

**Determination and assessment of odour in ambient air**

**(Guideline on odour in ambient air / GOAA)**

**dated 13<sup>th</sup> May, 1998**

**with background information**

**and interpretation to the GOAA**

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Vocabulary for the English version of the Guideline on odour in ambient air  
(not part of the German version)

In cases of doubt the German version is binding.

<b>English</b>	<b>Engl. abbrev.</b>	<b>German</b>	<b>German abbr.</b>
additional impact	I <sub>add</sub>	Zusatzbelastung	IZ
annoyance		Belästigung als Wirkung	
characteristic value		KenngroÙe	
development planning		Bebauungsplan	
Federal Immission Control Act		Bundesimmissions-Schutz-Gesetz	BImSchG
field measurement		Rasterbegehung	
German Technical Instructions on Air Quality Control		Technische Anleitung zur Reinhaltung der Luft	TA Luft
Guideline on odour in ambient air	GOAA	Geruchsimmissions-Richtlinie	GIRL
harmful effects on the environment		schädliche Umwelteinwirkungen	
immission		Immission	
immission limit value	I <sub>limit</sub>	Immissionswert	IW
initial impact	I <sub>initial</sub>	Vorbelastung	IV
Lander Committee for Pollution Prevention		Länderausschuss Immissionsschutz	LAI
mutual considerations in neighbour relations		gegenseitige Rücksichtnahme	
odour impact		Geruchsimmissionsbelastung	
percentage of odour time		Geruchszeitanteil	
plume measurement		Fahnenbegehung	
principles of planning laws		Grundsätze des Planungsrechts	
protection of existing installations		Bestandsschutz	
significant changes in the operation of an installation		wesentliche Änderung einer Anlage	
significant nuisance		erhebliche Belästigung	
total impact	I <sub>total</sub>	Gesamtbelastung	IG

## **Determination and assessment odour in ambient air**

### **(Guideline on odour in ambient air - *GOAA*)**

(13<sup>th</sup> May 1998)

#### 1 General remarks

The sources of annoying odours in the environment can be in particular polluted air from chemical installations, oil refineries, food industry, livestock farming and waste treatment plants as well as road traffic, domestic heating, agricultural activities and vegetation.

An assessment of this nuisance is particularly difficult. As a rule, pollutants in ambient air can be detected objectively in terms of mass concentrations by means of physical/chemical measurement methods. Comparing measured or possibly calculated ambient concentrations with limit values generally does not involve any special problems. In contrast to this, odour in ambient air can hardly be determined and assessed with such procedures. As odour nuisance mostly occurs even at very low concentrations and moreover due to the combined action of several substances, the determination of substances by means of physical/chemical measurement methods is extremely costly or not possible at all. Furthermore, the annoying effect of odours depends very much on the sensitivities and the subjective attitudes of the affected persons. This requires consideration of a large number of criteria when odours are to be detected/identified and assessed.

Whether an odour nuisance is significant and hence a harmful effects on the environment does not only depend on the concentration of the pollutant but also on the type of odour, the hedonic odour tone, the daily and seasonal distribution and the temporal pattern of nuisance, the use of the affected area and some other criteria (see Section 3.1). Some of these criteria, e.g. the hedonic odour tone, are not yet supported by sufficient scientific knowledge. They cannot, therefore, be used to establish generally valid regulations.

The German Technical Instructions on Air Quality Control (TA Luft) do not contain detailed requirements of methods to determine whether an installation emits odours which cause a significant nuisance as defined in § 3, Section 1, of the Federal Immission Control Act (Bundesimmissionsschutzgesetz, *BImSchG*). Therefore, it is recommended to observe the requirements laid down in this Guideline until pertaining federal administrative instructions are issued, in order to assure the use of uniform criteria and procedures in the assessment of

ambient odours to arrive at impartial decisions concerning any restrictions that might have to be placed on odour emitting installations.

The Guideline, suitably adapted, may also be applied to installations which do not require licensing.

In the case of livestock farming, the licensing authority may waive the requirements of the *GOAA* and decide that the provisions for receiving a license are fulfilled if minimum setback distances are observed (see Section 3.3.7.1.1 of the *TA Luft*), unless the special circumstances of the individual case (e.g. topographic features or initial odour impact) require a different approach. In the case of livestock farms not requiring a license, the licensing authority may proceed according to the guidelines VDI 3471 and VDI 3472 to arrive at a decision on whether minimum distances are met.

For assessing the significance of the odour impact, this Guideline sets limit values for odours in ambient air (immission\* limit values) for various land uses to serve as a fundamental measure. These limit values have to be compared with the characteristic values which take into account the initial odour impact contributed by other installations. The initial odour impact is determined with olfactory field measurements along the lines of guideline VDI 3940 (Assessment of Odours in Ambient Air by Field Inspections).

The following rule applies to determining the additional odour impact (see also Section 4.5):

Until guideline VDI 3788 Part 1 and its subsequent parts on odour dispersion modelling are adopted, dispersion models have to be applied the suitability of which is proved and is acknowledged by the competent authority.

The initial impact and the additional impact add up to the total odour impact which is compared with the immission limit value.

The Guideline also contains rules for cases in which the initial odour impact on an assessment square already exceeds the pertinent limit value (see Section 3.3 and Section 5) or where odours are caused by sources other than those listed in Section 3.1 (see Section 5).

In the cases listed in Section 3.3, a license should not be denied in spite of a limit value being exceeded if the additional impact from the installation under assessment is judged to be irrelevant by the criteria listed in Section 3.3. The same applies if weighting with other criteria having an influence on the reasonableness of the ambient odour impact results in the

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\* The word „immission“ is used in the sense of influence of air pollutants, in this case odour, on humans. This establishes an active view of air pollutants influencing receptors, in contrast to the passive view of receptors being exposed to air pollutants. If we neglect this more semantic difference, “immission” can be interpreted as exposure.

conclusion that the odour nuisance is not to be classified as being significant. The Guideline also provides rules concerning the cases in which the initial odour impact need not be determined or an estimate of the initial impact by dispersion modelling is admissible.

## 2. Conditions for limiting and releasing odour emissions to the atmosphere

On principle, prior to any odour impact assessment, it must be ascertained that all means of the state-of-the-art of odour abatement have been exhausted (see Section 3 of the German *TA Luft*) and that the release of residual emissions meets the requirement of Section 2.4 of the German Technical Instruction on Air Quality Control (see ruling by the Federal Administrative Court of 10 May 1990; Gew Archive 1991/8, page 312).

Waste gases as defined by Section 2.1.3 of the German *TA Luft* are air and other gases carrying odorous substances.

As a rule, the minimum height of waste gas stacks is chosen so that the characteristic value of the additional impact  $I_{\text{add}}$  (see Section 4.5) does not exceed the value of 0.06 on the assessment square with maximum impact.

In exceptional cases excessively high stacks may result; in these cases the pertinent authorities have to be consulted.

## 3. Assessment criteria

### 3.1 Immission limit values

Odours in ambient air need to be assessed according to this Guideline if the source can be identified to be an installation when following the procedure of Section 4.4.7, i.e. if the odours can be distinguished from road traffic, domestic heating, vegetation, manure spreading, and similar sources. As a rule, the odour impact has to be classified as significant nuisance if the total odour impact  $I_{\text{total}}$  (Section 4.6) exceeds the immission limit values  $I_{\text{limit}}$  listed in Table 1. These limit values are relative frequencies of odour-hours (see Section 4.4.1 and subsequent Sections).

Table 1: Immission limit values  $I_{\text{limit}}$  for different land use

residential and mixed areas	industrial and commercial areas
0,10	0,15

Other areas which are populated not only temporarily are to be assigned to column 1 or column 2 by applying the principles of development planning.

According to § 3 (1) of the Federal Immission Control Act (German *BImSchG*), harmful environmental impact is caused by “pollutions which due to their *type*, *level* and *duration* are likely to cause hazards, severe detriments or significant nuisance in the population at large or the neighbourhood”. The *type* of the ambient air pollution is identified by the description of the smell, the intensity *level* is quantified by odour determination above identification threshold and by means of the concept of the odour-hour (see Section 4.4.7), and the *duration* is expressed by the frequency of occurrence. As a rule, these methods characterise the odour impact sufficiently well.

Comparison with the limit values  $I_{\text{limit}}$  alone does not always suffice to assess the significance of a nuisance. Therefore, after assessment of the odour frequency, a regular check follows of whether there are indications of a necessary investigation into the individual circumstances as outlined in No. 5.

### 3.2 Scope of application of the immission limit values

The limit values are applicable only in conjunction with the determination of the characteristic values of the ambient odour impact according to the methods defined below. Going beyond the requirement of Section 4.4.1, the limit values take into account uncertainties which may arise from the olfactometric emission measurement and from the additional odour impact calculated according to the rules of Section 4.5.

### 3.3 Significance of contributions to ambient odours

Licensing of an installation shall not be refused because of the total odour impact being higher than the odour limit values of the *GOAA* if the future contribution to the total odour impact by the planned installation (characteristic value of the additional odour impact) does not exceed the limit value of 0.02 on any assessment square. If this limit is observed, it can be assumed that the installation will not significantly increase the level of nuisance caused by the initial odour impact (irrelevance of the additional odour impact).

Please see the relevant Section 2.2.1.2c of the German *TA Luft*.

#### 4. Determining the characteristic values of the ambient odour impact

##### 4.1 General remarks

There are several different methods to assess the significance of an ambient odour impact (see Table 2). The ambient odour impact is always quoted as a value (ambient odour characteristic), which represents the temporal perceptibility above a defined intensity level (identification threshold).

Table 2: Methods to determine the ambient odour impact

Method	initial odour impact Section 4.4	additional odour impact Section 4.5
Grid field measurements	preferred method	not possible
olfactometric determination of the ambient odour impact by a panel and calculation of the frequency distribution		
dispersion modelling computation of the odour impact expressed in odour units per m <sup>3</sup> from the odour emission rate (odour units per hour) and calculation of the frequency distribution	possible, but the emission data have to be supplied, either by olfactometric emission measurements or plume measurements	preferred method

Dispersion modelling can be applied if results of measurements or estimates indicate that the initial odour impact  $I_{\text{initial}}$  remains below 70% of the relevant limit value of Table 1 or if determining the odour impact by field measurements is deemed to be disproportional. If the initial impact is computed, all odour sources relevant in the assessment area have to be included.

Plume measurements according to guideline VDI 3940 can be applied in order to estimate unknown emissions in special cases (not for calculations of the odour frequency) or to calibrate dispersion models.

#### 4.2 Assessment during licensing

A distinction is made between the characteristic values of the initial odour impact  $I_{\text{initial}}$ , the additional impact  $I_{\text{add}}$  and the total impact  $I_{\text{total}}$ . They are determined for every assessment square in the assessment area. The initial impact is the odour impact originating from existing installations without the additional impact caused by the object which is to be licensed. The additional impact is to be determined according to Section 4.5.

The characteristic value of the total impact is calculated from the characteristic value of the initial impact and the additional impact as per Section 4.6.

When the odour flow rate is to be determined, all emissions from the whole installation have to be included. If significant changes in the operation of a facility are planned, the expected emissions of the section to be modified have to be regarded as well as the emissions from those sections which will be affected by the change.

In assessments necessary to obtain a license the correction factor  $k$  (see Section 4.4.1) is taken into account in field measurements because otherwise there is no acknowledged statistical certainty that the licensing requirements are met (see § 6 (1) German *BImSchG*). The reason is the uncertainty in field measurement results.

#### 4.3 Assessments during administrative surveillance

Such assessments may become necessary to make decisions on subsequent orders.

Subsequent orders are considered if the comparison of the characteristic value of the initial odour impact with the immission limit values in Table 1 shows that the limits are exceeded or if a significant nuisance is stated in cases discussed in Section 5.

In monitoring procedures, more measurement points (Section 4.4.6) on the assessment square (Section 4.4.3) or more frequent measurements (Section 4.4.7) may be required in order to determine whether the actual conditions warrant subsequent orders. Furthermore, plume measurements may be conducted to identify the odour source (Section 4.1). The correction factor  $k$  is ignored in this procedure.

If it is necessary to distinguish between several sources of equal odour character as addressed in Section 3.1, Paragraph 1, the meteorological factors affecting the dispersion of the odour emissions have to be recorded as well. The sectors of the wind direction and the location and density of the measurement points and the evaluation points of modelling are selected such that the perceived odours (in ambient air) can be identified and thus traced back to the individual emitters.

#### 4.4 Characteristic value of a initial odour impact in ambient air

##### 4.4.1 General remarks

The characteristic value  $I_{initial}$  of an initial odour impact is obtained from

$$I_{initial} = \frac{k \cdot n_v}{N}$$

where N is the sample size (N = 52 or 104) and  $n_v$  is the sum of the odour hours which were determined on the four corners of the assessment square (Section 4.4.7).

The correction factor k of Table 3 accounts for the statistical uncertainty of the odour impact determined with the sample sizes N = 52 or N = 104. The correction factor k was derived from a test of hypotheses with the binomial distribution.

Table 3: The correction factor k

sample size N	residential and mixed area	industrial and commercial areas
52	1.7	1.6
104	1.5	1.3

The initial odour impact is determined following a measurement plan approved by the licensing authority. It addresses the assessment area, the assessment squares, the emitting installation under assessment, the measurement height, the measurement period, the measurement times during the day, measurement points, measurement methods, frequency of

measurement, the duration of a single measurement and, if applicable, reasons for waiving measurements.

Unless this Guideline stipulates otherwise, further details of the measurement method may be gathered from guideline VDI 3940.

The applicant for a license may be exempted from determining the initial odour impact on the assessment squares if the estimated characteristic value of the initial odour impact does not exceed 50% of the limit value listed in Table 1. This estimate may be based on e.g. the frequency distribution of the wind directions, on dispersion modelling, preliminary field measurements etc. In these cases one half of the respective limit value in Table 1 is used as  $I_{\text{initial}}$  in the equations of Section 4.6.

The initial odour impact need not be determined either whenever the additional impact caused by the installation to be licensed does not exceed the irrelevance limit according to Section 3.3.

If there are definitely no other installations emitting odours, the initial odour impact  $I_{\text{initial}}$  is assumed to be 0.

Past measurement results or statements on odour emissions or ambient odour may be used only if the relevant conditions in the odour assessment area have not changed decisively in the meantime.

#### 4.4.2 Assessment area

The assessment area is the sum of all assessment squares (Section 4.4.3) which lie completely inside a circle about the centre of gravity of the emission sources with a radius of 30 times the stack height determined according to Section 2. The minimum radius is 600 m.

In installations with fugitive odour sources whose outlets are less than 10 m above ground the radius is selected in such a way that the distance between the circle line and the edge of the emitting site is nowhere less than 600 m.

#### 4.4.3 Assessment squares

The assessment squares are square-shaped subdivisions of the assessment area. Their sides are usually 250 m long if the odour impact on them is fairly homogeneous. Smaller squares should be chosen if the distribution of the odour impact is expected to be unusually uneven so

that the odour impact cannot be determined with sufficient approximation when the provisions of sentence 2 of this paragraph are observed. It is also admissible to enlarge the assessment square if the distribution of the odour over this square is consistently homogeneous. The limit values established in this Guideline (Section 3.1) do not have to be adapted because they were derived independently of the size of the squares. The grid of squares is aligned in such a way that the centre of gravity of the emission sources coincides with the centre of one of the squares.

#### 4.4.4 Measurement height

As a rule, the odours in ambient air are measured about 1.5 to 2.0 m above ground and at a horizontal distance of at least 1.5 m from buildings.

#### 4.4.5 Measurement period

The measurement period should be representative of a whole year. As a rule, it lasts six months; only in special cases may it be shortened to three months.

The measurements are to be distributed evenly over the 24 hours of the day to get representative results. Alternatively, they may be adapted to the operating hours of those emitters which are relevant for the initial odour impact. In this case the number of odour hours found is corrected by a factor which is the ratio of the operating time of the installation to the total time of the year.

#### 4.4.6 Measurement points

The measurement points have to be fixed as closely as possible to the nodes of the square grid into which the assessment area is dissected. If local circumstances prevent this, the nearest suitable point is selected. The measurement points have to be placed outside area sources.

On principle, measurement points are fixed in the neighbourhood of the installation only where the odour impact is relevant for a potential nuisance. These are particularly those areas which are populated not only temporarily. For instance, no measurement points are required in forests and in contiguous areas of agriculture or horticulture.

#### 4.4.7 Methods and frequency of measurement

As a rule, the odour impact has to be determined by olfactory field measurements (grid measurements) (see Section 4.1). During the measurement period, each corner of the assessment square is visited by members of the panel 13 or 26 times depending on the statistical certainty required (see Section 4.4.1). These visits should be distributed over the measurement period at equally long intervals. The results obtained on all four corners of an assessment square are added to the number  $n_V$  of odour hours for this assessment square. The sequence of visits to the measurement points is arranged in such a way that neighbouring measurement points are visited on different days. This ensures that, by moving spatial data collection, the characteristic value computed for every assessment square and every measurement period will contain data of four different measurement days.

The panel members for each individual field measurement are selected from a fixed pool of at least ten persons. The panel members' individual sensitivities to odours are established prior to the measurements. The results of these performance tests are recorded as shown in Annex B. Reference is made to the requirements outlined in Annex C and also the requirements set up by the Lander Committee for Pollution Prevention (German abbreviation *LAI*). They concern measuring institutes to be officially acknowledged for olfactory field measurements as per §§ 26, 28 of the German *BImSchG* (see individual regulations of each Land/federal state).

It is important to take care that only clearly identifiable odours shall be recorded, i.e. only those odours which can be traced back with sufficient certainty to equipment or the installation and which can be well distinguished from odours caused by road traffic, domestic heating, vegetation, manure spreading etc. (see Section 3.1).

Apart from that, only institutions conforming to §§ 26 and 28 of the German *BImSchG* with additionally certified pertinent qualifications are to be entrusted with the olfactometry measurement of initial odour impact.

Different odour intensities shall not be recorded in general because there is no evidence of a sufficiently reliable relationship between this odour property and the level of nuisance. When the limit values of Section 3.1 of this Guideline are used, all odours emitted by an installation which exceed the identification threshold are included. Apart from that, the fundamentals of guideline VDI 3940 apply.

The initial odour impact is determined with sufficient accuracy if the panel member stays for 10 minutes at each measurement point (measurement interval) and if the conditions described above are observed. The measurement is counted as one "odour hour", if the emitted odours are identified during 10 % of the measurement interval (percentage of odour time). The odour perceptions are recorded in data collection forms according to Annex A (example).

#### 4.5 Characteristic value $I_{add}$ of an additional odour impact in ambient air

The characteristic value  $I_{add}$  of the additional impact is calculated using a measurement unit of 1 odour unit per cubic meter ( $ou/m^3$ ) (identifiable odour) and taking into account what has been said in Section 1. The olfactometric determination of the emissions shall meet the requirements listed in Annex C and the requirements of odour measurements set up by the German *LAI*, i. e. the measurements shall be made by officially acknowledged institutes for odour assessments in accordance with §§ 26 and 28 of the German *BImSchG* (see individual regulations of each Land/federal state).

The spacing of the gridlines for dispersion modelling is one half of the spacing of the assessment squares defined in Section 4.4.3. The points of intersection of these dispersion gridlines are the calculation points in modelling (see German *TA Luft*, Annex C, Section 7). Apart from that, the conditions of Section 4.4.6 apply. The characteristic value  $I_{add}$  of additional odour impact is computed as follows:

$$I_{add} = \frac{n_z}{9 \cdot 8760}$$

where  $n_z$  is the number of odour hours at the nine evaluation points in modelling.

#### 4.6 Evaluation

The characteristic value  $I_{initial}$  of the initial odour impact is computed for every assessment square of the assessment area either from the results of the field measurements or of dispersion modelling. The additional impact  $I_{add}$  is obtained following Section 4.5.

The characteristic value of the total odour impact  $I_{\text{total}}$  is obtained by adding\* the characteristic values of the initial odour impact  $I_{\text{initial}}$  and the additional odour impact  $I_{\text{add}}$ :

$$I_{\text{total}} = I_{\text{initial}} + I_{\text{add}}$$

The characteristic value of the total odour impact is rounded to two decimal digits and compared with the pertinent (land use) limit value of Table 1.

## 5. Assessment in individual cases

For assessing whether ambient odour impact has a detrimental impact on the environment, it is not sufficient to only compare the limit values defined in Table 1 with the ambient odour characteristics found by observing this Guideline provided that:

- a) significant ambient odour impact occurs on individual assessment squares which originate from road traffic, domestic heating or from other sources addressed in the first paragraph of Section 3.1; or if
- b) extraordinary conditions such as disgusting or nausea causing odours, very intensive odours, unusual usage of the area or other extraordinary conditions indicate that
  - there are harmful effects on the environment although the limit values are observed; or
  - significant nuisance of the neighbourhood or the general population is not to be expected although the limit values are exceeded.

In these cases the total potential odour impact is determined and the portion which is contributed by operation of the installations falling within the scope of the first paragraph of Section 3.1. Subsequently, a decision is made whether the odour impact is significant and whether there is a relevant contribution from the installations under assessment.

Only that odour nuisance may be judged as a harmful effect on the environment which is significant in the framework of § 3, Section 1, of the German *BImSchG*. The significance is

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\* On principle frequencies which originate from mutually independent distributions cannot simply be added, see Section 2.6.5.3 of the German *TA Luft*. The algebraic summation of the initial impact and the additional impact is a simplification in the interest of practical application. It is derived from the multiplication theorem of the probability theory. It is assumed that the product term  $p_v \cdot p_z$  may be neglected because the partial probabilities  $p_v$  and  $p_z$  are significantly smaller than 0.1. (In this context,  $p_v$  is the probability of an odour identification during the initial odour impact and  $p_z$  is the probability of an odour identification during the additional odour impact.)

not an absolutely defined quantity but is to be determined in individual cases by weighting the pertinent and relevant circumstances.

While taking into account the probably typical situation on the site with regard to an initial odour impact, the following criteria shall preferably be used for the assessment of significant odour nuisance:

- the character of the neighbourhood, particularly the land use of the area as defined in development planning,
- regional development plans and agreed or stipulated restrictions on the usage of the land,
- special circumstances of the daily and seasonal distribution of the odour impact as well as type (e.g. disgusting odours) and intensity of the odour impact. For instance, odours causing disgust or nausea may already be hazardous to health.

Moreover, it has to be considered whether the usage of a property is subjected to mutual considerations in neighbour relations which for instance may require the persons annoyed by the odours to tolerate higher levels of odour impact. This will be particularly so with emitting installations whose existence is protected by law. Here nuisance will have to be tolerated even if in other situations they would have to be considered as being significant.

Annex A

Data Collection Form for Field Measurements

Panel member:

Date:

Measurement point.:

Start of measurement:

End of measurement:

1. minute	2. minute
<input type="text"/>	<input type="text"/>
3. minute	4. minute
<input type="text"/>	<input type="text"/>
5. minute	6. minute
<input type="text"/>	<input type="text"/>
7. minute	8. minute
<input type="text"/>	<input type="text"/>
9. minute	10. minute
<input type="text"/>	<input type="text"/>

Odour qualities

0 – no odour

1 – typical installation XY odour

2 – other installation XY odour

3 – odour from other installations\*

4 – other odours\*\*

Comments:

- \* odour from other installations have to be described
- \*\* other odour qualities have to be described, e.g. 4<sup>1</sup> barbecue smells, 4<sup>2</sup> home painting, 4<sup>3</sup> road paving etc.!

Meteorological data:

Wind strength:

calm	weak	moderate	severe	stormy
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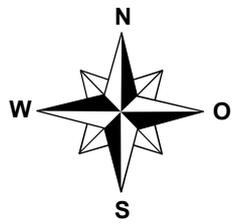
Cloudiness:

clear	broken	dense	closed
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Precipitation:

none	drizzle	rain	snowfall	fog	other
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Wind from direction:





## Annex C:

### Requirements of the olfactometric measurement method for determining odour emissions

In order to provide uniform determination of ambient odour impact, the European Standard "Air Quality - Determination of Odour Concentration by Dynamic Olfactometry" (EN 13725) will be implemented as a national standard after it has become effective on the European level. In the transition period until this standard will become effective the following guidelines for odour threshold determination are valid: Guideline VDI 2448, Part 1, Planning of discontinuous emission measurements of ducted (?) sources - (April 1992) as well as Guideline VDI 3881, Olfactometry; Odour Threshold Determination; Part 1 Fundamentals - (May 1986), Part 2, Sampling - (January 1987) and Part 4, Instructions for Application and Performance Characteristics, (draft in German December 1989).

Where these guidelines offer any choices, the following specifications apply when the ambient odour impact is determined according to this Guideline on Odour in Ambient Air:

At least three samples should be drawn per operating state and per emission source. For each sample the odorant concentration is determined in three runs. Sampling has to be followed immediately by the olfactometric analysis.

The panel members are questioned according to the "yes/no method" because experience has shown that it leads to more realistic results than the alternative "forced choice method". The complete data set for determining the odour perception threshold and the standard deviation of each value should be evaluated according to the probit analysis.

The panel should consist only of persons with an average odour sensitivity. The complete olfactometric measurement method is tested with the reference odorants H<sub>2</sub>S and n-Butanol.

In addition to the specifications of Annexes B and C, the attached "requirements by the German *LAI* of measuring institutes acknowledged for odour measurements" have to be met. The acknowledgement is based on §§ 26 and 28 of the German *BImSchG* (see also the administrative rules issued by the German Lander). Also attached are the guidelines for the acknowledgement and admission of expert institutions in environmental protection (see the pertinent administrative rules issued by the individual German Lander).

Background and Interpretation  
of the Guideline on Odour in Ambient Air (GOAA)

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ASSESSMENT IN INDIVIDUAL CASES

DEGREE OF NUISANCE OF THE NEIGHBOURS

ANNEX 1 TO THE INTERPRETATION OF THE GOAA

Leaflet "Meteorological Input Data for Dispersion Modelling According to the German Technical Instruction on Air Quality Control (TA Luft)

**(NOT INCLUDED)**

ANNEX 2 TO THE INTERPRETATION OF THE GOAA

Dr. Bernhard Prinz and Dr. Ralf Both: Determination and Evaluation of Ambient Odour Impact. In: Aus der Tätigkeit der LIS 1992, Essen, 1993 (today: North Rhine-Westphalia State Environment Agency).

**(NOT INCLUDED)**

**Background and Interpretation**  
**of the Guideline on Odour in Ambient Air**  
**(GOAA)**

The Guideline on Odour in Ambient Air and the accompanying Interpretation of the GOAA reflect today's state of the art. The GOAA evolved beyond the no longer valid administrative regulation "Application of the German Technical Instruction on Air Quality Control" (SMBI.NW. 7130) issued jointly by the Minister of the Environment, Regional Planning and Agriculture and the Minister of Commerce, Medium-Size Enterprises and Technology on 14 Oct. 1986. All usable suggestions were incorporated into the present issue of the GOAA.

**Ad Section 1 of the GOAA**

**ASSESSMENT OF ODOURS**

The decision whether a nuisance is to be considered significant and hence to have harmful effects on the environment is influenced by many criteria. These are, among others, the type of odour, the intensity of the odour, the diurnal and seasonal distributions of the nuisance, its temporal pattern and the land use. The approach of the GOAA is to provide immission\* limit values (cf. Section 3.1 of the GOAA) in terms of odour frequencies for the assessment of odours. However, comparison with limit values is not always sufficient. Therefore, a standard element of the assessment of the significance of a nuisance is to check whether there are reasons to proceed according to Section 5 of the GOAA which addresses individual cases. This check is performed after the odour frequencies have been determined.

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\* The word „immission“ is used in the sense of influence of air pollutants, in this case odour, on humans. This establishes an active view of air pollutants influencing receptors, in contrast to the passive view of receptors being exposed to air pollutants. If we neglect this more semantic difference, “immission” can be interpreted as exposure.

## IMMISSION LIMIT VALUE

The immission limit value is based on odour frequencies for following reasons. Field measurements were conducted by the Medical Institute for Environmental Hygiene (MIU German abbrev.) at the Heinrich Heine University in Dusseldorf to determine the odour annoyance of residents living in the neighbourhood of odour emitters. They showed among other findings that intensity measurements in addition to frequency measurements did not produce any new insight and that the scientific justification to include the hedonic tone was insufficient at that time. The latter finding was also confirmed in a hearing of experts held by the Ministry for the Environment and Transportation of Baden-Württemberg on 2 Oct. 1997.

A study was performed by MIU on behalf of Minister of Environment, Regional Planning and Agriculture in North Rhine-Westphalia entitled "Data collection for the North Rhine-Westphalian Guideline on Odour in Ambient Air in – psychophysiological and epidemiological findings on the perception and assessment of odours in ambient air"; (B. Steinhelder, G. Winneke, Dusseldorf 1992; in German only). The authors make comments as follows on the hedonic tone:

"We were not in a position to study the potential effects of the property "pleasant" or "unpleasant" of odours in ambient air on the degree of annoyance. Therefore, it is emphasized that the findings presented here and the immission limit values derived from them cannot be generalised without reservations on account of the relatively narrow spectrum of odour sources investigated.

...Furthermore, the odours emitted by various industrial sources differ by the significance of the nuisance they may induce because the hedonic quality of the odorant (pleasant vs. unpleasant) (...) apparently affects the degree of the nuisance ...: Comparing the degree of nuisance caused by an insulator factory, a tar oil refinery, a brewery and a chocolate factory showed that the chocolate factory produced less nuisance than the other installations although there was no difference in the quantitative odour impact. Despite these reservations, the immission limit values derived here can be used as well founded tools to distinguish 'significant' from 'insignificant' odour nuisances. "

The administrative rule (Circular) of 1986 concerning the German Technical Instruction on Air Quality Control allows lowering the limit values for very unpleasant odour immissions. The criteria in Section 5 of the GOAA also offer the possibility to take the hedonic tone into account in individual cases.

The immission limit values of the GOAA are based on the recognition of odours according to the concept of odour-hours. The MIU study does not state any advantage of real-time assessments over the odour-hour concept in field measurements (cf. Interpretation of the GOAA, comments on Section 4.4.7, "odour-hour").

## RECOGNITION OF ODOURS

In the assessment or prediction of odour impact by either field measurements or by dispersion modelling, respectively, only those odours may be recorded which can be identified, i.e. which can be traced back with sufficient certainty and without any doubt to installations and groups of installations and thus can be distinguished from odours generated by road traffic, domestic heating, vegetation, agricultural fertilisers (manure spreading) and other sources. This defines the term "clearly recognizable" (cf. Section 4.4.7 of the GOAA).

## THE GOAA AS A SYSTEM

Several comprehensive studies (by the North Rhine-Westphalia State Environment Agency and by the Municipal Department for Urban Development, Environmental Protection and Technology of Berlin) confirmed the soundness of the GOAA. In these studies results from field measurements according to the GOAA were compared with those of dispersion modelling according to the GOAA. The results obtained showed,

- that with the aid of the methods authorised by the GOAA the actual situation can be described with sufficient certainty; this includes the definition of the so-called odour hour;
- that the two methods permitted in the GOAA (i.e. the grid field measurements and the prediction of the odour impact air by dispersion modelling) yield comparable results. (Dispersion modelling is based on the measure of 1 odour unit/m<sup>3</sup>, which ensures that odours are predicted which are recognizable according to the GOAA; modelling with a measure of 3 odour units/m<sup>3</sup> would not be in compliance with the GOAA).

In the study of an agricultural case conducted jointly by the North Rhine-Westphalia State Environment Agency and by MIU, it was found that

- these results were confirmed by a questionnaire survey concerning odour annoyance;
- in the case of installations (livestock farms) above a certain size, the observation of existing regulations for minimum set back distances from the neighbours does not preclude the occurrence of a significant nuisance and hence harmful effects on the environment as defined in the Federal Immission Control Act (Bundesimmissionsschutzgesetz, BImSchG).

#### INITIATION OF AN EXPERT OPINION

The GOAA does not enforce an expert opinion according to its methods in every single case. This is only required if the competent licensing authority is convinced of its necessity. The decision lies within the responsibility of the authority. If the authority is convinced that by applying other regulations, such as guidelines VDI 3471 and 3472 or the minimum set back distance given by the German Technical Instruction on Air Quality Control, Section 3.3.7.1.1. for agricultural areas, the environment is effectively protected, then an expert opinion according to the GOAA is not compulsory. If, however, the authority concludes in problematic cases that an

expert opinion based on the GOAA is required in order to resolve doubts, it has to be made, even for agricultural installations. If common experience and knowledge of the locality lead to the conclusion that the observation of the minimum distances defined in the guidelines precludes harmful effects on the environment, no further investigations according to the GOAA are required; if, however, doubts remain, these investigations are necessary.

## PROCEDURE IN THE AGRICULTURAL SECTOR

In agriculture (livestock farming), the first step will usually be to check the distances from the neighbourhood. The checks follow the instructions of the German Technical Instruction on Air Quality Control (TA Luft German abbrev.), Section 3.3.7.1.1, and of the guidelines VDI 3471 and VDI 3472. The withdrawn guideline VDI 3473 ("cattle guideline") may not be used in the assessment.

When applying the German Technical Instruction on Air Quality Control, Section 3.3.7.1.1, and guidelines VDI 3471 and VDI 3472, the boundary conditions listed therein have to be strictly observed. The distances given in the VDI guidelines and the German Technical Instruction on Air Quality Control have been developed for the principle of taking precautionary measures which has to be observed independently from obligations to provide protection against harmful impacts. Maintaining minimum distances is usually sufficient to avoid harmful effects on the environment. However, experience has shown that the distances are insufficient for farms exceeding a defined livestock. Therefore, the distances listed in the German Technical Instruction on Air Quality Control and the above-mentioned VDI guidelines should under no circumstances be extrapolated to numbers of animals or livestock units which exceed the maximum numbers quoted in the guidelines. If the minimum distances are not observed, an assessment according to the GOAA is required as a rule. Other situations may arise in which, because of a favourable distribution of the wind directions, a license according to the GOAA may be granted even though the distance required by the VDI guidelines is not observed. In such a case, the obligation to protect the environment may be considered to be fulfilled. Manifest indications of harmful effects on the environment have to be followed up even in

cases in which the minimum distances are maintained; the GOAA is applied if necessary.

When assessing the odour impact, a distinction has to be made between intensive livestock farming and “rustic” animal farms. If in the latter case ventilation by windows is equated with forced ventilation, pessimistic but not necessarily realistic results are obtained. The special circumstances of the individual case have to be considered.

Open stables pose a problem for dispersion modelling because the emissions depend on the weather conditions, e.g. on wind direction and wind speed. Here the emission factors have to be determined particularly carefully. If detailed emission factors are not known, the emission needs to be determined at least for average meteorological conditions.

The assessment of odour impact caused by manure spreading (agricultural fertilisers, cf. Section 3.1 of the GOAA) is possible in connection with the determination of the total odour impact conducted in individual cases according to Section 5 of the GOAA; its abatement and manure treatment are not a topic of the GOAA.

## INSTALLATIONS NOT REQUIRING LICENSING

It lies within the discretion of the authority whether the GOAA is used to determine the demands placed on installations which need no license. The initial odour impact according to the GOAA includes not only contributions by installations exclusively licensed according to the building code but also the contribution by installations which are subject to § 4 of the Federal Immission Control Act. If installations not requiring a license emit odours which are harmful to the environment, it must first be ascertained that the state of the art to avoid harmful effects on the environment has been exhausted. Harmful effects on the environment which cannot be avoided by the state of the art have to be reduced to a minimum (Federal Immission Control Act, § 22, Paragraph 1.1.2). The interests of all parties involved have to be weighted to determine this minimum. Unreasonable measures cannot be imposed. An order to

shut down the installation can be based only on § 25, Paragraph 2 of the Federal Immission Control Act. The preconditions listed there are usually not met by the odour immissions. Orders may be imposed in individual cases on the basis of § 24 of the Federal Immission Control Act.

Regulations by the German states (Länder) regarding precautionary measures against environmental impact may have requirements beyond those of § 22 of the Federal Immission Control Act.

(Installations requiring licensing are addressed in Section 4.2 of the Interpretation of the GOAA.)

#### SUITABLE DISPERSION MODELS

ODIF or a comparable model are used by convention on the following boundary conditions:

The model can be applied to sources higher than 30 m above ground without restrictions on distances and to sources  $\leq 30$  m for distances up to 700 m. Alternatively, with stack heights up to 30 m, the dispersion may be calculated according to Annex C of the German Technical Instruction on Air Quality Control multiplied by a factor of 10. In ambiguous cases the pertinent authority has to be consulted.

If models other than ODIF or the German Technical Instruction on Air Quality Control with a factor of 10 are used, comparability of the models is to be proven to the pertinent authority.

#### OVERESTIMATING ODOUR FREQUENCIES

A license can be granted only if there is certainty that the conditions imposed for licensing will not be violated in the future (compare § 6 Paragraph 1 of the Federal Immission Control Act). Therefore, the assessment by the licensing authority must be on the safe side. In this respect overestimating the odour frequencies by the prediction method is permissible.

## Ad Section 2 of the GOAA

### COMPUTING THE STACK HEIGHT

The stack height is computed under the condition that the characteristic value on the assessment square (generally covering an area of 250 m by 250 m) with the maximum odour impact does not exceed 0.06 (relative frequency, cf. Section 3.1 of the GOAA, Paragraph 1). Following the principle of environmental precaution, this applies also to uninhabited areas. The assessment square which contains the odour source may be ignored in individual cases. While the GOAA was being compiled, the inclusion of an S-value for the stack height computation was discussed. However, the experts on dispersion came out against it because the different conditions of emission of the various installations are not adequately reflected with this method which in some cases would lead to unrealistically tall stack heights.

### COMPUTING STACK HEIGHTS IN AGRICULTURE

The rules in the GOAA to compute the stack height apply only to one central collective conduit which may be required in certain cases according to the German Technical Instruction on Air Quality Control, Section 2.4.2, Paragraph 2. (See also Section 3.1 of the Interpretation of the GOAA (Allotment of Frequencies of Ambient Odour Impact)).

According to the German Technical Instruction on Air Quality Control, Section 2.4, waste gases do not have to be released via a stack in every case.

## Ad Section 3.1 of the GOAA

### CLASSIFICATION OF IMMISSION LIMIT VALUES

In individual cases the classification of the immission limit values may be different from that in Table 1 of the GOAA. Examples:

- According to the definition given in § 5, Paragraph 1, of the German Ordinance on Building's Use BauNVO (German abbrev.) of 23 January 1990, rural villages may comprise buildings for agriculture and forestry, for housing, for commercial enterprises with low disturbing impact and for artisans who serve the needs of the local population. The interest of agriculture and forestry including their growth potential demand the highest consideration.

If the agricultural enterprises dominate in a village, it is classified as a commercial/industrial area ( $I_{\text{limit}} = 0.15$ ). If the village is developing into a residential area with only a few agricultural enterprises remaining it may be designated as a residential/mixed area ( $I_{\text{limit}} = 0.10$ ). In individual cases intermediate limit values or even larger values may be justified (cf. Section 5 of the GOAA).

- Camp grounds cannot demand a higher level of protection than the surrounding built-up area, unless they are individual cases with particular conditions.
- Vacation-home areas are generally to be treated like residential areas unless they are individual cases with specific boundary conditions.
- Allotment-garden areas are generally to be treated like commercial areas unless they are individual cases with specific boundary conditions.

#### ALLOTMENT OF FREQUENCIES OF AMBIENT ODOUR IMPACT

In practice, the GOAA is also used as a base for decisions in development planning. In this context the question of allotting the portions to the odour impact in ambient air to different installations may be difficult to answer. Several approaches may be considered (50% of the limit value, stack height computation (0.06), irrelevance of the additional odour impact (0.02), determining the initial impact and distributing the

"remainder"). Contributions to the odour impact by actually planned projects have to be included in the calculation of the allotments to other installations.

As a rule, a single installation to be licensed should not exhaust the applicable immission limit value.

Regardless of whether the initial or additional odour impact exceeds limit values, installations which require licensing (Federal Immission Control Act, § 5, Paragraph 1, No. 2) and also those which do not require licensing are required to comply with the state of the art. In order to provide room for future developments and to consider precautionary measures against environmental impact, the requirements set may possibly go beyond the present state of the art (see also pertinent regulations of the German states).

#### Ad Section 3.2 of the GOAA

#### CONFORMITY OF EXPERT OPINIONS WITH THE GOAA

Experts opinions to the effect that the requirements of the GOAA are met are insufficient unless supported by evidence. It lies in the nature of an expert opinions that the results are explained so that they can be reproduced. If this is not the case, respective additions to the experts opinions should be demanded.

#### Ad Section 3.3 of the GOAA

#### IRRELEVANCE OF THE ADDITIONAL ODOUR IMPACT

The irrelevance limit refers to the additional odour impact caused by the complete installation. Therefore, it is unlikely that several irrelevant cases add up to a total odour impact exceeding the immission limit values. The term "installation" does not mean an individual source nor the "entire industrial enterprise" but, in the case of installations requiring licensing, it is conformable to the definition in the Fourth

Ordinance to the Federal Immission Control Act. According to this definition, the term "installation" may comprise several sources. If an existing installation is altered substantially, the computation of the additional odour impact is based on the alterations; the emission of the existing parts of the installation is contained in the initial impact.

Irrelevance is given if the contribution to the ambient odour impact of the complete installation (including alteration) is irrelevant ( $<0.02$ ). Irrelevance of the alteration and thus of the installation-related change in odour impact on the neighbour is given if the new parts of the installation do not change the (rounded) characteristic value of the total odour impact. The irrelevance limit of 0.02 relative odour-hour frequency cannot be expanded.

The irrelevance limit of the additional odour impact refers only to areas where people stay not only temporarily.

The assessment of the contributions to the ambient odour impact depends decisively on whether the odours originate from one or more installations. More installations than one are always to be assumed if they belong to different operators (otherwise it may be regarded as a common installation if appropriate). The definition of an operator is determined by economic criteria (a "front" is not an independent operator!). If different operators have to be assumed after the break-up of an installation, the irrelevance limit of the additional odour impact applies to each of the two separated installations from the time of the break-up.

## CHECKING THE IRRELEVANCE OF THE ADDITIONAL ODOUR IMPACT AFTER LICENSING

Grid field measurements are not appropriate to check the irrelevance after an licensing. The sample sizes mentioned in Table 3 of the GOAA were derived with the aim of determining whether the immission limit values (0.10; 0.15) are observed. Larger sample sizes are required if evidence of the compliance with lower frequencies of odour impact (e.g. 0.02) is to be provided with equal statistical

certainty. They would first have to be determined by the method described in Annex 2 of the Interpretation of the GOAA. They would cause increased cost as compared with those of 52 or 104 grid field measurements. Furthermore, it would be necessary to ensure a clear distinction between the additional impact and the emission from other installations on the basis of the odour quality.

It would appear to be an inconsistency if the initial odour impact was not determined financial expense because it was estimated to be irrelevant but to determine it later. This could be done only for grave reasons, for instance if the complaints increased in number after the licensed installation was taken into operation or because of an explicit agreement at the time the licence was granted, for example, a stipulation in the license.

A better way to check whether irrelevance is still given is to conduct a new model computation of the ambient odour impact, which can now be based on olfactometric emission measurements at the finished installation while before only estimates based on analogies could be made.

#### Ad Section 4.1 of the GOAA

#### GRID FIELD MEASUREMENTS

The GOAA tends to prefer grid field measurements over dispersion modelling. This, however, does not mean that such field measurements have to be conducted in every case; in practice, grid field measurements are not very frequently performed. They serve, however, as a yardstick to assess the validity of dispersion modelling of ambient odour impact.

Results of the estimation of ambient odour impact by dispersion modelling should be checked carefully. If required, grid or plume field measurements have to be performed after start up of the installation. Such plume or grid measurements are particularly helpful with sources whose emission is difficult to measure (e.g. fugitive emission) or whose ambient air effects are difficult to forecast. Grid field measurements are then not compulsory; if required, plume measurements according

to guideline VDI 3940 can be used to indirectly determine odorant flows. With a sufficient number of measurements on several days at different distances downwind from the installation the fractions of time should be determined during which the odours are recognized. By means of a dispersion modelling program and including the related dispersion conditions that odour impact is then iteratively calculated which corresponds to the results of the plume measurements. The odorant flow obtained by this procedure can be used in the subsequent dispersion modelling of the odour impact according to the GOAA.

Because chemical analyses are not certain to produce results which are equivalent to those obtained with grid field measurements and subsequent dispersion modelling, the chemical analysis is not included in Table 2, in contrast to the 1993 version of the GOAA. Chemical analyses may be used, however, to gain exploratory knowledge.

#### Ad Section 4.2 of the GOAA

#### EXPANSION OF INSTALLATIONS

Installations which require licensing may be expanded only if it is certain that they cannot cause harmful effects on the environment (Federal Immission Control Act, § 6, Paragraph 1, No. 1, in conjunction with § 5, Paragraph 1, No. 1). If the existing installation is already a source of impermissible odour impact, it is not sufficient to reduce the emission of the expanded installation in such a way that the total ambient odour impact stays at the same impermissible level. Rather, provisions must be made in the enlarged installation not to produce any harmful effects on the environment. A certain room for the assessment is given if the pertinent immission limit value is only slightly exceeded and the odour impact added by the expansion may still be considered to be acceptable in view of the total ambient odour impact being unchanged. The decisive issue during the licensing procedure is whether or not harmful effects on the environment can be avoided with certainty.

Examples:

An existing installation is simultaneously being enlarged and improved. If after the enlargement the immission limit value is exceeded, the enlargement can be authorised only if its contribution to the odour immission is irrelevant.

- I. An existing installation causes an ambient odour impact of 0.13 (the pertinent limit value is 0.10). An improvement would result in 0.10; if the enlargement adds 0.02 to the odour impact so that the total impact would be 0.12, the enlargement is "not to be licensed" because in this case the possible improvements would be swallowed up by the enlargement (for the sake of simplicity, considerations concerning the initial impact and the assessment in individual cases etc. are ignored here).
  
- II. An existing installation causes an odour impact of 0.13; improvements would yield 0.12; the enlargement produces an additional impact of 0.004 so that the characteristic value (rounded) 0.12 would be obtained. In this case, the license may be granted because the additional impact caused by the enlargement is irrelevant.

If both the initial impact and the additional impact are determined by prediction, the calculations have to be done for the new total ambient odour impact and the old (initial) total ambient impact. The difference of the results yields the additional impact. This difference must not be compared with the irrelevance standard.

Section 2.2.3.2, sentence 3, of the German Technical Instruction on Air Quality Control is valid only for changes whose sole or main purpose is the reduction of the ambient odour impact. This clause cannot be applied to the enlargement of installations.

(Installations which need not to be licensed are addressed in the Interpretation ad Section 1 of the GOAA).

### Ad Section 4.3 of the GOAA

#### USE OF THE CORRECTION FACTOR IN GRID FIELD MEASUREMENTS

In grid field measurements within a licensing procedure the correction factor  $k$  (cf. GOAA, Section 4.4.1) has to be used because the observance of the licensing prerequisites cannot be regarded as statistically certain due to the uncertainties of the field measurements (cf. § 6, Paragraph 1 of the Federal Immission Control Act).

In contrast to this and to the 1993 version of the Guideline on Odour in Ambient Air, a correction factor need not be used in surveillance procedures.

If in a surveillance process 52 or 104 field measurements without the correction value  $k$  result in ambient odour impact exceeding the limit value, harmful effects on the environment are to be assumed, unless Section 5 of the GOAA allows a different ruling.

The reason for this differentiation lies in the different material burden of proof in cases of unresolvable doubts about the causes of harmful effects on the environment. Licensing procedures must ascertain (proof) the protection from significant nuisance by ambient odour impact whereas rulings according to §§ 17 and 24 of the Federal Immission Control Act follow the proof of breeches of obligations for the protection of the environment from immissions.

### Ad Section 4.4.1 of the GOAA

#### USE OF PAST MEASUREMENT OR ASSESSMENT RESULTS

The permission that results of past measurements or assessments of ambient odour impact and emission may be used if the main conditions have not changed deviates from the German Technical Instruction on Air Quality Control, where (in Section 2.6.3.2) an interval of 4.5 years is mentioned. The deviation appears to be justified

because of the special conditions in the case of ambient odour impact. A prerequisite is that the procedures have not changed in the meantime.

## STATISTICAL BACKGROUND OF THE CORRECTION FACTORS

The correction factors were derived by a test of hypotheses involving the binomial distribution. It is described in the guideline VDI 3940. In contrast to this VDI-guideline, however, the correction factors and the immission limit values of the GOAA were determined with an error probability of 20%. It is especially emphasised that this test of hypotheses is designed to make sure the population is protected from harmful effects on the environment (significant nuisance) through tests of compliance with immission limit values.

### Ad Section 4.4.2 of the GOAA

## ASSESSMENT AREA

In justifiable individual cases the assessment area and its size should be chosen so that an objective assessment of the problem is feasible.

### Ad Section 4.4.3 of the GOAA

## POSITION AND SIZE OF THE ASSESSMENT SQUARES

In individual cases the position of the grid squares may be adapted to the existing or future land use permitted by the planning and zoning regulations. Besides the standard size of the square (of 250 m by 250 m), grid mesh sizes of 125 m by 125 m, 100 m by 100 m, 50 m by 50 m and even assessment points are feasible, if the special conditions require this.

Inhomogeneous odour impact which may require smaller assessment squares usually occurs near installations with low sources (e.g. intensive livestock farming) or in areas with a distinct topographical structure. In such cases an agreement between the expert and the licensing authority on the methods to be applied is of particular importance.

A reduction in the size of the grid squares does not lead to a more stringent assessment of the ambient odour impact. Section 2.6.2.3 of the German Technical Instruction on Air Quality Control permits a reduction of the sizes of the grid squares if this leads to a more objective assessment in the specific case. This procedure does not affect the immission limit values defined in the GOAA because they were derived independently of the size of the squares.

#### Ad Section 4.4.5 of the GOAA

#### REPRESENTATIVITY OF THE MEASUREMENT PERIOD

If the measurement period covers less than 1 year, it is necessary that it contains portions of both the cold and the warm season. It may be shortened to 3 months in particular cases if the period of strongest emission and highest ambient odour impact is covered.

#### Ad Section 4.4.6 of the GOAA

#### POSITION OF THE MEASUREMENT POINTS OR THE MODEL POINTS

The requirements of Section 4.4.6 of the GOAA are also valid for choosing the model points and the assessment squares in dispersion modelling.

#### Ad Section 4.4.7 of the GOAA

## TESTING PANEL MEMBERS

Organisations which conduct field measurements with panels have to test their panel members themselves (the tests covering the whole measurement procedure should take place twice per year) and should be subjected to interlaboratory comparisons for quality assurance.

## ODOUR-HOUR

The odour-hour is defined in guideline VDI 3940 (1993). "An odour-hour is defined as a positively assessed single measurement. A single measurement has to be assessed as being positive, if the fraction of time during which an odour was unambiguously recognized exceeds a predefined percentage value".

This definition has been derived from the general properties of the sense of smell, in particular its pronounced ability to adapt. Accordingly, at the same absolute length of total odour recognition time, many short periods in which the odour recognition threshold is exceeded are more annoying than fewer but longer lasting periods within an observation period because in the second case the effect is shortened by adaptation. This is the reason why the concept of odour-hours weights many short odour episodes more heavily than fewer long ones.

In view of these facts, the concept of the odour-hour was incorporated in the Circular on implementation of the German Technical Instruction on Air Quality Control of 1986. It is also part of the present version of the GOAA.

The immission limit values defined in the GOAA are based on the definition of the odour-hour contained in the GOAA. This definition also contains the term "extent" which is used in § 3, Paragraph 1 of the Federal Immission Control Act in connection with the definition of harmful effects on the environment (cf. Section 3.1 of the GOAA).

### Ad Section 4.5 of the GOAA

#### DISPERSION MODELLING (NEAR-FIELD, REFERENCE LEVEL ABOVE GROUND)

Dispersion model calculations which are based on the normal (Gaussian) distribution are valid only at distances beyond 100 m from the source. Therefore, dispersion modelling may yield uncertain results at distances under 100 m. For these near-field distances of < 100 m frequently special methods have to be applied (such as estimating frequencies of wind directions, field measurements with a panel or more sophisticated dispersion models). Irrespective of from that it is to be noted that the model ODIF is calibrated for a reference level above ground of 2 m.

The results of dispersion modelling are to be presented as values referring to areas and points, not as iso-curves.

### Ad Section 5 of the GOAA

#### ASSESSMENT IN INDIVIDUAL CASES

The GOAA allows certain deviations from the immission limit values in well founded individual cases. This is a consequence of the finding by the MIU study that significant nuisance starts at relative odour-hour frequencies of 10 to 20 %.

#### Examples:

- Temporally limited operations can be judged correctly only by assessing them as individual cases; here the immission limit values of the GOAA have to be modified. Relevant parameters are: duration of the operation, the necessary level of protection in the affected vicinity, common ambient odour impact in the area, the time of the year in which odour events occur, etc. For example, if an operation lasts for six months, the applicable limit values may be based on the duration of

the operation and raised over those in the GOAA. It is all the more reasonable to modify the limit values for operating times of less than six months.

- For valleys dispersion modelling adapted to the special conditions has to be applied, if required.
- If odours occur only on a few days of the year but then very frequently, and/or if they are particularly annoying due to special meteorological conditions (e.g. mid-summer), or due to their intensity or because they are unusual, the applicable limit values may be reduced (for instance by one half). This is particularly true for cases of the so-called "limited air pollution prevention" (e.g. carpenter shops, lacquering shops, meat and fish smoking shops). However, in these cases, too, an assessment according to Section 2 of the GOAA (compliance with the state-of-the-art) is required.
- According to the Federal Immission Control Act only the neighbour has a right to be protected from harmful effects on the environment, not the user of the emitting installation. Assessing the degree to which the employees are affected by the odours emitted by their own installation falls into the domain of occupational safety and health; this odour impact cannot be added to the odour impact caused by another installation in the neighbourhood. The employees in other installations, however, are "neighbours", even if they stay there for only 8 hours per day. A shorter duration of stay (and perhaps the kind of work) may, however, give reasons to apply higher immission limit values.
- Assessing a health spa area requires other criteria than the immission limit values for the areas listed in the GOAA. At least the immission limit values for residential areas have to be applied. Depending on the special circumstances, the limit value may be lowered to 0.06 should a check of the specific case make this necessary.
- In principle, agricultural installations cannot be treated differently from other odour emitters because MIU (cf. ad Section 1 of the Interpretation of the GOAA "The Guideline as a system") has provided evidence that the basic relationships between odour frequencies and levels of nuisance exist also in a large piggery

with 3500 pigs. In individual cases with good reasons a limit value higher than 0.15 can be used. The MIU study found a range up to 0.20. Because odour impact caused by agricultural installations often occurs in thinly populated regions, one has to keep in mind that scattered residential homes in these regions cannot claim the same level of protection as, for example, residential areas. It is important to find fair solutions for such individual cases.

## DEGREE OF NUISANCE OF THE NEIGHBOURS

In individual cases (when checking criteria such as customary odours in a place, intensity, hedonic tone) it may be reasonable to directly determine the degree of nuisance of the neighbours. For this purpose, guideline VDI 3883, Part 1, "Effects and Assessment of Odours – Psychometric Assessment of Odour Nuisance - Questionnaires" (July 1997) may be used. This may be advisable because it produces reasons for applying assessment criteria which differ from the immission limit values defined in the GOAA.