

Detection and Assessment
of
Odour in Ambient Air

(Guideline on Odour in Ambient Air – GOAA)

dated 29 February 2008
with supplement of 10 September 2008

including
grounds and advice on interpretation
as of 29 February 2008

(second version, supplemented and up-dated)

Translator's note

This is the translation and interpretation – where necessary – of the German administrative guideline on the methods of how to qualify and quantify odours in ambient air in the surroundings of odour sources. Some of the German terms had to be interpreted rather than rigidly translated because their use is more or less vague so that the exact meaning changes throughout the text, depending on the context of the German term.

The most prominent example of this inevitable interpretation is the German term *Immission*. *Emission* and *Immission* are counterparts in German administrative language. They were derived from the Latin words *emittere* (literally *send out*) and *immittere* (literally *send in*). If transferred into English without change, *emission* and *immission* cannot be distinguished acoustically. This is why *immission* was strictly avoided in this translation. Instead, the term *exposure* seems to be the best possible solution to represent the phenomenon that is meant by the German *Immission* because people, animals, plants and materials are equally exposed to (air) pollution.

Another example are the counterparts *Belastung* (literally *load*) and *Belästigung* (literally *annoyance*) which serve to distinguish a physical-chemical stimulus from its (potential) psychological effect. As *Immission* and *Belastung* are often used synonymously, you will also find *exposure* for *Belastung*.

Last not least the German term *Anlage* covers industrial *production plants*, *waste treatment plants*, *livestock farms* and the like. In this guideline, the British term *plant* was preferred over the American term *facility*.

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1. General remarks

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

The approach to an assessment of this type of nuisance differs substantially from that of other ambient pollutions. 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 detection 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 severe and hence an environmental detriment does not only depend on the ambient odour concentration but also on the odour quality ("It smells like ..."), the odour intensity, the hedonic odour tone (pleasant, neutral or unpleasant), the daily and seasonal fluctuation of the resulting potential odour nuisance, the utilization of the affected area and some other criteria (see Sections 3.1 and 5). Scientific findings give evidence of the fact that the odour frequency is a parameter to describe the degree of odour nuisance in the neighbourhood with adequate accuracy.

The German Technical Instructions on Air Quality Control (*TI Air 2002*) give rules for the precaution* against environmental detriments caused by odour; it does not give rules for protection* from environmental detriment by odour in ambient air. This is why the provisions laid down in this Guideline have to be observed until pertinent uniform German Administrative Prescriptions will be published. Thus, it is made sure that uniform criteria and assessment methods will be used as a basis for equal treatment of assessing odour in ambient air and any resulting requirements of odour emitters.

*Translator's note: In German air pollution control law, *precaution* refers to undeveloped land and no existing pollution, while *protection* implies developed land and existing pollution.

The Guideline, suitably adapted, may also be applied to plants that do not require licensing.

In the case of livestock farming, the licensing authority may waive the determination of the characteristic values as per Section 4 and justify the agreement to licensing with the observation of the distances shown in the diagram of Section 5.4.7.1 of *TI Air*. However, a different approach may be required in individual cases due to exceptional conditions (such as a special topographic situation, an existing odour exposure). If the livestock farm under investigation is not subject to a licensing

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procedure, the authorities may approve the operation based on the observation of the distances published in the technical guidelines VDI 3471 (1986) and VDI 3472 (1986).

To assess the severity of the ambient odour exposure, this Guideline sets limit values for various area utilizations to serve as a regular standard for the maximum admissible ambient odour exposure. These limit values have to be compared with the characteristic values which also take into account the existing odour exposure contributed by other plants. The odour quality (livestock farms; see Section 4.6) and the hedonic odour tone (industrial plants; see Section 5) may be considered in particular by means of weighting factors.

As a rule, the existing odour exposure is determined with olfactory field measurements (grid measurements) along the lines of guideline VDI 3940 Part 1 (2006) or by means of odour dispersion calculation.

The expected additional odour exposure is determined by means of odour dispersion calculation (see Section 4.5). The procedure has to be based on guideline VDI 3788 Part 1 (2000), Annex 3 of *TI Air* and special adaptation to odour as described by L. Janicke and U. Janicke (2004). The existing and the expected additional odour exposure sum up to the total odour exposure which has to be compared with the exposure limit.

This Guideline also covers rules for assessment squares where the characteristic value of the existing exposure exceeds the exposure limit (see Sections 3.3 and 5) or where ambient odour is relevant from sources other than those stated 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 odour exposure from the plant 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 exposure results in the conclusion that the odour nuisance is not to be classified as being severe. The Guideline also fixes criteria for waiving any determination of the existing odour exposure.

2. Requirements of the limitation and the release of odour emissions

On principle, prior to any ambient odour assessment, it must be ascertained that all means of the state-of-the-art of odour abatement have been exhausted (see Section 5 of *TI Air*) and that the release of residual emissions meets the requirement of Section 5.5 of *TI Air* (see decision of the Federal Administrative Court of 10 May 1990; Gew Archiv 1991/8, page 312).

Waste gases as defined by Section 2.4 *TI Air* are air and other gases carrying odorous substances.

As a rule, the minimum height of waste gas stacks is chosen in such a way that the characteristic

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value of the expected additional exposure EXP_{add} (see Section 4.5) does not exceed the value of 0.06 on any of the assessment squares *.

*The factor for pleasant odours according to Section 5 does not apply to the calculation of stack heights. This is also valid for the factors listed in Table 4 (Section 4.6).

Excessively high stacks may result in exceptional cases; then the competent authorities have to be consulted.

3. Assessment criteria

3.1 Exposure limit values

Odours in ambient air have to be assessed according to this Guideline if – based on Section 4.4.7 – the source can be identified to be a plant, i.e. if the odours can be distinguished from road traffic, domestic heating, vegetation, manure spreading, and similar sources. As a rule, the odour exposure has to be classified as a severe nuisance if the total odour exposure EXP_{tot} (Section 4.6) exceeds the pertinent exposure limit value EXP_{lim} listed in Table 1. These limit values are relative frequencies of odour-hours (see Section 4).

Table 1: Exposure limits EXP_{lim} for different area utilization

| Residential and mixed areas | Commercial and industrial areas | Villages |
|-----------------------------|---------------------------------|----------|
| 0,10 | 0,15 | 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.

The exposure limit of the column “Villages” is applicable only to ambient odour from livestock farming considering the nuisance-relevant characteristic value IG_B (see Section 4.6 of GOAA).

According to § 3 (1) of the Federal Pollution Control Act *FPCA* (German *BImSchG*), environmental impairment 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 in the neighbourhood”. The type of ambient odour is considered by the description of the smell, the ambient odour level is quantified by odour detection above the identification threshold and by means of the concept of the odour-hour (see Section 4.4.7 of GOAA). The duration is expressed by the odour frequency. As a rule, these methods characterise the odour exposure sufficiently well.

Comparison with only the limit values EXP_{lim} does not always suffice to assess the severity of a nuisance. Therefore, after assessment of the odour frequency, a regular check follows of whether

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there are indications of a necessary investigation into the individual circumstances as outlined in Section 5.

3.2 Scope of application of the exposure limits

The limit values are applicable only in conjunction with the determination of the characteristic values of the ambient odour exposure 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 calculation of the expected additional odour exposure according to the rules of Section 4.5.

3.3 Significance of contributions to an ambient odour exposure

Licensing of an installation should not be refused because of the total odour exposure being higher than the odour limit values of the GOAA if the future contribution to the total odour exposure by the installation under investigation (characteristic value of the expected additional odour exposure) does not exceed the value of 0.02 on any assessment square which is populated not only temporarily (see Section 3.1). If this value is observed, it can be assumed that the installation will not significantly increase the annoying effect of the existing odour exposure (irrelevance of the expected additional odour exposure – criterion of irrelevance).*

* Regarding pleasant odours, the factor as per Section 5 does not apply to the check for observance of the irrelevance criterion. This is also valid for the factors of Table 4 (Section 4.6).

4. Determination of the characteristic value of an ambient odour exposure

4.1 General remarks

On principle, there are different methods to determine an ambient odour exposure (Table 2). The ambient odour exposure is always quoted as a value (characteristic value), which represents the temporal perceptibility above a defined intensity (identification threshold).

Dispersion modelling may preferably be applied if results of measurements or estimates indicate that the existing odour exposure EXP_{exist} remains below 70 % of the relevant limit value of Table 1 or if determining the odour exposure by field measurements is deemed to be disproportionate. If the existing exposure is computed, all odour sources relevant in the assessment area have to be included.

Plume measurements according to guideline VDI 3940 Part 2 (2006) may be applied in order to support mathematical conclusions to unknown emissions in special cases (not for calculations of the odour frequency).

Table 2: Methods to determine the ambient odour exposure

| Method | Existing odour exposure (Section 4.4) | Expected additional odour exposure (Section 4.5) |
|---|---|--|
| Dispersion calculation Calculation of the ambient odour exposure | feasible, but emission data have to be procured by olfactometric measurements (EN 13725 (2003)) or else plume measurements (VDI 3940 Part 2 (2006)) | to be preferred |
| Grid measurement (VDI 3940 Part 1 (2006)) Olfactory determination of an odour exposure | feasible | not feasible |

4.2 Determination of the characteristic value during licensing

A distinction is made between the characteristic values of the existing odour exposure EXP_{exist} , the expected additional exposure EXP_{add} and the total exposure EXP_{tot} . They are determined for every assessment square in the assessment area. The existing exposure is the odour exposure originating from existing installations without the expected additional exposure caused by the project which is to be licensed. The expected additional exposure is to be determined according to Section 4.5.

The characteristic value of the total exposure is calculated as per Section 4.6 from the characteristic value of the existing exposure and that of the expected additional exposure.

When the odour flow rate is 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.

During licensing, correction factor k (see Section 4.4.1) has to be considered in the report on the results of a grid measurement. Otherwise there is no acknowledged statistical certainty that the licensing requirements are met (see § 6 (1) German *FPCA*) due to the uncertainty in field measurement results.

4.3 Determination of the characteristic value during administrative surveillance

This action may become necessary to make decisions on subsequent orders. Subsequent orders are considered if comparison of the characteristic value of the existing odour exposure with the

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exposure limits in Table 1 shows that the limits are exceeded (this situation also requires the examination of the individual case) or if a severe nuisance is caused in cases discussed in Section 5.

In surveillance 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 (VDI 3940 Part 2 (2006)) may be conducted to identify the odour source (Section 4.1). The correction factor *k* is ignored in this procedure.

4.4 Characteristic value of the existing odour exposure

The existing odour exposure has to be determined either by grid measurements or by dispersion calculation. If the existing exposure is determined by grid measurements the conditions laid down in Sections 4.4.1 to 4.4.7 have to be observed.

4.4.1 General remarks

The characteristic value of the existing exposure EXP_{exist} results from equation (1),

$$EXP_{exist} = \frac{k \cdot n_{exist}}{N} \quad (1)$$

where *N* is the sample size (*N* = 52 or 104) and n_{exist} 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 is applicable only to grid measurements. It accounts for the statistical uncertainty of the odour exposure 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: List of correction factors k

| Sample size <i>N</i> | Residential / mixed areas | Commercial / industrial areas | Villages |
|----------------------|---------------------------|-------------------------------|----------|
| 52 | 1,7 | 1,6 | 1,6 |
| 104 | 1,5 | 1,3 | 1,3 |

The existing odour exposure is determined by grid measurement following a measurement plan approved by the competent licensing authority. The plan comprises among other parameters the description of the installation, the assessment area, the assessment squares, the individual measurement points including pertinent documentation (pictures, text), the measurement period, the measurement times during the day, the exact temporal plan of field inspections including the panel

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members, a list of names of the panel members involved, the recording method to determine the percentage of odour time, and – if applicable – the reason for waiving measurements.

Unless this Guideline stipulates otherwise, measurements are performed in accordance with technical guideline VDI 3940 Part 1 (2006).

The applicant for a license may be exempted from having determined the existing odour exposure on the assessment squares if the estimated characteristic value of the existing odour exposure 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, preliminary field measurements etc.

In these cases one half of the respective limit value in Table 1 is used as EXP_{exist} in the equations of Section 4.6. The existing odour exposure need not be determined either whenever the additional exposure 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 existing odour exposure EXP_{exist} is assumed to be 0.

Previous measurement results or statements on odour emissions or ambient odour shall be used only if the relevant conditions in the odour assessment area have not changed substantially 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 calculated emission pinpoint of all sources. Its radius is 30 times the stack height determined according to Section 2 of this Guideline. The minimum radius is 600 m.

In installations with scattered 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 square

The assessment squares are square-shaped subdivisions of the assessment area. Their sides are usually 250 m long if the odour exposure on them is fairly homogeneous. Smaller squares should be chosen if the distribution of the odour exposure is expected to be unusually uneven within one or more assessment squares so that the odour exposure 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 square size. The grid of squares is

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aligned in such a way that the calculated emission pinpoint of all sources coincides with the centre of one of the squares.

4.4.4 Measurement height

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

4.4.5 Measurement period

The measurement period should be representative of a whole year. As a rule, it may be reduced to six months; only in special cases may it be shortened to three months. Proof of representativity is to be given in accordance with VDI 3940 Part 1 (2006).

The measurements have to be distributed evenly over the 24 hours of a day to get representative results. Alternatively, they may be adapted to the operating hours of those emitters which are relevant for the existing odour exposure. In this case, every number of odour-hours found has to be corrected by a factor which considers the ratio of the operating time of the installation and the total time of the year.

4.4.6 Measurement points

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 closest adequate point next to the node has to be selected instead. 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 exposure is relevant for an administrative decision. 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 measurements

During the measurement period, each corner of the assessment square is visited by panel members 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. Each corner is visited 13 or 26 times during a six months' measurement period and 26 times during a 12 months' measurement period.

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The results obtained at all four corners of an assessment square are added up to the number n_V of odour-hours on 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 persons. During the whole measurement period, at least 10 panel members have to be employed at approximately the same intervals and at varying points. The panel members' individual sensitivities to odours are tested 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 German *Federal and Lander Committee on Pollution Control (FLCPC)* (German abbreviation *LAI*). They concern measuring institutes to be officially acknowledged for olfactory field measurements as per §§ 26, 28 of the German Federal Pollution Control Act *FPCA* (German abbreviation *BImSchG*); see also individual regulations of each German federal state.

The visits of the individual panel members must not be systematically restricted to certain weekdays and selected measurement points.

It is very important to take care that only clearly perceptible ambient odours shall be recorded, i.e. only those odours which can be traced back with sufficient certainty and beyond doubt to installations or equipment 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 olfactory measurement of an existing odour exposure.

Different odour intensities shall not be recorded during the measurement interval. So far no evidence of a sufficiently reliable relationship between this odour property and the level of nuisance has been found. All odours emitted by an installation which exceed the identification threshold have to be included when the limit values of Section 3.1 of this Guideline are consulted. Apart from that, the fundamentals of guideline VDI 3940 Part 1 (2006) apply.

The existing odour exposure 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 as defined previously 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) of this Guideline.

4.5 Characteristic value of the additional odour exposure

In accordance with Section 1 of this Guideline, the characteristic value of the expected additional odour exposure is calculated with the dispersion model described in Annex 3 of the German *TI Air* including the special adaptation to odour (L. Janicke, U. Janicke, (2004)).

The spacing of the gridlines is set in accordance with Section 4.4.3. The horizontal distance of the dispersion gridlines covering the area under investigation are set in accordance with the prescriptions of the German *TI Air*, Annex C, Section 7). It says that, as a rule, the horizontal distance of the grid lines is chosen such that it will not exceed the stack height.

The area under calculation is generally identical with the assessment area as per Section 4.4.2. In case of unusual orographic conditions, it may be required to extend the calculation area beyond that described in Section 4.4.2.

The olfactometric determination of emissions serving as input data for dispersion calculation has to comply with EN 13725 (2003) including Annex C of this Guideline and with the requirements set by the German *FLCPC* (*Federal and Lander Committee on Pollution Control*) to be met by institutions practising field inspections in the framework of § 26 of the German *FPCA* (reference is made to individual federal state regulations).

4.6 Evaluation

The characteristic value EXP_{exist} of the existing odour exposure is computed for every assessment square of the assessment area either from the results of the grid measurements or of dispersion calculation. The expected additional odour exposure EXP_{add} is obtained following Section 4.5.

The characteristic value of the total odour exposure EXP_{tot} is obtained by adding* the characteristic values of the existing odour exposure EXP_{exist} and the expected additional odour exposure EXP_{add} :

* On principle, frequencies which originate from mutually independent distributions cannot simply be added. The algebraic summation of the existing exposure and the expected additional exposure 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 $p_{exist} \cdot p_{add}$ may be neglected because the partial probabilities p_{exist} and p_{add} are significantly smaller than 0.1. (In this context, p_{exist} is the probability of an odour identification due to the existing odour exposure and p_{add} is the probability of an odour identification due to the expected additional odour exposure.)

$$EXP_{tot} = EXP_{exist} + EXP_{add} \quad (2)$$

As a rule, the total odour exposure is calculated by one arithmetic instruction provided that both the existing exposure and the expected additional exposure were determined by dispersion calculation.

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A nuisance-relevant characteristic value $EXP_{tot,nr}$ has to be calculated for the assessment of odour from livestock farming. This value has to be compared with the exposure limits in Table 1. Reference is made to Section 5.

The nuisance-relevant characteristic value $EXP_{tot,nr}$ results from multiplication of the total odour exposure EXP with the factor f_{tot} :

$$EXP_{tot,nr} = EXP_{tot} * f_{tot}. \quad (3)$$

Factor f_{tot} is calculated in accordance with equation (4)

$$f_{tot} = (1 / (H_1 + H_2 + \dots + H_n)) * (H_1 * f_1 + H_2 * f_2 + \dots + H_n * f_n) \quad (4)$$

where

n = index 1 to 4

$$H_1 = r_1$$

$$H_2 = \min [r_2; (r - H_1)],$$

$$H_3 = \min [r_3; (r - H_1 - H_2)],$$

$$H_4 = \min [r_4; (r - H_1 - H_2 - H_3)]$$

including

r overall odour frequency resulting from the sum of all emissions (unweighted odour frequency),

r_1 frequency of odour from fattening fowl,

r_2 unweighted odour frequency [t.n.: for animals not classified here],

r_3 frequency of odour from fattening pigs and sows

r_4 frequency of odour from dairy cows and young cattle

as well as

f_1 weighting factor for fattening fowl,

f_2 weighting factor 1 (e.g. for animals without weighting factor),

f_3 weighting factor for fattening pigs and sows,

f_4 weighting factor for dairy cows and young cattle.

The weighting factors for the individual types of animals are listed in Table 4. The typical odour frequency of animals not listed in Table 4 will appear without weighting factor in equation (4).

Table 4: Weighting factors f for individual types of animals

| Animal-dependent odour quality | Weighting factor f |
|---|--------------------|
| Fattening fowl (turkeys, broilers) | 1,5 |
| Fattening pigs, sows (up to a capacity of approx. 5000 fattening pigs or for a certain number of sows, respectively, considering the pertinent conversion factors) | 0,75 |
| Dairy cows including young cattle (also covering fattening bulls and calves, provided their contribution to the ambient odour exposure is negligible) | 0,5 |

The characteristic values of the total odour exposure EXP_{tot} and $EXP_{tot,nr}$, respectively, are calculated from the characteristic values of the existing odour exposure and of the expected additional exposure, all of them correct to three decimal places.

When comparing the characteristic values of the total odour exposure EXP_{tot} or $EXP_{tot,nr}$, resp., with the pertinent exposure limits in Table 1, values have to be correct to two decimal places.

5. Assessment in individual cases

In unusual circumstances, it will be inadequate to compare the characteristic values determined in accordance with this Guideline and the exposure limits set in Table 1 in order to make an assessment of a potential environmental detriment caused by odour exposure:

- a) There is a particularly high odour exposure on individual assessment squares which originates from road traffic, domestic heating or other sources, which need not be recorded as per Section 3.1 (1) – or
- b) There are extraordinary conditions regarding hedonic odour tone and odour intensity or unusual utilization of the land concerned or other atypical circumstances resulting in an indication that
 - environmental detriment is evident in spite of the exposure limits being observed (e.g. odours causing disgust or nausea) or
 - severe odour nuisance of the neighbourhood or the general population need not be expected despite the exposure limits being exceeded (e.g. prevailing of unambiguously pleasant odours).

Such cases entrain investigations into all the types of ambient odours that may appear as well as into the contributions caused by the operation of installations which need to be assessed in accordance with Section 3.1 (1). This procedure is followed by a decision on whether the odour exposure has to be regarded as severe and whether the installations contribute substantially to this situation.

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If the hedonic tone of an emission is unambiguously pleasant, its contribution to the total odour exposure may be weighted by a factor of 0,5. The decision to proceed like that is taken by the competent authority. Unambiguously pleasant odours from production installations are detected by means of polarity profiles – the method to classify the hedonic tone of emissions from installations [t.n.: VDI 3940 part 3].

Only that odour nuisance may be judged as an environmental detriment which is severe in the framework of § 3 (1) of the German *FPCA*. The severity is not a rigidly defined quantity but can only 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 existing odour exposure (common local practice), the following criteria shall preferably be used for the assessment of a severe odour nuisance:

- the character of the neighbourhood, particularly the land utilization of the area as defined in the development plan,
- regional development plans and agreed or stipulated restrictions on the utilization of the land,
- unusual circumstances regarding the daily and seasonal distribution of the odour exposure as well as the intensity and type of the odour (e.g. disgusting odours; e.g. odours causing disgust or nausea may already be hazardous to health).

Moreover, it has to be taken into account that the plot utilization may be subject to mutual considerations in neighbour relationships, which may for instance require the persons annoyed by the odours to tolerate higher levels of odour exposure. This will be particularly so with emitting installations whose existence is protected by law so that nuisance will have to be tolerated even if in other situations they would have to be considered as being severe.

Annex A

Data Collection for Field Odour Measurements

Panel member's name

Date:

Measurement point No.:

Beginning of measurement:

End of measurement:

| | |
|------------|-------------|
| 1st minute | 2nd minute |
| 3rd minute | 4th minute |
| 5th minute | 6th minute |
| 7th minute | 8th minute |
| 9th minute | 10th minute |

Description of odour qualities¹⁾

0 – no perceptible odour

1 -

2 -

3 -

4 -

5 -

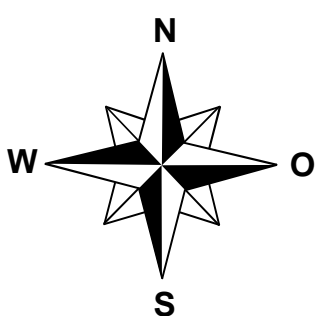
6 -

7 -

8 – odours from other installations

9 – other types of odours³⁾

- 1) "Odour quality" – Description of defined odour qualities depending on the conditions of the individual case
- 2) "odours from other installations" – The sources of such odours have to be found!
- 3) „other types of odours“ have to be characterized below in the line „Remarks“

| | | | | | | | |
|---|--|----------|---------------|---------------|----------|---|--|
| Remarks: | e.g. barbecues, private varnishing, asphaltting of a road | | | | | | |
| Weather data: | e.g. dry weather, fog, rain, temperature, wind direction etc. according to guideline VDI 3786 Part 9 (Oct. 1991) | | | | | | |
| Wind force | Wind direction from: | | | | | | |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 20%;">still</td> <td style="width: 20%;">gentle</td> <td style="width: 20%;">moderate</td> <td style="width: 20%;">strong</td> <td style="width: 20%;">blustery</td> </tr> </table> | still | gentle | moderate | strong | blustery |  | |
| still | gentle | moderate | strong | blustery | | | |
| Cloud cover | | | | | | | |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%;">none</td> <td style="width: 25%;">light</td> <td style="width: 25%;">cloudy</td> <td style="width: 25%;">fully covered</td> </tr> </table> | none | light | cloudy | fully covered | | | |
| none | light | cloudy | fully covered | | | | |
| Precipitation | | | | | | | |
| <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 16.6%;">none</td> <td style="width: 16.6%;">drizzle</td> <td style="width: 16.6%;">rain</td> <td style="width: 16.6%;">snowfall</td> <td style="width: 16.6%;">fog</td> <td style="width: 16.6%;">other</td> </tr> </table> | none | drizzle | rain | snowfall | fog | other | |
| none | drizzle | rain | snowfall | fog | other | | |

Annex B

Data on the proficiency of a panel and a laboratory regarding olfactometry and field inspections

The **measurement report on the emission measurements** has to be based on the uniform German federal report form (download e.g. http://www.mu.sachsen-anhalt.de/start/fachbereich03/fachinformationen/files/mustermessbericht_emission.pdf).

Tables 1 through 3 of this Annex show examples of the minimum data required in the report on emission measurements.

Proof of the proficiency of all panel members involved in the olfactometric measurement should be given for both n-butanol and H₂S, either on the individual level following Table 1 or as a summary according to Table 2. Table 1 lists all data to be recorded in the framework of quality assurance for the proficiency of the panel members with regard to the standard odours n-butanol and H₂S. The data record has to be complete for all individual threshold estimates of each panel member (dilution factors; blanks presented, if possible in the sequence of sample presentation; every response of every panel member).

Table 3 lists the information required to prove the proficiency of the laboratory. Precision A_{od} can only be given for n-butanol.

Furthermore, data on the calibration of the dilution equipment with reference material including predilution performance have to be inserted into the uniform German measurement report form (date of the latest calibration, type of reference material). A characterization of the standard odours n-butanol and H₂S are required as well (i.e. concentration, producer, date of production, warranty of stability).

The measurement report on the results of olfactometric measurements has to include the complete data record of every sample and of any test of panel members with the standard odour n-butanol during these measurements. This data record covers the dilution factors, the blanks presented, if possible in the sequence of sample presentations, and every response of the panel members.

Concerning the **measurement report on the field inspections**, only proof of the proficiency of the panel members involved is required with the standard odours n-butanol and H₂S. The necessary data may be recorded individually in analogy to emission measurements as per Table 1 or as a summary following Table 2.

Table 1: Results of the proficiency test of one panel member (minimum 10, maximum 20 individual threshold estimates)

| Panel member Name / ID | | | Date of birth: Gender: | | | Odour: | | n-Butanol <input type="checkbox"/> | | H ₂ S <input type="checkbox"/> | | | | | | | | | | |
|------------------------|------------------|-------------------------------|---------------------------|------------------------|-------------------------|------------------|------|------------------------------------|------|---|---|-----|--|------------------|--------------------------------|----------------------------------|--|------|------|--------|
| No. | Date | Round ¹ / start | Test gas μmol/mol | Number of blanks | False blanks (FB) | Dilution factors | | | | | | | | Z _{ITE} | y _i nmol/ mol | log ₁₀ y _i | | | | |
| 1 | 15 April 2007 | .../10:08 h | 59,8 | 2 | - | 8192 | 4096 | N ² | 2048 | 1024 ³ | N | 512 | | | | | | 1448 | 41,3 | 1,6159 |
| 2 | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | |
| ... | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | |

| | | | |
|--------------------|----------|---|-------------------------------------|
| | | | \bar{y}_{ITE} |
| | | | S _{ITE} |
| | FB % | 10 ^{\bar{y}_{ITE}} nmol/mol | 10 ^{S_{ITE}} |
| Selection criteria | FB ≤ 20% | 20 ≤ 10 ^{\bar{y}_{ITE}} ≤ 80 ⁴ | 10 ^{S_{ITE}} ≤ 2,3 |

FB false blanks
 S_{ITE} standard deviation of the individual threshold estimate
 y_i value of test result i
 \bar{y}_{ITE} average of individual threshold estimates
 Z_{ITE} individual threshold estimate, expressed as a dilution factor

¹ Round – consecutive numbering of individual threshold estimates performed on one day.
² Blank
³ In this example, a grey background means that an odour was detected.
⁴ Only applies to n-butanol.

Table 2: Summary of proficiency test results of panel members

| Odour: n-Butanol <input type="checkbox"/> H ₂ S <input type="checkbox"/> | | | | | | | | | |
|---|----|---------------|--------|--|--------------------|----------------|----------------------------------|----------------|------|
| Panel member | | | | valid individual threshold estimates (ITE) | | | | | |
| Name | ID | Date of birth | Gender | Date of 1st ITE | Date of latest ITE | number of ITEs | $10^{\bar{y}_{ITE}}$ nmol/mol | $10^{s_{ITE}}$ | FB % |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

[see EN 13725]

FB false blanks

s_{ITE} standard deviation of the individual threshold estimate

\bar{y}_{ITE} average of individual threshold estimates

Table 3: Proficiency of the laboratory (overall sensory quality) (minimum 10 test results of the last 12 months)

| Odour: n-Butanol <input type="checkbox"/> H ₂ S <input type="checkbox"/> | | | | | | | |
|---|------------|-------------------------------------|------------------------------|------|---------------------|-----------------------|-----------------|
| No. | Date/start | Names of the panel members involved | Test gas $\mu\text{mol/mol}$ | FB % | $\bar{Z}_{ITE,pan}$ | y_i nmol/mol | $\log_{10} y_i$ |
| 1 | | | | | | | |
| 2 | | | | | | | |
| ... | | | | | | | |
| 10 | | | | | | | |
| Selection criteria | | | | | | \bar{y}_w | |
| | | | | | | s_r | |
| | | | | | | $r \leq 0,477$ | R |
| | | | | | | $A_{od} \leq 0,217^1$ | A_{od} |
| | | | | | | $FB \leq 20\%$ | |

[see EN 13725]

A_{od} accuracy of the odour measurement

FB false blanks

r limit value for repeatability

s_r standard deviation calculation of repeatability

y_i value of test result i

\bar{y}_w average of test results of one laboratory

$\bar{Z}_{ITE,pan}$ Geometric mean of Z_{ITE} of all valid panel members in one measurement, after retrospective screening

¹ Applies to n-butanol only.

Annex C

Requirements of the olfactometric measurement to determine odour emissions

Odour emissions are determined in accordance with the European Standard EN 13725 "Air Quality – Determination of the odour concentration by dynamic olfactometry" (2003). Apart from that, the rules of Section 5.3 of the German *TI Air* have to be observed.

As far as these documents leave a choice of action, their application in the framework of this Guideline on Odour in Ambient Air shall be governed by the following stipulations:

At least three samples should be taken per operation cycle and per emission source. The olfactometric analysis of these samples has to be done immediately after sampling. As a rule, one sample is taken continuously for 30 min.

Panel members are selected by means of the standard odours n-butanol and H₂S. Only assessors with an average odour sensitivity are selected for panel members.

The selection of assessors follows EN 13725 (2003) for n-butanol and should be performed in analogy to EN 13725 for hydrogen sulphide. To this end, at least 10 and no more than 20 of the individual threshold estimates per assessor shall be taken into account. The results of every assessor have to be established on three non-consecutive days. After selection, the proficiency test results of every panel member will be continuously taken down and stored.

Unless already done during measurements, three individual threshold estimates per panel member are performed at least once every 6 months with the test gases n-butanol and hydrogen sulphide. Every result of these reference measurements are taken down and are considered to the evaluation of the proficiency test of both, the panel members and the laboratory. Selection of reference measurement results for proficiency testing is not allowed.

Evaluation of the proficiency test for panel members is done by calculating the selection criteria according to EN 13725 (2003) from the last 10 to 20 individual threshold estimates. The results are then compared with the selection criteria:

- number of the standard deviation $\leq 2,3$ (for n-Butanol and H₂S)
- number of the mean value of all counted threshold estimates ranks between 20 nmol/mol and 80 nmol/mol (applies to n-butanol only).

No reference value (EROM) has been set for hydrogen sulphide. The mass concentration of hydrogen sulphide at the odour threshold is usually approx. 1 µg/m³.

Panel members who do not comply with these requirements will be excluded from all measurements until they comply again.

Proof of proficiency of the laboratory (overall sensory quality of the laboratory) is given at least once a year. To this end, at least 10 test results of the laboratory obtained during the last 12

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months are evaluated and compared with the selection criteria (The last 10 test results of the laboratory are sufficient for an evaluation with hydrogen sulphide):

- repeatability $r \leq 0,477$ (for n-butanol and H₂S)
- accuracy $A_{od} \leq 0,217$ (for n-butanol only)

In addition to the rules of this Annex B, the “Requirements set by the German *FLCPC* have to be observed. They need to be met by institutions practising ambient odour inspections in the framework of §§ 26, 28 of the German *FPCA* have to be observed (reference is made to individual state regulations). In addition to that, the German administrative guideline on the publication and acknowledgement of experts in pollution control needs to be adhered to.

**Grounds and advice on interpretation of GOAA
(version dated 29 February 2008)**

See Section 1 of GOAA

Assessment of odours
Derivation of the exposure limits
Identification of odours
The system GOAA
Initiation of an expert report
Approach on agricultural sources
Facilities not requiring licensing
Adequate dispersion models

See Section 2 of GOAA

Calculation of stack height
Stack height in agriculture

See Section 3.1 of GOAA

Classification of exposure limits
Allocation of odour exposure frequencies

See Section 3.2 of GOAA

Conformity of expert reports with GOAA

See Section 3.3 of GOAA

Irrelevance criterion (for additional odour exposure)
Irrelevance check following a licensing procedure
Application of the irrelevance criterion in external undeveloped areas

See Section 4.1 of GOAA

Methods to quantify odour exposure

See Section 4.2 of GOAA

Expansion of a plant

See Section 4.3 of GOAA

Application of the correcting factors in grid measurements
Application of the correcting factors in external undeveloped areas

See Section 4.4.1 of GOAA

Use of previous measurement results and statements
Statistical background of the correcting factors

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See Section 4.4.2 of GOAA

Assessment area

See Section 4.4.3 of GOAA

Position and size of the assessment squares

Assessment squares: Basis of the overall assessment of an exposure

See Section 4.4.5 of GOAA

Representativity of the measurement period

See Section 4.4.6 of GOAA

Position of measurement points / assessment squares

See Section 4.4.7 of GOAA

Testing panel members

Odour-hour

See Section 4.5 of GOAA

Dispersion calculation

See Section 4.6 of GOAA

Determination of the total exposure by means of dispersion calculation

Determination of the nuisance-relevant characteristic value $EXP_{tot,nr}$

See Section 5 of GOAA

Examination of the individual case

Degree of annoyance in the neighbourhood

Annex 1 of the advice on interpretation of GOAA

Method of hedonic classification of plant odours

Annex 2 of the advice on interpretation of GOAA

1. Quoted literature (References)
2. Scientific fundamentals

Grounds and advice on the interpretation of the GOAA

GOAA and the pertinent advice on its interpretation reflect the present optimum state of the art. This is also confirmed by the expertise 2004 of the German Council of Experts on Environment (CEE; German SRU = Sachverständigenrat für Umweltfragen). They recommended the competent authorities to take the Guideline on Odour in Ambient Air established by the German *FLCPC* as their source for important hints for licensing procedures (CEE, 2004, Tz. 587).

The GOAA evolved beyond the no longer valid common circular decree called “Application of the Technical Instructions on Clean Air” (SMBl. NW 7130), which was published on 14 October 1986 by the North-Rhine Westphalian Ministry for Environment, Planning and Agriculture and the Ministry for Economics, Medium-sized Business and Technology. The first supplement of the GOAA dated 21 Sept. 2004 added a detailed description of the odour hedonics. This addition was due to results obtained from the research project “Investigations into the effects of odour intensity and hedonic odour tone on the degree of odour annoyance” (Hedonics Project (2003)). New findings entrained consideration of hedonics in the assessment of odour exposure. All practicable suggestions of this research project were in the GOAA version of 21 Sept. 2004.

This second supplement and amendment of GOAA covers the different potentials for odour annoyance generated by animal-specific odour exposure, the local practice and habits of agricultural odour emissions and the privileges granted to agriculture in external undeveloped land. These amendments go back to the results of the research project “Assessment of agricultural odours” (2006).

See Section 1 of GOAA:

Assessment of odours

The judgement whether an odour nuisance is to be considered severe and thus an environmental detriment depends on a large variety of criteria. Among others, these are the odour quality (“It smells like..”), the hedonic odour tone (pleasant, neutral, unpleasant), the odour intensity, the diurnal and seasonal fluctuation of exposure, the rhythm in which the odour exposure will appear, the utilization of the land, the local habits and practice of exposure to agricultural odours. The GOAA system established exposure limits (see Section 3.1 GOAA) represented by odour frequencies. However, comparison with the limit values is not always sufficient. A check for an indication to better proceed as per Section 5 of GOAA in exceptional individual cases is a regular element of the decision whether a nuisance is severe. This check follows the determination of the odour frequency.

Derivation of the exposure limits

The basis of the set exposure limits is the odour frequency. One of the basic elements of setting these limits were field investigations of the Medical Institute for Environmental Hygiene *MIEH* (Ger-

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man MIU = Medizinisches Institut für Umwelthygiene) at the Heinrich Heine University in Düsseldorf. They monitored the odour annoyance in the neighbourhood of various odour emitters ("MIU Study" (1992)). Among other findings, this survey showed no significant extra knowledge for an odour assessment if the odour intensity was determined in addition to only the odour frequency. At that time, there had not yet been sufficient scientific data to support a regular measurement of the hedonic odour tone. This statement was confirmed during a hearing of experts about the GOAA which was initiated by the Baden-Württemberg Ministry for Environment and Traffic on 2nd October 1997. The 1992 MIEH study comments as follows on the importance of hedonics:

"We were not in a position to study the potential effects of the odour property "pleasant" or "unpleasant" in ambient air on the degree of annoyance. Therefore, it is emphasized that the findings presented here and the exposure 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 their nuisance potential because the hedonic tone of the odour (pleasant vs. unpleasant) (...) apparently affects the degree of the nuisance ...: Comparison of 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 exposure. Despite these reservations, the exposure limit values derived here can be used as well-founded tools to distinguish 'severe' from 'not severe' odour nuisance. "

The relationship between exposure and effect concerning the exposure to industrial odours and the degree of odour nuisance in the neighbourhood of industrial plants was confirmed by the "Hedonics Project" (2003), the exposure being objectified by means of the odour frequency and its basis, the odour-hour concept.

Furthermore, the ambient hedonic odour tone from emitting plants turned out to have a significant effect. There was a definite difference in the annoyance reaction on "pleasant" odours on the one hand and on "unpleasant" and "neutral" facility odours, on the other hand. There was no indication for a more detailed distinction. In contrast to the hedonic tone, the odour intensity again turned out to be of none or marginal importance for the odour effect which was already found in the MIEH study (1992).

A suggestion is made in the report on the Hedonics Project (2003) e.g. to consider the hedonic odour tone by means of a bonus/malus. It is recommended to apply the relevant curves of exposure and effect for a decision on the bonus of an odour source which was classified and verified to be pleasant.

The relationship between exposure and effect, basis of the limit values of GOAA, was confirmed once more in the project "Assessment of agricultural odours", this time particularly for livestock farming. A comparison of the results of both projects, "Assessment of agricultural odours" and "Hedonics" emphasizes the fact that a distinction of the annoyance effect is impossible on the basis of the hedonic tone of livestock odours because all of the animal-specific odour qualities were classified to be "unpleasant". However, in contrast to industrial odours, it is feasible to distinguish the annoyance effects on the basis of the (animal-specific) odour qualities. It turned out that "cattle

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odour” and “pig odour” are less annoying than “industrial odours”, while “fowl odour” is significantly more annoying than “industrial odour”.

The exposure limits of the GOAA are based on the detection of recognizable odour and the odour-hour concept. The MIEH study (1992) did not show any advantage of the full-time odour monitoring over the odour-hour concept during field inspections. The odour-hour concept, which was also the basis of the projects “Hedonics” (2003) and “Assessment of agricultural odours” (2006), continued to prove a suitable tool (see also advice on interpretation of Section 4.4.7 of GOAA “odour-hour”).

Identification of odours

Odours in ambient air may be recorded only if they can be identified during odour detection in the field or in odour exposure prognoses by means of dispersion models. Odour identification means that the odours can be identified with sufficient certainty and unambiguously to originate from plants or facility units so that they can be distinguished from traffic odours, domestic heating, vegetation, manure spreading or similar sources. This explanation defines the term “clear perception” (see Section 4.4.7 GOAA).

The system GOAA

Several comprehensive studies (by the North-Rhine Westphalia State Environment Agency, the Saxony State Agency for Environment and Geology, 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 grid measurements according to the GOAA were compared with those of dispersion modelling according to GOAA. The results showed,

- that the actual situation can be described with sufficient certainty by means of the methods authorised by GOAA;(this includes the definition of the odour-hour concept);
- that the two methods permitted in the GOAA (i.e. the grid field measurements and ambient pollution prognosis) yield recognizable odours and thus comparable results.

The ample investigations of the “Hedonics Project” (2003) are another proof of the suitability of the GOAA system. The most important findings are:

- an ambient odour exposure can be detected sufficiently well with the GOAA methods,
- the GOAA methods guarantee that an adequate description of the degree of neighbourhood annoyance is basically feasible by means of odour frequencies based on the odour-hour concept
- consideration of the hedonic odour tone is necessary only for definitely pleasant odours
- the odour intensity is not necessary to describe the degree of odour annoyance in the neighbourhood; as soon as neighbours are able to identify an odour and assign it to its source, the odour may trigger an annoyance.

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Moreover, further new findings resulted from the project „Assessment of agricultural odours“ (2006). It is important to remember that the results of this project are confined to the difference in annoyance potential of animal-specific ambient odours. There is e.g. no need to measure the emissions or the emission potentials of different livestock management methods to find out the relationship between odour exposure and odour annoyance (any differences in the odour emission potentials are still detected in the framework of emission measurements, provided that they can be quantified).

The most important findings of the project „Assessment of agricultural odours“ (2006) are as follows:

- The degree of annoyance in the neighbourhood increases with a rising odour exposure caused by agricultural odours (odour frequency expressed in percentage of annual hours); which proves the relationship between exposure and effect.
- The odour quality which is classified according to types of animals (fowl, pigs, cattle) has a definite effect on the exposed persons. The odour quality “cattle” is hardly annoying. The odour quality “pig” has a significantly higher annoying effect, and the odour quality “fowl” has the strongest effect in terms of annoyance.
- The parameter hedonics turned out to be irrelevant in the framework of the livestock farms under investigation in this project because livestock odours (cattle, pigs, fowl) were all classified as unpleasant. Odour intensity also turned out to be irrelevant for the annoying effect.

Initiation of an expert report

The GOAA does not enforce an expert report according to its methods in each and every case. The expert report 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 environmental detriment is effectively avoided by other tools, the determination of the characteristic values according to Section 4 of GOAA is not compulsory. The tools may be e.g. guidelines VDI 3471 (1986) and VDI 3472 (1986) or the minimum distance set by the German *TI Air*, Section 5.4.7.1 (2002), for agricultural areas, or conflict management. However, if the authority concludes in problematical cases that an expert report based on the GOAA is required in order to resolve doubts, it has to be ordered, even for agricultural installations. No further investigations according to the GOAA are required where common experience and knowledge of the locality lead to the conclusion that the observation of the minimum distances defined in the guidelines quoted above precludes environmental detriment. However, these investigations are necessary if doubts remain.

Approach on agricultural sources

Rules for minimum distances

The general procedure in agriculture is to first check the distance to the neighbourhood. The check is based on Section 5.4.7.1 *TI Air* for farms subject to licensing and on guidelines VDI 3471 (1986) and VDI 3472 (1986) for farms not undergoing licensing. The drafts of guidelines VDI 3473 and VDI 3474 can not be considered to assess the situation. As there was no consensus for a final version they cannot be recognized as the “publication of an expert evidence”.

During application of Section 5.4.7.1 *TI Air* , and of guidelines VDI 3471 and VDI 3472, respectively, the boundary conditions listed therein have to be strictly observed. The distances given in the VDI guidelines and the German *TI Air* were developed to support the principle of taking precautions against new air pollution from planned facilities, which has to be observed independently of the obligation to provide protection against harmful impacts from existing plants. Maintaining minimum distances is usually sufficient to avoid environmental detriment. However, experience has shown that the distances are insufficient for farms exceeding a defined livestock. Therefore, the distances listed in the *TI Air* and the above-mentioned VDI guidelines should under no circumstances be extrapolated to numbers of animals or livestock units (LU) which exceed the maximum numbers quoted in these administrative and technical guidelines, respectively.

Apart from that, the following aspects will also limit or exclude the applicability of the established set-back distances:

- Superposition of odour plumes
- Existing odour exposure
- Large dimensions of the plant
- Extraordinary topographic conditions
- Extraordinary meteorological conditions

As a rule, the minimum distances of *TI Air* (Section 5.4.7.1) or the full distances instead of 50 % as per guidelines VDI 3471 (1986) and VDI 3472 (1986), respectively, have to be observed in the direction of residential areas.

However, observance of only these distances will be insufficient to conclude the absence of any environmental detriment on condition that – in accordance with Section 4.4.2 GOAA –

- environmental detriment is expected due to the accumulating effect of various odour sources. This is true for situations where the circles of the minimum distances of various adjoining livestock farms meet or overlap, or if other emission sources are near by such as cattle farms, biogas installations etc.
- the relevant sites exposed in the assessment area are situated leeward of the farm under assessment, with reference to the sectors of the main wind directions.

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Therefore, a check has to be made during licensing whether the relevant sites exposed in the assessment area as per Section 4.4.2 GOAA are situated within the reach of additional livestock farm odours and other odour sources.

As a rule, the characteristic values have to be determined and compared to the limits as per Section 4 ff GOAA if the distances are not observed. Then situations may exist where the license can be given in view of the distribution of wind directions although the distances of the VDI guidelines are not observed. In these cases, the obligation to protect the neighbourhood can be recognized as having been met.

In villages, a higher degree of odour exposure is admissible than that in residential areas. However, one can not rule out the possibility that there is already an air pollution from other livestock farms. If so, observance of (half of) the minimum distances as per guidelines VDI 3471 (1986) and VDI 3472 (1986) cannot be accepted as the only justification of an admissible license for a livestock farm.

Exposure limits

The exposure limits listed in Table 1 are valid in agriculture first of all for farms subject to a licence based on the pollution control legislation. If the limits are applied to agricultural plants not requiring such a licence, an examination of the individual case is necessary. A higher level of odour exposure might be tolerable e.g. because of local practice and habits. If this applies, the exposure limits may be taken as aims to solve an existing conflict. The establishment of intermediate values may be an alternative. If a residential area is next to an external undeveloped area, the set intermediate value should not exceed the exposure limit for villages.

Local practice and habits

As far as local practice and habits concerning agricultural odours are concerned, we have to remember that the generation of rural districts is the result of historical developments under various natural, social and economic conditions. Historically grown villages combine the activities of agriculture, small-scale companies, craftsmen, and residents. The farms, some of which have been existing for several generations, are the characteristic elements of villages. Livestock in villages is mostly a full-time or part-time family business and is far below the size that needs licensing according to the German *FPCA*. Agricultural activities with their inherently frequent odour emissions may be regarded as part of the local practice and habit in view of this inevitable scatter of differently utilized land and in respect of the necessary acceptance and mutual considerations in neighbour relations. The number of sources within a village which contribute to the odour exposure, cannot be neglected.

Due to their historical development, former East Germany enjoys an increased consideration of the local practice and habit. Their farm buildings which were characteristic of the villages in past times, had to be given up in the course of collectivization. They were replaced by large units which were constructed mostly close to the villages, but in external undeveloped areas under the planning law. They have been operating there for decades. As a consequence there are hardly any agricultural

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activities left within the village, but the pertinent residential areas are typically situated directly adjacent to the livestock farms. The assignment of the exposure limit for villages can therefore be justified for plots of land in the reach of such livestock farms. In individual cases it may even be justified to exceed this limit.

Open climate stable

Open climate stables are a problem for dispersion calculation because the emissions depend on the meteorological conditions (e.g. speed and direction of the wind across the stable). Therefore, the emission factors have to be determined with special care. If no detailed emission factors are available, the emission has to be determined at least for the average weather conditions.

Liquid manure odours

According to the results of the project "Assessment of agricultural odours" (2006) the odour of liquid manure generally need not be assessed (manure spreading; see Section 3.1 GOAA) in order to decide on the total exposure. By way of exception, as per Section 5 of GOAA, it may be necessary to also consider liquid manure odours in assessing the overall exposure. However, manure odour abatement and manure treatment are not covered by GOAA.

Consideration of mutually adjacent livestock farms

It is common practice not to include the residential buildings of mutually adjacent livestock farms in the assessment of an odour exposure. This was also adopted in dispensation of justice where the owners of the emitting farms are deemed persons "sharing the same fate" (Lower Saxony, Higher Administrative Court, decision of 25 July 2002, Ref. 1 LB 980/01). In view of the sensory effect, this decision seems to be sensible at least for farms keeping the same type(s) of animal(s). The expenditure in field measurements will be extremely high if e.g. a distinction has to be made between the odours from the pigsties of two neighbouring farmers. Moreover, it is not plausible to pretend that e.g. the odour exposure from the own pigsty is not annoying (or cannot be taken into account in the odour assessment) while those of the adjacent pigsty are considered to be annoying.

In the case of different types of animals with distinctly discernible odour qualities, the residential buildings of adjacent livestock farms should be included in the assessment. However, the level of severe nuisance in such a case can be assumed to be significantly higher than the level established for an uninvolved third party (see also Advice on interpretation of Section 5 of GOAA).

The same applies to neighbours who no longer keep livestock, but still live on the external undeveloped land. A decision of the Higher Administrative Court of North-Rhine Westphalia (18 March 2002, Ref. 7 B 315/02) says that even an odour frequency of 50 % of the annual hours need not necessarily be sufficient reason to define an intolerable exposition for a "typical agricultural residence". "There was no elaboration on a health hazard, either," explains the Court. This value gives evidence of the particularities of individual cases. However, it should NOT be the regular basis for such conditions.

Zoning

The GOAA is also used for decisions in zoning. The future level of ambient odour exposure in the planned residential area is then estimated on the basis of dispersion calculation. The calculation also covers (well advanced) projects of neighbouring livestock farms, if applicable. In the course of the zoning procedure, GOAA ensures that the interests of both, future inhabitants and farmers involved, are respected.

If higher exposure limits are e.g. set for the neighbourhood of livestock farms, they need to be considered in the zoning procedure. This results in shorter distances between livestock and residents. It is not allowed to take different assessment criteria, depending on the type of administration process, because the main aspect in all processes definitely is the severity of odour nuisance.

Plants not requiring licensing

The application of GOAA is not a must in fixing the requirements of plants not requiring licensing. If, however, the existing odour exposure is determined in accordance with GOAA, the odour contribution from plants with a permission based on only the building law have to be considered in addition to the portions coming from plants licensed in accordance with the meaning of § 4 of the *FPCA*.

In case of environmental detriment due to odour exposure caused by installations not requiring licensing, a check is made of whether everything feasible of the state of the art has been done to avoid environmental detriment. Any unavoidable detriment left has to be reduced to a minimum according to the state of the art (§ 22 section 1, phrase 1, No. 2 *FPCA*). The definition of the minimum has to be based on a balance of interests of all parties concerned. Excessive measures cannot be ordered. Plants close-down is restricted to the provisions of § 25 section 2 *FPCA*. However, these conditions do not apply to odour exposure in general. In individual cases, orders may be based on § 24 *FPCA*.

Federal State regulations for precautions (in external undeveloped areas) may include requirements beyond those in § 22 *FPCA*

(See section 4.2 of advice on interpretation of GOAA for plants subject to licensing)

Adequate dispersion models

The concept of how to determine an ambient pollution is based on existing VDI Guidelines. The overall calculation system of an ambient pollution prognosis was described by Janicke, L. und Janicke, U. (2003, 2004). The requirements laid down in *TI Air Annex 3* together with the special adaptation to odour dispersion were considered in the reference calculation model AUSTAL2000.

If different models are applied, proof of the comparability of these models has to be given to the competent administration.

See Section 2 of GOAA:

Calculation of the stack height

The assessment square with the maximum exposure is generally represented by the value 0.06 (relative frequency as per section 3.1, paragraph 1 of GOAA) and taken as a basis for stack height calculation. As a rule the pertinent assessment square covers an area of 250 m by 250 m. This also applies to uninhabited areas to satisfy the principle of precaution [t.n.: in external undeveloped areas]. The assessment square with the odour source may generally be ignored.

Consideration of an S factor [t.n.: material-related factor as per *TI Air*] in stack height calculations was discussed during establishment of the GOAA, but was not regarded adequate by the experts in dispersion calculation. The differing emission conditions of individual plants could not have been taken into due account which would have resulted in unrealistic stack heights.

Stack height calculation in agriculture

The rules for stack height calculation in GOAA are valid only for one collective stack which is obligatory – if applicable – according to section 5.5.2 paragraph 2 *TI Air* (see also advice on interpretation of section 3.1 of GOAA dealing with the allocation of odour exposure frequencies).

During stack height calculation for stacks customary in agriculture a check has to be made whether the effective source height (“Abgasfahnenüberhöhung”) needs to be considered. Pertinent advice can be taken from the draft guideline VDI 3783 Part 13 (2007).

See Section 3.1 of GOAA:

Classification of exposure limits

The classification of exposure limits according to the levels of the (German) ordinance on the use of buildings (BauNV) is inadequate because these detailed levels do not represent the annoyance effect of odour exposure. The odour assessment according to GOAA has to be based on the real use of buildings.

In individual cases the classification of the exposure limits may be different from that in Table 1 of the GOAA. Examples:

- According to § 5 of the (German) ordinance on the use of buildings (BauNV), rural villages may comprise buildings for agriculture and forestry, for housing, for commercial enterprises with low disturbing potential and for craftsmen who serve the needs of the local population. The interest of agriculture and forestry including their growth potential demand the highest consideration.

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This is done by fixing the exposure limit to 0,15. An interpolation between rural villages and external undeveloped areas is possible in well-founded individual cases, which may result in limit values up to 0,20 on the outskirts of a village.

- Transient areas between undeveloped land and purely residential areas may be treated in the same way. Depending on the individual case, intermediate limits up to 015 may be taken as an assessment basis (see also decision dated 26 April 2007, Ref. 7D4/07.NE, of the High Administrative court of North-Rhine Westphalia). The transient area has to be defined exactly.
- If a rural village developed into a residential area, the classification for a mixed residential area is necessary ($EXP_{lim} = 0,10$). Even then it is possible to fix intermediate limit values on well-founded arguments (see section 5 of GOAA).
- (Building) Projects in external undeveloped areas as per § 35 paragraph 1 of the (German) building law can only be permitted by way of exception. Agricultural premises are explicitly permitted. Living in external undeveloped areas entrains a lower level of protection from ambient pollution. Therefore it is possible to fix a limit of up to 0,25 for agricultural odours in external undeveloped areas after checking the particular boundary conditions of the individual case.
- Camp grounds cannot demand a higher level of protection than the surrounding built-up area, unless they are individual cases with extraordinary conditions. As a rule, the same applies to nursery-schools, schools and old people's homes because odour exposure is no health risk. However, an accelerated investigation is recommended in case of complaints from these sensitive settlements (nursery schools, schools, old people's homes). Stress is laid on the exceptions mentioned in Section 5.
- Vacation-home areas generally are 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.

Allocation of odour exposure frequencies

In practice, the GOAA is also used as a basis for zoning decisions. In this context the question of allocating portions of ambient odour to different plants may be difficult to answer. Several approaches may be considered (50 % of the exposure limit, stack height calculation (0,06), irrelevance criterion (0,02), determining the existing odour exposure and distributing the "remainder"). Contributions to the odour exposure by actually planned projects have to be included in the calculation of the allotments to other plants.

As a rule, a single plant to be licensed should not exhaust the applicable exposure limit.

Regardless of whether the existing or the expected additional odour exposure exceeds limit values, plants which require licensing (Federal Pollution Control Act, § 5, Paragraph 1, No. 2) and – if applicable – also those which are not subject to licensing are required to comply with the state of the art. In order to provide room for future development and to consider precautionary measures against environmental detriment, the requirements set may possibly go beyond the present state of the art (see also pertinent regulations of the German states).

See Section 3.2 GOAA:

Conformity of expert reports with 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 report that the results are explained so that they can be reproduced. If this fails respective additions to the experts reports should be demanded. In accordance with the GOAA prescriptions it is e.g. obligatory to comment on the existing exposure if the expected additional exposure is assumed to be $EXP_{add} > 0,02$.

See Section 3.3 of GOAA:

Irrelevance criterion for additional odour exposure

The irrelevance criterion refers to the additional odour exposure caused by the entire plant. Therefore, it is impossible that several irrelevant expansions of one plant add up to a total ambient odour exposure exceeding the exposure limit. The term " plant " does not mean an individual source nor the "entire industrial enterprise" but, in the case of plants requiring licensing, it corresponds to the definition in the Fourth Ordinance to the (German) Federal Pollution Control Act. According to this definition, the term " plant" may comprise several sources.

Even if an existing plant is altered substantially, the term "irrelevance" means that the pollution contribution of the entire plant (including the alteration) will meet the criterion of irrelevance. Or else, it means that the contribution of the substantial alteration has no effect on the total pollution reflected by the (rounded) characteristic value. This can be achieved if e.g. the plant is enlarged and pollution abatement measures are taken at the same time, provided that the exposure limit is observed (see also advice on interpretation of Section 4.2 of GOAA). A relative odour-hour frequency of 0,02 as the threshold of irrelevance must not be exceeded.

The irrelevance criterion refers only to areas where people stay longer than just temporarily.

The assessment of the ambient odour contributions depends decisively on whether the odours originate from one or more plants. More plants than one are always to be assumed if they belong to different operators (otherwise it may be regarded as common plants 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 breaking-up of plants, the irrelevance principle applies to each of the two separated plants from the time of breaking-up.

Irrelevance check following a licensing procedure

Grid measurements are not appropriate to check the irrelevance after licensing. The sample sizes mentioned in Table 3 of the GOAA were derived with the aim of determining whether the exposure limits are observed. A larger sample size is required if evidence of the compliance with lower frequencies of odour exposure (e.g. 0,02) is to be provided with equal statistical certainty. They would first have to be determined by the method described in the literature quoted in the advice on interpretation of Section 4.4.1. 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 on the basis of the odour quality between the additional exposure and the emission from other plants.

It would appear to be an inconsistency if the existing odour exposure was not determined to save 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 plant 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 make a new prognosis of the ambient odour exposure, which can now be based on olfactometric emission measurements at the finished facilities while before only analogy-based estimates could be made. These measurements have to be performed by a laboratory acknowledged in accordance with § 26 of the (German) Federal Pollution Control Act and so far not involved in the licensing procedure of that plant.

Application of the irrelevance criterion in external undeveloped areas

There are hardly any spatial restriction in external undeveloped areas where agricultural aims are privileged and where farmers want to save their expansion potential as far as possible. It is in fact realistic to have numerous farms, either existing or under construction or expansion, around a residential area which may each have only an irrelevant effect on the odour pollution in the residential area. This would, however, entrain considerable accumulation of ambient odours. Practical experience proves that an excess of the exposure limits cannot be excluded in these cases.

So far, this problem has been tackled in different ways. Parts of Lower Saxony have a “low irrelevance” rule. It is assumed that a calculated odour frequency of 0,004 caused by a planned new stable will not have an effect on the rounded characteristic value as per Section 4.6 GOAA so that the stable may be constructed.

An alternative for cases creating fear of excessive accumulation is to include the existing total exposure in the assessment of the situation as a supplement of the required calculations. This means that a check has to be made whether – in view of the already existing exposure – an additional contribution of 0,02 may be tolerated.

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This is why it is absolutely possible to grant a licence to the first plant with an irrelevant contribution to the ambient odour exposure, while the licence application will be rejected to the second irrelevant contributor. This is justified on the basis of § 3 of the Federal Pollution Control Act in order to avoid environmental detriment because – depending on the individual case – an increasing accumulation is feared. Reference is made to Section 5 of GOAA.

See Section 4.1 GOAA:

Methods to quantify the odour exposure

Dispersion calculations may be applied to check the observance of the licence prerequisites provided that the emissions can be determined sufficiently well.

As the case may be, approval measurements will have to be made after the start of operation by means of field inspections with panel members (plume or grid measurements). This applies particularly to sources providing difficulties in measuring emissions (e.g. fugitive emissions) or in predicting their effects in the neighbourhood. These extraordinary circumstances do not necessarily entrain grid measurements. If adequate, also plume measurements for the indirect determination of the odour flow rate may be used according to guideline VDI 3940 Part 2 (2006). Sufficiently numerous intersection line measurements should be made on several days and at different distances downwind of the plant in order to detect the percentage odour time at the various measurement points. Then that odour emission which corresponds to the result of the plume measurement is calculated with an adequate dispersion method by means of iterative calculations and consideration of the pertinent meteorological dispersion situation. The resulting odour flow rate is then taken to support the real exposure prognosis in accordance with GOAA.

Apart from that, the validity of odour exposure prognoses may be verified with the help of grid measurement results.

As far as the procedure of field inspections is concerned, reference is made to the (planned) guidelines VDI 3940 Part 3 (draft 2008) and Part 4 (draft 2008).

As 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 was waived in GOAA versions after 1993. Chemical analyses may be used, however, to gain exploratory knowledge.

See Section 4.2 GOAA:

Expansion of plants

Plants subject to licensing may expand only if it is certain that they cannot cause environmental detriment (Federal Pollution Control Act, § 6, Paragraph 1, No. 1, in conjunction with § 5, Paragraph 1, No. 1). In analogy with *TI Air* Section 3.5.4, improvements may only be permitted on condition that the modification serves a reduction in ambient pollution, either exclusively or at least to a large extent, and the individual situation does not require a withdrawal of the licence. The fundamental obligation to observe the exposure limits remains unaffected by this decision.

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If both the existing odour exposure as well as the expected additional odour exposure are estimated by dispersion calculation, the new total exposure and the former total exposure (now existing exposure) need to be calculated. Their difference has to be regarded as the expected additional exposure which must not be compared with the irrelevance criterion.

(See advice on interpretation of Section 1 GOAA concerning installations not requiring licensing.)

See Section 4.3 GOAA:

Application of correction factors in grid measurements

In grid field measurements within a *licensing procedure* the correction factor k (see 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 (see § 6, Paragraph 1 of the Federal Pollution Control Act).

In contrast to this a correction factor need not be used in *surveillance procedures*.

Unless Section 5 of the GOAA allows a different ruling, environmental detriment is to be assumed if in a surveillance process 52 or 104 field measurements without the correction value k result in ambient odour exposure exceeding the limit value.

The reason for this distinction lies in the different material burden of proof in cases of unresolvable doubts about the causes of environmental detriment. Licensing procedures have to ascertain (prove) the **protection** from severe nuisance by ambient odour exposure whereas rulings according to §§ 17 and 24 of the Federal Pollution Control Act follow the proof of **violations** of obligations to protect the environment from ambient pollution.

Correction factors are not applied if the results of grid measurements are used to validate the emission data applied in the pollution prognosis, e.g. for fugitive emissions.

Application of correction factors in external undeveloped areas

In the course of licensing procedures concerning external undeveloped areas, the applicable correction factor is 1,3 for a sample size of 52 inspections and 1,2 for a sample size of 104 inspections when the weighted exposure limit amounts to 0,25.

See Section 4.4.1 GOAA:

Use of previous measurement results and statements

The permission that results of previous measurements or statements regarding ambient pollution and emissions may be used if the main conditions have not changed deviates from *TI Air* (Section 4.6.3.1), where an interval of five years is mentioned. The deviation appears to be justified because of the special conditions in the case of ambient odour, however, on condition that the methods and procedures have not changed in the meantime.

Statistical background of the correction factors

The correction factors were derived from a test of hypotheses involving the binomial distribution. Details were published by Prinz and Both (1993). The correction factors and the exposure limits of the GOAA were determined with an error probability of 20%. It is particularly emphasised that this test of hypotheses is designed for compliance with exposure limits to make sure that the population is protected from environmental detriment (severe nuisance).

See Section 4.4.2 GOAA:

Assessment area

The assessment area has to be positioned and sized in such a way that an objective assessment of the individual problem is feasible.

See Section 4.4.3 GOAA:

Position and size of the assessment squares

The position of the grid squares is adapted to the existing or future land use permitted by the planning and zoning regulations, or else to special on-site conditions (e.g. insufficient accessibility of the measurement points). 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 required and justified in individual cases (see VDI 3940 Part 1 (2006)).

Inhomogeneous odour exposure which may require smaller assessment squares usually occurs near installations with low sources (e.g. livestock farming) or in areas with a distinct topographical structure. In such cases it is particularly important for the expert and the licensing authority to agree on the methods to be applied.

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It is impossible to fix a value for grid measurements which represents the beginning of an inhomogeneous exposure because the measurement planning has to be finished prior to the exposure being known. However, indications of the adequate size of the assessment squares may be taken from VDI 3940 Part 1 (2006).

In case of dispersion calculation, an inhomogeneous exposure may be assumed if the characteristic values of two adjacent squares differ by a factor of 0,04. If these squares are relevant for the overall assessment, they have to be reduced in size.

Assessment squares: Basis of the overall assessment of an exposure

The exposure limits of the GOAA were derived from the results of field inspections with simultaneous annoyance sampling. The size of the assessment squares to be chosen depends on the existing odour exposure (homogeneity in the vicinity of the plant) and on the individual necessities of the situation. Therefore, the size of the assessment squares may vary between 250 m by 250 m down to a point (only if justified by way of exception). A reduction in square size does not entrain a more rigorous assessment. The reduction aims at finding an adequate solution from case to case. The exposure limits set in GOAA remain unaffected by the reductions because their derivation is independent of the square size.

See Section 4.4.5 of GOAA:

Representativity of the measurement period

If the measurement period covers less than 12 months, it should be ascertained that portions of both the cold and the warm season are included. It may be considered to cut it to three months provided that the period of strongest emission or highest ambient odour exposure are covered, respectively.

See Section 4.4.6 of GOAA:

Position of measurement points / assessment squares

The general sense of Section 4.4.6 of GOAA also applies to the choice of assessment squares in dispersion calculation.

See Section 4.4.7 of GOAA:

Testing panel members

Measurement institutions conducting field inspections with panels have to employ tested persons. According to annex C of GOAA, this test has to follow the instructions of EN 13725 (2003). The complete measurement procedure has to be performed at least twice a year with the substances n-butanol and H₂S. Furthermore, the institutions have to participate in interlaboratory tests for quality assurance in olfactometry.

Odour-hour

The odour-hour is defined in guideline VDI 3940 Part 1 (2006). "One odour-hour means one positively assessed single measurement. A single measurement has a positive result if the fraction of time during which an odour was unambiguously identified comes up to or exceeds a predefined percentage value".

This definition was derived from the general properties of the sense of smell, in particular its pronounced ability to adapt to stimuli. It is assumed that, although the summarized duration of all odour episodes is identical, many short excesses of the odour threshold in one measurement interval have a higher effect on odour annoyance than only a few continuous stimuli with a shortened effect due to adaptation. Consequently, 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 *TI Air* of 1986. It is also part of the present version of the GOAA.

The exposure limits defined in the GOAA are based on the concrete 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 Pollution Control Act (BImSchG) in connection with the definition of environmental detriments (see Section 3.1 of the GOAA).

See Section 4.5 of GOAA:

Dispersion calculation

Advice on dispersion calculation including measures for quality assurance of the exposure prognosis may be taken from draft guideline VDI 3783 Part 13 (2007).

The results of dispersion calculations are area-related values as a basis for an assessment in the framework of GOAA. Isolines are inadequate to this end.

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The complete expertise with dispersion calculation also includes files concerning protocol, input data and results.

See Section 4.6 of GOAA:

Determination of the total odour exposure by means of dispersion calculation

The addition of existing and expected additional exposure resulting in the total exposure is only applicable on condition that the existing exposure was found in grid measurements as per VDI 3940 Part 1 (2006). If a prognosis is based on only dispersion calculation to find the total odour exposure, the odour emissions from the existing sources (existing exposure) and those of the new sources (additional exposure) represent the input data of one **common** calculation. It is important to make sure that all odour sources affecting the assessment area are comprised in the dispersion calculation.

Determination of the nuisance-relevant characteristic value $EXP_{tot,nr}$

The special procedure of determining the nuisance-relevant characteristic value guarantees the weighting of a type of livestock in accordance with its actual contribution to the ambient odour exposure. This is independent of whether the total exposure EXP_{tot} was calculated or measured in the field, and whether EXP_{tot} is higher or lower than or equal to the sum of the individual contributions in terms of frequencies.

Consideration of **all** elements of each and every assessment procedure is required in order to find out the practical effect of a set animal-specific factor on the overall assessment of an individual ambient odour situation (more or less rigorous requirements). The isolated consideration of the weighting factors of individual types of livestock does not fulfil the demands of the assessment system. It is obligatory to also take into account the pertinent exposure limit in order to get an idea of the resulting extent of the regulation. For example, a high assessment value in the external undeveloped land needs completion by the planned bonus for pigs and cattle to reflect the actual situation.

Types of animals which were not investigated in the frame of the project on „Assessment of agricultural odour“ cannot be characterized by a weighting factor.

Regional deviations from the weighting factors of Table 4 are acceptable provided that scientific investigations prove a different annoyance reaction of the exposed persons.

Particular stress is laid on the fact that the rule for fattening pigs in Section 4.6 is valid only up to a livestock of 5000 pigs (or the equivalent of breeding sows, depending on the pertinent conversion factor). Livestock farms with more than 5000 fattening pigs were not investigated in the above-mentioned project or else the results had to be waived due to particular conditions on site. Therefore, the pig factor of Table 4 of Section 4.6 GOAA is not applicable in these cases.

See Section 5 of GOAA

Examination of the individual case

The GOAA allows certain deviations from the exposure limit values in well founded individual cases.

Examples of examinations of individual extraordinary cases:

- An adequate assessment of seasonal production plants can only be achieved by means of individual rules; the pertinent GOAA exposure limits have to be modified. The following aspects need to be considered among others: duration of the production season, classification of the exposed area, local practice and habits concerning ambient odours, annual season of exposure. If the production season lasts for e.g. 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 raise the limit values for operating times of less than six months.
- A dispersion model adapted to consider the features of an individual case has to be applied to valleys, 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 exposure limits might 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, an assessment according to Section 2 of the GOAA (compliance with the state-of-the-art) is required in these cases, too.
- According to the Federal Pollution Control Act (BImSchG) only the neighbour has a right to be protected from environmental detriment, not the user of the emitting plant. Assessing the degree to which the employees are affected by the odours emitted by their own plant falls into the domain of occupational safety and health. The existing odour exposure of the employees cannot be added to the odour exposure on these premises caused by a plant in the neighbourhood. The employees in other plants, 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 exposure limits.
- Assessing a health spa area requires other criteria than the exposure limits for the areas listed in the GOAA. At least the exposure limit for residential areas has to be applied. As a rule, the exposure limit of a health spa should not exceed 0,06. This is particularly true for high-quality air resorts.
- A factor of 0,5 may be applied to the contribution of a definitely pleasant odour to the total exposure. Definitely pleasant plant odours can be determined with the method of hedonic

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classification of plant odours (see Annex 1 of “Grounds and advice on interpretation of GOAA).

The assessment of a mixed area requires one separate sample each for unpleasant and pleasant odours, either by grid measurement or by exposure prognosis. Then the annoyance-relevant characteristic value is calculated in analogy with equation (4) of Section 4.6 GOAA including factor 0,5 for exposure to definitely pleasant odours. An exemption of “pleasant plants” from any limitation of odour-hour frequencies is waived for several reasons. An odour-hour frequency of only 30 % is supported by the findings of the hedonic project (2003). The potential change in annoyance reaction of the neighbours at higher frequencies has not been clarified sufficiently. It may well be assumed that the annoyance response of the neighbours will change from a certain higher level.

In this context, it has to be emphasized that, in contrast to panel members, neighbours do not qualify the pleasant odours from plants as being pleasant; they will characterize them as increasingly unpleasant with increasing odour intensity. The statement that neighbours have to tolerate pleasant odours at unlimited frequencies is obviously difficult to communicate to the exposed persons and therefore untenable. The Hedonics Project (2003) and the project on “Assessment of agricultural odours” (2006) showed that odour intensity has only marginal effects on the annoyance.

- Regarding the examination of extraordinary individual cases please refer to the advice on and interpretation of section 1 GOAA „Procedure in agriculture“.

Degree of annoyance in the neighbourhood

In individual cases (when checking criteria such as ambient odours due to local practice and habits, intensity, hedonic tone) it may be reasonable to directly determine the degree of annoyance of the neighbours. For this purpose, guideline VDI 3883, Part 1 (1997) may be used. This may be an adequate justification for applying assessment criteria other than the exposure limits defined in the GOAA.

Annex 1 of the grounds and advice on interpretation of GOAA

Method of hedonic classification of plant odours

1. Introduction

The findings of the study by Sucker et al (2003) give evidence of the fact that it is possible to classify plant odours by means of a definite hedonic tone based on the polarity profiles developed by Eyferth (VDI 3882 Part 2 (1994), p. 7). As a consequence, polarity profiles have to be used for the hedonically definite classification of plant odours. Thus, the fast and reliable hedonic characterization of a plant will be feasible.

The aim of this hedonic characterization (see Section 5 and advice on interpretation of Section 5 of GOAA) is to find out whether the plant odours under investigation have a **definitely pleasant hedonic odour tone**. Experience has shown that only a few plant odours fall in this category.

A separate hedonic assessment is required for each odour quality where individual sections of one plant emit different odour qualities. It may be possible to have a “definitely pleasant hedonic odour tone” in the emission of individual plant units or during a defined production process. Particular attention is to be paid to odour qualities changing with the distance from the source.

As an assessment of plant impacts is impossible in the planning stage, investigations have to be performed at comparable plants. The new plant will then undergo an assessment after start of operation.

2. Method of polarity profiles

Polarity profiles [in the GOAA] exclusively serve the hedonic classification of plant odours. The hedonic tone of the odour emission from a plant can be characterized as “definitely pleasant” if the profiling result shows a definite correlation of the plant odour profile with the concept “fragrance”.

Panel members for hedonic classifications have to be suitable for their task in the sense of the GOAA definition and simultaneously need a certain experience in determining ambient odours. Moreover, orders for hedonic classifications of plant odours shall only be given to institutions acknowledged on the basis of § 26 *FPCA* including the expertise in “Odour – ambient exposure”.

Prior to a plant odour classification, panel members have to be trained in the hedonic assessment of odours and in working with the polarity profiles on different pleasant and unpleasant odours. Thus, they will improve their skills in handling the profile scales and in assessing an olfactory impression by linguistic means.

The method of polarity profiles consists of two steps – 1. the establishment of polarity profiles for the concepts “fragrance” and “stench”, and 2. the on-site establishment of polarity profiles for the plant odour under investigation.

During the **first step**, **every** panel member creates a “fragrance” and a “stench” profile by using all of the 29 pairs of terms (see subsections 3.1 and 3.2 below). These profiles need to be developed associatively and in the abstract, i.e. offside the reach of the plant odour. There should be no ambient odour during profiling. The minimum number of panel members required is ten. There is no need to develop these two profiles more often than once a year.

In addition to the criteria set in the GOAA for the proficiency of a panel member, their profiles for “fragrance” and “stench” are taken as complementary criteria. A panel member is suitable for hedonic odour tone assessments

- 1.) if he/she uses the terms „depressing“, „stale“, „discontented“, „disharmonious“, „ugly“ and „unpleasant“ in the assessment of the concept „stench“, i.e. a value between 1 and 3 was ticked, **and**
- 2.) if he/she uses the terms „uplifting“, „fresh“, „contented“, „harmonious“, „beautiful“ and „pleasant“ in the assessment of the concept „fragrance“, i.e. a value between 1 and 3 was ticked,

In case of deviations from this prerequisite occurring more than once, the panel member concerned must not be employed for the hedonic classification of plant odours.

In the **second step** the panel members establish on-site polarity profiles of the plant odour (see subsection 3.3). To this end, they take up an adequate position in the odour plume next to the emission source where they first get acquainted with the odour. At the selected measurement spot panel members are positioned at short distance from each other to avoid mutual disturbance and manipulation. It is recommended to invite the panel members to describe the odour in their own words and only afterwards start the establishment of polarity profiles. The odour under investigation should not be present during that procedure in order to avoid habituation to the olfactory stimulus. However, the odour plume may be entered again, if necessary.

In order to prevent the panel members from getting into a routine while filling in the polarity profile, subsection 3.2 comprises a profile with changed order of terms and partly also a change in left/right position of terms. These changes have to be taken into account during data input.

A minimum of 32 profiles per type of plant odour has to be established on-site in the course of at least four days not following each other. The total number of panel members employed is at least 10. A maximum number of polarity profiles of four should be evaluated per panel member per plant odour type. It is necessary to establish the profiles at two different distances from the odour source on at least one day in order to find out whether the hedonic odour tone will change with the reduction in odour concentration.

The **evaluation** is based on equation 1. The values (scores) on the left side of the profile (see subsection 3.3.1) are inserted as negative values and those on the right side as positive values. Then the scores for each pair of terms of each panel member are weighted with the hedonic factor

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scores of subsection 3.4, i.e. they are multiplied by the factor scores. After that, the arithmetic mean value of the total of weighted scores per pair of terms is calculated.

$$M_j = \frac{1}{n} \sum_{i=1}^n (R_{x,j} * HF_j) \quad (1)$$

| | |
|------------|--|
| $R_{x,j}$ | Observation value of a panel member concerning stimulus x scored at pair j of polarity terms (e.g. +2) |
| HF_j | Hedonic factor score at polarity j |
| M_j | Mean value of the total of weighted scores at pair j of polarity terms |
| n | Number of panel members |
| Polarity j | Pair of terms (e.g. „depressing – uplifting“; „fresh – stale“) |

Comparison of the resulting profile with the representative profiles of “stench” and “fragrance” (subsection 3.5) is done by means of a product-moment correlation (linear regression). The weighted and averaged data can be depicted in a graph together with the representative profiles of “stench” and “fragrance”.

The prerequisite of the classification of a plant emission as definitely pleasant is a correlation of the plant profile of more than +0,5 with the representative “fragrance” profile and less than -0,5 with the representative “stench” profile. The plant profile results from the weighted and averaged scores for every pair of words of all panel members.

An example of the evaluation is presented in subsection 3.6.

3. Forms, Tables, Examples

The forms and tables described in subsection 2 are depicted below for practical application, if required.

The procedure is explained by taking the odour of raspberries (subsection 3.6) as an example.

3.1 Fragrance profile

Name: Age: Gender:

By using the pairs of opposites, describe the associations that the following concept gives rise to:
F R A G R A N C E.

In each line, immediately tick off the number that comes closest to your association. Some of the adjectives are employed figuratively rather than literally. The more the right-hand characteristic applies, the further to the right you place your tick, and the more the left-hand characteristic applies, the further to the left you place your tick. You should choose the "0" in the middle as infrequently as possible.

It is only your subjective impression that counts here. Proceed intuitively, swiftly and without pre-meditation!

| | | | | | | | | | |
|-----|-------------|---|---|---|---|---|---|---|---------------|
| 1. | strong | 3 | 2 | 1 | 0 | 1 | 2 | 3 | weak |
| 2. | coarse | 3 | 2 | 1 | 0 | 1 | 2 | 3 | fine |
| 3. | depressing | 3 | 2 | 1 | 0 | 1 | 2 | 3 | uplifting |
| 4. | robust | 3 | 2 | 1 | 0 | 1 | 2 | 3 | delicate |
| 5. | heavy | 3 | 2 | 1 | 0 | 1 | 2 | 3 | light |
| 6. | old | 3 | 2 | 1 | 0 | 1 | 2 | 3 | young |
| 7. | wild | 3 | 2 | 1 | 0 | 1 | 2 | 3 | gentle |
| 8. | exciting | 3 | 2 | 1 | 0 | 1 | 2 | 3 | calming |
| 9. | rough | 3 | 2 | 1 | 0 | 1 | 2 | 3 | smooth |
| 10. | dark | 3 | 2 | 1 | 0 | 1 | 2 | 3 | light |
| 11. | savoury | 3 | 2 | 1 | 0 | 1 | 2 | 3 | sweet |
| 12. | interesting | 3 | 2 | 1 | 0 | 1 | 2 | 3 | boring |
| 13. | cold | 3 | 2 | 1 | 0 | 1 | 2 | 3 | hot |
| 14. | awake | 3 | 2 | 1 | 0 | 1 | 2 | 3 | tired |
| 15. | shallow | 3 | 2 | 1 | 0 | 1 | 2 | 3 | deep |
| 16. | quiet | 3 | 2 | 1 | 0 | 1 | 2 | 3 | loud |
| 17. | soft | 3 | 2 | 1 | 0 | 1 | 2 | 3 | hard |
| 18. | spicy | 3 | 2 | 1 | 0 | 1 | 2 | 3 | mild |
| 19. | dull | 3 | 2 | 1 | 0 | 1 | 2 | 3 | sharp |
| 20. | playful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | serious |
| 21. | empty | 3 | 2 | 1 | 0 | 1 | 2 | 3 | full |
| 22. | passive | 3 | 2 | 1 | 0 | 1 | 2 | 3 | active |
| 23. | fresh | 3 | 2 | 1 | 0 | 1 | 2 | 3 | stale |
| 24. | contented | 3 | 2 | 1 | 0 | 1 | 2 | 3 | discontented |
| 25. | harmonious | 3 | 2 | 1 | 0 | 1 | 2 | 3 | disharmonious |
| 26. | mild | 3 | 2 | 1 | 0 | 1 | 2 | 3 | pungent |
| 27. | peaceful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | aggressive |
| 28. | beautiful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | ugly |
| 29. | pleasant | 3 | 2 | 1 | 0 | 1 | 2 | 3 | unpleasant |

3.2 Stench profile

Name: Age: Gender:

By using the pairs of opposites, describe the associations that the following concept gives rise to:
STENCH.

In each line, immediately tick off the number that comes closest to your association. Some of the adjectives are employed figuratively rather than literally. The more the right-hand characteristic applies, the further to the right you place your tick, and the more the left-hand characteristic applies, the further to the left you place your tick. You should choose the "0" in the middle as infrequently as possible.

It is only your subjective impression that counts here. Proceed intuitively, swiftly and without pre-meditation!

| | | | | | | | | | |
|-----|-------------|---|---|---|---|---|---|---|---------------|
| 1. | strong | 3 | 2 | 1 | 0 | 1 | 2 | 3 | weak |
| 2. | coarse | 3 | 2 | 1 | 0 | 1 | 2 | 3 | fine |
| 3. | depressing | 3 | 2 | 1 | 0 | 1 | 2 | 3 | uplifting |
| 4. | robust | 3 | 2 | 1 | 0 | 1 | 2 | 3 | delicate |
| 5. | heavy | 3 | 2 | 1 | 0 | 1 | 2 | 3 | light |
| 6. | old | 3 | 2 | 1 | 0 | 1 | 2 | 3 | young |
| 7. | wild | 3 | 2 | 1 | 0 | 1 | 2 | 3 | gentle |
| 8. | exciting | 3 | 2 | 1 | 0 | 1 | 2 | 3 | calming |
| 9. | rough | 3 | 2 | 1 | 0 | 1 | 2 | 3 | smooth |
| 10. | dark | 3 | 2 | 1 | 0 | 1 | 2 | 3 | light |
| 11. | savoury | 3 | 2 | 1 | 0 | 1 | 2 | 3 | sweet |
| 12. | interesting | 3 | 2 | 1 | 0 | 1 | 2 | 3 | boring |
| 13. | cold | 3 | 2 | 1 | 0 | 1 | 2 | 3 | hot |
| 14. | awake | 3 | 2 | 1 | 0 | 1 | 2 | 3 | tired |
| 15. | shallow | 3 | 2 | 1 | 0 | 1 | 2 | 3 | deep |
| 16. | quiet | 3 | 2 | 1 | 0 | 1 | 2 | 3 | loud |
| 17. | soft | 3 | 2 | 1 | 0 | 1 | 2 | 3 | hard |
| 18. | spicy | 3 | 2 | 1 | 0 | 1 | 2 | 3 | mild |
| 19. | dull | 3 | 2 | 1 | 0 | 1 | 2 | 3 | sharp |
| 20. | playful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | serious |
| 21. | empty | 3 | 2 | 1 | 0 | 1 | 2 | 3 | full |
| 22. | passive | 3 | 2 | 1 | 0 | 1 | 2 | 3 | active |
| 23. | fresh | 3 | 2 | 1 | 0 | 1 | 2 | 3 | stale |
| 24. | contented | 3 | 2 | 1 | 0 | 1 | 2 | 3 | discontented |
| 25. | harmonious | 3 | 2 | 1 | 0 | 1 | 2 | 3 | disharmonious |
| 26. | mild | 3 | 2 | 1 | 0 | 1 | 2 | 3 | pungent |
| 27. | peaceful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | aggressive |
| 28. | beautiful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | ugly |
| 29. | pleasant | 3 | 2 | 1 | 0 | 1 | 2 | 3 | unpleasant |

3.3.1 Profile to assess the plant odour

NAME:

ODOUR:

LOCATION:

DATE:

Describe the current odour stimulus with reference to the following pairs of opposites.

Sniff the air and familiarize yourself with the odour. Then start to describe the odour. To this end, immediately tick off the number in each line that comes closest to your association. Some of the adjectives are employed figuratively rather than literally. The more the right-hand characteristic applies, the further to the right you place your tick, and the more the left-hand characteristic applies, the further to the left you place your tick. You should choose the "0" in the middle as infrequently as possible. If you have the feeling mid-way that you can't remember the odour, you can sample the odour again.

It is only your subjective impression that counts here. Proceed intuitively, swiftly and without pre-meditation!

| | | | | | | | | | |
|-----|-------------|---|---|---|---|---|---|---|---------------|
| 1. | strong | 3 | 2 | 1 | 0 | 1 | 2 | 3 | weak |
| 2. | coarse | 3 | 2 | 1 | 0 | 1 | 2 | 3 | fine |
| 3. | depressing | 3 | 2 | 1 | 0 | 1 | 2 | 3 | uplifting |
| 4. | robust | 3 | 2 | 1 | 0 | 1 | 2 | 3 | delicate |
| 5. | heavy | 3 | 2 | 1 | 0 | 1 | 2 | 3 | light |
| 6. | old | 3 | 2 | 1 | 0 | 1 | 2 | 3 | young |
| 7. | wild | 3 | 2 | 1 | 0 | 1 | 2 | 3 | gentle |
| 8. | exciting | 3 | 2 | 1 | 0 | 1 | 2 | 3 | calming |
| 9. | rough | 3 | 2 | 1 | 0 | 1 | 2 | 3 | smooth |
| 10. | dark | 3 | 2 | 1 | 0 | 1 | 2 | 3 | light |
| 11. | savoury | 3 | 2 | 1 | 0 | 1 | 2 | 3 | sweet |
| 12. | interesting | 3 | 2 | 1 | 0 | 1 | 2 | 3 | boring |
| 13. | cold | 3 | 2 | 1 | 0 | 1 | 2 | 3 | hot |
| 14. | awake | 3 | 2 | 1 | 0 | 1 | 2 | 3 | tired |
| 15. | shallow | 3 | 2 | 1 | 0 | 1 | 2 | 3 | deep |
| 16. | quiet | 3 | 2 | 1 | 0 | 1 | 2 | 3 | loud |
| 17. | soft | 3 | 2 | 1 | 0 | 1 | 2 | 3 | hard |
| 18. | spicy | 3 | 2 | 1 | 0 | 1 | 2 | 3 | mild |
| 19. | dull | 3 | 2 | 1 | 0 | 1 | 2 | 3 | sharp |
| 20. | playful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | serious |
| 21. | empty | 3 | 2 | 1 | 0 | 1 | 2 | 3 | full |
| 22. | passive | 3 | 2 | 1 | 0 | 1 | 2 | 3 | active |
| 23. | fresh | 3 | 2 | 1 | 0 | 1 | 2 | 3 | stale |
| 24. | contented | 3 | 2 | 1 | 0 | 1 | 2 | 3 | discontented |
| 25. | harmonious | 3 | 2 | 1 | 0 | 1 | 2 | 3 | disharmonious |
| 26. | mild | 3 | 2 | 1 | 0 | 1 | 2 | 3 | pungent |
| 27. | peaceful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | aggressive |
| 28. | beautiful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | ugly |
| 29. | pleasant | 3 | 2 | 1 | 0 | 1 | 2 | 3 | unpleasant |

**3.3.2 Profile to assess the plant odour
with the pairs of concepts in a different order**

NAME: ODOUR

LOCATION: DATE:

Describe the current odour stimulus with reference to the following pairs of opposites.

Sniff the air and familiarize yourself with the odour. Then start to describe the odour. To this end, immediately tick off the number in each line that comes closest to your association. Some of the adjectives are employed figuratively rather than literally. The more the right-hand characteristic applies, the further to the right you place your tick, and the more the left-hand characteristic applies, the further to the left you place your tick. You should choose the "0" in the middle as infrequently as possible. If you have the feeling mid-way that you can't remember the odour, you can sample the odour again.

It is only your subjective impression that counts here. Proceed intuitively, swiftly and without pre-meditation!

| | | | | | | | | |
|------------|---|---|---|---|---|---|---|---------------|
| stale | 3 | 2 | 1 | 0 | 1 | 2 | 3 | fresh |
| exciting | 3 | 2 | 1 | 0 | 1 | 2 | 3 | calming |
| loud | 3 | 2 | 1 | 0 | 1 | 2 | 3 | quiet |
| dull | 3 | 2 | 1 | 0 | 1 | 2 | 3 | sharp |
| full | 3 | 2 | 1 | 0 | 1 | 2 | 3 | empty |
| strong | 3 | 2 | 1 | 0 | 1 | 2 | 3 | weak |
| ugly | 3 | 2 | 1 | 0 | 1 | 2 | 3 | beautiful |
| depressing | 3 | 2 | 1 | 0 | 1 | 2 | 3 | uplifting |
| mild | 3 | 2 | 1 | 0 | 1 | 2 | 3 | spicy |
| heavy | 3 | 2 | 1 | 0 | 1 | 2 | 3 | light |
| light | 3 | 2 | 1 | 0 | 1 | 2 | 3 | dark |
| savoury | 3 | 2 | 1 | 0 | 1 | 2 | 3 | sweet |
| boring | 3 | 2 | 1 | 0 | 1 | 2 | 3 | interesting |
| mild | 3 | 2 | 1 | 0 | 1 | 2 | 3 | pungent |
| active | 3 | 2 | 1 | 0 | 1 | 2 | 3 | passive |
| awake | 3 | 2 | 1 | 0 | 1 | 2 | 3 | tired |
| aggressive | 3 | 2 | 1 | 0 | 1 | 2 | 3 | peaceful |
| pleasant | 3 | 2 | 1 | 0 | 1 | 2 | 3 | unpleasant |
| delicate | 3 | 2 | 1 | 0 | 1 | 2 | 3 | robust |
| harmonious | 3 | 2 | 1 | 0 | 1 | 2 | 3 | disharmonious |
| hot | 3 | 2 | 1 | 0 | 1 | 2 | 3 | cold |
| soft | 3 | 2 | 1 | 0 | 1 | 2 | 3 | hard |
| gentle | 3 | 2 | 1 | 0 | 1 | 2 | 3 | wild |
| contented | 3 | 2 | 1 | 0 | 1 | 2 | 3 | discontented |
| smooth | 3 | 2 | 1 | 0 | 1 | 2 | 3 | rough |
| shallow | 3 | 2 | 1 | 0 | 1 | 2 | 3 | deep |
| young | 3 | 2 | 1 | 0 | 1 | 2 | 3 | old |
| playful | 3 | 2 | 1 | 0 | 1 | 2 | 3 | serious |
| fine | 3 | 2 | 1 | 0 | 1 | 2 | 3 | coarse |

3.4 Hedonic factor scores*

| | Pairs of adjectives | | Factor scores |
|----|---------------------|---------------|---------------|
| 1 | strong | weak | 0,69 |
| 2 | coarse | fine | 1,37 |
| 3 | depressing | uplifting | 1,46 |
| 4 | robust | delicate | 1,27 |
| 5 | heavy | light | 1,19 |
| 6 | old | young | 1,26 |
| 7 | wild | gentle | 0,95 |
| 8 | exciting | calming | 0,66 |
| 9 | rau | glatt | 0,98 |
| 10 | dark | light | 1,19 |
| 11 | savoury | sweet | 0,86 |
| 12 | interesting | boring | -0,38 |
| 13 | cold | hot | 0,90 |
| 14 | awake | tired | -0,21 |
| 15 | shallow | deep | -0,37 |
| 16 | quiet | loud | -0,71 |
| 17 | soft | hard | -0,97 |
| 18 | spicy | mild | -0,66 |
| 19 | dull | sharp | -0,53 |
| 20 | playful | serious | -0,87 |
| 21 | empty | full | 0,21 |
| 22 | passive | active | 0,19 |
| 23 | fresh | stale | -1,21 |
| 24 | contented | discontented | -1,11 |
| 25 | harmonious | disharmonious | -1,26 |
| 26 | mild | pungent | -1,10 |
| 27 | peaceful | aggressive | -1,10 |
| 28 | beautiful | ugly | -1,34 |
| 29 | pleasant | unpleasant | -1,36 |

* calculated from 180 stench and fragrance profiles (N = 39 audited panel members, 19 women, age average 30 years (range from 17 to 56 years), proficiency test in accordance with the criteria in subsection 2.

3.5 Values of the representative fragrance and stench profiles*

| | Pairs of adjectives | | Representative profil value | |
|----|---------------------|---------------|-----------------------------|-----------|
| | | | Stench | Fragrance |
| 1 | strong | weak | -1,92 | -0,51 |
| 2 | coarse | fine | -3,47 | 2,79 |
| 3 | depressing | uplifting | -3,83 | 3,35 |
| 4 | robust | delicate | -3,08 | 2,21 |
| 5 | heavy | light | -2,84 | 1,75 |
| 6 | old | young | -2,87 | 2,37 |
| 7 | wild | gentle | -1,48 | 1,35 |
| 8 | exciting | calming | -1,08 | 0,18 |
| 9 | rau | glatt | -1,90 | 1,14 |
| 10 | dark | light | -2,65 | 2,00 |
| 11 | savoury | sweet | -1,65 | 0,64 |
| 12 | interesting | boring | 0,01 | 0,75 |
| 13 | cold | hot | -0,98 | 1,56 |
| 14 | awake | tired | 0,03 | 0,32 |
| 15 | shallow | deep | -0,53 | 0,17 |
| 16 | quiet | loud | -1,40 | 0,84 |
| 17 | soft | hard | -2,26 | 1,76 |
| 18 | spicy | mild | -0,77 | 1,22 |
| 19 | dull | sharp | -1,04 | 0,30 |
| 20 | playful | serious | -1,86 | 1,44 |
| 21 | empty | full | 0,30 | 0,35 |
| 22 | passive | active | 0,25 | 0,29 |
| 23 | fresh | stale | -3,15 | 2,94 |
| 24 | contented | discontented | -2,70 | 2,51 |
| 25 | harmonious | disharmonious | -3,43 | 3,18 |
| 26 | mild | pungent | -3,05 | 2,05 |
| 27 | peaceful | aggressive | -2,90 | 2,18 |
| 28 | beautiful | ugly | -3,83 | 3,57 |
| 29 | pleasant | unpleasant | -3,91 | 3,77 |

* calculated from 180 stench and fragrance profiles (N = 39 audited panel members, 19 women, age average 30 years (range from 17 to 56 years), proficiency test in accordance with the criteria in subsection 2.

3.6 Evaluation of raspberry odour (by example)

3.6.1 Original data*

| | | Panel member 1 | Panel member 2 | Panel member 3 | Panel member 4 | Panel member 5 | Panel member 6 | Panel member 7 | Panel member 8 | Panel member 9 | Panel member 10 | Panel member 11 | Panel member 12 | Mean value | Factor scores |
|-------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|------------|---------------|
| strong | weak | -2 | -2 | -2 | -2 | -2 | 3 | 2 | 1 | 3 | -1 | -1 | 1 | -0,17 | 0,69 |
| coarse | fine | 3 | 2 | 1 | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2,33 | 1,37 |
| depressing | uplifting | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2,08 | 1,46 |
| robust | delicate | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | -2 | 2 | 1,92 | 1,27 |
| heavy | light | 3 | 2 | 1 | 1 | 3 | 2 | 2 | 2 | 3 | 3 | 1 | 3 | 2,17 | 1,19 |
| old | young | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 2,25 | 1,26 |
| wild | gentle | -1 | 1 | 2 | -2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 3 | 1,25 | 0,95 |
| exciting | calming | -2 | -1 | 1 | -2 | 1 | 1 | 2 | 1 | 3 | -1 | 2 | 2 | 0,58 | 0,66 |
| rau | glatt | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 1,58 | 0,98 |
| dark | light | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 3 | 2,00 | 1,19 |
| savoury | sweet | 3 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 2 | 2 | 1 | 3 | 2,33 | 0,86 |
| interesting | boring | -2 | -2 | -1 | -2 | -2 | -2 | -2 | -1 | -2 | -2 | -1 | -2 | -1,75 | -0,38 |
| cold | hot | 0 | 2 | 1 | 2 | 1 | 2 | 0 | 2 | -2 | 3 | 1 | 2 | 1,17 | 0,90 |
| awake | tired | -2 | -2 | -1 | -2 | -1 | -2 | -1 | -1 | -1 | -2 | -2 | -1 | -1,50 | -0,21 |
| shallow | deep | 0 | 2 | 1 | 1 | 1 | 1 | 0 | -2 | -1 | 2 | -1 | -1 | 0,25 | -0,37 |
| quiet | loud | 1 | -1 | -1 | -1 | -2 | -1 | -2 | -2 | -1 | -2 | -1 | -2 | -1,25 | -0,71 |
| soft | hard | -1 | -2 | -2 | -1 | -2 | -1 | -2 | -1 | -2 | -3 | -2 | -2 | -1,75 | -0,97 |
| spicy | mild | -2 | -1 | -1 | -2 | -3 | -1 | 0 | 1 | -1 | -1 | -2 | -2 | -1,25 | -0,66 |
| dull | sharp | 0 | 0 | -1 | 0 | -1 | 0 | 0 | -1 | -1 | 0 | 1 | -1 | -0,33 | -0,53 |
| playful | serious | -1 | -2 | -1 | -1 | -2 | -2 | -2 | -2 | -2 | -1 | -1 | -3 | -1,67 | -0,87 |
| empty | full | 1 | 2 | 1 | 3 | 2 | 2 | 0 | -2 | 2 | 1 | 1 | 2 | 1,25 | 0,21 |
| passive | active | 2 | 2 | 1 | 2 | 2 | 2 | 0 | 1 | 1 | 2 | 2 | 2 | 1,58 | 0,19 |
| fresh | stale | -3 | -2 | -1 | -2 | -2 | -2 | -2 | -2 | -3 | -2 | -2 | -1 | -2,00 | -1,21 |
| contented | discontented | -2 | -3 | -1 | -3 | -2 | -2 | -2 | -2 | -2 | -3 | -2 | -2 | -2,17 | -1,11 |
| harmonious | disharmonious | -2 | -3 | -1 | -2 | -2 | -1 | -2 | -2 | -2 | -3 | -3 | -2 | -2,08 | -1,26 |
| mild | pungent | -1 | -3 | -1 | -1 | -2 | -1 | -2 | -2 | -2 | -3 | -2 | -2 | -1,83 | -1,10 |
| peaceful | aggressive | -2 | -3 | -2 | -2 | -3 | -1 | -2 | -2 | -2 | -3 | -1 | -2 | -2,08 | -1,10 |
| beautiful | ugly | -2 | -3 | -1 | -3 | -2 | -2 | -2 | -2 | -3 | -2 | -3 | -3 | -2,33 | -1,34 |
| pleasant | unpleasant | -3 | -3 | -2 | -3 | -2 | -2 | -2 | -3 | -3 | -3 | -3 | -3 | -2,67 | -1,36 |

* calculated from 12 raspberry profiles (N = 12 audited panel members, 1 woman, age average 51 years (range from 33 to 61 years), proficiency test in accordance with the criteria in subsection 2

3.6.2 Original data multiplied by factor scores*

| | | Panel member 1 | Panel member 2 | Panel member 3 | Panel member 4 | Panel member 5 | Panel member 6 | Panel member 7 | Panel member 8 | Panel member 9 | Panel member 10 | Panel member 11 | Panel member 12 | Average |
|-------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|---------|
| strong | weak | -1,38 | -1,38 | -1,38 | -1,38 | -1,38 | 2,07 | 1,38 | 0,69 | 2,07 | -0,69 | -0,69 | 0,69 | -0,12 |
| coarse | fine | 4,11 | 2,74 | 1,37 | 2,74 | 4,11 | 4,11 | 2,74 | 2,74 | 4,11 | 4,11 | 2,74 | 2,74 | 3,20 |
| depressing | uplifting | 4,38 | 2,92 | 1,46 | 2,92 | 2,92 | 2,92 | 2,92 | 2,92 | 4,38 | 2,92 | 2,92 | 2,92 | 3,04 |
| robust | delicate | 3,81 | 2,54 | 2,54 | 1,27 | 2,54 | 2,54 | 2,54 | 3,81 | 3,81 | 3,81 | -2,54 | 2,54 | 2,43 |
| heavy | light | 3,57 | 2,38 | 1,19 | 1,19 | 3,57 | 2,38 | 2,38 | 2,38 | 3,57 | 3,57 | 1,19 | 3,57 | 2,58 |
| old | young | 3,78 | 2,52 | 1,26 | 2,52 | 2,52 | 2,52 | 2,52 | 2,52 | 3,78 | 3,78 | 2,52 | 3,78 | 2,84 |
| wild | gentle | -0,95 | 0,95 | 1,90 | -1,90 | 1,90 | 1,90 | 1,90 | 1,90 | 1,90 | 0,95 | 0,95 | 2,85 | 1,19 |
| exciting | calming | -1,32 | -0,66 | 0,66 | -1,32 | 0,66 | 0,66 | 1,32 | 0,66 | 1,98 | -0,66 | 1,32 | 1,32 | 0,39 |
| rau | glatt | 0,98 | 0,98 | 1,96 | 0,98 | 1,96 | 0,98 | 1,96 | 1,96 | 1,96 | 1,96 | 0,98 | 1,96 | 1,55 |
| dark | light | 1,19 | 2,38 | 2,38 | 2,38 | 2,38 | 2,38 | 2,38 | 2,38 | 2,38 | 3,57 | 1,19 | 3,57 | 2,38 |
| savoury | sweet | 2,58 | 2,58 | 0,86 | 1,72 | 2,58 | 1,72 | 2,58 | 2,58 | 1,72 | 1,72 | 0,86 | 2,58 | 2,01 |
| interesting | boring | 0,76 | 0,76 | 0,38 | 0,76 | 0,76 | 0,76 | 0,76 | 0,38 | 0,76 | 0,76 | 0,38 | 0,76 | 0,67 |
| cold | hot | 0,00 | 1,80 | 0,90 | 1,80 | 0,90 | 1,80 | 0,00 | 1,80 | -1,80 | 2,70 | 0,90 | 1,80 | 1,05 |
| awake | tired | 0,42 | 0,42 | 0,21 | 0,42 | 0,21 | 0,42 | 0,21 | 0,21 | 0,21 | 0,42 | 0,42 | 0,21 | 0,32 |
| shallow | deep | 0,00 | -0,74 | -0,37 | -0,37 | -0,37 | -0,37 | 0,00 | 0,74 | 0,37 | -0,74 | 0,37 | 0,37 | -0,09 |
| quiet | loud | -0,71 | 0,71 | 0,71 | 0,71 | 1,42 | 0,71 | 1,42 | 1,42 | 0,71 | 1,42 | 0,71 | 1,42 | 0,89 |
| soft | hard | 0,97 | 1,94 | 1,94 | 0,97 | 1,94 | 0,97 | 1,94 | 0,97 | 1,94 | 2,91 | 1,94 | 1,94 | 1,70 |
| spicy | mild | 1,32 | 0,66 | 0,66 | 1,32 | 1,98 | 0,66 | 0,00 | -0,66 | 0,66 | 0,66 | 1,32 | 1,32 | 0,83 |
| dull | sharp | 0,00 | 0,00 | 0,53 | 0,00 | 0,53 | 0,00 | 0,00 | 0,53 | 0,53 | 0,00 | -0,53 | 0,53 | 0,18 |
| playful | serious | 0,87 | 1,74 | 0,87 | 0,87 | 1,74 | 1,74 | 1,74 | 1,74 | 1,74 | 0,87 | 0,87 | 2,61 | 1,45 |
| empty | full | 0,21 | 0,42 | 0,21 | 0,63 | 0,42 | 0,42 | 0,00 | -0,42 | 0,42 | 0,21 | 0,21 | 0,42 | 0,26 |
| passive | active | 0,38 | 0,38 | 0,19 | 0,38 | 0,38 | 0,38 | 0,00 | 0,19 | 0,19 | 0,38 | 0,38 | 0,38 | 0,30 |
| fresh | stale | 3,63 | 2,42 | 1,21 | 2,42 | 2,42 | 2,42 | 2,42 | 2,42 | 3,63 | 2,42 | 2,42 | 1,21 | 2,42 |
| contented | discontented | 2,22 | 3,33 | 1,11 | 3,33 | 2,22 | 2,22 | 2,22 | 2,22 | 2,22 | 3,33 | 2,22 | 2,22 | 2,41 |
| harmonious | disharmonious | 2,52 | 3,78 | 1,26 | 2,52 | 2,52 | 1,26 | 2,52 | 2,52 | 2,52 | 3,78 | 3,78 | 2,52 | 2,63 |
| mild | pungent | 1,10 | 3,30 | 1,10 | 1,10 | 2,20 | 1,10 | 2,20 | 2,20 | 2,20 | 3,30 | 2,20 | 2,20 | 2,02 |
| peaceful | aggressive | 2,20 | 3,30 | 2,20 | 2,20 | 3,30 | 1,10 | 2,20 | 2,20 | 2,20 | 3,30 | 1,10 | 2,20 | 2,29 |
| beautiful | ugly | 2,68 | 4,02 | 1,34 | 4,02 | 2,68 | 2,68 | 2,68 | 2,68 | 4,02 | 2,68 | 4,02 | 4,02 | 3,13 |
| pleasant | unpleasant | 4,08 | 4,08 | 2,72 | 4,08 | 2,72 | 2,72 | 2,72 | 4,08 | 4,08 | 4,08 | 4,08 | 4,08 | 3,63 |

* calculated from 12 raspberry profiles (N = 12 audited panel members, 1 woman, age average 51 years (range from 33 to 61 years), proficiency test in accordance with the criteria in subsection 2

3.6.3 Correlation of the representative fragrance and stench profiles with the profile of raspberry odour *

| | | Representative stench profile | Representative fragrance profile | Raspberry mean value |
|-------------|---------------|----------------------------------|-------------------------------------|-------------------------|
| strong | weak | -1,92 | -0,51 | -0,12 |
| coarse | fine | -3,47 | 2,79 | 3,20 |
| depressing | uplifting | -3,83 | 3,35 | 3,04 |
| robust | delicate | -3,08 | 2,21 | 2,43 |
| heavy | light | -2,84 | 1,75 | 2,58 |
| old | young | -2,87 | 2,37 | 2,84 |
| wild | gentle | -1,48 | 1,35 | 1,19 |
| exciting | calming | -1,08 | 0,18 | 0,39 |
| rau | glatt | -1,90 | 1,14 | 1,55 |
| dark | light | -2,65 | 2,00 | 2,38 |
| savoury | sweet | -1,65 | 0,64 | 2,01 |
| interesting | boring | 0,01 | 0,75 | 0,67 |
| cold | hot | -0,98 | 1,56 | 1,05 |
| awake | tired | 0,03 | 0,32 | 0,32 |
| shallow | deep | -0,53 | 0,17 | -0,09 |
| quiet | loud | -1,40 | 0,84 | 0,89 |
| soft | hard | -2,26 | 1,76 | 1,70 |
| spicy | mild | -0,77 | 1,22 | 0,83 |
| dull | sharp | -1,04 | 0,30 | 0,18 |
| playful | serious | -1,86 | 1,44 | 1,45 |
| empty | full | 0,30 | 0,35 | 0,26 |
| passive | active | 0,25 | 0,29 | 0,30 |
| fresh | stale | -3,15 | 2,94 | 2,42 |
| contented | discontented | -2,70 | 2,51 | 2,41 |
| harmonious | disharmonious | -3,43 | 3,18 | 2,63 |
| mild | pungent | -3,05 | 2,05 | 2,02 |
| peaceful | aggressive | -2,90 | 2,18 | 2,29 |
| beautiful | ugly | -3,83 | 3,57 | 3,13 |
| pleasant | unpleasant | -3,91 | 3,77 | 3,63 |
| | Correlation: | Representative stench profile | | -0,90 |
| | Correlation: | Representative fragrance profile | | 0,93 |

Thus, raspberry odour satisfies the criterion for hedonically definitely pleasant odours.

* calculated from 12 raspberry profiles (N = 12 audited panel members, 1 woman, age average 51 years (range from 33 to 61 years), proficiency test in accordance with the criteria in subsection 2.

Annex 2 of the advice on interpretation of GOAA

1. Quoted Literature

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