a whole, once again taking into account the general principles set out in Regulation 11.

It would normally be the case that the imposition of conditions securing BAT also secure that no significant pollution is caused. Should a situation arise where this is not the case then the Regulator may refuse the issue of a Permit altogether. The point at which significant pollution occurs is a professional judgement which takes into account the nature of the operation and what is technically achievable, informed by this Guidance Note and the appropriate Sector Guidance Note.

***The relationship of this note to other guidance***

The information required by the **IPPC Permit Application Form** relates directly to the legal requirements of the PPC Regulations. The IPPC Sector Guidance Notes explain, for each industrial sector, the information which the applicant must supply and the indicative standards which should normally be met in order to demonstrate compliance with each of those requirements.

Each IPPC **Sector Guidance Note** will outline indicative BAT for odour control for the specific activities associated with that sector. Where the EU has issued a **BAT Reference document (BREF)** for a sector, the information it contains on odour will have been taken into account in producing the UK Sector Guidance Note. Odour-related issues, however, tend to be very installation specific and, in accordance with the PPC Regulations, departures from any national standards can be justified at a local level on the grounds of the technical characteristics of the installation concerned, its geographical location and the local environmental conditions.

The purpose of this IPPC **Horizontal Guidance Note** is to provide supplementary information which is relevant to all sectors to assist applicants in responding to the requirements relating to odorous emissions described in the Sector Guidance Notes and the Permit application form.

This Note is made up of two parts which cover general issues relating to the regulation, assessment and control of odorous releases and ***should be used in conjunction with the appropriate Sector Guidance Note to determine BAT and appropriate Permit conditions for a specific installation, taking local factors into account.***

Guidance on the odour control requirements of the Waste Management Licensing regime can be found in Reference 13. An explanation of the current status of that guidance with respect to IPPC and PPC landfill operations is also given in the document.

Separate odour guidance for intensive livestock installations regulated under IPPC is to be published: IPPC Guidance Note “Odour management at intensive livestock installations” (Reference 29) is likely to be released for consultation in early 2003.

## 1.2 IPPC and odour

***Odour pollution: what standard are we aiming for?***

There are difficulties surrounding any quantitative assessment of whether "pollution" in the form of offence to the sense of smell is occurring and therefore what preventative measures, through the application of BAT, are appropriate. There can be a tendency to make a judgement based upon the presence or absence of complaints. However the lack of complaint should not necessarily imply the absence of an odour problem as there will be an underlying level of annoyance present before complaints are made.

The point at which "pollution" in the form of offence to the sense of smell is occurring is taken to be the point at which there is "reasonable cause for annoyance". Consequently the aim of BAT should be to ensure that there is *"no reasonable cause for annoyance"*[4].

***What benchmarks are there for odour pollution?***

Benchmarks for limiting exposure to polluting substances are usually aimed at avoiding harm to health and epidemiological evidence is used to determine appropriate numerical values for such limits. In the case of odour the scientific basis underpinning regulation is still a developing field. The response to exposure to an odour is primarily subjective – how strong is it, what does it smell like and how often/when does it occur and in what context? Each individual will make his own subjective assessment which will either lead to a feeling of annoyance, or it will be considered to be acceptable. Limits can only be based upon a knowledge of what level of exposure is generally "acceptable" in terms of the exposure of sensitive receptors in general.

Attributes and quantification of odorous release are discussed in Appendix 1 and factors affecting response and acceptability are discussed in Appendix 2.

An odorous emission can consist of a single substance, or there can be a dominant substance present. Alternatively it may be a mixture of several or many substances, some or all of which may be odorous. As everyone knows from experience, some odours are more offensive and have more potential to cause annoyance than others although several interlinked factors, as described above, also play a part in determining whether a particular odour is acceptable or not. Benchmarks must therefore take relative offensiveness into account if they are to be meaningful. Benchmarks should also be adjusted to take local circumstances into account.

Where emissions from an odorous activity can be measured or predicted by comparison with similar operations, and then modelled, it is possible to compare the modelled ground level concentration of odour at sensitive receptors to the installation-specific benchmark "acceptable" concentration. This gives an indication of whether there may be reasonable cause for annoyance and the degree of that annoyance. The Operator should use BAT to work toward attaining this acceptable ground level concentration but it should be remembered that there may be a delay until it can be achieved or, in some cases, BAT may not be able to deliver this. Installation-specific factors and the local receiving environment are taken into account in determining what BAT is in a particular situation. An appropriate benchmark will be determined by considering the receiving environment. Measurement of ground level concentrations of odour at sensitive receptors is rarely possible for a number of reasons – in particular the concentration is too low and often fluctuates – and so the benchmark, or the Permitted achievable concentration, has to be translated into an emission concentration at source so that compliance can be determined against this emission limit value, not the ground level concentration.

The use of benchmarks is described in Appendix 5 and the numerical values of benchmarks are listed in Appendix 6. The way in which these values are derived is explained in Appendix 2.

***How do you determine whether exposure is acceptable?***

There are a number of different methods for assessing the impact of odorous emissions on local receptors. The amount of detail required in carrying out an assessment will depend to large extent upon the risk of causing annoyance and any complaint or enforcement history. If emissions can be measured or predicted, then acceptability can be assessed by comparing the predicted ground level concentrations with the benchmark (as described above).

If emissions cannot be measured or predicted then the acceptability of the impact has to be determined in another way because it will not be possible to make a direct comparison with a numerical benchmark.

[4] (The following does not apply in Scotland). The concept of "annoyance" occurs in several legal provisions (within the Control of Pollution Act 1974 s62(2)(d)(iii) and Noise and Statutory Nuisance Act 1993, schedule 3 6(b)). Odour is also regulated through the statutory nuisance provisions of Part III of the Environmental Protection Act 1990.

Impact assessment methodologies, including alternative means for assessing impact when emissions cannot be directly measured or predicted, are described in Appendix 3.

***BAT for Odour***

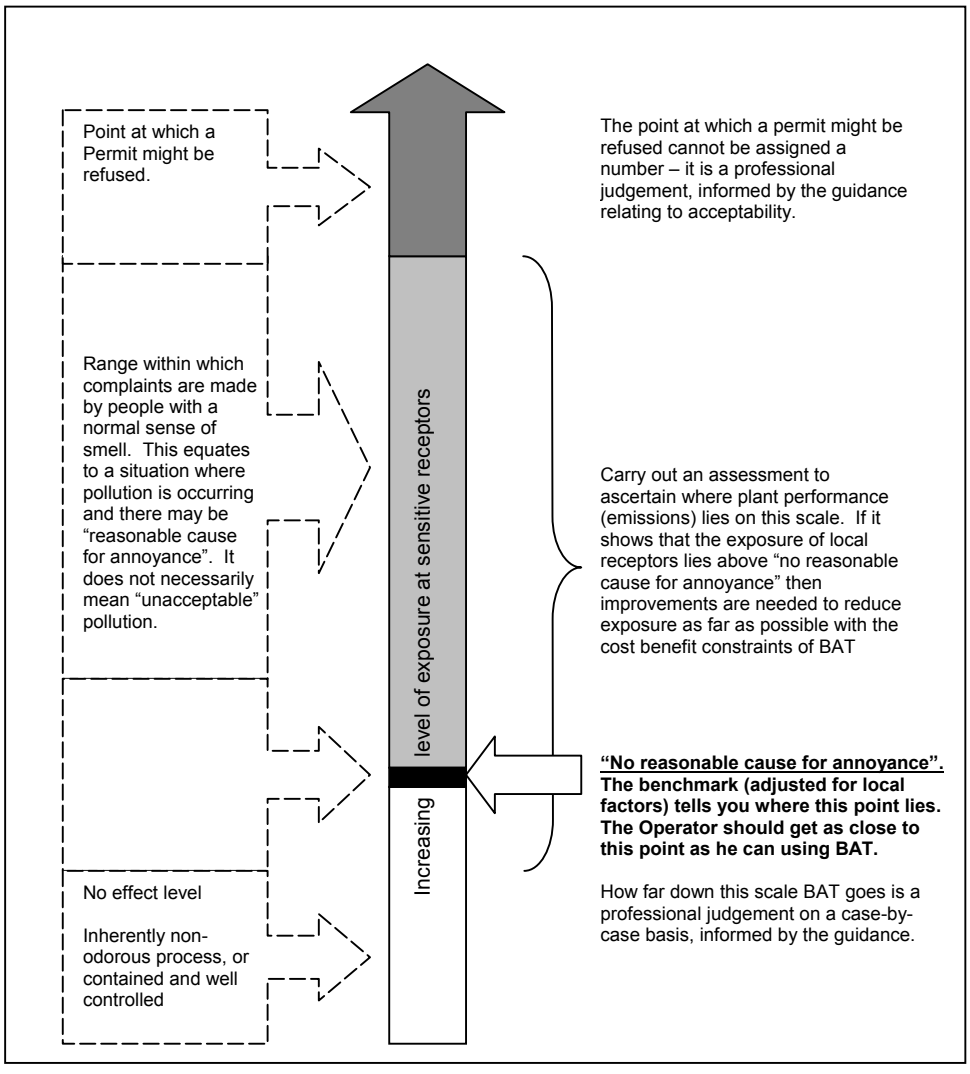
In summary, where there is potential for pollution in the form of offence to the sense of smell (i.e. where there is potential for reasonable cause for annoyance), the aim of BAT should be to achieve the following:

- To keep the exposure to odour at sensitive receptors below the level at which it would give reasonable cause for annoyance. (This would normally be the aim of most planning or other conditions applied by Local Authorities).
- To prevent the generation of odour where possible.
- To contain the odour and use effective treatment techniques, or other means of minimising emissions, where prevention is not possible.
- To promote the use of good practices for the control of odour, including adequate maintenance and cleaning, storage, containment etc.

The odour impact assessment will show if improvement is required and indicate how much improvement is needed. Exactly what constitutes BAT in any given situation will be a professional judgement informed by the Sector Guidance and this Guidance Note.

Figure 1.1, below, shows the relationship between "reasonable cause for annoyance" and the occurrence of pollution, the "no reasonable cause for annoyance" benchmark, and the aim of BAT. The benchmark will have different numerical values depending upon the nature of the odour (see Appendix 6). See below for further description.

**Figure 1.1: "no reasonable cause for annoyance".**



Unless the risk of causing annoyance is very low, the Operator will have carried out an odour impact assessment as part of the Permit application process (see Section 2.2). Where an existing installation has a history of odour complaints and obvious problems, a detailed odour assessment as part of the application will be required.

Where odour emissions from an installation can be measured, the actual modelled ground level concentration at sensitive receptors can be compared to the benchmark. This will provide an indication of the amount of additional control which will be needed to achieve the level of "no pollution", in the form of offence to the sense of smell, ie "no reasonable cause for annoyance", and the Operator should get as close to this value as BAT allows. For an existing plant such benchmarks might be used where odour cannot be contained and there is a risk of causing annoyance. For new installations or expansion/modification to existing plant, they could be used as a planning tool to indicate whether the impact will be acceptable and/or to calculate chimney height for adequate dispersion or the efficiency required of abatement equipment.

Where odour emissions cannot be measured or predicted then comparison with these benchmarks cannot be undertaken. The assessment of odour impact can be made upon the various forms of community-based survey (described in Appendix 3) and complaint history, combined with a review of practices associated with the process or activity.

***Permit conditions***

In many cases it will be appropriate to use a "standard" Permit condition for control of odorous emissions which is based on implied BAT. (Refer to Section 2.5.2). Where non-standard Permit conditions need to be applied this Guidance Note advocates a proportionate approach according to the degree of risk of causing annoyance at local receptors.

Where it is necessary to impose odour-related conditions there are different types of conditions that may be appropriate. Choice will depend upon the type of operation and the nature of the emissions and whether there is an actual or potential problem.

Section 2.4 deals with the assessment of the Operator's determination of BAT and Section 2.5 discusses the options for Permit conditions. In England & Wales the Environment Agency is currently developing an approach using Permit templates which may restrict the choice of condition in a given Sector.

***New and existing installations***

The requirements set out in this Guidance Note and in the appropriate Sector Guidance Note apply to both new and existing activities, but it will be more difficult to justify departures from them in the case of new activities. New installations will be expected to meet BAT from the outset and to demonstrate that odour prevention or minimisation has been built in to process design. Where any odorous releases are to be made, a detailed odour impact assessment would normally be required, based upon predicted emissions and local topography and other local factors.

For most existing plant, especially where there are no existing odour-related limits and no history of odour-related problems, the focus will be on the need to ensure that there is no reasonable cause for annoyance so far as is possible through the application of BAT, which will generally relate to "good practice".

Where there is risk of adverse environmental impact (in terms of odour-related annoyance), BAT is likely to require a higher level of expenditure. Where insufficient information is available to effectively characterise and quantify emissions, a more detailed inventory of the materials used and subsequent releases may be required and/or monitoring undertaken (generally at source). These may indicate the need for additional odour reduction measures.

Where additions are proposed to existing plant or activities the aim should be, wherever feasible, to ensure that these do not add to the concentration or other characteristics of the exposure at sensitive receptors beyond a point where it will cause annoyance or increase the level of annoyance.

The following applies in England & Wales.

***Relationship between IPPC and other regulatory regimes***

The release of odours from trade, industrial and business premises is regulated under several different legislative regimes. When an application is submitted for an IPPC Permit, the Operator may already have a framework of specific odour-related conditions in place as part of an Integrated Pollution Control (IPC) or Local Authority Pollution Control (LAPC) authorisation, a waste management licence (the relevant objectives) or arising from an abatement notice served under Part III of the Environmental

Protection Act 1990 (statutory nuisance). When an A1 installation is issued with an IPPC Permit, existing IPC and LAPC authorisations relating to that activity will be superseded[5].

Where installations transfer from Local Authority pollution control to the Agency, it will normally be of benefit to take advice from Local Authority officers concerning any previous odour problems.

**Part III of the Environmental Protection Act 1990** is concerned with "statutory nuisances" and is regulated by Local Authorities. Unless the Secretary of State has granted consent, a Local Authority may not begin summary proceedings in respect of a nuisance where proceedings can be brought under the IPPC regime. This is to avoid "double jeopardy" for IPPC Operators, and is consistent with previous arrangements under IPC. However, activities that are not covered by IPPC, even if they are located on the same site as an IPPC installation but are not part of the installation, may be regulated under the statutory nuisance provisions. Members of the public may, however, bring private prosecutions under Section 82 of the EPA 1990.

The defence against proceedings for a statutory nuisance is that the "Best Practicable Means" (BPM) are being used to prevent the nuisance. The preventative measures that an Operator should take at an IPPC installation, through the application of BAT, to protect against odorous emissions will be broadly the same as for a BPM defence.

**The Town and Country Planning Act 1990** specifies controls over development under planning law. The planning system complements the pollution control policies by regulating the location of development and the control of operations in order to avoid or minimise adverse effects on the land use and on the environment, i.e. to ensure serious detriment to the amenities of the locality does not occur. Planning controls are not an appropriate means of regulating the detailed characteristics of potentially polluting activities and, where a new installation is concerned, it is likely that the most favourable outcome would be achieved by effective liaison between Planners and Agency officers at an early stage in the process.

Specific requirements for landfill sites which transfer from the **Waste Management Licensing regime** to PPC or IPPC will be described in guidance for that sector. As an interim measure Reference 13 should be consulted.

In **Northern Ireland**, legislation implementing the IPPC Directive is in preparation. There are however significant differences in waste legislation and planning legislation. Further information on the interfaces between IPPC and other legislation in Northern Ireland will be included in revisions to this guidance. In the mean time please contact the Environment and Heritage Service for further information.

[5] In relation to waste disposal and recovery operations coming into IPPC, the relevant objectives will still apply.

# 2 APPLICATION, DETERMINATION & PERMITTING

## 2.1 Overview

***Stages of the permitting process***

The process of Permitting can be broken down into a number of stages:

- Pre-application discussions and receipt of a "duly made" application (see Section 2.2);
- Consultation with statutory consultees and the public (see Section 2.3);
- Assessment of the Operator's BAT proposals (i.e. determination of BAT) (see Section 2.4); and
- Setting Permit conditions (see Section 2.5).

On-going regulation and ensuring compliance are described in Section 3.

## 2.2 Applying for an IPPC permit

The application requirements are laid down in the Regulations. Detailed requirements for odour are set out in each Sector Guidance Note and any accompanying documentation.

***The following issues should be taken into account.***

The level of detail supplied should be in keeping with the risk of causing odour-related annoyance at sensitive receptors.

Where an installation poses no risk of odour-related environmental impact because the activities undertaken are inherently non-odorous, this should be justified in writing by the applicant and no further information relating to odour need normally be supplied.

Where an existing installation has a history of odour complaints and problems, a detailed odour assessment as part of the application will be required.

The following text provides an overview of the type of odour-related information which will be required from the Operator in his application. There is some variation between sectors however according the type of activities undertaken and the nature of the odour sources associated with those activities.

***Application requirements - general***

**Where odour could potentially be a problem**, the Operator should supply the information as indicated below.

1. *Information relating to sensitive receptors.*
   - Type of receptor and location relative to the odour sources
   - An assessment of the impact of odorous emissions on the receptors.

     *Where an existing installation has a history of odour complaints and obvious problems, a detailed odour assessment as part of the application will be required.*
   - An overview of any complaints received, what they relate to (source/operation) and remedial action taken.
2. *Inventory of odorous materials/sources and release points.*

   The types of odorous substances used or generated, intentional and fugitive (unintentional) release points and monitoring undertaken.
3. *Actions taken to prevent or reduce.*
   - A description of the actions taken to prevent and/or reduce odour annoyance for each odour source.
   - A demonstration that the indicative BAT requirements are being complied with.
   - Identification of any circumstances or conditions which might compromise the ability to prevent or reduce odour annoyance, and a description of the actions that will be taken to minimise the impact.

   There may be a requirement placed upon the Operator to provide some or all of this information in the form of an odour management plan. *[This is described in* Appendix 7 *of this guidance note]*.

Where the activities do lead to odour emissions which are detectable beyond the installation boundary but there is no history of complaints because of remote location or other reason that **could** be subject to change in the future, the Operator should have due regard to the possibly temporary nature of the situation and ensure that improvement is factored into longer term plans. Significant modifications to plant should still be expected to meet standards required of new plant and in any event the general BAT requirement will still apply to existing plant.

## 2.3 Consultation

Where the Agency has not previously regulated a particular installation, the Local Authority statutory consultee response would normally be expected to provide an important input to inform the process of determination where there is an actual or potential odour problem. In cases where activities have previously been regulated for odour under Local Authority Pollution Control, or the nuisance provisions of EPA'90, there may be considerable value in pre-application discussion with the Local Authority rather than awaiting the formalities of statutory consultation.

There may also be other relevant factors such as the presence of a Site of Special Scientific Interest (SSSI) or Special Areas of Conservation (SACs), Special Protection Areas (SPAs) or Areas of Special Scientific Interest (ASSIs) as designated in Northern Ireland.

Whilst insufficient information is available to suggest that odour exposure causes detrimental effects in animals at the concentration likely to be experienced in the environment, areas of beauty or tranquillity are likely to be frequented by members of the public from whom consultation responses might be received.

## 2.4 Assessment of the Operator's BAT proposals

### *1. Is there sufficient information?*

***Evaluation of the Operator's application***

The Operator should have addressed all of the information requirements relating to odour as set out in the Sector Guidance Note and application documentation, or to have described why these are not relevant to his application.

**The amount of information supplied and the level of detail should be proportionate to the level of risk of causing annoyance** (as can be gained from some knowledge of the previous odour history of the operation). The information supplied must however be sufficient to allow the actual level of risk to be determined. Depending on the circumstances, information relating to seasonal or other periodic odour-generating activities, cleaning or maintenance operations etc which may produce high levels of odour, is particularly important.

The amount and type of information required on odour impact is described in the following section.

Part 2 to this note: "Assessment & Control" (Reference 1) describes assessment methodology and the most commonly encountered British Standards, CEN standards and other guidance that is relevant to this subject area.

Recommended parameters for modelling of odorous releases are described in Appendix 4 of this document.

### *2. Assessing the environmental impact*

The requirements described in this Section, and who is responsible for them, are summarised in Figure 2.1. This Figure also indicates sources of guidance for each step.

The impact of odour on the environment is considered in terms of offence to the human sense of smell. This is less easily defined than many other indicators of pollution. The concept of "reasonable cause for annoyance" has been adopted in this Note as the level at which pollution by way of offence to the human sense of smell can be said to be occurring.

***An odour impact assessment will usually be required if:***

- the application is for a new installation or an extension to an existing facility (if the activities could release odour). Note that an assessment undertaken as part of an application for Planning

permission may not be sufficient for an IPPC application (see below) although duplication of effort should be avoided as far as possible

- there is a history of complaints or odour problems and/or
- odour is detectable beyond the boundary.

Guidance Note H1: "Environmental assessment and appraisal of BAT" should be consulted when comparing the odour performance of control options – i.e. for options appraisal (Reference 12).

***When should this be submitted?***

This will usually be required as part of the application but exceptionally, for existing plant, it may be permissible, subject to the judgement of the Regulator, to provide this as a condition of the Improvement Programme if the work cannot be carried out in sufficient time. This may be the case where, for example, particularly detailed assessment is needed or occasional batch operations need to be assessed. However the application must contain sufficient information to allow suitable Permit conditions to be put into place.

***What sort of assessment is required, and how detailed?***

***What type of assessment is required and how detailed?***

*The level of detail and scope of the assessment carried out by the Operator should be proportionate to the risk of causing offence to the human sense of smell.* The higher the risk, the more detailed the investigation should be and the Operator will be expected to expend more effort at greater cost in quantifying the impact. The level of risk can be approximated by considering, for example, the complaint history, the type of operation, the proximity of housing and any previous regulatory intervention.

The Operator may have submitted monitoring or odour impact assessment reports as part of the application. These may have been commissioned to fulfil other purposes such as demonstration of compliance with planning consents or for a planning application. The Regulator will need to decide how far these go in providing useful information. The Operators should not, however, submit reports in place of the more detailed information required by the Sector Guidance. They should be additional to the requirements of the application, not instead of it.

A number of "tools" are available for assessing the environmental impact of odorous releases. These range in complexity from simple (and imprecise) to detailed (with a corresponding increase in accuracy). It may be appropriate to undertake a simple assessment as a screening exercise or scoping study to identify and/or prioritise sources before carrying out more detailed work. In some cases where risk is low a simple screening assessment may suffice on its own.

The choice of assessment type will also be dependent upon whether odour emissions from the operation can be measured or predicted. Some forms of impact assessment need emissions to be measured, but where this is not possible assessment methodologies are available which use the subjective views expressed by local residents as input. See below for sources of information relevant to this.

It is particularly important to consider the subjective elements of an exposure in addition to any modelled output – what type of odour is it? (i.e. how offensive is it?) – under what conditions are a particular population exposed? – what is the history of this population with respect to this odour?

***Sources of information***

Figure 2.1 identifies the sources of information within this guidance note and other Agency guidance relating to odour impact assessment.

Appendix 3 gives an overview of the odour impact methodologies available and shows which type might be appropriate for different circumstances.

Appendix 4 outlines recommended parameters for dispersion modelling of odours.

Part 2 of this Note (Reference 1) describes individual methodologies in more detail.

Reference 29 describes requirements for assessment of the impact of intensive livestock operations.

***Comparing actual releases with the benchmark for an "acceptable" level of exposure.***

Where the results of the odour impact assessment take the form of a predicted exposure of local receptors (a concentration value at ground level), the next stage in the process is to compare the plant performance with the benchmark level of exposure that is considered to be "acceptable" (refer to Appendices 5 and 6).

The Operator will be expected to carry out this comparison of actual and acceptable exposure. This will provide an indication of how much improvement is needed and will allow a description of the actions the Operator will take to prevent/reduce using BAT to be drawn up, as outlined in Section 2. The Operator will have to provide sufficient background information and justification to allow the Regulator to check through the calculations and agree the assumptions and outcome.

For Permitting purposes, exposure of receptors is generally expressed in terms of an equivalent emission limit value at the point of arising or discharge, as this can be measured for compliance purposes, whilst the actual exposure concentration cannot.

Appendix 6 describes a methodology for deriving installation specific emission limit values relating to acceptability.

The Operator will have to demonstrate that BAT is being used, or will be used, to get as close as possible to meeting the exposure level which is "acceptable". Where new plant is concerned, the Operator should have considered prevention and minimisation of odours at the design stage and should be using BAT from the outset.

Where the benchmarks described above cannot be applied, other ways of determining whether odour exposure is acceptable can be used. These alternatives are outlined in Appendix 3 and described in more detail in Section 1 of Part 2 of this note (Reference 1).

## *3. Indicative BAT Requirements for odour*

1. The requirements for odour control will be installation-specific and dependent upon the sources and nature of the potential odour, and the proximity of sensitive receptors. In general terms:
   - where odour can be ***contained***, for example within buildings, the Operator should ensure that the maintenance of the containment and the management of the operations are such as to prevent its release
   - where ***odour releases are expected to be acknowledged in the Permit***, (i.e. contained and treated prior to discharge or discharged for atmospheric dispersion):
     - for existing installations, the releases should be modelled to demonstrate the odour impact at sensitive receptors. The target should be to prevent/reduce the frequency of exposure to ground level concentrations that are likely to cause annoyance. Where there is no history of odour problems then modelling may not be required although it should be remembered that there can still be an underlying level of annoyance without complaints being made
     - where incidents or failure to control are liable, in the view of the Regulator, to increase the odour impact at receptors, the Operator should take appropriate and timely action, as agreed with the Regulator, to prevent further annoyance. It may be appropriate to document this in the form of an odour management plan (see Section 2.5.2 and Appendix 7)
     - for new installations or substantial changes the releases should be modelled and it is expected that the Operator will meet the highest level of protection that is achievable with BAT from the outset
   - where odour generating ***activities take place in the open***, (or potentially odorous materials are stored outside) a high level of management control and use of best practice will be expected

2. Where an installation releases odours but has a low environmental impact by virtue of its remoteness from sensitive receptors Operators may still be required to work towards achieving the standards described in the relevant Sector Note, but the timescales allowed to achieve this might be adjusted according to the perceived risk.

Further guidance on control techniques is given in Guidance Note H4 Part 2 "Assessment and Control" (Reference 1).

***BAT for open-air operations***

Where plant can be contained within buildings, good design and effective management can usually achieve a high level of containment. However some operations are carried on in the open (examples are lagoons and landfills), where containment is not feasible. In such cases the layout, engineering aspects, management procedures and the day-to-day operation can all reduce the odour impact at surrounding areas. In some cases a degree of containment may be possible, for example the use of covers on slurry catchment areas or waste water treatment tanks, or covered conveyors. However, where such options are unavailable it is important for Permit conditions to be based around good management techniques, taking local factors into account.

In the case of landfill operations, the Agency Guidance for the Regulation of Odour at Waste Management Facilities under the Waste Management Licensing regime contains useful information (Reference 13) and should be consulted until sector-specific PPC/IPPC guidance is available.

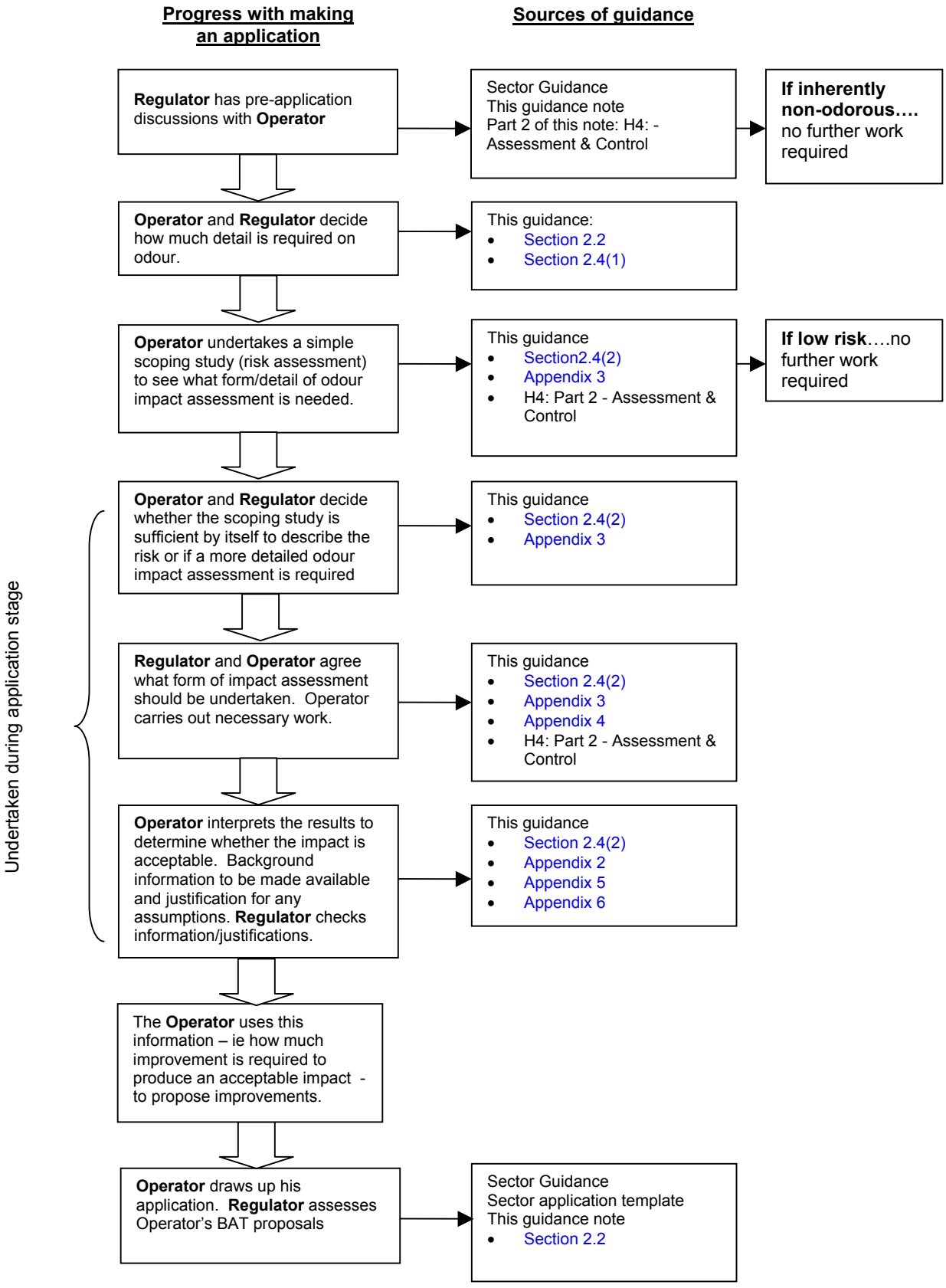
***What standard are we trying to achieve?***

The aim should be to avoid "reasonable cause for annoyance" at sensitive receptors, i.e. to keep within a level of exposure that a high proportion of the exposed population finds "acceptable" on a long-term basis. This subject is covered in more detail in Appendix 2.

## *4. Cross media assessment (H1)*

In determining BAT across an installation, odour will have to be considered and balanced within the wider context of the impact of other releases to different environmental media (air, land and water), and against usage of energy and raw materials. Odour cannot therefore be considered in isolation from other impacts on the environment. Further explanation of this relationship is given in Section 1.1. In many cases there will not be any conflict between the needs of the different environmental media but, where they do arise, Reference 12, *Technical Guidance Note H1 "Environmental Assessment and Appraisal of BAT",* contains methodologies for the assessment of such cross media impacts.

**Figure 2.1: Odour impact assessment – where to look for guidance**



## 2.5 Options for permit conditions

***A proportionate approach should be taken to the setting of Permit conditions according to the degree of environmental risk (of causing odour-related annoyance) posed by the installation.***

***The role of implied BAT***

Regulation 12(10) states that: "there is implied in every permit a condition that, in operating the installation or mobile plant, the operator shall use the best available techniques for preventing or, where that is not practicable, reducing emissions from the installation or mobile plant." Regulation 12(11) provides that this implied obligation does not apply in relation to any aspect of the operation of the installation which is covered by a specific Permit condition.

Therefore, where odour-related conditions are not specifically written into a Permit, there remains an obligation on the Operator to use BAT to implement and maintain appropriate preventative measures against pollution in the form of offence to the sense of smell. This is often referred to as "implied BAT".

It may be appropriate to have no odour conditions in the Permit and rely upon this residual responsibility. This is relevant where an installation has no history of an odour-related problem and there is no reason to believe that pollution in the form of offence to the sense of smell is likely to be caused. However, where this is due only to remoteness of location, the Operator should still be required to reduce odour emissions as far as the balance of cost and benefits allows and particular account should be taken of potential land use changes in Local Plans etc.

**The following pages describe the approaches which can be taken to Permitting of odorous releases under IPPC. In England & Wales the Environment Agency is currently developing an approach using Permit templates which may restrict the choice of condition in a given Sector. Account Managers should ensure that they are using the current version of the appropriate Sector regulatory package, as developments in the regulatory approach may mean that templates are revised from time to time.**

### 2.5.1 Overview and underlying considerations

**The following general rules apply**

- Where odour cannot be reliably contained within the installation boundary (even using good management techniques/best practice), the target to aim for at sensitive receptors should be "no reasonable cause for annoyance". This target must be balanced against BAT in each particular circumstance and, for existing plant, consideration given to the timescales over which this can be achieved.
- Preventing the generation of odours at source is the preferred option, for example by substitution of materials or changing the process.
- Where odour generation is not preventable, odours should be minimised at source and/or contained with effective treatment prior to discharge.
- Where odours can be contained the target should be to maintain containment and to avoid fugitive releases.

Where full containment is not feasible, the management of odour will depend heavily upon prevention/reduction by means of good management techniques.

The following issues need to be taken into account

- As odour is a subjective issue and the legal requirement relates to preventing/reducing offence to the sense of smell, it may be appropriate to impose one or more conditions which relate to the sense of smell – the presence and offensiveness of odour - particularly where mixtures of odorous substances are present as they are less easily measured than single compounds.
- Seasonal variation in the level of annoyance experienced/expressed is common. This may relate to differences in the process or the raw materials, or it may be simply because local residents are outside when the weather is better or have the windows open in summer. Worst case is therefore a valid consideration.

***Monitoring-related requirements.***

The points outlined below are described in more detail in Part 2 to this document (Reference 1).

"Measurement" of odours in the conventional sense can be difficult. When drafting Permit conditions relating to compliance monitoring of odours, the following should be taken into account.

- Most odours are mixtures of compounds and a knowledge of the chemical species present in the mixture rarely gives any indication of the human response. The subjective view can be obtained by using olfactometry, although this can be expensive and time consuming. Continuous monitoring is not possible and olfactometry would only normally be specified as a means of periodic check monitoring. (Laboratory assessment typically cost about £150 per sample (average), sample collection and transport is additional to this). Samples have a short life – often less than 30 hours.
- Simplified olfactometry (also called sniff testing, or subjective testing) can be undertaken at a specified location as a compliance check by the Regulator against a condition relating to the presence of odour, or for day-to-day monitoring of the effectiveness of control by the Operator. An appropriate methodology should be followed (Appendix 8). The possibility that the Operator may have developed a tolerance or decreased sensitivity as a result of regular exposure should be considered.
- In some cases it may be possible to set up continuous or frequent monitoring of surrogates, i.e. a single substance which is representative of the odour characteristics of the emission. Once the relationship is established, there must be a linear response to changes in total odour concentration to enable quantitative information to be obtained. Linearity is rarely maintained across the whole scale - a near zero value for the surrogate may still leave a strong residual odour (this is often found in the waste water industry). Sometimes "calibration" values can be established to adjust for systematic non-linearity.
- The collection of meaningful samples of ambient air (e.g. at an affected area in the community, or at the installation boundary) for assessment by olfactometry is subject to a number of difficulties, particularly due to low concentration, and so is not commonly undertaken. Collection of samples for instrumental analysis is sometimes possible but fluctuation in concentration is often rapid and only direct reading instruments can give an indication of the exposure profile. A result which is averaged over a long period is rarely useful as it is the peaks which tend to cause annoyance, even if very transient. This would not normally be undertaken for routine compliance monitoring, (see Part 2 of this Note).

***How to treat "background" odours***

Odours are not generally additive in the same way as noise. A "new" odour cannot be added to an existing background or "ambient" odour level to give a figure for total odour. This reflects the way in which the brain responds to odour. The brain has a tendency to "screen out" those odours which are always present or those that are normal to that environment; this might take the form of a tolerance to a constant background of local odours. An intermittent or fluctuating or new odour can stand out against this background. Normal background odours such as from traffic, grass cutting, plants etc, indeed the "normal" medley of "environmental" odours amounts to anything from 5 to 40ou/$m^3$ (see Reference 16). A new odour at much lower concentration can still be noticeable against this background. This "screening out" is different to olfactory fatigue where receptors in the nose become fatigued and less effective at detecting a particular smell.

Olfactometry already assumes that all odour concentrations are above background, i.e. it effectively ignores it. There may be occasions, however, when it needs to be considered, for example if there are known to be additive or synergistic effects with other odours or substances that are present in a particular environment.

Each case must be considered on its own merits, however where receptors are exposed to high levels of industrial odours from a variety of other sources it may be appropriate to consider the cumulative burden and reduce target emission levels accordingly. (See Appendix 6).

## 2.5.2 Options for odour-related conditions

***Options for odour conditions:***

***Overview***

This section describes the main "types" of conditions that can be applied to the control of odorous releases. However the combination to be applied in any given situation will be a judgement based upon:

- the nature of the process or activity
- the type of source – for example, is it containable or in the open air, is there an emission point?
- the level of control to be exerted
- what is achievable with BAT
- other installation-specific factors.

The relevant Sector-specific guidance note will indicate particular problems and requirements for that sector and should take precedence over the general guidance given here.

Each condition must be able to satisfactorily pass the five key tests of being **reasonable, necessary, precise, relevant and enforceable**, the latter being particularly important on qualitative and numerical conditions. Conditions should not conflict with each other such that an Operator may be in compliance with one condition but out of compliance with another.

***The following types of condition can be considered:***

1. relating to the process/activity itself or to management of the process (which may effectively form "surrogates" in place of the continuous monitoring of emissions)
2. relating to the presence of offensive odour at sensitive receptors or other specified location
3. point source emission limit values derived from acceptable exposure levels (benchmarks) at sensitive receptors, and the associated monitoring requirements
4. the requirement to produce and maintain an odour management plan.

These are described in the following sub-sections.

Generally specific process-related conditions on the management and control of odour are the most appropriate Permit conditions as they most easily meet the tests referred to above. However, in certain cases it may be appropriate to combine such conditions with an emission limit value (where odorous emissions can be measured for compliance purposes) or a sensitive receptor/boundary condition (generally where odorous emissions cannot be measured, or there is a risk of fugitive emissions, and compliance therefore needs to be assessed by reference to a subjective experience).

***Process-related conditions, (equivalent parameters or technical measures)***

There is a potentially wide range of conditions which may be used to restrict or direct aspects of the operation to prevent or reduce odour. Part 2 of this Note covers a range of control techniques and technologies which are applicable to a number of sectors (Reference 1). **Sector Notes will give specific examples of BAT**, including good practice and technology. Generic examples are given below, but the Sector Note should be consulted in the first instance.

***Restrictions can be placed upon activities*** that have the potential to generate odour, or on the timing of odorous activities, for example:

- restrictions on the type of material which may be received:
  - example (for hazardous/non-hazardous waste recovery or disposal) – restrictions on acceptance of mercaptans, low molecular weight amines etc
  - restrictions placed upon the maximum allowable weight or percentage of an odorous component - for example the sulphur content of fuel
- restrictions on how odorous material is to be handled, or on containment requirements:
  - relating to containment - containers to be opened only within dedicated handling areas with air extraction to an abatement system.

***Conditions relating to optimised operation of abatement systems,*** for example*:*

- A condition covering incinerator operation may specify the residence time (typically 1 second for odour control) and the temperature (typically 850$^{o}$C for odour control).
- A condition covering biofiltration operation may specify parameters such as residence time (approximately 30 to 60 seconds depending on the application), rate of watering, inlet moisture content and temperature, adequate air distribution, mechanisms to ensure that bed by-pass does not occur, and depth and type of media. There may also be requirements to periodically turn the bed material to avoid compaction and to monitor the pressure drop across the bed.
- A condition covering scrubber operation may specify pH conditions, liquid flow rates, pump operation alarms.
- A condition covering a batch adsorption operation may specify residence time and maximum bed life-time. (When dealing with odours, it is difficult to establish the maximum bed life-time from first principles and therefore there may well be some trial and error in determining the bed life).

It may be appropriate in some cases to specify a standard in terms of demonstrating the efficiency of odour abatement equipment by periodically taking simultaneous extractive samples at the inlet and outlet for subsequent olfactometry or other analysis.

***Conditions which apply in adverse situations***. For example, under some circumstances it may be considered necessary to apply conditions which only come into effect under conditions which may lead to increased exposure of receptors:

- requiring the process (or a part of the process) to commence shut-down procedures when the wind direction will result in odour exposure which is deemed to be unacceptable. (Relying upon information from the local Met station is not usually advised as wind direction can vary locally. It is better to have the necessary equipment, with continuous logging facility, installed on-site).

The Operator should be required to keep suitable permanent records to show (i) when such adverse conditions occur and (ii) that the required action was taken.

The Operator should not rely upon complaints to demonstrate that there is a problem but, nevertheless, should have a system in place for responding to any complaints that do occur.

*A note on "adverse" weather conditions:*

The normal variability in local weather conditions should have been taken into account in the process of modelling the impact on sensitive receptors. This will have considered local meteorology and the "normal" pattern of conditions. Where an emission limit is based upon this impact assessment (usually based upon 98$^{th}$ percentile) then the increased exposure effect (if there is one) caused as a result of the unusual [adverse] conditions should fall within the 2% of the year that the specified criteria can be exceeded.

The local weather data available for the Met Office does not always reflect very localised conditions – for example a valley location may produce its own inversions. Where this type of local effect is leading to an increased exposure of local receptors, it may be appropriate to consider conditions which apply under specific weather circumstances (as described above).

**The condition will have to include quite precise detail on how the particular circumstances will be identified and what will be done. A better alternative in such a situation would be to require the Operator to state how this will be done and subsequent actions; an odour management plan can provide a means to do this.**

Part 2 of this guidance note (Reference 1) covers a range of management techniques and abatement options to minimise odorous emissions.

## *Receptor-based conditions*

### *What is a receptor-based condition?*

A "receptor-based condition" relates to the presence or detectability of odour at a location frequented by people – i.e. sensitive receptors.

The annoyance response of a community exposed to odour, particularly complex mixtures of odorous compounds, is based upon their subjective evaluation of the exposure, therefore it is valid to frame a permit condition in these same subjective terms and to test compliance using the human nose.

### *Examples of receptor-based conditions*

Conditions relating to a subjective experience must be appropriately qualified by stating who will make the assessment and where. The unacceptable situation, i.e. the presence of odour, must be defined in

such a way that the assessor (the Agency officer) can reasonably make a decision on the spot as to whether it has been breached or not. Usually this relates to "offensiveness".

Such a condition should always be used with a qualifying statement which describes the circumstances under which the condition applies. The qualifying statement should ideally refer to the application of BAT, so that the condition as a whole cannot be said to undermine the concept of BAT which is central to the PPC regulatory regime. It is arguable that such a condition adds little to specific process-related conditions or, in their absence, "implied BAT", but its use in certain cases where potential odour annoyance is an issue may serve to focus the Operator's attention and efforts on the effective management of odour. Such a condition may also be appropriate where:

- it is difficult to specify BAT in Permit conditions where response to abnormal/infrequent events is dependent upon a range of variable circumstances, but where it is considered that measures could be taken to avoid reasonable cause for annoyance at sensitive receptors, and
- it is considered that specific conditions relating to BAT should achieve "no reasonable cause for annoyance" at sensitive receptors but that it may be impossible to identify where non-compliance has occurred after the event, for example a vent or door left open temporarily.

Where it is not feasible to use a receptor-based condition, a boundary condition might be considered. This is a condition which relates to the detectability of odour at the boundary of the Operator's premises, or land over which he has control. A boundary condition may be useful where sources on more than one installation are impacting upon the same receptor(s). A boundary condition is closer to source than a receptor-based condition. It is also easier for the Operator to keep a check on his performance and compliance with the condition.

For example:

> *All emissions to air from the installation shall be free from offensive odour as perceived by an authorised Officer of the Agency [at location xyz] [outside of the installation boundary] unless the Operator has used the Best Available Techniques to prevent, and where that is not practicable, to reduce, odorous emissions.*

The determination of whether the odour is "offensive" should be made on the basis that episodes of odour exposure in the locality could be frequent and persistent. The determining officer may be exposed for a few minutes only but the determination needs to take into account the likely long-term response of nearby receptors who may be exposed on a regular basis. Clearly, some odours are more offensive than others but it should be remembered that any odour has the potential to be offensive, depending upon factors such as concentration, duration and frequency of exposure, the context within which the exposure takes place and other factors unique to the individual exposed. The instantaneous impression may be of a relatively inoffensive odour but regular exposure, particularly at high concentration, often leads to a change in perception.

Offensiveness is discussed in Appendices 1 and 2.

A procedure for such investigations/determining compliance is given in Appendix 8.

***Odour management plan***

***What is an odour management plan?***

An odour management plan is a working document for managing odour issues within the installation. The content will differ from installation to installation, depending on the type of odorous activity undertaken and the complexity of those activities and their relationship to each other. Depending upon the general approach to Permit conditions, the plan may include all elements of odour management or be restricted to those which relate to "incident" management. It may be appropriate to incorporate the plan into the Permit by reference, so that enforcement is possible in respect of its requirements.

An example and template are given in Appendix 7.

***Emission limits/ allowable releases based on BAT***

**See also Section 2.5.1.(1) relating to compliance and monitoring considerations when determining suitable Permit conditions. Part 2 of this Note (Reference 1) gives more detailed information on sampling and quantitative and qualitative assessment of odours.**

Emissions from point or area (surface) sources can be sampled at source and the volume flow rate or mass release determined for either a single odorous substance or for "total odour", given in odour units (see Appendix 1). This will set a baseline for emission limits for the purpose of Permitting.

***Emission limits for point sources***

These could be specified in the form of:

- odour units for mixtures of odorous components (assessed by means of olfactometry)
- mg, or μg, $m^{-3}$ of a single odorous substances (measurement by a standard analytical method, or continuous monitor)
- mg, or μg, $m^{-3}$ of a surrogate substance which is representative of the mixture.

Section 4.1.1 of Part 2 of this Note outlines the issues surrounding dilution of odorous gas streams prior to release. Dilution may have some effect on the emission characteristics which will affect dispersion but will not alter the mass of odour released. It is largely the mass, subject to local dispersion effects, which affects the potential for annoyance at receptors. It may therefore be advantageous to frame an emission limit in terms of odour units per second.

$$E = D \times F$$

Where E is the odour emission rate (odour units/second)

D is the odour concentration (odour units/$m^3$)

F is the volumetric flow rate ($m^3$/second)

***Emission limits for area sources***

Although the emission rates of area sources (both solid and liquid) can be measured, emission limits have not been widely used for compliance purposes, although measurement is used for prediction of impact. This does not mean that emission limits could not be used but the sampling locations and conditions would need to be clearly set out. Specification of process management techniques might often be more appropriate than monitoring-based conditions.

***Determination of emission values which represent an acceptable level of exposure.***

It is possible to calculate maximum release rates which, after dispersion, are considered to be unlikely to produce reasonable cause for annoyance at sensitive receptors (see Appendix 6). For the purposes of Permitting any emission limits must be based on what is achievable through the application of BAT.

A receptor-specific level of exposure which equates to "no reasonable cause for annoyance" can be determined using either emission limit values given in Appendix 5 or, the methodology given in Appendix 6 to calculate odour exposure (acceptability) criteria. This can be worked back using a dispersion model to give an emission rate equivalent to "no reasonable cause for annoyance". The Operator should go as far as possible towards attaining the "no reasonable cause for annoyance" emission level, within the cost benefit constraints of BAT.

The use of modelled exposure criteria and what they actually mean in terms of the occurrence of odour at receptors is explained in Appendix 6.

***Multiple source installations***

**What approach should be taken if there is more than one source type on the same installation?**

There may be a combination of different source "types" on an installation, and these may have different odour characteristics. Where this is the case, a common-sense approach should be taken, but the following can be used as a general guide:

- the emphasis should be on control at source for each individual source
- model multiple sources together using an appropriate model. A common sense approach will need to be taken where sources are spread across a large installation in which case it may be appropriate to consider individual or groups of sources in terms of the specific receptors that may be affected. Also, on a large installation consider, where appropriate, the effect of distance from the source to different receptors, depending on the wind direction

- where sources are completely different in terms of their odour characteristics it may be better to consider them separately in terms of impact on receptors. The combined impact may, or may not, be additive from a perceptual point of view. It may take a visit to the area, or evaluation of complaints to decide upon the best approach to take. It may be obvious where one odour is clearly stronger or more offensive, or exposure to one particular odour is more frequent than another, and
- where there are different odour source types on an installation care may be needed to make sure that there is no confusion regarding which condition applies to which source. Using a boundary fence condition for one source when there are authorised discharge points based on odour exposure (acceptability) criteria for other odorous releases may produce confusion over compliance unless the odour types are completely different and can be recognised as such at receptors or other point where the condition applies.

# 3 ONGOING REGULATION

## 3.1 Complaint investigation

This section describes the investigation of complaints from a Regulator's perspective with a view to determining whether a variation of Permit conditions is necessary and/or if enforcement action is indicated.

**When considering enforcement action the appropriate policy documents and regulatory guidance should be consulted and the relevant procedures followed.**

It is particularly important to ensure that complete and well-ordered records of all actions taken to respond to complaints and any subsequent follow-up actions are kept on file to form an audit trail.

Appendix 9 outlines the assessment tools available for complaint investigation and also contains a suggested template for a complaint form specific to odour.

### 3.1.1 Identification of source

A number of methods are commonly used to assist in source identification:

- **Odour descriptors** are often used to assist in identification where the source is not immediately obvious, or where there are several different sources close together. A descriptor is a comparison with a more familiar odour that the complaint odour smells like. This "familiar smell" is then matched with a chemical equivalent. The information can be sought from complainants at the same time that other information is recorded. Alternatively, it may be possible to identify key chemical components by a description of their specific odour characteristics. A list of descriptors and associated chemical substances is given in Appendix 10. It is often difficult to obtain a consistent description of the same smell from different individuals and it is not unusual to find that the complainant's description is influenced by an opinion of the type of activity that goes on at a suspected source.
- A knowledge of the **direction from which the wind is blowing** towards receptors can help to confirm a source or indicate a direction in which to look for an odour-generating activity which has appropriate characteristics.
- Local **maps can be used to plot the location** of complaints and/or the locations where odour is detected during investigation. Wind direction and time/date need to be carefully recorded.
- A portable **GC-MS can be used for "fingerprinting"**, i.e. to analyse air samples at the complaint's location in order to ascertain the identity and concentration of the main odorous components. If this information does not allow positive identification of the source from a knowledge of the activities carried out, then sampling of those potential sources using the same technique can enable a match to be made. Occasionally the odour is found to be a product of more than one source, overlaid on top of each other. The extent of dilution and the need for sampling at receptors to coincide with periods of exposure (particularly if they are brief) can restrict the usefulness of this method. The cost of the instrument and the expertise required for analysis and subsequent evaluation also limit its use as a "quick check" method for everyday use. It can however be useful where there is on-going uncertainty regarding the source and who is responsible.

### 3.1.2 Use of complaint records

There are a number of factors which affect how and when complaints are made and this makes it difficult to use complaints as an accurate reflection of the overall level of annoyance in a community.

There tends to be a "threshold" which has to be reached before initial complaints are made, thereafter complaints may be made more readily. The number of people actually experiencing the effects of annoyance caused by odour (and noise) appears to be much higher than the number of registered complaints. In the Netherlands, the annoyance caused by environmental stressors (noise, traffic, odours and others) is investigated by systematic year-on-year surveys (which disguise the purpose to avoid bias). The prevalence of annoyance as measured by survey is typically much higher than the number of registered complaints. Regulatory control should aim to reduce or prevent this general underlying dissatisfaction, not simply stop complaints being submitted.

Complaint records are however useful for looking at the distribution of complaints around a source over a period of time. Identifying locations on a local map can show the footprint of a problem. They can also indicate underlying trends. (See also Section 1.3.1 of Part 2 to this Note – Reference 1).

### 3.1.3 Use of field surveys to determine nature/extent of exposure

In addition to complaint records, there are a number of odour impact assessment tools that can be used to look at exposure characteristics and patterns - frequency, strength, duration – from the viewpoint of those exposed. These have already been described with respect to making a Permit application, but they can give valuable information to assist in complaint investigation. For example the extent of the footprint of a particular installation can be estimated when it is not possible to measure or reliably estimate emissions (for example, where there are multiple release points, particularly where there are substantial fugitive releases).

(i) To evaluate community response, the following can be used:

- attitude surveys (based on past exposures)
- population panels or odour diaries (on-going assessment of the current situation).

(ii) To evaluate the extent and magnitude of the exposure in the community, field judges/panels can be used.

These vary in both the cost and/or effort and the period of time needed to establish the necessary pattern or obtain relevant information. With the exception of complaint histories, these assessment tools would typically be used where there are serious or ongoing problems with odour exposure. There are standardised methodologies available for undertaking such work. They are described in more detail in Part 2 of this document (Reference 1).

### 3.1.4 Other considerations in complaint investigation

At a distance from the source there may be some modification of the characteristics of an odour.

- As an emission disperses in the atmosphere components within the mixture may behave differently according to their physical and chemical characteristics. Some components may "drop out" before others as a result of their diffusion characteristics. Some substances may undergo oxidation in the atmosphere, or there may be interaction between components so that the mixture changes with time. The result is that the nature of the particular odour changes over a distance, so complaints relating to the same source may give different descriptions. Chemical transformations taking place over a longer time period tend not to be so important in this context as most odour issues are "near field".
- For every substance the perceived intensity (strength) decreases to different extents for the same decrease in concentration. This can be important for control purposes because some substances may be particularly lingering at very low concentration and will need to be reduced still further (see Appendix 1). Modelling will not take this into consideration.
- Sometimes complaints can be received from an individual, or a small group, when those around them seem to be unaffected. This could be due to different sensitivities or other local issues, but it is useful to visit the location and consider lines of sight with the source and obstacles which can deflect air flow. It has been known for a single house in a terrace to be affected whilst others are not due to such "funnelling" effects. More usually though this is due to particular sensitivity.

### 3.1.5 Sensitivity of the exposed population and individuals within it

There can be large differences between individuals in terms of their sensitivity, likes and dislikes and attitudes to a particular exposure. This is discussed in Appendices 1 and 2.

Section 1.2 describes the standard which regulation aims to achieve, i.e. no reasonable cause for annoyance. BAT is determined by consideration of a number of factors - the sensitivity of the environment and other local factors, cost and benefits and other installation-specific considerations. Timescales taken to achieve BAT are also a key element which may affect the levels of exposure.

Regulation aims to protect as many of the exposed population as possible within the constraints of what is technically achievable with BAT, but we have to recognise that this may mean that, even within "no reasonable cause for annoyance" some individuals may be annoyed or complain. Some individuals may detect odour at concentrations considerably below what might be considered "normal" for the population, (see Appendix 2 and Reference 15). The exposure of such individuals should be reduced as far as possible within the cost/benefit balance of BAT. Factors affecting response are discussed in Appendix 2.

### 3.1.6 Common Incident Classification System

For the purpose of categorising odour "incidents" the odour-specific section of the Common Incident Classification System (CICS) should be consulted. This applies to England & Wales only. This

document (Reference 14) is for internal use and can be accessed via the intranet on the CICS Homepage or Solutions.

# REFERENCES

For a full list of available Technical Guidance see Appendix A of the *Guide to Applicants* or visit the Environment Agency web site http://www.environment-agency.gov.uk. (Business & Industry section). Many of the references below are available free of charge for viewing or download on the web site. The same information can also be accessed via the SEPA web site http://www.sepa.org.uk, or the EHS web site www.nics.gov.uk/ehs. Most titles will also be available in hard copy from The Stationery Office (TSO). Some existing titles are not yet available on the web site but can be obtained from The Stationery Office.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# DEFINITIONS RELATING TO THE LEGISLATION

| | |
|---|---|
| A1 activity | An activity listed in Schedule 1 of the Pollution Prevention and Control (England and Wales) Regulations 2000 and designated for Agency control. |
| A2 activity | An activity listed in Schedule 1 of the Pollution Prevention and Control (England and Wales) Regulations 2000 and designated for Local Authority control. In Scotland SEPA will regulate all Part A activities, as will EHS in Northern Ireland. |
| BAT | Best Available Techniques. "Indicative" BAT is set out in each Sector Guidance Note whilst BAT for a particular installation must take local factors into account. A comprehensive definition of BAT is given in "IPPC – A Practical Guide", Edition 2 (Reference 6). |
| BPM | Best Practicable Means |
| BREF | BAT Reference Document |
| DEFRA | Department for Environment, Food and Rural Affairs |
| EHS | Environment and Heritage Service (Northern Ireland) |
| ELV | Emission Limit Value |
| EPA'90 | Environmental Protection Act 1990 |
| HSE | Health & Safety Executive |
| IPC | Integrated Pollution Control – the regulatory regime described in Part I of the Environmental Protection Act, 1990 for the purpose of preventing or minimising pollution of the environment due to the release of substances into any environmental medium. Regulation is the responsibility of the Agency. |
| IPPC | Integrated Pollution and Prevention Control – the term generally used to describe the regime applied to those activities which are described in Annex I of the IPPC Directive (96/61) |
| PPC | Pollution Prevention and Control – the term generally used to describe the regulatory framework set out in the Pollution Prevention and Control Regulations (PPC Regs). It is also applied to those additional (ie non-IPPC) activities which appear in Schedule 1 of the PPC Regs but which are not described in the IPPC Directive. |
| LA | Local Authority |
| LAPC | Local Air Pollution Control - the regulatory regime described in Part I of the Environmental Protection Act, 1990 for the purpose of preventing or minimising pollution of the environment due to the release of substances into the air. Regulation is the responsibility of Local Authorities. |
| Pollution | Emissions as a result of human activity which may be harmful to human health or the quality of the environment, cause offence to any human senses, result in damage to material property, or impair or interfere with amenities and other legitimate uses of the environment. (Pollution Prevention and Control Regulations 2000). For odour this is taken to mean offence to the sense of smell. |
| SEPA | Scottish Environment Protection Agency |
| WML | Waste Management Licensing - the regulatory regime described in the Waste management Licensing Regulations, 1994. |

# GLOSSARY OF TERMS RELATING TO ODOUR

**Acceptability criterion** A level of exposure (of sensitive receptors) which, according to current understanding, is acceptable to the majority of the population. These criteria are expressed in terms of a number of odour units as a percentile of a year of hourly means and are based upon dose effect studies undertaken around a number of odour-emitting industry types. The term "odour exposure criterion" has the same meaning.

**Analytical assessment** An assessment of an odorous sample using instrumentation to provide a information on the concentration and possibly identification of the chemical species present. Compare with "sensory" assessment.

**Anosmia:** Lack of sensitivity to olfactory stimuli – unable to detect odours at all (compare with hyposmia)

**Area source** A surface-emitting source, which can be solid (for example the spreading of wastes, material stockpiles) or liquid (storage lagoons, effluent treatment plant).

**Detection threshold** The point at which an increasing concentration of an odour sample becomes strong enough to produce a first sensation of odour in 50% of the people to whom the sample is presented. This is a laboratory-based test and should be conducted according to the relevant CEN standard. The odour concentration at the detection threshold is one odour unit.

**Exposure** Concentration x duration x frequency of the odour to which a receptor is exposed.

**Fugitive releases** Unintentional emissions from e.g. flanges, valves, doors, windows – that is, points which are not designated or intended as release points.

**Hedonic tone** A judgement of the relative pleasantness or unpleasantness of an odour made by assessors in an odour panel. A methodology is described in VDI 2882. (Compare with "offensiveness"). Odours which are more offensive will have a negative hedonic score whilst less offensive will have a positive score. Hedonic scores are listed in Appendix 10.

**Hyposmia** Partial inability to detect odours (compare with anosmia)

**Odour concentration** The amount of odour present in a cubic metre of sample gas at standard conditions. The odour concentration is measured in European odour units ($ou_E\ m^{-3}$). The odour concentration at the detection threshold is defined to be 1 $ou_E\ m^{-3}$. If an odour sample has been diluted in an olfactometer by a factor of 10,000 to reach the detection threshold, then the concentration of the original sample is 10,000 odour units.

**Odour unit:** The amount of odorant(s) that, when evaporated into 1 cubic metre of neutral gas at standard conditions, elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM), evaporated in one cubic metre of neutral gas at standard conditions

**Offensiveness** An expression of the degree of unpleasantness of one odour relative to another. The perceived offensiveness of an odour will vary between individuals as a result of both physical and psychosocial differences, but in a population a relatively consistent response on the relative offensiveness of different odours is returned.

**Olfactometer** Apparatus in which a sample of odorous gas is diluted with neutral gas in a defined way and presented to a odour panel under reproducible conditions.

**Panel member** An assessor who is qualified to judge samples of odorous gas, using olfactometry within the scope of the CEN Olfactometry standard. An assessor has to fall within defined limits of sensitivity as set out in the CEN standard.

**Point source** An intentional point of release such as a vent or chimney, where it is usually possible to obtain a sample in order to quantify the mass release rate

**ppb** Parts per billion

**ppm** Parts per million

| | |
|---|---|
| **Recognition threshold** | The odour concentration which has the probability of 0.5 of being recognised under the conditions of the test. The recognition threshold is generally a higher concentration than the detection threshold. It is generally two or three odour units in a laboratory setting but may be higher than this outside the lab. |
| **Sample** | The odorous gas sample which is assumed to be representative of the gas mass or gas flow under investigation, and which is examined for odour concentration. |
| **Sensitive receptor** | People who are exposed to odour released from a given source, or have the potential to be exposed. Unlike other pollutants, odour at environmental exposure levels is not considered in terms of possible detrimental effects on animals and plants. |
| **Sensory** | Relating to the human response to a particular stimulus (in this case, odour). Compare with "analytical" methods of assessment. |

# APPENDIX 1 - Attributes and quantification of odorous releases

## Describing odour

There are four interlinked (sensory) characteristics that are used to describe an odorous emission:

1. ***Hedonic tone***
   This is a judgement of the relative pleasantness or unpleasantness of an odour made by assessors in an odour panel. The method for measuring hedonic tone is given in VDI 3882, Part 2 (Reference 18).

   Outside of a laboratory setting this parameter can be subject to substantial variation between individuals. Some odours may be pleasant when weak but unpleasant when strong, or when exposure is frequent. A list of "hedonic scores" is given in Appendix 10 – this is a ranking of everyday odours which can assist in determining relative offensiveness of different odours. (These are also referred to as "Dravnieks").

2. ***Quality/Characteristics***
   This is a qualitative attribute which is expressed in terms of "descriptors", e.g. "fruity", "almond", "fishy". This can be of use when establishing an odour source from complainants' descriptions. Alternatively, it may be possible to identify key chemical components by a description of their specific odour. A list of descriptors is given in Appendix 10.

3. ***Concentration***
   The "amount" of odour present in a sample of air. It can be expressed in terms of ppm, ppb or in mg $m^{-3}$ of air for a single odorous compound. More usually a mixture of compounds are present and the concentration of the mixture can be expressed in odour units per cubic metre ($ou_E$).

4. ***Intensity***
   Faint to strong. *Perceived intensity* – is the magnitude (strength) of *perception* of an odour. Intensity increases as concentration increases but the relationship is logarithmic. Increases or decreases in concentration of an odour do not always produce a corresponding proportional change in the odour strength as perceived by the human nose. This can be important for control where an odour has a strong intensity at low concentration as even a low residual odour may cause odour problems. The method for measuring intensity is given in VDI 3882, Part 1 (Reference 17).

Odour quality, hedonic tone and concentration influence the perceived odour intensity (and potential for annoyance), although the response to a particular odour will vary between individuals.

The most commonly used of the above attributes is concentration, but the hedonic tone (which is a consideration in "offensiveness") is also important. The following terms – detection threshold, recognition threshold and odour units - are largely used to describe concentration.

***Detection threshold***

The threshold of detection is the point at which the increasing concentration of an odour sample becomes strong enough to produce a first sensation of odour. As there is some variation amongst individuals, the definitive threshold value is a statistically derived value that represents an "average" response from 50% of trained observers. A list of odour threshold values is given in Appendix 10 for individual odorous compounds. Such values are expressed in ppm, ppb or in mg $m^{-3}$ of air and are different for different substances

*Mixtures of odorous compounds* are treated in much the same way - the "strength" is considered in terms of the number of times that a sample of the mixture has to be diluted before it becomes just detectable to 50% of the panel of observers (this point is equivalent to one odour unit). The concentration of the original sample is expressed in terms of the number of dilutions or in odour units. Other ways of expressing the same thing are TON (Threshold Odour Number) or DTT (Dilutions To Threshold).

A number of different methodologies have been used over the years and so there can be incompatibility between the quoted threshold of detection (and hence the magnitude of one odour unit) for the same substance or mixture. This is most noticeable in the figures given for odour threshold values for single compounds in Appendix 10; they can vary by orders of magnitude between different publications, depending on the test method used. As a general rule, the more recent values are more reliable than older ones.

***Recognition threshold***

The concentration at which an odour becomes *recognisable* is not the same as the concentration at which it is detectable. Whilst the detection threshold is the point at which it can be ascertained that an odour is present, a higher concentration is usually required before the odour can be recognised, i.e. it can be categorised or described by a trained observer. The recognition threshold is generally about three times the detection threshold, although this may be higher outside of a laboratory setting.

***Odour units***

***What is an odour unit?***

An odour unit, as described above, is a measure of the concentration of a mixture of odorous compounds in a sample. It is determined by means of olfactometry (described in Part 2 of this Note).

The unit links a physiological response (the detection of odour by the nose) to exposure to a particular sample and expresses it in terms of a single number. The sample could be one of many odorous substances or mixture of substances, and so the odour unit will vary between test samples. A baseline value for the odour unit is defined in a standard method given in the draft CEN standard on olfactometry (Reference 19) using n-butanol. This is used to "calibrate" odour panel members. An odour unit as defined by the CEN standard is 1 $ou_E$. (European Odour Unit)

A considerable amount of work has been undertaken in the Netherlands on odour exposure and response but it should be noted when looking at earlier work that the pre-CEN odour unit differs from the European odour unit by a factor of 2 (one European odour unit equates to two Dutch odour units).

***How "strong" is an odour unit?***

The figures given here are generalised assumptions based upon laboratory-based experiments on perceived intensity. They are given here to provide some context to discussion of exposure to odours and guideline values.

- 1 $ou_E$ $m^{-3}$ is the point of detection
- 5 $ou_E$ $m^{-3}$ is a faint odour
- 10 $ou_E$ $m^{-3}$ is a distinct odour.

However, it is important to consider the following points to put this into the context of a non-laboratory situation:

- people are continuously exposed to a medley of "background" odours at different concentrations, and can often be unaware of them – individuals may develop a "tolerance", i.e. the receptors in the nose lose sensitivity and/or the mind may screen them out. In the laboratory the determination of the detection threshold is made against a background of non-odorous air and carefully controlled conditions. Normal background odours such as from traffic, grass cutting, plants, etc, ie the "normal" medley of "environmental" odours, amounts to anything from 5 to 40$oum^{-3}$ (Reference 16, also see Section 2.5.1).
- The recognition threshold is often about three odour units, although it can be less for offensive substances and more if a person is distracted by other stimuli.
- A rapidly fluctuating odour is often more noticeable than a steady background at low concentration;

***Offensiveness***

Offensiveness is related to the "unpleasantness" of an odour. The perceived offensiveness of an odour will vary from person to person, and for any particular odour the offensiveness may vary according to concentration and the context within which the exposure takes place (for example, at meal times, or when feeling unwell). Historical events associated with a particular odour can also affect attitude.

The 1936 Public Health Act defined a number of "offensive" trades. Nearly all involved animal remains, or by-products. This Act has now been superseded, and many of these activities (where still undertaken) will not be A1 activities regulated by the Agency in England & Wales. They will however be regulated by SEPA in Scotland and EHS in Northern Ireland. It is still however a useful pointer to the types of compounds which could reasonably be considered to be amongst the more offensive. Sulphides and mercaptans for example may be present in the emissions from a range of other Agency-regulated processes where putrescible materials are handled or arise from anaerobic breakdown of materials.

The offensiveness of an odour will affect the concentration at which annoyance occurs and the degree of that annoyance. This is very relevant to regulation of odorous releases. Persistence and frequency of exposure are also important. Some odours will be offensive to nearly everybody, whilst others may be relatively inoffensive. However, all odours have the potential to be offensive and cause annoyance if exposure is frequent and at high concentration. See also Appendix 8 which gives a procedure for subjective testing that includes offensiveness as a category.

In addition to the Offensive Trades mentioned above, other sources of information which may help in determining how offensive a particular odour is, relative to other odours, are:

- Hedonic Scores (also referred to as “Dravnieks”).
  This is a list of everyday odours, based on data from the USA, which are ranked in terms of relative pleasantness and unpleasantness (see Reference 20). Less detailed information is available for industrial type odours. These are listed in Appendix 10, under the heading “hedonic scores”, together with a description of how they were derived.
- UK and European odour ranking study
  A study has been undertaken in the Netherlands amongst people dealing with odour professionally (see Reference 15). This has subsequently been repeated amongst a similar group in the UK to identify any significant differences between the groups. Several hundred responses have been evaluated and work is currently underway with a much larger group.

  Table A1.1 shows the ranking according to the UK results and compares these with the Dutch results and the USA hedonic (Dravnieks) scores. This shows that the rankings show good general agreement between nationalities for the purpose of determining the relative offensiveness of different everyday and industrial odours.

**Table A1.1: Ranking table for everyday and industrial odours**

| Generic odours | Hedonic score Dravnieks,1994 | Ranking | Ranking | Ranking | Ranking | Ranking | Ranking | Environmental odours |
|---|---|---|---|---|---|---|---|---|
| Descriptor | USA | UK median | UK mean | NL mean | NL mean | UK mean | UK Median | Descriptor |
| Roses | 3.08 | 4 | 4.4 | 3.4 | 1.7 | 2.5 | 1 | Bread Factory |
| Coffee | 2.33 | 3 | 4.5 | 4.6 | 4.6 | 3.9 | 2 | Coffee Roaster |
| Cinnamon | 2.54 | 4 | 4.9 | 6 | 5.1 | 4.6 | 3 | Chocolate Factory |
| Mowed lawn | 2.14 | 4 | 4.9 | 6.4 | 8.1 | 7.7 | 6 | Beer Brewery |
| Orange | 2.86 | 4 | 5.2 | 5.8 | 9.8 | 8.5 | 8 | Fragrance & Flavour Factory |
| Hay | 1.31 | 7 | 6.9 | 7.5 | 9.4 | 9.2 | 8 | Charcoal Production |
| Soap | 0.96 | 8 | 7.8 | 7.3 | 14 | 10.3 | 9 | Green Fraction composting |
| Brandy | | 9 | 8.8 | 7.8 | 9.8 | 10.5 | 9 | Fish smoking |
| Raisins | 1.56 | 8 | 8.8 | 7.9 | 9.6 | 11 | 10 | Frozen Chips production |
| Beer | 0.14 | 9 | 9.5 | 9.3 | 9.8 | 11.3 | 11 | Sugar Factory |
| Cork | 0.19 | 10 | 10 | 10.5 | 9.8 | 11.7 | 12 | Car Paint Shop |
| Peanut Butter | 1.99 | 10 | 10.4 | 11.1 | 12.8 | 12.6 | 12 | Livestock odours |
| Vinegar | -1.26 | 14 | 13.3 | 14.8 | 11.2 | 12.7 | 13 | Asphalt |
| Wet Wool | -2.28 | 14 | 14 | 14.1 | 13.2 | 14.2 | 15 | Livestock Feed Factory |
| Paint | -0.75 | 15 | 14 | 14.4 | 13.2 | 14.3 | 14 | Oil Refinery |
| Sauerkraut | -0.6 | 15 | 14.6 | 12.8 | 8.3 | 14.4 | 15 | Car Park Bldg |
| Cleaning Agent | -1.69 | 15 | 14.7 | 12.1 | 12.9 | 16.1 | 17 | Wastewater Treatment |
| Sweat | -2.53 | 18 | 16.6 | 17.2 | 15.7 | 17.3 | 18 | Fat & Grease Processing |
| Sour Milk | -2.91 | 19 | 18 | 17.5 | | 17.7 | 10 | Creamery/milk products |
| Cat's Pee | -3.64 | 19 | 18.8 | 19.4 | | 17.7 | 19 | Pet Food Manufacture |
| | | | | | | 17.8 | 18 | Brickworks (burning rubber) |
| | | | | | 17 | 18.3 | 19 | Slaughter House |
| | | | | | 14.1 | 18.5 | 20 | Landfill |

The above outcome in terms of ranking has been used in Appendix 6 in considering the relative offensiveness of different odour types.

## The measurement of odour

***The following is an overview of the methods for measuring odour. The different methods mentioned are covered in more detail in Part 2 of this note – "Assessment and Control" (Reference 1).***

In general terms odour can be "measured" in terms of:

***Analytical techniques***

- **Chemical analysis** – a sample is analysed to give the concentration of the different chemical species present. This information can then be used to calculate a total "odour concentration", although it doesn't take into account what the mixture smells like, ie its character or its offensiveness. This includes wet chemistry (drawing a sample through a solution), as well as sample collection followed by instrumental analysis, for example, gas chromatography (GC). Sometimes a single substance is chosen from all the compounds present to represent the total mixture (a surrogate).

- Direct reading **instrumental analysis** - provides information on the concentration of specific chemical species. This includes portable analysers (including portable GCs and GC-MS which can provide information in the concentrations of each constituent component relative to each other) as well as colorimetric tubes. The "electronic nose" also comes into this category but is a "difference" monitor – ie it detects a deviation from a set pattern of compounds.

***Sensory methods (ie relating to the human response):***

- A **sensory assessment** - gives an assessment of the physiological response to a particular mixture - strength, quality, characteristics - which provides information on the likely population response. This is obtained by exposing trained individuals to samples of the odorous air, either in the laboratory or in the field. Olfactometry and simplified olfactometric screening (also called sniff testing or subjective assessment), come within this categorisation as well as a number of field-based methodologies as outlined in Appendix 3.

These categories do not have clear cut-off points and some assessment methodologies could be considered to fall into more than one category.

Selection of a particular method will depend upon:
- the purpose of the measurement
- the frequency (once off or frequent/continuous) etc
- the location at which the odour is sampled
- whether a point source or surface/area source
- the complexity of the emission - a single compound or a complex mixture.

Part 2 of this note considers the following techniques and shows the context within which their use might be appropriate:

| | |
|---|---|
| ***Chemical analysis*** | Gas chromatography and GC-MS<br>Substance-specific wet chemistry methods |
| ***Direct reading instruments*** | Colorimetric tubes<br>The "electronic nose"<br>Portable analysers |
| ***Sensory assessment*** | Olfactometry<br>Simplified olfactometric screening – sniff/subjective testing |

# APPENDIX 2 - Factors affecting human response

## The aim of this Appendix

This Appendix underpins Sections 2 and 3 of this document, and aims to give an overview of:

- the terms used to describe an adverse response
- the chain of events which lead from a release of odour to annoyance
- the reasons for variation in response between individuals – why some are more sensitive than others, and
- how much odour is annoying – and how much is acceptable.

**This is compiled from the best information that has been made available at the time of writing. It is acknowledged that more research on the response to odours would be desirable and this text will be reviewed should additional relevant data become available.**

## The characteristics of individuals which affect their response to odours

***The sensitivity of the general population, and of individuals, to odours***

Olfactory acuity (the ability to smell a certain odour) in the population follows a lognormal distribution. Two percent are predictably hypersensitive and 2 percent are insensitive. The insensitive range includes those who are unable to smell at all (anosmic) and those who are partially unable to smell (hyposmic). A person may be relatively insensitive to one smell and abnormally sensitive to another.

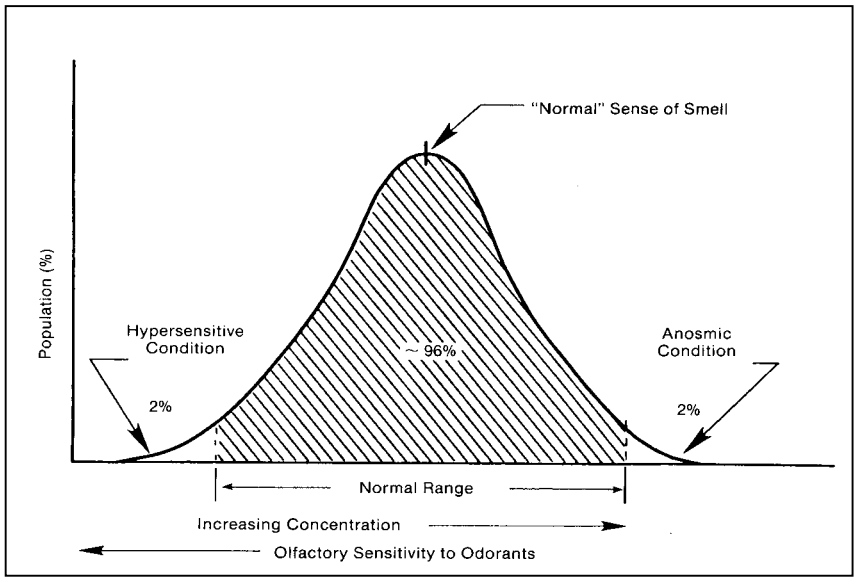



**Figure A2.2: Diagram representing a frequency distribution of olfactory sensitivity**

The non-specified values on the horizontal axis (e.g. ppb n-butanol at detection threshold) are typically expressed in log values (after log transformation).

***Variation between individuals***

There are a number of factors which affect the variation in response to odours between individuals. These can be broadly described as:

(i) physical, and
(ii) psychosocial

*Physical:*

The ability to detect odours varies with age; increasing age correlates with decreasing ability. Women tend to show a slightly heightened sensitivity compared with men at any given age. Smoking habits can affect olfactory sensitivity, with smokers being less sensitive than non-smokers.

*Psychosocial:*

Once a person detects an odour there are a number of factors which may affect the way in which he/she responds. These include the history of previous exposure, current state of health and perception of risks to health from emissions, economic dependence on the source, expectations, coping strategies, residential satisfaction and personality. See Reference 15 for more detailed information.

The following theories have been tested and confirmed by various researchers (Reference 15).

- Individuals with health complaints have a higher probability of experiencing annoyance than others at the same exposure level, (the link is the occurrence of annoyance, not a link between exposure to odour and prevalence of health complaints).
- Individuals who are anxious that odour is related to a health risk have a higher probability of experiencing odour-induced annoyance than those who are not anxious.
- Where an individual has a history of exposure and odour related annoyance it may lead to a long term heightened annoyance sensitivity, even a number of years after the high exposure has been abated.

*Individuals with increased tolerance*

There are three main divisions of individuals who can have an increased tolerance to particular odours (excluding those who have a decreased ability to detect odours) (Reference 15).

(i) Those who have a vested interest, i.e. individuals with an economic interest in the activity associated with the source of odour are less likely to experience annoyance than others and can tolerate a higher dose before they become annoyed.

(ii) Those who are accustomed to it – a higher dose can be tolerated better than by someone who is not accustomed to it, but not as much as those with a vested interest.

(iii) Those who either do not perceive the odour as a result of attention to other, more important, life matters or those who automatically develop a coping strategy.

*Hypersensitive individuals*

The most sensitive section of the population will be able to detect some odours at a concentration that lies below the threshold of detection for the majority of the population. Within this, further sub-sets can be identified:

(i) Those who have an acute awareness of an odour exposure situation: there is a difference between the level of odorant that *can* be detected and the level which *will* be detected, i.e. where the attention of the subject is focussed upon the sole objective of detecting odour as compared to someone who is distracted by other matters.

(ii) Those who have a medical condition which can produce a degree of hypersensitivity. In addition to the increased likelihood of annoyance in those with health problems, some medical conditions may increase sensitivity to odours in some individuals.

## How much odour is annoying - and what is “acceptable”?

Complaints can serve as good indicators of an operational malfunction and the effectiveness of on-going control, but cannot provide a reliable estimation of the state of annoyance of a community. They are ungraded, all-or-nothing, responses and are not suitable for measuring small amounts of annoyance in a sensitive way. They only occur when a certain threshold of dissatisfaction has been exceeded.

Guideline values published by the World Health Organisation (see Appendix 5) indicate “acceptable” benchmark exposure levels, which are based on avoidance of annoyance, for a handful of single odorous substances, but equivalent benchmarks do not exist for mixtures of substances. This document, in Appendix 6, sets out a method for determining values for an acceptable ground level concentration for odorous mixtures which are tailored to particular installations, as required by the Regulations.

***Dose-effect studies***

The only realistic way of estimating the actual level of annoyance in a particular community resulting from exposure is by carrying out dose-effect studies locally. Such a study links the exposure (determined by mathematical modelling of emissions from the installation) to the level of annoyance (which is determined by a standardised questionnaire that disguises the purpose of the survey). Alternatively the response can be based on complaint records but this is less accurate, (Reference 15).

A number of these studies have been undertaken in Europe for different industry/process types using a common methodology and the information has been extrapolated for application to other populations with due regard for any particular local factors. Such studies are fairly limited at present, (Reference 15).

Exposure is usually quantified in terms of a frequency of occurrence over a year of hourly average concentrations above a certain limit odour concentration; e.g. 2 odour units per cubic metre ($ou_E \cdot m^{-3}$) as a 98-percentile of hourly averages of odour concentration for a year: $C_{98}$ = 2 $ou_E \cdot m^{-3}$. This is calculated from an estimated or measured odour emission from the source, and local meteorological (“worst case” is usually considered) and terrain input data, using an atmospheric dispersion model.

# APPENDIX 2 - FACTORS AFFECTING RESPONSE

In this document “no reasonable cause for annoyance” describes a point where the majority of the exposed population (90%) report that they are not annoyed, i.e. they find exposure at that level is acceptable. The 10% “annoyed” point is reckoned to be a lower limit of detection for the assessment methodology, i.e. the point at which we can show with good statistical confidence that the result is “real” and does not arise from the methodology used in the survey. Beyond this point, according to our current understanding, it is considered likely that there may be reasonable cause for annoyance. A description of these studies is outlined in Reference 15. Work will be on-going to further expand our understanding.

***Does the level of acceptability vary according to the offensiveness of the odour?***

The dose-effect studies have shown that the more offensive the odour, the lower the acceptable exposure level. There are no clear cut-off points for categorising the degree of offensiveness but, (see Appendix 1 and Reference 15), it is possible to obtain a reasonably consistent ranking of relative offensiveness across a sample population and between populations. Further work is being undertaken to support this.

***Determination of installation-specific acceptability***

Using the outcomes from the dose-effect studies, a series of indicative odour exposure “acceptability” criteria for mixed odours have been derived for different types of industrial odours based on their relative offensiveness, (Reference 15). These relate to modelled ground level concentrations at sensitive receptors and represent our best understanding of a level of exposure which is reported as being acceptable by a high proportion of those exposed. This information is as close as we can get with the current level of understanding to determining a numerical value which represents “no reasonable cause for annoyance”.

IPPC requires that installation-specific factors be considered in determining appropriate Permit conditions. The appropriate indicative odour exposure criterion will therefore need to be adjusted for the local environment as described in Appendix 6. The resulting installation-specific odour exposure acceptability criterion can be used as a basis (benchmark) for determining the appropriate maximum odour emission rate that equates to “no reasonable cause for annoyance” and the Operator should go as far as possible towards achieving this by the application of BAT (see Section 2.4 and Section 1.2)

The indicative odour exposure acceptability criteria and a simplified methodology for determining an installation-specific criterion are given in Appendix 6.

***Should the size of the exposed population be taken into account?***

The balance of cost and benefits will shift towards the expectation that the cost of odour control will be greater where the environment is more sensitive, for example where the exposed population is large. A larger population is likely to contain a greater number of hypersensitive individuals. Conversely, where an odorous release is remote from any population the balance of costs and benefits might be expected to tip towards the expectation of lower expenditure when compared to the previous example. However, the possibility of future development closer to the installation should be always be considered and, should this occur, then BAT may be adjusted accordingly. It should be remembered that a sensitive receptor can also be a park or a footpath.

The indicative odour exposure acceptability criteria given in Appendix 6 are based upon dose response studies and what we currently understand to be a “lower limit of detection” in terms of the percentage exposed individuals reporting annoyance. Normally no adjustment would be required for population size as it is already taken into account but it might be appropriate to make an adjustment where the “footprint” of effect is large and a large number of people are affected.

# APPENDIX 3 - An overview of odour impact assessment

***This Appendix should be read in conjunction with Section 2.4.***

*Part 2 of this document – Assessment and Control – describes a number of these tools in more detail.*

*Appendix 4 of this Note gives an outline of recommended parameters for mathematical dispersion modelling.*

## The aim of this Appendix

This Appendix (together with Section 2.4 (2)) describes odour-specific aspects of environmental impact assessment and outlines the tools that are available to do this.

It outlines:

- the circumstances under which an odour impact assessment may be required
- the types of methodologies that are available
- the process of selecting the right methodology for a particular situation
- the considerations that need to addressed during the process of planning and undertaking an assessment
- the process of comparing the result with a benchmark or other indicator of acceptability (which leads into Appendices 5 and 6)

## When is an odour impact assessment needed?

***To provide a baseline for a Permit application:***
An odour impact assessment will be needed if:

- the application is for a new installation or an extension to an existing installation if the activities could release odour which could potentially impact upon sensitive receptors. Note that an assessment undertaken as part of an application for Planning permission may not be sufficient for an IPPC application
- there is a history of complaints or odour problems, and/or
- odour is detectable beyond the boundary or at sensitive receptors.

***For comparing different abatement options:***
Guidance Note H1: "Environmental assessment and appraisal of BAT" should be consulted when comparing the odour performance of control options – i.e. for options appraisal (Reference 12).

*Guidance Note H1 covers:*

- screening out of those installations which are of sufficiently low risk (from an odour point of view) to warrant no further information on odour
- screening out of insignificant sources on an installation which poses some risk to sensitive receptors (this guidance note – H4 - will provide the information to assess those sources which are not screened out by H1), and
- a methodology to compare different proposed abatement options (which may be to abate odour, or for a wider purpose) in terms of their total environmental impact, ie looking at issues such as energy use, wastes generated, water or other raw material usage, costs etc.

***Other reasons for undertaking an assessment:***
In addition to providing a baseline relating to the odour impact, an assessment might also be undertaken for:

- predicting the impact of a new plant, or an extension/modification of existing plant
- investigating complaints (see Section 29 and Appendix 9)
- comparing the effect of different operational changes, or
- looking at long term trends.

# APPENDIX 3 - AN OVERVIEW OF TOOLS FOR ENVIRONMENTAL IMPACT ASSESSMENT

## What sorts of "tools" are available?

Several methodologies, or "tools", are available for assessing the environmental impact of odorous releases. These range in complexity from simple (and imprecise) to detailed (with a corresponding increase in accuracy). It may be appropriate to undertake a simple assessment as a screening exercise or scoping study to identify and/or prioritise sources before carrying out more detailed work. In some cases where risk is low a simple screening assessment may be sufficient on its own.

Odour impact assessment tools can be broadly classified into two types.

(i) Those that estimate the "footprint" of effect of the activity by mathematical modelling of actual or estimated/predicted emissions:
- simple "indicative" models, e.g. dmax or Schauberger & Piringer (for livestock)
- complex mathematical atmospheric dispersion models.

(ii) Those that use information collected at the receptor(s), based on the opinions and judgement of those exposed, to estimate the extent of the footprint.
   (a) Assessment of community response:
   - complaint histories (based on past and present experiences)
   - attitude surveys (based on past exposures)
   - population panels or odour diaries (on-going assessment of the current situation).

   (b) Assessing the extent and magnitude of the exposure in the community:
   - field judges/panels.

These are described in Section 1 of Part 2 to this Note (Reference 1).

There is also a third form of assessment which relates to the process or activity rather than to impact on receptors – this is to undertake a thorough review of materials used and generated, products, wastes and release points. This is described in Section 1.4 of Part 2 of this Note (Reference 1).

## Selecting the appropriate methodology for assessing odour impact

Selection of an appropriate assessment methodology is not always straightforward. Considerations will need to include:
- why is the work being undertaken? (see preceding text)
- have assessments been carried out previously? (there may be a need to follow a previous methodology)
- how much detail is required (and what is the cost of obtaining it?)
- is the risk of causing annoyance high or low? (more detail will be required if the risk is high, if it is very low an assessment may not be required.)

Also the type of source, and ease of obtaining emissions data, should be considered:
- can emissions be measured or predicted?
- can information be obtained from those exposed to the odour?

An indication of what might be suitable for the purpose of providing an impact assessment for Permit application purposes can be gained from the type of operation/or source type (as per Table A3.1). The table also indicates in broad terms how the level of risk can be addressed in the choice of methodology. The previous history will also have some bearing on this.

## Undertaking an assessment and interpreting the output

Figures A3.1 and A3.2 on the following pages outline the process of undertaking an odour impact assessment and the potential outcomes for activities or operations where:

(i) (Fig A3.1) the odour emission rate can be measured, estimated or predicted. This applies to source type 1 (where assessment is required), source types 2 and 3, source types 5/6.

(ii) (Fig A3.2) the odour emission rate cannot be measured, estimated or predicted. This applies to source type 1 (where assessment is required), 4, 5/6)

The "source types" referred to above are described in more detail in Table A3.1 overleaf.

# APPENDIX 3 - AN OVERVIEW OF TOOLS FOR ENVIRONMENTAL IMPACT ASSESSMENT

**Table A3.1 and Figures A3.1 and A3.2 are not meant to be prescriptive.** They can be used to give an indication of the options available and the thought process leading up to an assessment and the interpretation of the output. Appendices 5 and 6 describe the benchmarks which link exposure and acceptability.

Detailed information on assessment methodologies is given in Part 2 of this document (Reference 1).

# APPENDIX 3 - AN OVERVIEW OF TOOLS FOR ENVIRONMENTAL IMPACT ASSESSMENT

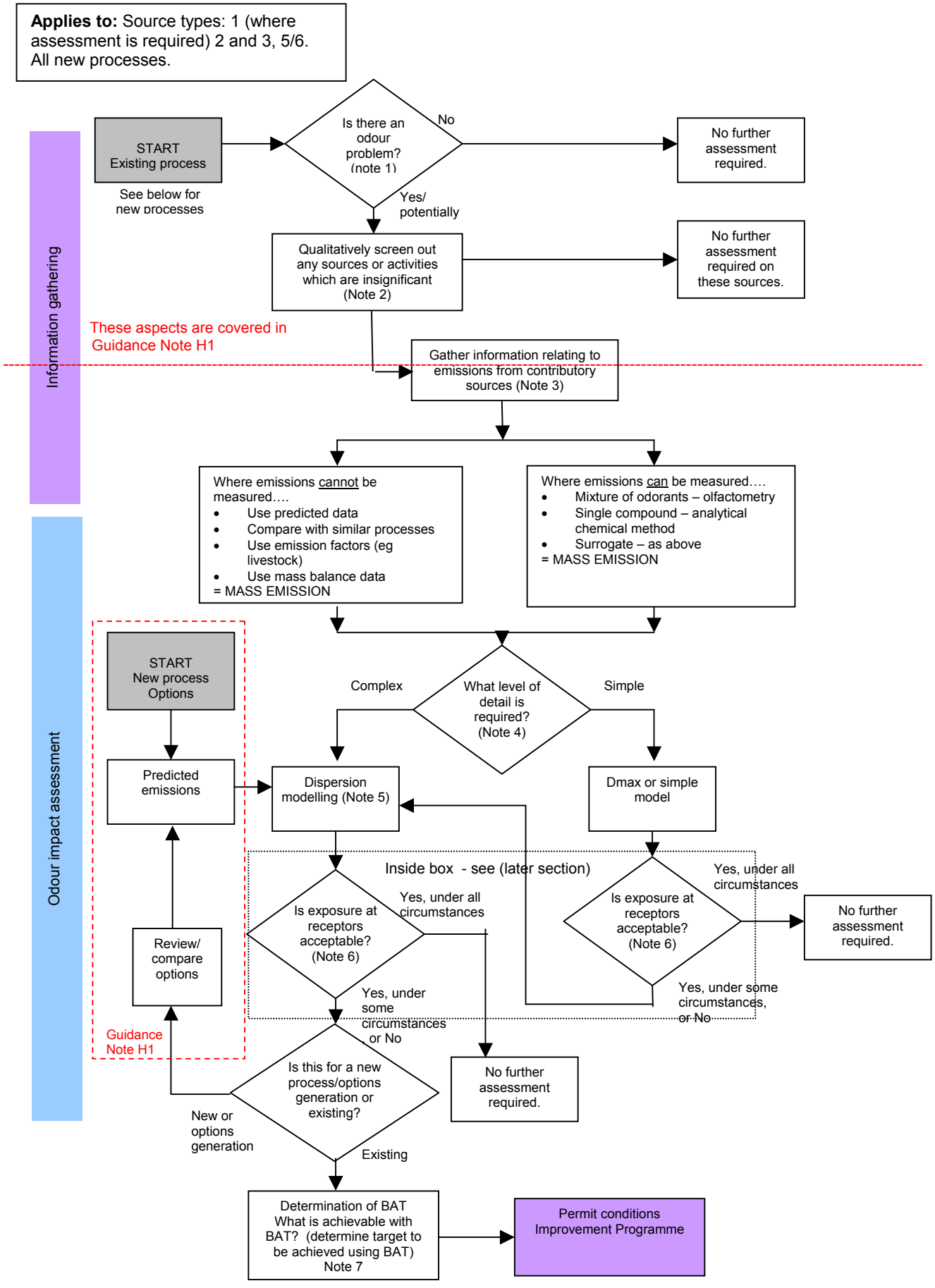
**Table A3.1: Guide to Impact Assessment requirements for Permit Application purposes**

| Odour source type | Examples of this source type | Factors affecting the amount of effort involved | Type of impact assessment tool which might be suitable. |
|---|---|---|---|
| 0. Inherently non-odorous activities undertaken | | Short justification/statement required. No further assessment work need be undertaken. | Not applicable |
| 1. Low odour risk due to remote location | Installation is remote from receptors, no complaints have been received. Odour emissions may be sufficiently high that complaints would be received if receptors were closer, or if new land development encroaches on the installation boundary. | More effort may be required to predict the potential impact of new plant. A simple risk assessment may not be sufficient for a new installation if the process is potentially odorous. | Simple risk assessment showing radius of effect may suffice. Use actual or predicted emissions. (See Part 2). |
| 2. Contain, treat and discharge. Dispersion is not relied upon as little or no residual odour. | Treatment leaves no residual odour and discharge may be at high or low level. Odour stream may be fed into and consumed within a further process (e.g. reception hall air from a municipal waste incinerator is used as combustion air).<br><br>There is no requirement to rely upon dispersion as a means of control. | The risk of annoyance should generally be low unless there is a malfunction or poor control/high level of variability and treatment is not sized correctly.<br><br>Frequent malfunction = higher risk and more effort. | Depends upon level of risk. If high, as for source type 3.<br><br>If risk is low can use radius of effect (See Part 2)<br><br>Measure actual emissions, may need to predict for worst case. There may be some opportunity for using surrogate substances which are easier to measure/predict (see 2.5.1 and Part 2).<br><br>For new installations the requirement will depend upon the type of activity and proximity of receptors. There will usually be a need to model worst case odour scenarios. |
| 3. Contain, treat (maybe) and discharge. Reliance on dispersion to prevent residual odour from causing annoyance. Release is usually at high level. | Odour may arise from raw materials or be generated during the process. Treatment leaves a residual odour, or there may be no treatment. There is a reliance on dispersion to prevent annoyance at receptors. Release is usually at high level – may be a stack or roof vents. | The amount of effort expended on the assessment and time allowed for acquiring the necessary input data may depend upon the effectiveness of control and/or efficiency of treatment.<br><br>The risk of annoyance may be higher if dispersion is poor and or receptors are close. Even if dispersion is good there may be occasional grounding of plume in adverse weather conditions. | Simple (or scoping study) – calculate radius of effect if control is good and consistent and stack emission data is available.<br><br>It will be more difficult to measure emissions where there are a large number of vents – it may be appropriate to measure at one vent and multiply up. For livestock use emission factors (See Part 2 of this Note).<br><br>Where risk is higher (for example because emissions are variable, dispersion can be poor, receptors are close) – more detailed assessment is necessary. Measure or predict emissions and undertake dispersion modelling to ascertain ground level concentration at sensitive receptors (see Appendix 4).<br><br>Calculate installation-specific odour exposure (acceptability) criterion for mixtures of odorous substances (Appendix 6). Compare actual to what is acceptable.<br><br>Use of surrogates may be acceptable – see 2.5.1 and Part 2 |
| 4. Open air operation. No containment. | Odour cannot be contained within the process by virtue of the type of activity (e.g. effluent treatment plant which cannot be covered, lagoons etc). BAT requires good management techniques and adherence to best practice. | More effort should be expended where management control is poor and receptors are close. | If it is possible to measure or predict emissions (for the range of conditions), then as for source type 2<br><br>If not possible, then may need to rely on complaint histories or get Operator to carry out attitude surveys as an improvement condition (see Part 2) or use field judges.<br><br>There may be some opportunity for using surrogate substances which are easier to measure/predict (see 2.5.1 and Part 2). Use of the odour potential may be appropriate (See Part 2). |
| 5. Odorous activity or resulting odour is potentially containable, although it may not have been achieved at the time of Permitting. | The odour has the potential to be contained but has not been or containment is incomplete. There may currently be multiple fugitive releases or buildings with openings. BAT is containment.<br><br>Example – clinical waste store. Additional control measures include temperature control and storage time restrictions. | Will depend upon number and type of sources, level of control and variability of the process. | If it is possible to measure or predict emissions (for the range of conditions), then as for source type 2.<br><br>If not possible, then may need to rely on complaint histories or get Operator to carry out attitude surveys or use field judges as an improvement condition (Part 2)<br><br>A detailed source inventory and prioritised work plan should be provided by the applicant. |

| Odour source type | Examples of this source type | Factors affecting the amount of effort involved | Type of impact assessment tool which might be suitable. |
|---|---|---|---|
| 6. Odorous activity or resulting odour is potentially preventable, although it may not have been achieved at the time of Permitting. | Generation of odour can be avoided for example by substitution of materials or changing operating conditions or parameters but has not yet been achieved. BAT is to prevent generation. | Will depend upon number and type of sources, level of control and variability of the process. | If it is possible to measure or predict emissions (for the range of conditions), then as for source type 2<br><br>If not possible, then may need to rely on complaint histories or get Operator to carry out attitude surveys as an improvement condition (see Part 2)<br><br>A detailed source inventory and prioritised work plan should be provided by the applicant. |

Source types 5 and 6 are similar for assessment purposes, but Permit conditions and improvement programmes would generally be different.

**Figure A3.1: Odour impact assessment where emission rate can be measured, estimated or predicted**



***Notes to accompany Figure A3.1***

**Note 1** This includes consideration of "worst case", e.g. no problem during the winter but complaints in the summer, or, only when the wind blows from the NE, or if complaints have been received ….this indicates the need for a "yes" response.

**Note 2** Insignificant in terms of contributing to the overall impact at sensitive receptors (under all operating conditions).

**Note 3** Where sources are completely different in terms of their odour characteristics it is often better to consider them separately in terms of impact on receptors. The combined impact may, or may not, be additive from a perceptual point of view. It may take a visit to the area, or evaluation of complaints to decide upon the best approach to take. It may be obvious where one odour is clearly stronger or more offensive, or exposure to one particular odour is more frequent than another.

**Note 4** The higher the risk, the more detail is required. However, it may be appropriate to carry our a simple scoping study first in order to ascertain the degree of risk in very general terms (ie in terms of whether complaints are likely) or to identify the priorities for more detailed work.

**Note 5** See Appendix 4 for guidance on recommended input parameters.

Model multiple sources together using an appropriate model. A common sense approach will need to be taken where sources are spread across a large installation in which case it may be appropriate to consider individual or groups of sources in terms of the specific receptors that may be affected. Also, on a large installation consider if different sources affect different receptors and also the effect of wind direction.

**Note 6** Relate model output to complaint history or compliance with conditions relating to subjective assessment. The consideration should include "worst case". Consider what is actually achievable with BAT.

**Note 7** The relevant Sector Guidance Note should be consulted in determining whether the Operator's proposals constitute BAT.

Compliance with odour exposure acceptability criteria (Appendix 6) and other odour benchmarks can rarely if ever be determined by taking measurements at the receptor. For regulatory purposes an appropriate benchmark will need to be interpolated to give an emission at source – which can be measured or calculated for compliance purposes.

The emission concentration which is acceptable for the purpose of preventing or minimising pollution in the form of offence to the sense of smell must then be compared with any relevant limits for specific compounds (i) as given in Sector Guidance, or (ii) devised for the purpose of maintaining air quality or (iii) avoiding harm to health.

Because many substances have a low odour threshold, in the majority of cases the restrictions imposed to avoid odour annoyance will be more stringent than those described above.

***Fig A3.1: Inside box – Impact Assessment (detail)***

***Is exposure acceptable at receptors?***

Acceptability in terms of the exposure of sensitive receptors is based upon comparison of the predicted exposure at sensitive receptors with:

1. guideline values for single substances (very limited number of substances – Appendix 5), or
2. odour thresholds (or multiples thereof) for single substances (see Appendix 5)
3. odour exposure criteria for mixtures of odorants, which can be adjusted for the particular local environment. (See Appendix 6)

The guideline values and odour exposure criteria are based upon avoiding "reasonable cause for annoyance". For single substances it is possible to derive an equivalent level of acceptability using published odour threshold values. This process is described in Appendix 5.

Sensitivity analysis of model predictions to critical model input parameters should be carried out. Conclusions and assessment need to take into account uncertainties in model predictions.

SEE FOLLOWING FLOWCHART WHICH DESCRIBES THE ACTIONS & DECISIONS REQUIRED

***Continued from previous page…… detail of impact assessment – is exposure acceptable?***

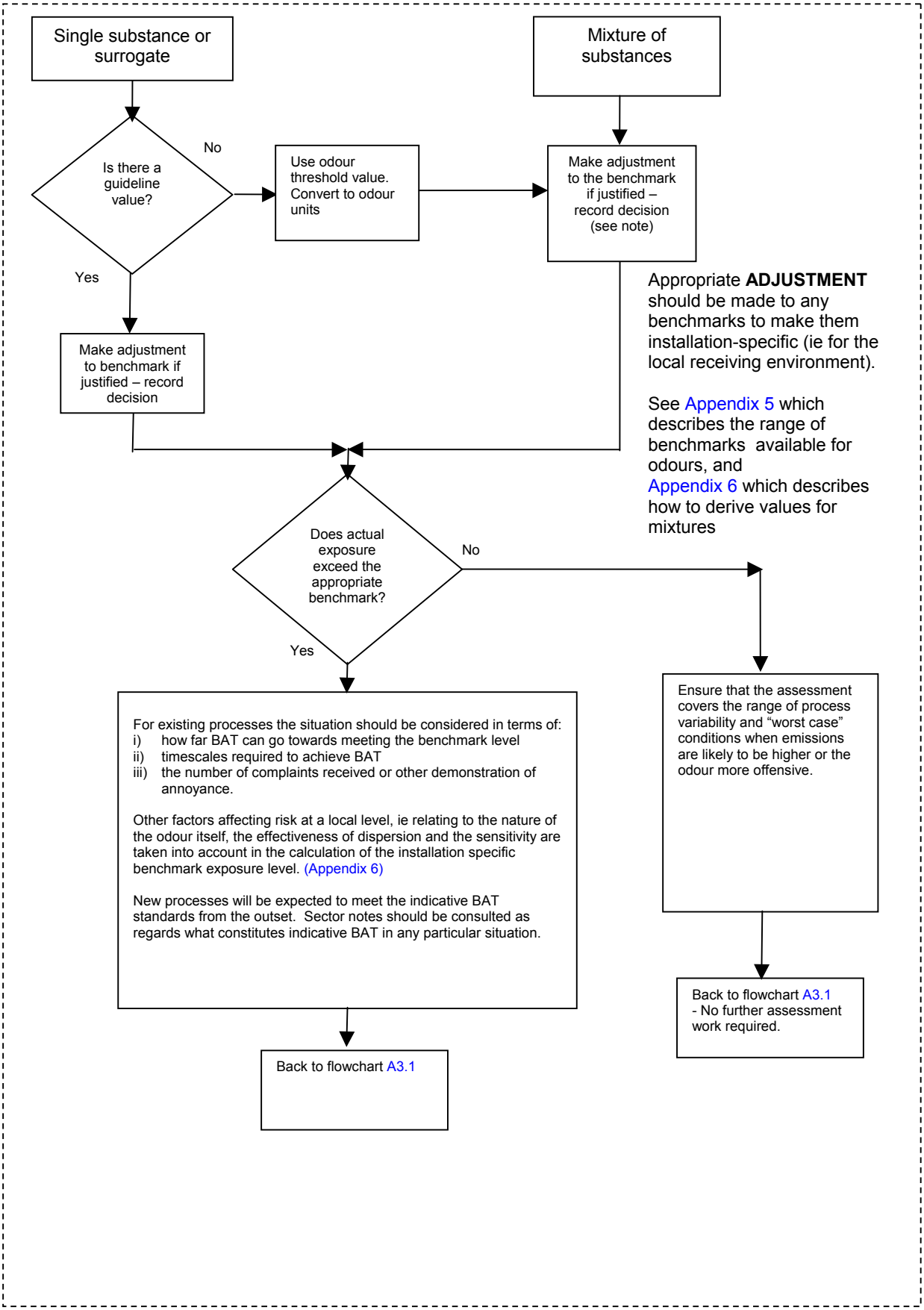
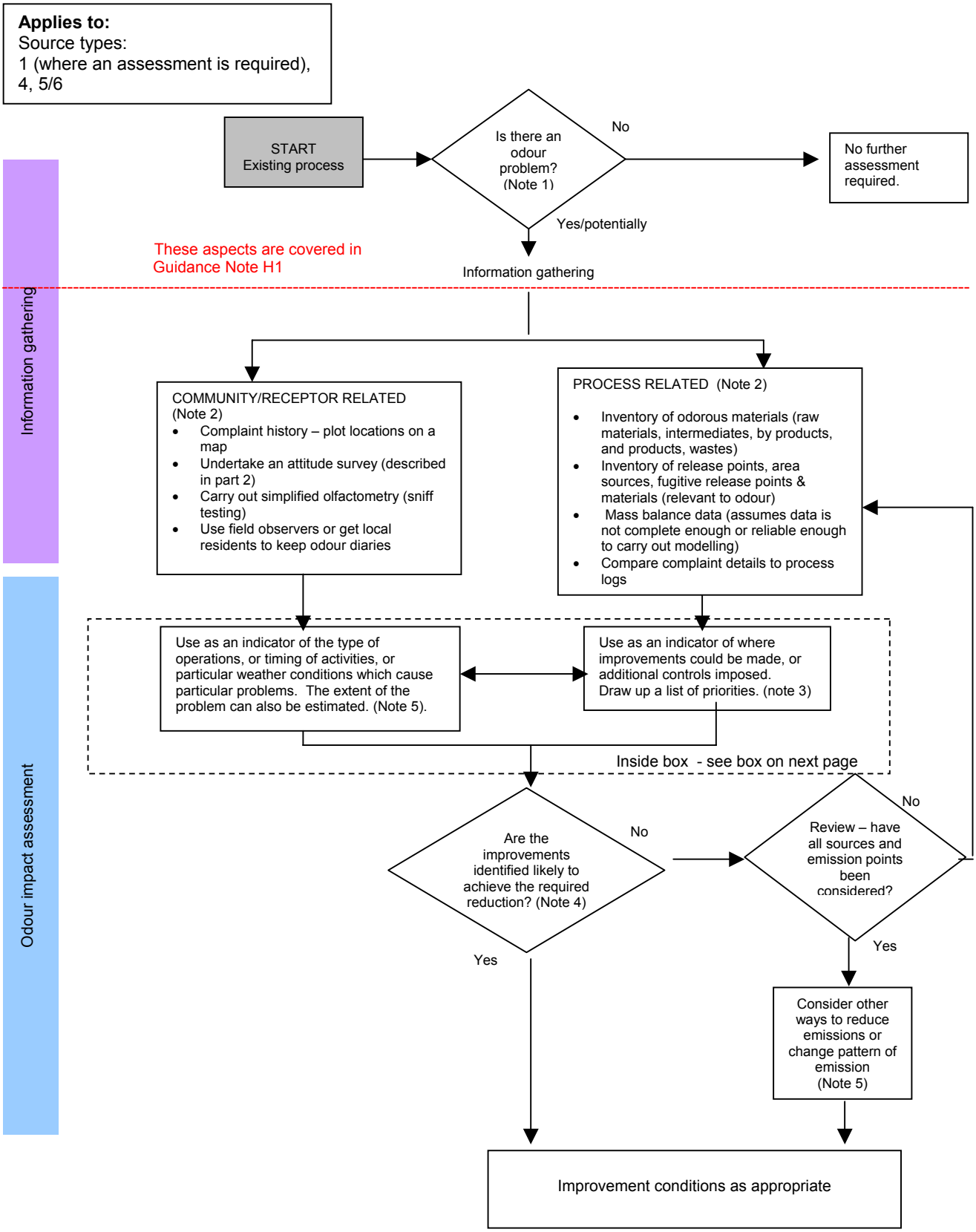


**Figure A3.2: Odour impact assessment where emission rate cannot be measured, estimated or predicted**



## APPENDIX 3 - AN OVERVIEW OF TOOLS FOR ENVIRONMENTAL IMPACT ASSESSMENT

***Notes to accompany Figure A3.2***

**Note 1** This includes consideration of "worst case", e.g. no problem during the winter but complaints in the summer, or, only when the wind blows from the NE, or if complaints have been received ….this indicates the need for a "yes" response.

**Note 2:** The methods for collecting information are described in Horizontal Guidance on Odour (H4) – Part 2 (Reference 1)

**Note 3**: consult the relevant Sector Guidance and this note. Improvements should be tackled on the basis of the list of priorities drawn up. Reassessment and review should be undertaken as successive improvements are made.

**Note 4**: See Appendix 2, 5 and 6 for guidance on what level of exposure is likely to be acceptable.

**Note 5**: Evaluation of the community response (e.g. odour diaries, complaints or surveys), or the outcome of subjective testing can give an indication of the degree of reduction needed and to prioritise the order in which specific issues are tackled. Consider:

- How strong is the odour?
- Is it constant in strength or fluctuating?
- Does it form a constant background or is there any pattern to the exposure?
- Does it smell the smell the same all the time, or does it change?
- Over what area is the effect felt?

It may be possible to match particular aspects of the exposure to specific events, operating parameters or weather conditions.

Examples of ways to reduce odour include:

- reducing throughput when adverse wind direction is likely to cause annoyance at sensitive receptors
- restricting particular operations at weekends or public holidays
- moving odorous operations to a less sensitive site, where possible.

***Inside box – Impact Assessment (detail)***

***Where impact cannot be measured in numerical terms, it has to be assessed in terms of the way in which exposed receptors respond, or alternatively based upon the views of an experienced observer (the regulatory officer), i.e. a qualitative assessment rather than quantitative.*** Information relating to response can be used as an indicator of how much exposure needs to be reduced by – i.e. a target for reduction.

The degree of exposure can be estimated by considering factors such as: (see Appendices 1 and 2)

Is odour present or not?
How strong is it?
How often is it present/pattern of exposure?
How "offensive" is it?

And

How many complaints have been received?
Do these relate to identifiable incidents or activities, or are they well distributed over time?

The aim, in applying BAT, should be to reduce odour exposure to the point where there is "no reasonable cause for annoyance". This may not mean "no odour".

***Use exposure as an indicator of where improvements could be made, or additional controls imposed.***

The consideration of exposure patterns may identify specific operations or materials which need to be better controlled or restricted in some way in order to achieve the desired reductions. Evaluation of the operation/process should give an insight into how reductions can be achieved. Sources should be prioritised as far as possible in terms of their contribution to the overall exposure and measures to reduce can be tackled in this order.

# APPENDIX 4 - Modelling of odorous releases

*This Appendix is NOT intended to be a guide to dispersion modelling. It is a necessarily brief outline of some of the main issues relating to the modelling of odorous releases, where these differ from non-odorous releases. It is included in order to promote consistency of approach and to allow comparison with the indicative values given for the purpose of assessing applications made under IPPC and for determining suitable Permit conditions. It is recognised that some of the information given below does not represent the latest research advances but it describes a tested approach. Expert opinion should be sought where there is doubt.*

## The role of dispersion modelling

Where the odour emission rate from a source is known by measurement or can be estimated, the odour concentration in the vicinity can be predicted by means of dispersion modelling. The model attempts to describe the effects of atmospheric turbulence on the emission(s) as they undergo dilution and dispersion in the surrounding environment. Concentration is *one* of the factors that determine the impact of a given odour on sensitive receptors (see Appendix 1).

The output from the modelling process is compared with an odour exposure (acceptability) criterion (in odour units) or a guideline value for avoiding annoyance (in ppb or $\mu g\ m^{-3}$). These are statistical means of linking the mass odour emission from a process to the impact as a ground level concentration, in terms of probability of occurrence, taking frequency of occurrence into account. It is sometimes necessary to evaluate impact above ground level, such as in high rise buildings and expert advice should be sought where necessary.

An example of an odour exposure criterion might be:

3 $ou_E\ m^{-3}$ as a 98th percentile of a year of hourly means

To visualise the extent of odour impact it is useful to produce contour plots showing odour concentrations around the source or highlighting where concentrations exceed the appropriate guideline value or odour exposure criterion (Appendix 5).

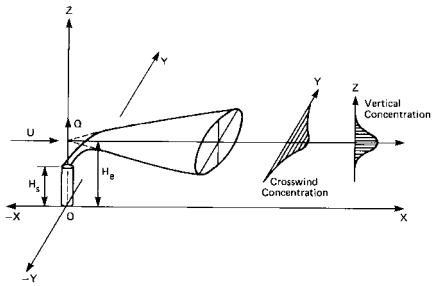



**Figure A4.1: Dispersion modelling**

# APPENDIX 4 - MODELLING OF ODOROUS RELEASES

## Dispersion models

A range of different models have been used for modelling the impact of odorous releases. Such models have a number of common features but there are differences in the way that data is dealt with between the older gaussian models and the new generation models such as AERMOD and ADMS. In particular there are differences in the representation of the behaviour of the atmosphere, ie a move from Pasquill Gifford stability categories to Monin Obhukov, and the calculation (or input) of upper air parameters.

Modelling of odorous releases is a developing field when compared to modelling of other pollutants, and there are a number of areas which need further validation, such as peak to mean ratios and appropriate averaging times.

This document proposes a "recommended" approach to odour modelling for the following reasons:

- to bring about a degree of consistency and to allow comparison between different installations and sectors
- the relationship between odour exposure and annoyance has been established in a number of epidemiological studies, upon which the indicative exposure values (benchmarks) for acceptability given in Appendix 6 are based. A particular modelling approach has been used in all of these studies. For the purpose of consistent approach in applying the indicative values given in this document the same relationships need to be maintained, hence the objective should be to use the same parameters that were used to establish the dose-effect relationships in the underlying studies.

The Agency does not favour or prescribe the use of any particular model. It is left to Operators/applicants to justify their choice of model (including the version). However the chosen model (and specific version) has to be fit for purpose and based on established scientific principles. It also needs to have been validated and independently reviewed. For the purpose of transparency, the Agency expects full technical specifications, validation and review documents of the chosen model (and the specific version) to be publicly available (Reference 30)

The indicative benchmarks given in Appendix 6 have been derived using older generation models. If using newer models to compare the actual performance against the benchmark, it is possible that the installation-specific results may show a numerically higher result than would have been the case with use of an older generation model. If the predictions from the use of a new generation model are likely to exceed the benchmark and there is an actual or potential odour problem, then the Agency will re-assess the situation as appropriate. This is seen as an interim situation whilst further work is undertaken to compare the different approaches. It is expected that revisions of this document will refine the approach if better information becomes available.

In some circumstances there may be a valid reason for taking a different approach to that suggested here. In such cases, the methodology used should be described and justification given.

For the purpose of predicting odour impact within the scope of this document, models and input data with the following characteristics are preferred:

- gaussian plume and new generation models – such as ISCST3, ISC Prime, Aermod, Aermod Prime and ADMS
- to represent conditions for an "average year" hourly meteorological data for a period of at least three, preferably five years should be used
- one-hour average concentrations should be calculated for all hours in the meteorological data-set
- exposure to be expressed as the concentration corresponding with the 98$^{th}$ percentile of the distribution of hourly values
- to incorporate critical receptors as discrete receptors
- the ability to account for the effects of buildings and topography on the plumes from point sources.

This is covered in more detail in Table A4.1.

**Table A4.1: Dispersion modelling – recommended parameters**

| **Dispersion modelling for odour impact assessment – recommended parameters (where different from modelling of no-odorous substances)** | |
|---|---|
| ***Emission parameters*** | |
| *Quality of source emission data* | Use the relevant British Standards where available for taking samples. Analyse or quantify samples according to the relevant standards (see Part 2 of this Note (Reference 1).<br>A CEN standard: "Air Quality – determination of odour concentration by dynamic olfactometry, prEN 13725 (CEN / TC264/WG2, 1998)", to be formally adopted shortly, is in wide use internationally in defining the methodology for olfactometric testing of samples. Laboratories working to this standard should be used for undertaking sensory assessment.<br>Where the emission concentrations and/or parameters fluctuate then an assessment of this should also be undertaken.<br>Appendix 1 gives further detail on olfactometry and its limitations, as does Part 2 of this Note. |
| *Choice of sampling times (relative to process operations)* | In most cases it will be appropriate to consider the impact of the worst case emissions scenario (e.g. maximum production level, most odorous materials used, where odour varies with season use highest odour levels). The appropriate justifications should be given. Section 3 of Part 2 discusses sample collection (Reference 1). |
| *Other specific considerations relating to emissions:* | Where releases are of less than 1-hour duration it is possible to model as a "puff" release.<br>Plume rise - as for other gaseous emissions. In the case of flares, estimate the buoyancy flux of the flare from the heat content of the combustible components and their efficiency of combustion. In order to get a value for mass release of odour from the flare the odour input to the flare and the destruction efficiency must be used. |
| *Area sources* | Sample collection is described in Section 3 of Part 2 of this Note (Reference 1). |
| ***Model input parameters*** | |
| *Meteorological parameters* | Where odour emissions are continuous or the fluctuations are predictable, modelling can be carried out using sequential hourly meteorological datasets or for particular lines of meteorological data coinciding with odour complaints. When emissions occur less predictably modelling can be carried out for set combinations of wind speed and atmospheric stability with appropriate wind directions. Historically, Pasquill-Gifford stability classes have been used but in new generation models representative values of MO length and boundary layer height should be used to define unstable, stable and neutral conditions.<br>The meteorological data should be representative of the area in which the installation is situated. It should be noted that the closest meteorological station is not necessarily the most representative.<br>Where complaints are frequent it is useful to collect on-site wind direction and speed data, as this allows better correlation of complaints with potential odour sources. If modelling is to be undertaken, information on cloud cover or net solar radiation is also needed. |
| *Terrain* | Terrain with gradients of more than 1:10 can have a significant impact on ground level concentration of odour. In such cases dispersion calculations should incorporate these features. |
| *Grid resolution* | Grid resolution can also have a significant impact on predicted maximum odorant ground level concentration, although care should be taken in over-interpretation of data from fine grid resolutions. |
| *Critical / sensitive Receptors* | Critical receptors should be identified as discrete receptors in the dispersion model. Critical receptors *may* include housing, offices, parkland, recreational areas and retail areas plus SSSIs, SPAs and SACs, and ASSIs in Northern Ireland. |
| *Buildings (wake)* | A structure produces an area of wake effect influence that extends out to a distance of five times L directly downwind from the trailing edge of the structure, where L is the lesser of the building height or the projected building width. If the stack is within this area of influence its effects should be accounted for within the dispersion model. |
| ***Model output parameters*** | |
| *Averaging time* | For the reasons given above, an averaging time of one hour should normally be used. A typical feature of exposure to odorous emissions is the very rapid human response which occurs when exposed to fluctuations in emissions; this can take place within a matter of 2 or 3 seconds unlike other non-odorous pollutants where response may be delayed by months or years (i.e. health effects). Short averaging times, down to a duration of one second, have been used to try and reflect this rapid response. However a standardised approach based on a shorter duration has not yet been validated (see sub-section following this table). |
| *Percentiles* | A range of different percentiles have been used in the setting of air quality and odour exposure acceptability criteria. This guidance recommends use of the 98$^{th}$ percentile of a year of hourly means for comparative purposes, as stated on the previous page. |

| ***Reporting***[6] | |
|---|---|
| *Justification of Procedure* | The type of modelling procedure chosen should be described and justified in relation to the objectives. Reasons for factors having been included or excluded should be considered within the text. This commonly would include terrain effects, influences of buildings meteorology and source behaviour. |
| *Presentation of Results* | Presentation would commonly include quantitatively labelled graphical summaries (such as a suitable map overlaid with concentration contour plots). |
| *Audibility* | Dispersion modelling should be fully auditable. All data sources should be referenced. Commonly input files to the dispersion model are included as an appendix. |

The Agency document "Air Dispersion Modelling Requirements" (Reference 27) provides guidance on reporting format and other requirements.

[6] Royal Meteorological Society (1995) Atmospheric Dispersion Modelling: Guidelines on the Justification of Choice and Use of Models and the Communication and Reporting of Results. Royal Meteorological Society.

## Peak to mean ratios

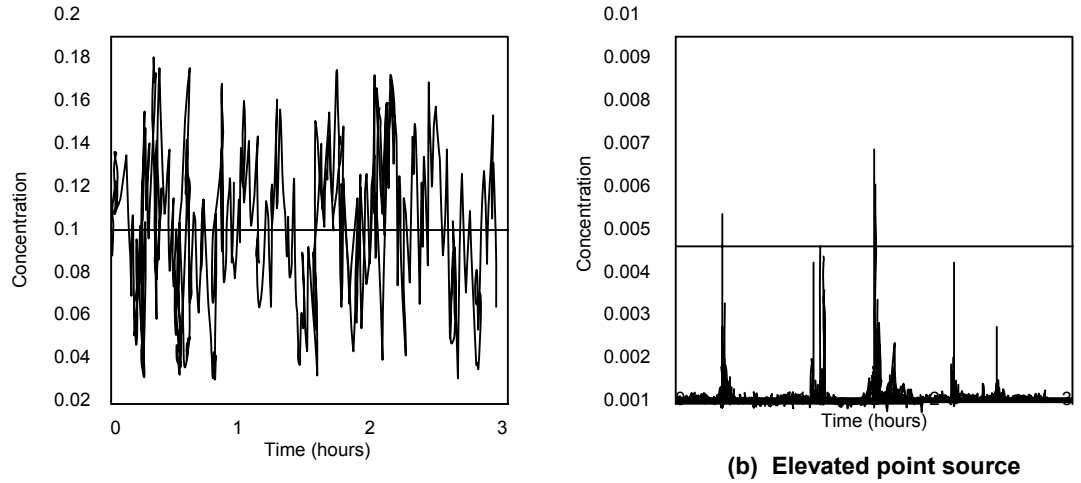
The peak to mean ratio is an aspect of odour dispersion that is currently being researched by a number of parties. At present there is insufficient information upon which to base a regulatory approach. The concept is described in the following paragraphs as it may provide explanation for specific patterns of exposure that occur.

The peak to mean ratio (peak concentration divided by mean concentration) describes the degree of fluctuation that takes place as the plume disperses downwind. It is well recognised that the peaks in concentration and their frequency of occurrence are determining factors for the perception of odour.

The main variables which affect the size and frequency of peaks are:

- source type - area, line or point. The height above ground level and the effect of other buildings and topography are relevant
- distance between the source and receptor
- the stability/turbulence of the mixing layer.

It has been shown that there are potentially large differences between area ground level sources and tall point sources in terms of the downwind fluctuation to which a receptor would be exposed (Reference **23**) as illustrated in Figure A4.2 below. This shows that point sources at a height can produce considerably greater peak to mean ratios than area sources (as can point sources at ground level).




**(a) Area source**

**(b) Elevated point source**

This shows how the pattern of exposure for 1000m downwind of a source varies in conditions of neutral atmospheric stability according to the nature of that source. Downwind of an area source, a receptor would be exposed to a fluctuating concentration (units are arbitrary in this representation), but one which lies closer to the centreline (average) than for a point source which may produce better dispersion but considerably bigger peak concentrations relative to the average, (Reference **24**).

**Figure A4.2: Variations in downwind concentrations from (a) an area source and (b) an elevated point source**

Although the work illustrated above contributes significantly to our understanding, it only provides a starting point in terms of accurately predicting actual odour annoyance and further investigation and validation is needed. Until this is available, the relationship between a percentile of hourly averages and the level of annoyance as indicated by surveys undertaken according to a defined methodology remain the best basis for determining odour exposure acceptability criteria.

In some methodologies (e.g. D1 - Reference **22**) this fluctuation is taken into account in the form of a “safety factor”.

# APPENDIX 5 - Emission limit values and exposure benchmarks for odour

## Use of benchmarks

There may be a need to use exposure benchmarks for planning/predictive purposes.

1. The impact of a proposed installation, extension to an existing installation, or in stack height calculation for effective dispersion or residual odours – will the proposed installation or extension lead to a situation of "no pollution" at receptors?

2. As an indicator of the degree of efficiency required of proposed abatement equipment (how much improvement is needed to produce "no pollution").

And possibly, if the need can be justified.

1. To consider the likelihood of complaints being made in a given exposure situation, much as BS4142 is used for determining the likelihood of noise complaints, or to retrospectively evaluate the local exposure situation (on a long term basis) if complaints have been received.

2. In the case of existing plant, the appropriate benchmark can be used to determine the installation-specific maximum mass emission which should avoid "odour pollution" (ie taking local topography and meteorology into account). It is envisaged that this test need normally only be undertaken once at application if justified; any further work would be periodic stack monitoring against that mass emission (if process-based information cannot provide the necessary data).

## What are benchmarks?

Odour exposure benchmarks are numerical values which represent an "acceptable" level of exposure which, for the purpose of this guidance, equate to "no pollution" in terms of offence to the sense of smell.

It should be noted that exposure benchmarks are predicted ground level concentrations which are calculated by mathematical modelling of measured emissions. They cannot be measured at ground level and are, in any case generally averaged over long time periods (a year in the case of odour). They cannot be applied when it is not possible to meaningfully measure emissions at source, for example if there are many fugitive emission points

This Appendix, together with Appendix 6, describes benchmarks for odorous emissions, i.e. levels of odour exposure which are deemed "acceptable" and which should not lead to reasonable cause for annoyance.

**Ground level concentrations or criteria based on acceptability should not be applied directly as Permit conditions. Determining compliance with them in this form is not possible, making them meaningless as conditions**.

Where point sources are present, the emission equivalent to the acceptable ground level concentration can be calculated and these emission limit values can be used as Permit conditions where appropriate. The emission limit values imposed in any particular case will depend upon the installation-specific circumstances and what is achievable through the application of BAT. For area sources where the emission rate is difficult (or meaningless) to measure, emphasis should be on the Odour Management Plan and general good practice.

**The appropriate sector regulatory package should be consulted before deciding upon Permit conditions (see Section 2.5).**

## What benchmark values are there for odour?

Benchmarks for odour are derived from several sources:

- World Health Organisation guideline values (as a ground level concentration) which aim to prevent annoyance resulting from exposure to single odorous compounds
- indicative benchmarks for exposure to mixtures of odorous substances which are based on acceptability (odour exposure acceptability criteria)
- it is also possible to calculate a multiple of a published odour threshold value (for a single substance) which is equivalent to the "acceptability" level.

## Which values should be used in any particular case?

There are relatively few guideline values for odour exposure. The World Health Organisation has devised a small number of values for limiting annoyance, but these are for single compounds. Odour threshold values have been used to limit the "strength" of an odour is relative to its detection threshold but again, these relate to single compounds.

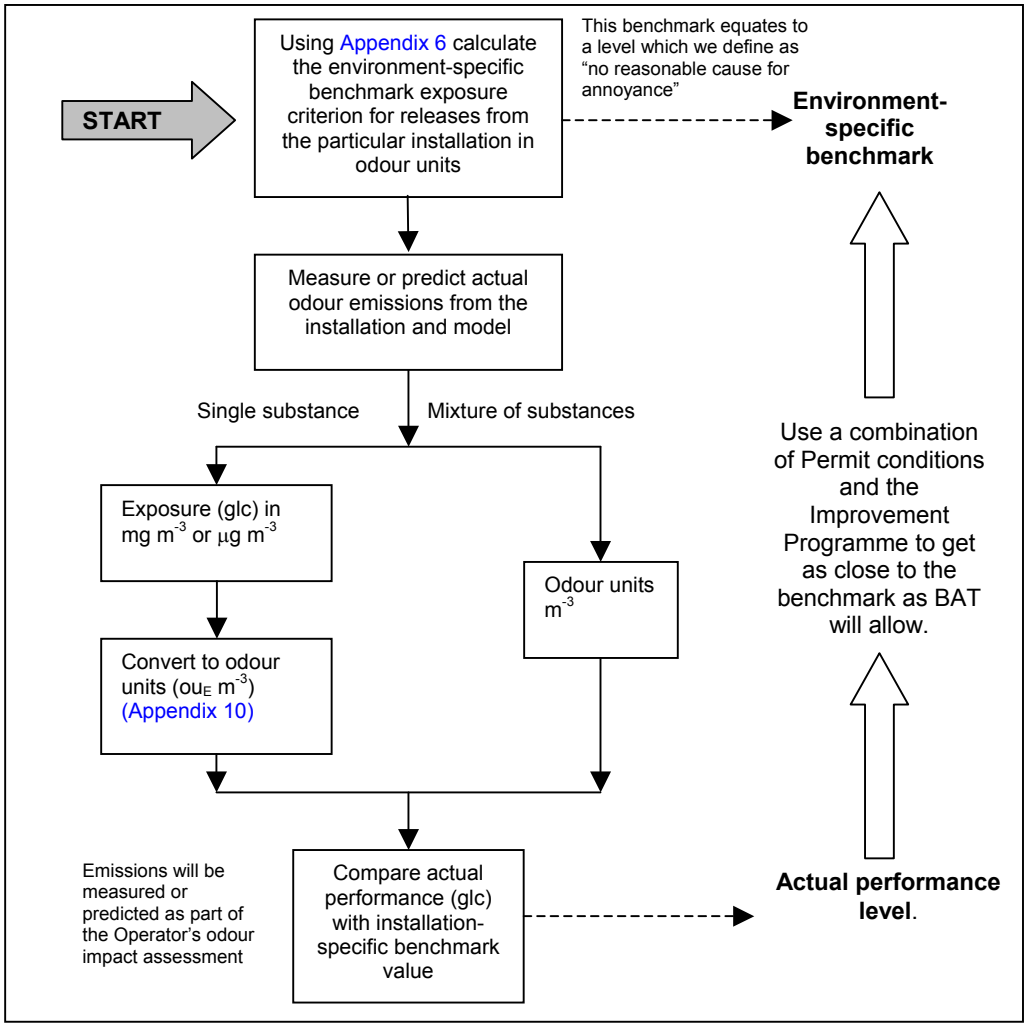
Most odours are mixtures of compounds, sometimes several hundred, which are present in varying concentrations relative to each other. Exposure criteria for mixed odours are in use (commonly 5ou as a 98$^{th}$ percentile of hourly means) although, in researching this document, no scientific evidence has been found to show how these relate to annoyance. Convention and increasingly wide use appears to have played a part in their adoption.

This document proposes a series of indicative standards which are based upon dose-effect studies carried out in Europe over a period of several years. The standards are described in Appendix 6 and the underlying studies are discussed in Reference 15. Work to relate these studies to UK populations is on-going and UK-based dose effect studies are planned.

**For the purposes of IPPC the following procedure (Figure A5.1) is proposed for the purpose of establishing environment-specific exposure "standards" or benchmarks to any form of odorous emission where the emission can be measured and the risk of causing annoyance justifies it. The benchmark equates to "no reasonable cause for annoyance" for a specific receiving environment. The benchmark will have to be converted to an equivalent emission at source to allow meaningful comparison of how an Operator is performing relative to "no reasonable cause for annoyance".**

**The Operator must take the appropriate action to reduce his emissions get as close to the level of emission which equates to the benchmark as far as the cost benefit constraints of BAT allow.**

**Figure A5.1: Applying installation-specific exposure standards to odour-emitting activities**



Where health-based standards or guideline values exist for specific substances, these should be compared to the benchmark value as calculated above. The more stringent should be used as a benchmark. The odour thresholds for many substances are very low therefore it will be unusual for the odour exposure benchmark to be numerically higher than other pollution control limits.

## Other standards or guideline values

***Use of odour threshold values***

The odour threshold value is the concentration at which an odorous substance becomes detectable to 50% of a test panel. The exposure concentration at which the odour (i) will be recognisable, and (ii) exposure is likely to lead to reasonable cause for annoyance, will be different multiples of the odour threshold. The emission rate at source which is equivalent to the odour threshold at sensitive receptors can be calculated by using an atmospheric dispersion model.

The actual emission in mg $m^{-3}$ of odorous substance can be converted to odour units and compared with the odour exposure acceptability criteria described in Appendix 6 (refer to Figure A5.1, above).

***Quality Objectives***

Some of the substances for which air quality objectives exist are odorous:

- sulphur dioxide
- benzene
- butadiene

***Emission limits set in sector specific guidance notes***

For example:

- volatile organic compounds (VOCs)
- ammonia
- hydrogen sulphide

***World Health Organisation guideline values***

The World Health Organisation provide exposure guideline values for a limited range of substances as 24-hour average concentrations, (see Reference 21). These were derived with the aim of providing a basis for protecting the public from the adverse effects of air pollution.

For a few of these substances which exhibit malodorous properties at concentrations below that at which toxic effects occur, guideline values have been established for avoidance of substantial annoyance. Again these relate to single species, rather than compounds present in mixtures.

**Table A5.1: Guideline values based on sensory effects or annoyance reactions,**

(averaging time of 30 minutes.)

| Odorous substance | Detection threshold | Recognition threshold | WHO Guideline value set to protect against "substantial annoyance" |
|---|---|---|---|
| Carbon disulphide in viscose emissions | | | 20μg $m^{-3}$ |
| Hydrogen sulphide | 0.2 - 2.0μg $m^{-3}$ | 0.6 - 6.0μg $m^{-3}$ | 7μg $m^{-3}$ |
| Styrene | 70μg $m^{-3}$ | 210 – 280μg $m^{-3}$ | 70μg $m^{-3}$ |
| Tetrachloroethylene | 8mg $m^{-3}$ | 24 - 32mg $m^{-3}$ | 8mg $m^{-3}$ |
| Toluene | 1mg $m^{-3}$ | 10mg $m^{-3}$ | 1mg $m^{-3}$ |

"Substantial annoyance" does not appear to have been defined.

***Derivations of Occupational Exposure Limits (OELs)***

In general terms occupational exposure limits (OELs) are not really suitable for determining a level of annoyance – they are derived from health-related data and the transposition of these limits from workplace to community is not straightforward.

# APPENDIX 6 - Installation-specific odour exposure "acceptability" criteria for mixed odours

## Overview

This Appendix sets out a number of indicative odour exposure criteria for mixtures of odorants associated with different industry types. These indicative criteria must then be "adjusted" for local the factors on an installation-specific basis. These criteria indicate the exposure that the particular local environment (ie exposed people) can tolerate without reasonable cause for annoyance. They can be used as:

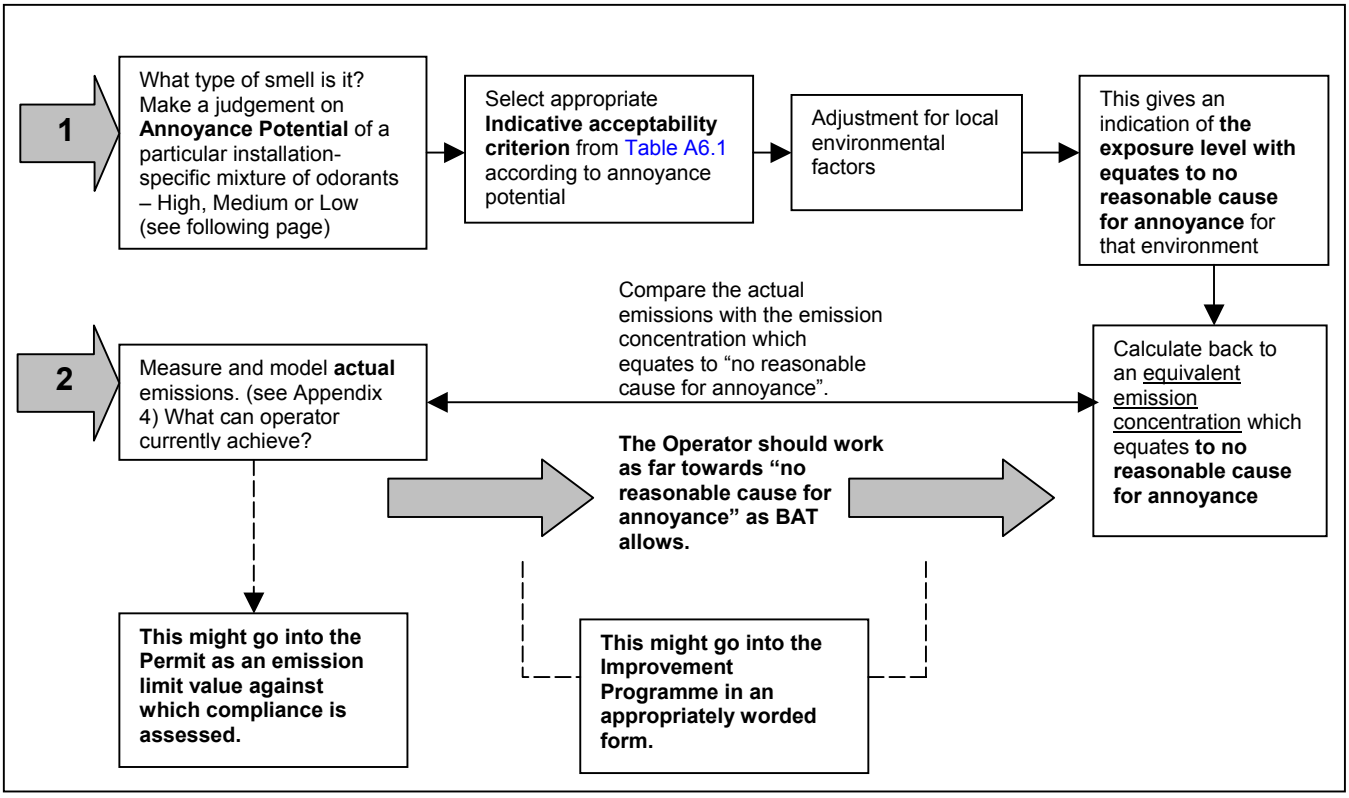
- an indicator of how much improvement is needed or to size abatement equipment
- for planning purposes to predict the acceptability of the impact of a planned installation or extension to an existing operation
- to calculate a suitable chimney height to provide an acceptable exposure at receptors.

Such criteria cannot be used in this form as Permit conditions but can be used to determine equivalent emission limit values as described in Appendix 5 and shown below in Figure A6.1. ***This methodology is based on best available data. It is necessarily simplistic in the way that it has treated some of the factors. It will be revised as necessary in the light of any relevant new research findings.***

The use of odour exposure criteria is only meaningful where the emissions from the installation can be measured or predicted, otherwise there will be no realistic input data for modelling and no means for assessing whether the criterion is being met.

**The expectation is that, where relevant, the Operator will carry out Steps 1 and 2 below and provide sufficient justification and background data for the Regulator to determine the validity of the assessment and the assumptions made. This will be required where the risk of causing annoyance justifies it.** The Regulator will determine suitable permit conditions based upon the outcome, according to the relevant sector regulatory package.

**Figure A6.1: Derivation of installation-specific odour exposure criteria for existing installations .**



# APPENDIX 6 - INSTALLATION-SPECIFIC EXPOSURE CRITERIA

## Annoyance potential

*Annoyance potential is the likelihood that a specific odorous mixture will give reasonable cause for annoyance in an exposed population*.

Not all odours have the same potential to cause annoyance – for example odours arising from putrescible materials, are typically considered to be more "offensive" than odours from a bakery which might be better tolerated. It should be remembered however that **ANY** odour has the potential to cause offence if, for example, the odour is strong and/or exposure is frequent. The list below (Table A6.1) is based around a ranking of industrial-type odours which was carried out in the UK recently (as described in Appendix 1). The results are consistent with those from the Netherlands and Germany. A larger UK study is currently underway and the table below will be reviewed in line with any different outcomes.

This ranking gives some indication of ***relative*** offensiveness. These have then been categorised as "low", "medium" and "high" offensiveness and exposure criteria have been assigned to each category. These categories are indicative only and do not have definite cut-off points in terms of the industry types listed. Although this ranking is based upon the views of a number of people; within this there may be individuals who respond differently, (see Appendix 1 – "Offensiveness")

**Table A6.1: Indicative odour exposure criteria for ground level concentration of mixtures of odorants**

***Relative "offensiveness" of odour***

More offensive odours……

Activities involving putrescible waste
Processes involving animal or fish remains
Brickworks
Creamery
Fat & grease processing
Wastewater treatment
Oil refining
Livestock feed factory

---------- ▶

Intensive livestock rearing
Fat frying (food processing)
Sugar beet processing

These are odours which do not obviously fall within the HIGH or LOW categories

---------- ▶

Chocolate manufacture
Brewery
Confectionery
Fragrance and flavourings
Coffee roasting
Bakery

Less offensive odours
(not inoffensive)

These categorisations are indicative only
Table A1.1 lists a wider range of industrial odours.

| | |
|---|---|
| HIGH | **Indicative Criterion**<br>**1.5 $ou_E$ $m^{-3}$**<br>**98th percentile** |
| MEDIUM | **Indicative Criterion**<br>**3.0 $ou_E$ $m^{-3}$**<br>**98th percentile** |
| LOW | **Indicative Criterion**<br>**6.0 $ou_E$ $m^{-3}$**<br>**98th percentile** |

(a). Select most appropriate category – high, medium or low - for the particular odour type (or most offensive odour if there is more than one distinct odour released from the particular installation). The model shows three distinct categories to simplify the process; in reality the gradation is continuous.

(b). Select the corresponding indicative criterion from Table A6.1 and use this as a starting point. See also Table A1.1 which gives a wider range of odour types.

(c) Now make adjustments for any relevant local factors and record the decision.

(d) The end result will be an installation-specific odour exposure criterion in terms of odour ground level concentration at sensitive receptors. This equates to "no reasonable cause for annoyance".

Compare this with:
- what the operator is currently achieving
- what is achievable with BAT

to derive Permit conditions.

New installations will be expected to meet indicative BAT standards (as set out in the appropriate Sector Guidance Note) from the outset.

The criteria given are based upon: (see Appendix 4)
- 98$^{th}$ percentile
- 1 hour averaging time

***Offensiveness of odour - some considerations*** (see also Appendix 1)

- Odours from some industry types such as chemical manufacture will vary across the sector and the nature of any odorous emission will be dependent upon the types of materials used and products manufactured.
- There may be a difference in the odour described by local residents and the odour as experienced at source. Odours can change in nature over distance (Section 3.1.4).
- For some types of process or activity there will be variation in odour intensity, and possibly character also, depending upon the stage of the cycle (e.g. livestock) or upon season (e.g. landfilling of putrescible wastes).

A list of "**hedonic scores**" is given in Appendix 10; these scores indicate *relative* "pleasantness" or "unpleasantness" based upon descriptions of what an odour smells like. These may assist in determining the relative offensiveness of an odour where it is not possible to categorise it in terms of an industry type or process.

## Adjustments for local factors

In accordance with the PPC Regulations, installation-specific factors should be taken into account in determining emission limit values. These factors relate to both the technical characteristics of the plant and also local conditions:

When deriving installation-specific benchmarks for odour the following types of environmental factors should be considered:

***Local conditions***

- Where an odour has generated a high level of complaints over a prolonged period of time, the population may become hypersensitive to that odour. As such, even if the levels of odour were reduced to what would be an acceptable level in other areas may still give rise to justifiable complaints.
- This effect may be more pronounced in densely populated areas where the numbers of hypersensitive individuals would be greater.

There may be other relevant local factors in addition to the above. Local topography does not need to be taken into account in determining a benchmark as such, but it will need to be included in the input to a dispersion model when calculating the equivalent emission at source to meet the benchmark.

Technical aspects of the operation will need to be considered in determining BAT, but not in determining the installation-specific odour exposure criterion as the latter only considers the local receiving environment.

Where an adjustment is considered to be necessary, the indicative odour exposure criteria given in Table A6.1 can be adjusted upwards (ie less stringent) or downwards (more stringent). If the environment is considered to be insensitive the need to apply such criteria at all should be reconsidered.

As an example of an adjustment to reduce the level of exposure, the criteria given in Table A6.1 become:

High Criterion: 1.0 $ou_E$ $m^{-3}$ as the 98$^{th}$ percentile of a year of hourly averages (from 1.5$ou_E$)

Medium Criterion: 2.5 $ou_E$ $m^{-3}$ as the 98$^{th}$ percentile of a year of hourly averages (from 3$ou_E$)

Low Criterion: 5.5 $ou_E$ $m^{-3}$ as the 98$^{th}$ percentile of a year of hourly averages (from 6$ou_E$)

The indicative odour exposure criteria are based upon a number of different populations but if an installation-specific criterion does not provide for "no reasonable cause for annoyance", for a specific population then it may need to be re-visited. However the degree to which BAT allows the installation-specific criterion to be met should be taken into account.

***Other considerations***

A number of other considerations may need to be taken into account.

- Where the receptors are remote from the source it would be unlikely that the Operator would need to go through the full process of calculating an installation-specific odour exposure criterion unless there is some other sensitivity, and the balance of costs and benefits would be expected to be less heavily weighted towards more expenditure when compared to a more sensitive location
- Under some circumstances where more local information is required in determining the level at which acceptability criteria should reasonably be set, it may be appropriate to undertake a survey of annoyance in the community. The methodology is described in Section 1 of Part 2 to this Note
- Where many complaints have been received, the calculated odour exposure criterion could be calibrated against a plot of locations of complaints around the source.

# APPENDIX 6 - INSTALLATION-SPECIFIC EXPOSURE CRITERIA

## Using exposure criteria - what it means in practice for regulation

The odour exposure criteria given in Table A6.1 have been derived from dose effect studies and describe ground level concentrations of different odour types which have been reported at interview by those exposed as being "acceptable" in the long term. The following description aims to explain what these criteria actually mean in terms of the odour to which those people interviewed were exposed and what it might mean where these criteria are used for planning or regulatory purposes.

### *What are odour exposure criteria?*

Odour exposure criteria are a statistical means of linking the odour emission from a process to the impact (concentration) at ground level, in terms of probability of occurrence, taking frequency of occurrence into account. They are determined by mathematical dispersion modelling of source emission data and other local data.

They are probability-based and therefore are not absolute "limits"; they are merely indicative of an average concentration that is likely to occur for a specified percentage of the time over a year.

An example of the way an odour exposure criterion is set out might be:

*x* $ou_E$ $m^{-3}$ *as a* $98^{th}$ *percentile of a year of hourly means*

A $98^{th}$ percentile value "*x*" of a year of hourly averaged concentrations means that hourly averaged concentrations will be less than or equal to *x* for 98% of the year. For 2% of the year, hourly averaged concentrations will be higher than or equal to *x*.

An odorous emission which is equivalent to the odour exposure criterion at ground level does not, therefore, mean that receptors do not experience odour at all.

### *Factors affecting response*

The average concentration, duration and frequency of exposure (and also the type of odour) are important in determining the likely response of receptors. However the magnitude of the peaks is often the factor determining whether an acceptable situation becomes annoying for those exposed. The magnitude of the peaks may be a feature of the process (i.e. the emissions vary) or it may be related to the height and type of source (point sources can give much greater peak to mean ratios downwind than area sources) or to atmospheric conditions (see Appendix 4 – peak to mean ratios).

### *Using odour exposure criteria in Permitting*

The aim should be to identify a criterion using this Appendix where the average exposure level is not likely to give reasonable cause for annoyance and, in the case of an existing process, the Operator should use BAT to get as close to this as possible.

*There might be several reasons for excursions proving to be too frequent: (i.e. the average exposure is greater than the atmospheric dispersion modelling predicts, or the peaks are frequent and of high concentration)*

- there might be particularly "difficult" topography which impairs dispersion and brings the plume to ground
- the meteorological data used may not adequately reflect the local situation, for example in a valley subject to inversion conditions, or it may be for a dissimilar area
- the emissions may be very variable and worst case has not been used in the calculations
- there may be fugitive emissions which have not been taken into account.

Other factors, such as the uncertainties in source measurement and in modelling, will also need to be considered in any assessment.

Odour exposure criteria cannot be used directly as conditions because compliance is impossible to determine as the measurement of odorants is very rarely possible at such dilute concentrations as are present in ambient air samples and in any case the exposure is averaged over a year.

The emission rate at source is used to calculate the actual ground level concentration. The actual ground level concentration should be compared with the desired ground level concentration which aims to give no reasonable cause for annoyance and the Operator should get as close to this level as possible using BAT. It is however the emission rate which is used as a condition NOT the exposure benchmark itself. Monitoring can then be undertaken to show compliance with the condition.

Continuous monitoring is possible for some odorous substances, but where mixtures are present olfactometry is usually the most suitable means of quantification, unless a suitable surrogate can be identified (see Section 2.5.2). Olfactometry is more expensive to undertake than some techniques, hence periodic monitoring – quarterly or half yearly (or according to risk) is usually specified for compliance purposes. A parallel means of ensuring that emissions are fairly constant between compliance checks is to impose a condition relating to a relevant process parameter, i.e. something that can be continuously or frequently checked and which is a surrogate for the emission concentration. This might be pH and circulation rate of scrubber liquor, or flow rate (back pressure) through a carbon bed, for example.

# APPENDIX 7 - Template for an Odour Management Plan

**This Appendix should be read and interpreted in conjunction with:**

- **the information on application requirements given in the appropriate Sector Guidance Note and Application Forms**
- **Section 2.5 of this guidance, and any current requirements relating to the use of Permit conditions.**

## What is an Odour Management Plan?

An odour management plan is a working document for managing odour issues on the installation.

Whilst an odour management plan could be used to cover all aspects of odour management on an installation, in most cases it is likely to contain a description of foreseeable events which may lead to an increased odour impact at sensitive receptors and which are *outside the control of the Operator*, and for which it is agreed that it is not BAT to provide backup or alternative. It will also contain a description of the actions which will be taken in each case to minimise the impact.

The nature of those events and the subsequent actions should be agreed with the Agency at the time of drawing up the document. A means of recording the failure and demonstrating that the appropriate actions were indeed taken must be put in place by the Operator. It should be stressed that such events would be infrequent; if they occur regularly then BAT needs to be re-evaluated in the light of the degree of environmental impact.

In order to prepare the plan, the operator will need to consider:

- the activity which produces the odour and the point(s) of odour release (both intentional and unintentional)
- possible process or control failures or abnormal situations which could lead to an increased level of exposure
- the potential outcome of each failure scenario in respect of the likely odour impact on local sensitive receptors
- the actions which are to be taken to mitigate the effect of the odour release, and details of the persons responsible for the actions on the installation.

## What should be included?

There are four main types of failure which may lead to an increase in emissions of offensive odour. These are:

- those which have potential to affect the process and the generation of odour
- those which affect the ability to abate/reduce odour
- those which affect the ability to contain odour (where releases are not normally permitted)
- those affecting dispersion between the source and sensitive receptors (for permitted release points such as vents, stacks or permitted open (area) sources.

Within all of these general headings there are causative factors which the operator could take actions to prevent and there may also be potential failure scenarios which are outside of his control and for which it as been agreed that it is not BAT to provide back-up or mitigation. For example it may not be BAT to provide a stand-by generator against the possibility of very infrequent power supply interruptions. It is the latter that will be of particular interest to the Regulator.

Examples of the issues which might need to be considered under the above headings are given in Table A7.1

A suggested template is given in Table A7.2

## APPENDIX 7 – ODOUR MANAGEMENT PLAN

**Table A7.1: Issues to consider in an Odour Management Plan**

| *Nature/cause of failure* | *Examples of issues to consider* |
|---|---|
| **Those which have potential to affect the process and the generation of odour** | Examples of factors which the Operator should normally have made arrangements for are:<br>• materials input (seasonal variation in weather may affect odour of materials), particularly if putrescible<br>• process parameters (changes in temperature/pressures)<br>• rate of throughput or increased hours of operation<br>• anaerobic conditions develop |
| **Those which affect the ability to abate/reduce odour** | Examples of factors which might be considered to be outside of Operator's control and best dealt with by management actions:<br>• power failure (if accepted to be BAT not to provide backup)<br>• external failure of other utilities, e.g. water supply. (Where the Operator has signed up to an interruptible utility supply, there may be some debate as to whether an interruption is outside of the Operator's control).<br>• start up/shut down (depending on frequency of occurrence and the nature of the process). |
| | Examples of factors which the Operator should normally have made arrangements for are:<br>• breakdown of abatement kit/pumps<br>• poor performance of biofiltration or poisoning<br>• saturation of a carbon filter bed and subsequent breakthrough of odorants<br>• below optimum temperature of incinerator/boiler etc<br>• saturation of scrubber liquor |
| **Those which affect the ability to contain odour (where releases are not normally permitted)** | Examples of factors which might be considered to be outside of the Operator's control and best dealt with by management actions:<br>• power failure (if accepted to be BAT not to provide backup) |
| | Examples of factors which the Operator should normally have made arrangements for are:<br>• failure of automatic doors, i.e. in open position<br>• failure in procedures to maintain containment (human error) |
| **Those affecting dispersion between the source and sensitive receptors (for permitted release points such as vents, stacks or permitted open (area) sources):** | Examples of factors which might be considered to be outside of the Operator's control and best dealt with by management actions:<br>• short term weather patterns which fall outside of the normal conditions for that area (ie highly unusual, not just the normal meteorological pattern - for example inversions and other conditions unfavourable to dispersion should have been considered in designing the process). |
| | Examples of factors which the Operator should normally have made arrangements for are:<br>• weather – wind direction, temperature, inversion conditions if these are normal variants of local weather<br>• loss of plume buoyancy/temperature<br><br>*Note: the above are design issues to a large extent – the process should be designed to prevent/reduce odour to the required level (a level of acceptability) which takes the range of meteorological conditions into account.* |

The specific arrangements for dealing with accidents will have been dealt with separately within the application. These can be cross-referenced where appropriate.

**Table A7.2: Suggested template for an odour management plan**

This is a suggested outline only and can be amended, as appropriate, to reflect different situations.

| Where does odour occur and how is it generated? | Identify the release points. | Identify possible failures or abnormal situations. Nature/cause of failure | Potential outcome if failure occurs | What measures have been put into place to prevent or reduce the risk of this failure? | What actions are taken And who is responsible? |
|---|---|---|---|---|---|
| Describe the activity or process in which odorous materials are used or generated. | For each activity or process described in the previous column, list the intentional release points, e.g. vents, chimneys, exhausts, and the fugitive release points. | For each source – identify particular difficulties which affect odour generation, abatement, containment or transport/ dispersion in the atmosphere.<br><br>***See Table A7.1 for examples*** | Identify the local receptors who are likely to be affected and the nature or degree of the impact. | | What actions are taken? Describe the measures that have been put into place to reduce the impact should a failure occur.<br><br>These actions need to be agreed with the Regulator. Such actions may be as minor as closing doors or more significant – slowing production or shutting down under adverse conditions.<br><br>Who (post) is responsible for authorising the actions described? |
| | | | | | |
| | | | | | |

Example entries are given in Table A7.3

## APPENDIX 7 – ODOUR MANAGEMENT PLAN

**Table A7.3: Odour management plan – Example entries**

The following table contains a number of fictitious examples. In the case of failures outside of the control of the Operator, for any one installation, very few "incidents" per year are to be expected. If more are likely, then BAT should be reviewed and the odour emission potential reduced. Where failures are preventable, there should be no failures.

| Where does odour occur and how is it generated? | Identify the release points. | Identify possible failures or abnormal situations. Nature/cause of failure | Potential outcome if failure occurs | What measures have been put into place to prevent or reduce the risk of this failure? | What actions are taken And who is responsible? |
|---|---|---|---|---|---|
| | | Failure of scrubber liquor pumps due to power failure | Scrubber failure. Release of unabated off-gas to atmosphere.<br>(50,000 odour units/$m^3$).<br>Local residents may experience odour annoyance.<br>Duration - until pumps re-started or process shutdown. | (This assumes it is not BAT to provide a back-up generator) | Instigate process shutdown procedure (30 mins)<br><br>Advise regulator by telephone immediately (phone no:….)<br>Duty manager |
| | | Failure of self-closing (roller) doors – mechanical failure or power failure | escape of odour from main storage area. May cause odour to be detected at nearby houses – raw material odour<br>Infrequently. Duration….(until action taken to correct) | Manual operation possible. Monthly inspection of door operation | Manually close doors.<br><br>Inform Chargehand<br><br>Storage area operators |
| | | Inversion conditions may cause odour annoyance at New Village | Complaints likely to be received from New Village.<br>Occurrence: very infrequent – once or twice a year | Weather station located on site with logging facility.<br><br>Daily weather forecast received from Met office. | Finish current batch but reduce temperature if possible. Hold further batches of Product X. Product Y can be run on reduced temperature.<br>Duty manager |

# APPENDIX 8 - Protocol for subjective testing ("sniff-testing")

(Also referred to as olfactometric screening or simplified olfactometric testing).

This protocol is included here in order to ensure a consistent approach to the assessment of odours on and around PPC installations. This is a very useful quick test which can provide a subjective "snap-shot" assessment of the presence, strength and character of an odour either within an installation boundary, at the boundary or in the area/community surrounding the site.

The assessment might be carried out for the following reasons:

- as part of the routine regulation of an installation
- by the Operator to assess his state of compliance, and
- as a tool in complaint investigation - used by Operator or Regulator.

Routine assessments can help to build up a picture of the odour impact of the installation on the surrounding environment over a period of time. Assessments which are targeted at adverse weather conditions or particularly odorous cycles of an operation allow "worst case" scenarios to be developed. Ideally the same methodology should be used to follow up complaints.

A record should be kept of the meteorological conditions at the time of testing together with information relating to the operations and activities being undertaken at the time.

The general principles are covered below. A full procedure for assessing odour from Waste Management Facilities is given in Reference 13.

***General considerations***

When undertaking an assessment, the following points need to be considered.

- Frequency of assessment should be determined by the potential for odour generation, the number of complaints or as required by any relevant Permit conditions.
- Consideration may also need to be given to evaluating the sensitivity of the person(s) carrying out this form of assessment. If necessary this can be confirmed by means of olfactometry. Obviously anyone with a poor sense of smell should be excluded. It is important to remember that regular exposure to a particular odour can produce olfactory fatigue. This can be particularly relevant where an Operator carries out daily checks at the perimeter or further afield.
- To improve (or to check) data quality the test can be conducted by two persons working independently during the same time period.
- The person(s) undertaking the assessment should avoid strong food or drinks, including coffee, for at least half an hour before undertaking the assessment. Strongly scented toiletries should be avoided as well as the use of deodorisers in the vehicle used during the assessment.
- Colds, sinusitis or sore throat can affect the sense of smell. Planned assessments should be re-scheduled if possible or undertaken by someone else, otherwise the fact should be clearly noted on the report.
- The health and safety of the individual undertaking the assessment should not be compromised. Containers or vents should never be sniffed where there is any possibility of them containing, or having contained, substances which may be harmful, or if the content is unknown. The Agency's Health & Safety Procedures Manual should be consulted as appropriate.

***Testing location***

Where possible move from areas of weaker strength to stronger. The exact location will depend on the purpose of the assessment but when investigating off-installation odour start well down wind and move towards the installation. It should be remembered that an odour may change in character over a distance as a result of dilution and/or conversion (see Section 3.1.4).

A number of factors may determine the choice of location, including:

- permit conditions relating to the installation boundary or sensitive receptors
- complaints received
- proximity of housing to the installation
- wind direction at the time of testing.

An assessment may involve walking along a route selected according to the above factors, or to the conditions found upon arrival. Alternatively points may be fixed in order to evaluate the changing situation over a period of some weeks or months, or may vary from test to test according to local conditions. The latter may be of use in identifying worst case conditions.

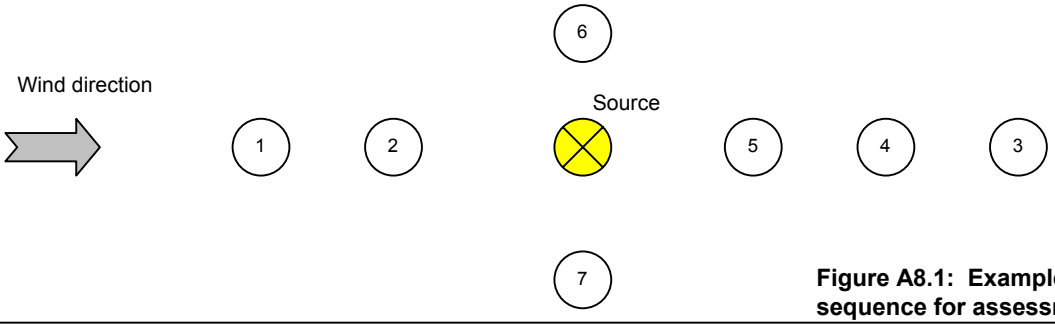



**Figure A8.1: Example of a possible sequence for assessment**

***Data collection and recording***

Parameters of interest are:

- detectability / Intensity
- extent & persistence
- sensitivity of the location where the assessment is being made with regard to receptors, and
- offensiveness

A note should also be made of any external activities such as agricultural practices that could be either the source, a contributor to, or a confounding factor in a particular odour event.

The categories of intensity, extent and sensitivity are:

**DETECTABILITY / INTENSITY**

1 No detectable odour
2 Faint odour (barely detectable, need to stand still and inhale facing into the wind)
3 Moderate odour (odour easily detected while walking & breathing normally)
4 Strong odour
5 Very strong odour (possibly causing nausea)

**EXTENT & PERSISTENCE** (assuming odour detectable, if not then 0)

1 Local & transient (only detected on installation or at installation boundary during brief periods when wind drops or blows)
2 Transient as above, but detected away from installation boundary
3 Persistent, but fairly localised
4 Persistent and pervasive up to 50m from plant or installation boundary
5 Persistent and widespread (odour detected >50 m from installation boundary)

**SENSITIVITY OF LOCATION WHERE ODOUR DETECTED** (assuming detectable, if not then 0)

1 Remote (no housing, commercial/industrial premises or public area within 500m)
2 Low sensitivity (no housing, etc. within 100m of area affected by odour)
3 Moderate sensitivity (housing, etc. within 100m of area affected by odour)
4 High sensitivity (housing, etc. within area affected by odour)
5 Extra sensitive (complaints arising from residents within area affected by odour)

**OFFENSIVENESS**:
The assessment of the offensiveness of odour is necessarily based upon the subjective sensory olfactory response of an observer. Determination of offensiveness depends upon intensity in addition to character, frequency of exposure and persistence (see below).

The determination of whether the odour is “offensive” should be made on the basis that episodes of odour exposure in the locality could be frequent and persistent. The determining officer may be exposed for a few minutes only but the determination needs to take into account the likely long-term response of nearby receptors who may be

exposed on a regular basis. Clearly, some odours are more offensive than others but it should be remembered that any odour has the potential to be offensive, depending upon factors such as concentration, duration and frequency of exposure, the context within which the exposure takes place and other factors unique to the individual exposed. The instantaneous impression may be of a relatively inoffensive odour but regular exposure, particularly at high concentration, often leads to a change in perception.

The following matters should be considered when determining the degree of potential offence.

**Nature/character** - odours that would be generally accepted as 'unpleasant' will be potentially offensive. For example, odours from an oil refinery would generally be accepted as unpleasant in comparison to odour from, for example, a bakery. The strength of an odour referenced to its detection threshold can be quantified and the higher the odour strength, the more the likelihood of an odour being detected.

**Frequency of exposure** - odours that are released frequently or continuously from the installation are more likely to be determined to be offensive than occasional transient releases. Odour frequency is often assessed in conjunction with persistence in the environment.

**Persistence** - odours which persist in the environment for a long period after release (that is do not readily disperse to a level where the odour is no longer detected) are more likely to be judged as offensive. Less unpleasant odours may be offensive if the releases are continuous or frequent and persistent. The persistence of an odour is also affected by the meteorological conditions.

Categories for **OFFENSIVENESS** are, (taking into account strength, persistence and typical frequency of exposure):

1 Potentially offensive
2 Moderately offensive
3 Very offensive

The observation period should be over a standard time, generally 5 minutes at each location. During this time the intensity and extent can be evaluated.

A record should be made of the atmospheric condition prevalent during the assessment. In the absence of an anemometer, the wind speed can be approximated using the Beaufort scale.

Installation-specific information should be recorded - activities being undertaken, deliveries made, process operating parameters, any departures from "normal" operating conditions or activities.

***Beaufort scale***

**Table A8.1: The Beaufort scale**

| Force | Description | Observation | km/hr |
|---|---|---|---|
| 0 | Calm | Smoke rises vertically | 0 |
| 1 | Light air | Direction of wind shown by smoke drift, but not wind vane | 1-5 |
| 2 | Light breeze | Wind felt on face; leaves rustle, ordinary vane moved by wind | 6-11 |
| 3 | Gentle breeze | Leaves and small twigs in constant motion | 12-19 |
| 4 | Moderate breeze | Raises dust and loose paper; small branches are moved | 20-29 |
| 5 | Fresh breeze | Small trees in leaf begin to sway, small branches are moved | 30-39 |
| 6 | Strong breeze | Large branches in motion; umbrellas used with difficulty | 40-50 |
| 7 | Near gale | Whole trees in motion; inconvenience felt when walking against wind | 51-61 |

## APPENDIX 8 – TESTING PROTOCOL

### Key reporting parameters

The key reporting parameters are set out in the following suggested example of a reporting form :

**ODOUR ASSESSMENT REPORT** **FILE NO. .....**

| **INSTALLATION/ LOCATION** | | **DATE** | |
|---|---|---|---|
| Weather | | Wind (strength & direction) | |
| Temperature (deg. C) | | Bar. Pressure (mbar) if known | |
| Ground condition | | General air stability, (if known) | |
| General air quality | | Cloud cover/height Low, high, very high | |
| Time: start | | Time: Finish | |

Plan attached showing location & extent of odour Yes/No

| **COMPLAINT RECEIVED** | Yes/No | Date & Time complaint(s) received | |
|---|---|---|---|
| Location of complaint area | | Number of complaints which may relate to same source | |
| Grid Reference (where location is not a property) | | Time odour noticed & duration | |

| **TEST LOCATION (and time)** | **Intensity 1 - 5** | **Extent 1 – 5** | **Sensit-ivity 1 - 5** | **Offensive ness 1 - 3** | **Sources within the installation**(potential or actual) | **External sources** (i.e. potentially confounding sources/factors) |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Additional comments

Signature: Persons contacted regarding process:

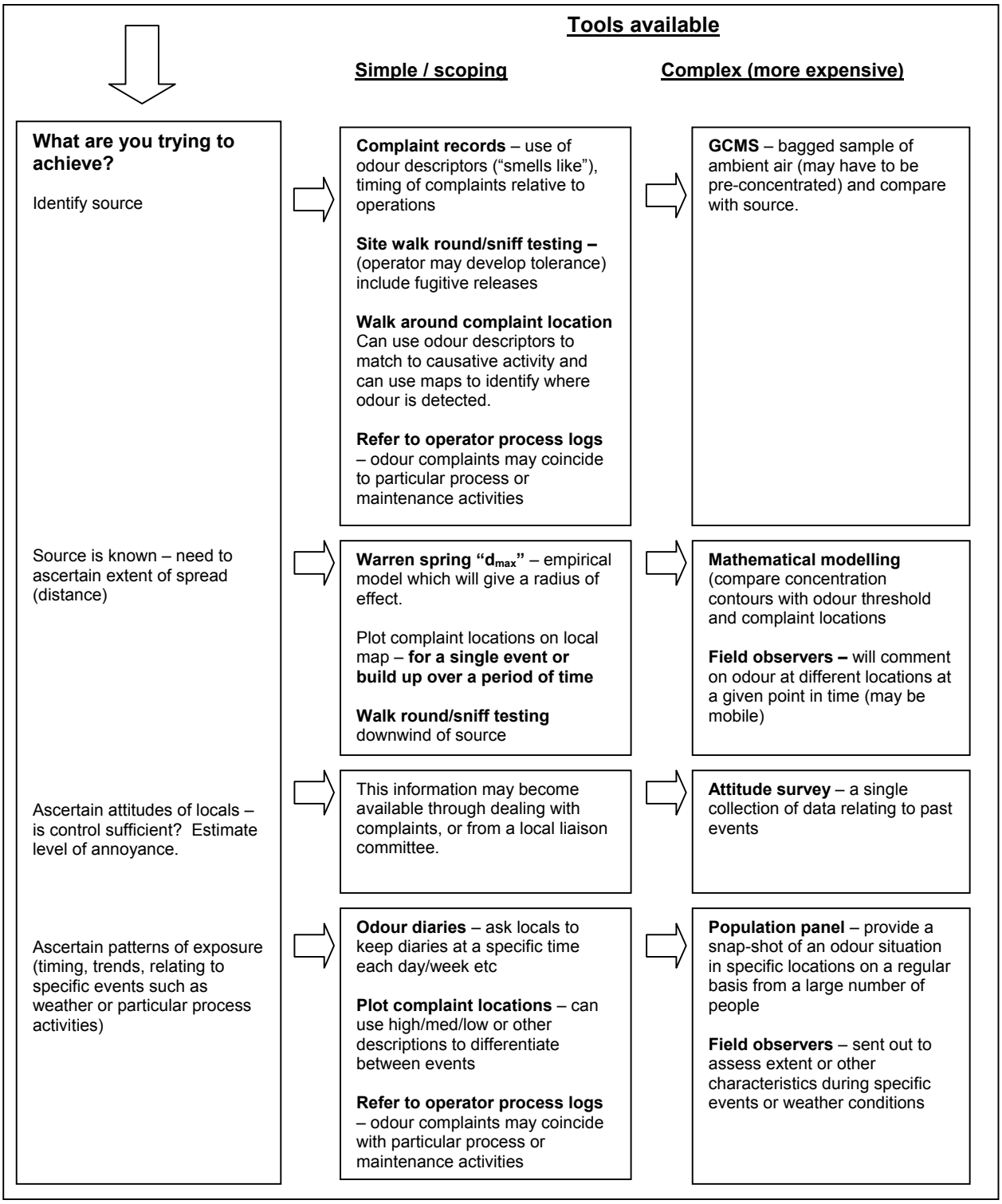
**Action required** (continue overleaf if required)

# APPENDIX 9 - Tools for complaint investigation

Where the source and/or extent of odour impact are not immediately obvious, there are a number of tools of varying complexity available for investigative purposes. These are summarised and compared in Figure A9.1, below

The methodologies shown below are described in more detail in Part 2 of this document "Assessment & Control".

**Figure A9.1: Complaint investigation tools**



## Typical form for the reporting of an odour-related complaint

| | | | |
|---|---|---|---|
| | ***Odour Complaint Report Form*** | | Sheet No |
| Date: | Installation to which complaint relates | Grid Reference: | |
| Name and address of complainant: | | | |
| Tel no. of complainant: | | | |
| Time and date of complaint: | | | |
| Date, time and duration of offending odour: | | | |
| Location of odour, if not at above address: | | | |
| Weather conditions (ie, dry, rain, fog, snow): | | | |
| Cloud cover (0-8): | | | |
| Cloud height (low, high, very high): | | | |
| Wind strength - (light, steady, strong, gusting)<br>Or use Beaufort scale: | | | |
| Wind direction: | | | |
| Complainant's description of odour (i.e. comparison with other odours, strong/weak, continuous, fluctuating): | | | |
| Has complainant any other comments about the odour? | | | |
| Are there any other complaints relating to the installation, or to that location? (either previously or relating to the same exposure) | | | |
| Any other relevant information: | | | |
| On-site activities at time the odour occurred: | | | |
| Operating condition at time offensive odour occurred<br>(e.g. flow rate, pressure at inlet and pressure at outlet) | | | |
| | | | |
| | | | |
| Form completed by | | Signed | |

| ***Actions taken (and outcome):*** |
| --- |
| |
| Completed by: Date: |

# APPENDIX 10 - Tabulated information

## Odour descriptors

Descriptors can help to establish the source of an odour and it is useful, when recording information from a complainant, to seek their description of the odour.

It should be noted that some commercial substances have odour characteristics which are very different to the pure form - for example, carbon disulphide ($CS_2$) has an ethereal (fruity) odour that is far more "pleasant" than the commercial grade which has a "rotten cabbage" smell resulting from the presence of impurities (mercaptans).

**Table A10.1: Odour descriptors for commonly encountered compounds**

| Substance | Odour | Substance | Odour |
|---|---|---|---|
| Acetaldehyde | Apple, stimulant | Dimethyl sulphide | Rotten vegetable |
| Acetic acid | sour vinegar | Diphenylamine | Floral |
| Acetone | chemical/sweetish/solvent | Diphenyl sulphide | Burnt rubber |
| Acetonitrile | Ethereal | Ethanol | Pleasant, sweet |
| Acrylaldehyde | Burning fat | Ethyl acetate | Fragrant |
| Acrolein | Burnt sweet, pungent | Ethyl acrylate | Hot plastic, earthy |
| Acrylonitrile | Onion, garlic, pungent | Ethylbenzene | Aromatic |
| Aldehydes C9 | Floral, waxy | Ethyl mercaptan | Garlic/onion, sewer, decayed cabbage, earthy |
| Aldehydes C10 | Orange peel | Formaldehyde | Disinfectant, hay/straw-like, pungent |
| Allyl alcohol | Pungent, mustard like | Furfuryl alcohol | Ethereal |
| Allyl chloride | Garlic onion pungent | n-Hexane | Solvent |
| Amines | Fishy, pungent | Hydrogen sulphide | Rotten eggs |
| Ammonia | Sharp, pungent odour | Indole | Excreta |
| Aniline | Pungent | Iodoform | Antiseptic |
| Benzene | Solvent | Methanol | Medicinal, sweet |
| Benzaldehyde | Bitter almonds | Methyl ethyl ketone | Sweet |
| Benzyl acetate | Floral (jasmine), fruity | Methyl isobutyl ketone | Sweet |
| Benzyl chloride | Solvent | Methyl mercaptan | Skunk, sewer, rotten cabbage |
| Bromine | Bleach, pungent | Methyl methacrylate | Pungent, sulphide like |
| Sec-Butyl acetate | Fruity | Methyl sulphide | Decayed vegetables |
| Butyric acid | Sweat, body odour | Naphthalene | Moth balls |
| Camphor | Medicinal | Nitrobenzene | Bitter almonds |
| Caprylic acid | Animal like | Phenol | Sweet, tarry odour, carbolic acid |
| Carbon disulphide | Rotten vegetable | Pinenes | Resinous, woody, pine-like |
| Chlorine | Irritating, bleach, pungent | Propyl mercaptan | Skunk |
| Chlorobenzene | Moth balls | Putrescine | Decaying flesh |
| 2-Chloroethanol | Faint, ethereal | Pyridine | Nauseating, burnt |
| Chloroform | Sweet | Skatole | Excreta, faecal odour |
| Chlorophenol | Medicinal | Styrene | Penetrating, rubbery, plastic |
| p-Cresol | Tar-like, pungent | Sulphur dioxide | Pungent, irritating odour |
| Cyclohexane | Sweetish when pure, pungent when contaminated | Thiocresol | Rancid, skunklike odour |
| Cyclohexanol | Camphor, methanol | Toluene | Floral, pungent, moth balls |
| Cyclohexanone | Acetone-like | Trichloroethylene | Solventy |
| Diamines | Rotten flesh | Triethylamine | Fishy, pungent |
| 1,1-Dichloroethane | Ether-like | Valeric acid | Sweat, body odour, cheese |
| 1,2-Dichloroethylene | Chloroform-like | Vinyl chloride | Faintly sweet |
| Diethyl ether | Pungent | Xylene | Aromatic, sweet |
| Dimethylacetamide | Amine, burnt, oily | | |

**References**The Royal Society of Chemistry, "Chemical Safety Data Sheets" Volumes 1 and 5.
Knowlton J and Pearce S, "Handbook of Cosmetic Science and Technology".
Leonardos G, Kendall D and Bernard N, "Odour threshold determinations of 53 odorant chemicals" JAPCA Volume 19, No 2, 1969.
Turk, "Atmospheric gases and vapors" Annals New York Academy of Sciences.

## Hedonic Scores (1)

This table is continued on the following page.

These scores are also referred to as "Dravnieks" and are derived from laboratory-based experiments. They give an indication of the relative pleasantness or unpleasantness of one odour when compared to another. When considering odours from industrial activities, the descriptors given in the previous table can be used. Alternatively refer to the European odour ranking survey results in Appendix 2.

***Use of these scores***
The higher the positive "score", the more "pleasant" the odour descriptor, and the greater the negative figure the more "unpleasant" the odour descriptor. The terms pleasant and unpleasant are used to indicate relative response rather than a sign of a positive or negative level of satisfaction. Zero cannot be considered to be neutral.

**Table A10.2: Hedonic scores (1)**

| Description | Hedonic Score | Description | Hedonic Score | Description | Hedonic Score |
|---|---|---|---|---|---|
| Cadaverous (dead animal) | -3.75 | Fishy | -1.98 | Wet paper | -0.94 |
| Putrid, foul, decayed | -3.74 | Musty, earthy, mouldy | -1.94 | Medicinal | -0.89 |
| Sewer odour | -3.68 | Sooty | -1.69 | Chalky | -0.85 |
| Cat urine | -3.64 | Cleaning fluid | -1.69 | Varnish | -0.85 |
| Faecal (like manure) | -3.36 | Kerosene | -1.67 | Nail polish remover | -0.81 |
| Sickening (vomit) | -3.34 | Blood, raw meat | -1.64 | Paint | -0.75 |
| Urine | -3.34 | Chemical | -1.64 | Turpentine (pine oil) | -0.73 |
| Rancid | -3.15 | Tar | -1.63 | Kippery-smoked fish | -0.69 |
| Burnt rubber | -3.01 | Disinfectant, carbolic | -1.60 | Fresh tobacco smoke | -0.66 |
| Sour milk | -2.91 | Ether, anaesthetic | -1.54 | Sauerkraut | -0.60 |
| Stale tobacco smoke | -2.83 | Burn, smoky | -1.53 | Camphor | -0.55 |
| Fermented (rotten) fruit) | -2.76 | Burnt paper | -1.47 | Cardboard | -0.54 |
| Dirty linen | -2.55 | Oily, fatty | -1.41 | Alcoholic | -0.47 |
| Sweaty | -2.53 | Bitter | -1.38 | Crushed weeds | -0.21 |
| Ammonia | -2.47 | Creosote | -1.35 | Garlic, onion | -0.17 |
| Sulphurous | -2.45 | Sour, vinegar | -1.26 | Rope | -0.16 |
| Sharp, pungent, acid | -2.34 | Mothballs | -1.25 | Beery | -0.14 |
| Household gas | -2.30 | Gasoline, solvent | -1.16 | Burnt candle | -0.08 |
| Wet wool, wet dog | -2.28 | Animal | -1.13 | Yeasty | -0.07 |
| Mouse-like | -2.20 | Seminal, sperm-like | -1.04 | Dry, powdery | -0.07 |
| Burnt milk | -2.19 | New rubber | -0.96 | | |
| Stale | -2.04 | Metallic | -0.94 | | |

## Hedonic Scores (2)

**Table A10.2: Hedonic scores (2)**

| Description | Hedonic Score | Description | Hedonic Score | Description | Hedonic Score |
|---|---|---|---|---|---|
| Cork | 0.19 | Crushed grass | 1.34 | Maple syrup | 2.26 |
| Black pepper | 0.19 | Celery | 1.36 | Pear | 2.26 |
| Musky | 0.21 | Green pepper | 1.39 | Caramel | 2.32 |
| Raw potato | 0.26 | Tea leaves | 1.40 | Coffee | 2.33 |
| Eggy (fresh eggs) | 0.45 | Aromatic | 1.41 | Meaty (cooked, good) | 2.34 |
| Mushroom | 0.52 | Raisins | 1.56 | Melon | 2.41 |
| Beany | 0.54 | Cooked vegetables | 1.58 | Popcorn | 2.47 |
| Geranium leaves | 0.57 | Clove | 1.67 | Minty, peppermint | 2.50 |
| Grainy (as grain) | 0.63 | Nutty | 1.92 | Lemon | 2.50 |
| Dill | 0.87 | Coconut | 1.93 | Fragrant | 2.52 |
| Woody, resinous | 0.94 | Grapefruit | 1.95 | Fried chicken | 2.53 |
| Soapy | 0.96 | Perfumery | 1.96 | Cinnamon | 2.54 |
| Laurel leaves | 0.97 | Peanut butter | 1.99 | Cherry | 2.55 |
| Eucalyptus | 0.99 | Spicy | 1.99 | Vanilla | 2.57 |
| Molasses | 1.00 | Banana | 2.00 | Pineapple | 2.59 |
| Incense | 1.01 | Almond | 2.01 | Apple | 2.61 |
| Malty | 1.05 | Sweet | 2.03 | Peach | 2.67 |
| Caraway | 1.06 | Buttery, fresh butter | 2.04 | Violets | 2.68 |
| Soupy | 1.13 | Grape juice | 2.07 | Fruity, citrus | 2.72 |
| Bark, birch bark | 1.18 | Honey | 2.08 | Chocolate | 2.78 |
| Anise (liquorice) | 1.21 | Cedarwood | 2.11 | Floral | 2.79 |
| Oak wood, cognac | 1.23 | Herbal, green, cut grass | 2.14 | Orange | 2.86 |
| Seasoning (for meat) | 1.27 | Cologne | 2.16 | Strawberry | 2.93 |
| Leather | 1.30 | Fresh green vegetables | 2.19 | Rose | 3.08 |
| Raw cucumber | 1.30 | Fruity, other than citrus | 2.23 | Bakery (fresh bread) | 3.53 |
| Hay | 1.31 | Lavender | 2.25 | | |

**References**

(Reference 20) Dravnieks A, Masurat T, Lamm R A, “Hedonics of Odours and Odour Descriptors”: in *Journal of the Air Pollution Control Association,* July 1984, Vol. 34 No. 7, pp 752-755

(Reference 13) Guidance for the Regulation of Odour at Waste Management Facilities under the Waste Management Licensing Regulations, July 2001, Version 2.3

## Odour threshold values

The quality of odour detection threshold data can be poor. *"Odour measurement and control - an update"* (Woodfield and Hall 1994) (Reference 26) differentiates between chemicals for which threshold values have been determined by a recognised test method (dynamic dilution olfactometry), and those chemicals where threshold values have not been determined by a recognised test method. The data quality for compounds determined by recognised methods are more likely to approach the "true value". The table below contains those odour threshold values which have been determined using recognised test methodologies.

**Table A10.3: Odour threshold values of common odorants**

| Compound | mg $m^{-3}$ | ppm | Compound | mg $m^{-3}$ | ppm |
|---|---|---|---|---|---|
| Acetic acid | 0.043 | 0.016 | 2-Hydroxyethyl acetate | 0.527 | 0.114 |
| Acetic anhydride | 0.0013 | 0.00029 | Light fuel oil | 0.053 | |
| Acetone | 13.9 | 4.58 | 3-Methylbutanal | 0.0016 | 0.0004 |
| Acrylic acid | 0.0013 | 0.0004 | 2-Methyl-1-butanol | 0.16 | 0.041 |
| Amyl acetate | 0.95 | 0.163 | Methyldithiomethane | 0.0011 | 0.00026 |
| iso Amyl acetate | 0.022 | 0.0038 | 2-Methyl 5-ethyl pyridine | 0.032 | 0.006 |
| Benzene | 32.5 | 8.65 | Methyl methacrylate | 0.38 | 0.085 |
| 1,3-Butadiene | 1.1 | 0.455 | 3-Methoxybutyl acetate | 0.044 | 0.007 |
| 1-Butanol | 0.09 | 0.03 | 1-Methoxypropan-2-ol | 0.0122 | 0.003 |
| 2-Butanol | 3.3 | 1 | 1-Methoxy-2-propylacetate | 0.0075 | 0.0014 |
| 2-Butanone (MEK) | 0.87 | 0.27 | 2-Methyl-1-pentanol | 0.096 | 0.021 |
| Butoxybutane | 0.03 | 0.005 | 2-Methyl pentaldehyde | 0.09 | 0.02 |
| 2-Butoxyethanol | 0.0051 | 0.00097 | 4-Methyl-2-pentanone (MIBK) | 0.54 | 0.121 |
| 2-Butoxyethyl acetate | 0.045 | 0.0063 | 2-Methyl-2-propanol | 71 | 21.46 |
| Butoxypropanol | 0.191 | 0.0324 | $\alpha$-Methyl styrene | 0.021 | 0.003 |
| Butyl acetate | 0.047 | 0.0066 | 1-Nitropropane | 28.2 | 7.09 |
| 2-(2-Butoxyethocy)ethanol | 0.0092 | 0.0013 | 1-Octene | 0.33 | 0.066 |
| 2,2-butoxyethoxyethyl acetate | 0.015 | 0.0016 | 2-Octene | 0.5 | 0.1 |
| Carbon tetrachloride | 280 | 40.73 | 2-Octyne | 0.03 | 0.006 |
| Carbon sulphide | 0.0275 | 0.0102 | 2,4-Pentanedione | 0.045 | 0.01 |
| m-Cresol | 0.0013 | 0.0003 | 1-Pentanol | 0.02 | 0.0051 |
| o-Cresol | 0.0028 | 0.0005 | Petroleum naptha | 0.2 | |
| p-Cresol | 0.0029 | 0.0006 | Phenyl ether | 0.0021 | 0.0003 |
| Cyclohexane | 315 | 83.8 | 2-Picoline | 0.014 | 0.0034 |
| Cyclohexanone | 0.083 | 0.019 | Propanal | 0.014 | 0.0054 |
| Dichloromethane | 3.42 | 0.912 | 2-Propanol | 1.185 | 0.442 |
| Diesel | 0.06 | | 2-Propen-1-ol | 1.2 | 0.47 |
| Dimethyl adipate | 7.101 | 0.913 | iso Propylamine | 0.158 | 0.06 |
| Dimethyl glutarate | 1.212 | 0.169 | Propylbenzene | 0.048 | 0.009 |
| Dimethyl succinate | 0.992 | 0.152 | Propylene-n-butylether | 0.206 | 0.01 |
| 1,4-Dioxane | 30.6 | 7.78 | Propyl ether | 0.024 | 0.0053 |
| 1,3-Dioxolane | 56.3 | 17.02 | Styrene | 0.16 | 0.0344 |
| Diphenylmethane | 0.41 | 0.55 | 1,1,2,2-Tetrachloroethane | 1.6 | 0.21 |
| Ethoxypropanol | 0.161 | 0.035 | Toluene | 0.644 | 0.16 |
| Ethoxypropyl acetate | 0.0052 | 0.0008 | Trichloroethylene | 8 | 1.36 |
| Ethyl acetate | 2.41 | 0.61 | Trimethylamine | 0.0026 | 0.001 |
| Ethyl alcohol | 0.28 | 0.136 | Xylene (mixed) | 0.078 | 0.016 |
| 2-Ethyl-1-butanol | 0.07 | 0.015 | 2,3 Xylenol | 0.0037 | 0.0007 |
| 2-Ethyl-1-hexanol | 0.5 | 0.086 | 2,4 Xylenol | 0.064 | 0.0117 |
| 2-Ethylhexyl acrylate | 0.6 | 0.073 | | | |
| 2-Furaldehyde | 0.25 | 0.058 | | | |
| 1-Hexanol | 0.005 | 0.0011 | | | |
| Hydrogen sulphide | 0.00076 | 0.0005 | | | |

***Other sources of threshold values***

*Compilation of odour threshold values in air and water, Central Institute for Nutrition and Food Research, TNO, Netherlands, June 1997. Editors: van Gembert L J; Nettenbrejer A H.*

*Compilation of odour and taste threshold values data, American Society for Testing and Materials, ASTM Data Series DS 48A. Editor: Fazzalari F A.*

The documents listed above contain odour threshold values for a much wider range of substances. The fact that a document is listed does not necessarily mean that the values given are consistent with other documents and it is advisable to cross-check values with more than one source as there can be considerable variation. This list is not exhaustive and other published values exist.

## Converting mg $m^3$ to odour units using odour threshold values

Chemical analysis of a sample taken at source can be used to determine a mass emission or compliance with an emission limit. The emission can be modelled to give a predicted ground level concentration at receptors.

To allow the impact of a source to be considered in terms of odour concentration, the data can be converted to odour units by using odour threshold values as given overleaf. This can be only reliably be applied to single compounds. It does not work well with mixtures (ie by adding the relative contributions of each to the total mixture) as it does not take synergistic or additive effects into account.

The odour concentration of a mixture can be estimated by:

$$D = C_a/T_a$$

D is the odour concentration of a mixture (dimensionless, odour units $ou_E\ m^{-3}$)
$C_a$ is the chemical concentration of compound (a) in mg $m^{-3}$
$T_a$ is the published odour threshold value of compound (a) in mg $m^{-3}$

**However, there can be large uncertainties in the:**

- **quality of threshold data;**
- **quality of chemical data.**