APPENDIX 5 – EMISSION LIMIT VALUES FOR ODOUR

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 8 – TESTING PROTOCOL

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.

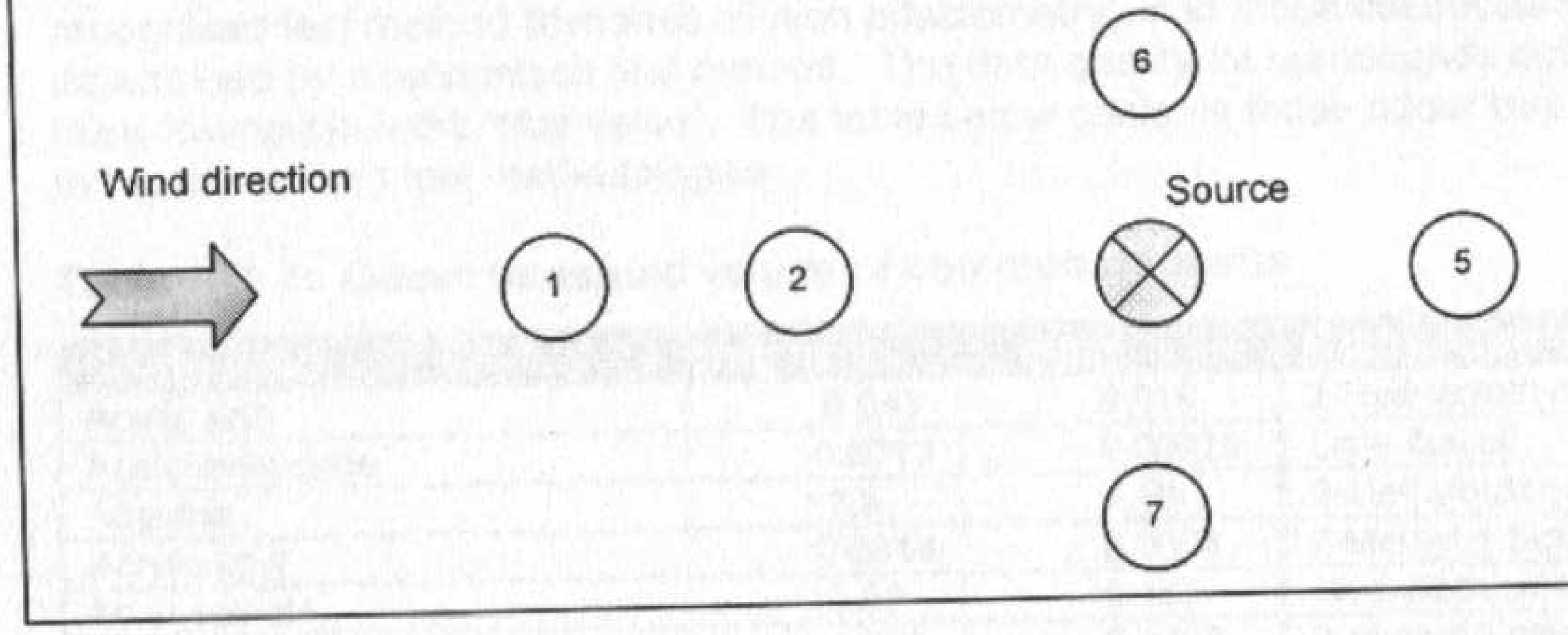

Figure A8.1: Example of a possible sequence for assessment

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

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	α-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.

APPENDIX 10 - TABULATED INFORMATION

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.**