BS EN 16841-2:2016

BSI Standards Publication

# Ambient air — Determination of odour in ambient air by using field inspection

## Part 2: Plume method

**National foreword**

This British Standard is the UK implementation of EN 16841-2:2016.

The UK participation in its preparation was entrusted to Technical Committee EH/2/3, Ambient atmospheres.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2016

ISBN 978 0 580 87335 5

ICS 13.040.20

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2016.

**Amendments/corrigenda issued since publication**

| Date | Text affected |
| --- | --- |

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 16841-2

November 2016

ICS 13.040.20

English Version

# Ambient air - Determination of odour in ambient air by using field inspection - Part 2: Plume method

Air ambiant - Détermination de la présence d'odeurs par mesures de terrain - Partie 2 : Méthode du panache

Außenluft - Bestimmung von Geruchsstoffimmissionen durch Begehungen - Teil 2: Fahnenmessung

This European Standard was approved by CEN on 10 September 2016.

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**CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels**



Ref. No. EN 16841-2:2016 E

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# European foreword

This document (EN 16841-2:2016) has been prepared by Technical Committee CEN/TC 264 “Air quality”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2017, and conflicting national standards shall be withdrawn at the latest by May 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights

EN 16841, *Ambient air - Determination of odour in ambient air by using field inspection* consists of the following parts:

— *Part 1: Grid method*

— *Part 2: Plume method*

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

# Introduction

Part 1 (grid method) and Part 2 (plume method) of this European Standard describe methods for direct assessment of odours in ambient air.

This European Standard supplements the dynamic olfactometry method described in EN 13725 which is generally only suitable for measurement of odour emissions 'at source'. As the practical lower detection limit is typically ≥ 10 $ou_E/m^3$, EN 13725 cannot be applied to directly determine odour exposure in the field (i.e. measure faint odours at the concentration where they can just be recognized).

The methods for measuring odour presented in this European Standard make direct use of odour perception, the effect of odorants on the human sense of smell. The standard involves the use of qualified human panel members in the field to directly assess the presence of recognizable odours in ambient air, and provide data that can be used to characterize odour exposure in a defined assessment area. The standard presents two key approaches as summarized as follows:

— Part 1 describes a grid method which uses direct assessment of ambient air by panel members to characterize odour exposure in a defined assessment area.

— Part 2 (presented in this document) describes a plume method to characterize the presence of odour by determining the extent of the downwind odour plume of a source.

Although the ultimate application of this method is in monitoring the risk of exposure to odours and the resulting odour annoyance, there is no direct relation between the presence of recognizable odours and the occurrence of odour annoyance. The process leading to odour annoyance being experienced by an individual or a community is highly complex. Additional investigations are necessary to establish a link between odour exposure and the risk of odour annoyance, which is profoundly influenced by odour exposure frequency, by the type and hedonic tone of the odour perceived, and by the characteristics of those exposed to the odour (the receptor). The relationship between odour exposure and annoyance is not within the scope of this European Standard.

The sensory methods described are only suitable for the assessment of odour in ambient air. They are not suitable for the assessment of substances that cannot be detected by sensory methods, in particular when these substances may cause health effects not directly related to their perceived smell.

# 1 Scope

This part of the European Standard describes the plume method for determining the extent of recognizable odours from a specific source using direct observation in the field by human panel members under specific meteorological conditions.

The plume method involves the determination of the presence or absence (YES/NO) of recognizable odours in and around the plume originating from a specific odorant emission source, for a specific emission situation and under specific meteorological conditions (specific wind direction, wind speed and boundary layer turbulence). The unit of measurement is the presence or absence of recognizable odours at a particular location downwind of a source. The extent of the plume is assessed as the transition of absence to presence of recognizable odour.

The primary application of this standard is to provide a common basis for the determination of the odour plume extent in the member states of the European Union.

The results are typically used to determine a plausible extent of potential exposure to recognizable odours, or to estimate the total emission rate based on the plume extent, using reverse dispersion modelling.

The field of application of this European Standard includes the determination of the extent of the recognizable odour plume downwind from a source, under specific meteorological conditions (e.g. wind direction, wind speed, turbulence, etc. (see 7.3.2).

This European Standard does not include:

— the measurement of intensity of ambient odours;

— the measurement of hedonic tone of ambient odours;

— the measurement of the odour exposure in ambient air over a longer time period in an assessment area;

— the calculation of estimated source emission rate from plume assessment using reverse dispersion modelling.

An overview of the interaction between existing odour exposure assessment methods is given in Annex A including grid method (Part 1), plume method (Part 2) and olfactometry according EN 13725.

# 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13725:2003, *Air quality - Determination of odour concentration by dynamic olfactometry*

# 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**sensory adaptation**
temporary modification of the sensitivity of a sense organ due to continued and/or repeated stimulation

Note 1 to entry Adaptation can also occur as a result of a gradually increasing stimulation.

[SOURCE: ISO 5492:2008, 2.6, modified – Added Note 1 to entry.]

**3.2**
**assessor**
somebody who participates in odour testing

[SOURCE: EN 13725:2003, 3.1.5]

**3.3**
**crossing (for the dynamic plume method)**
series of single measurements by a panel member starting at an odour absence point, crossing the plume direction more or less at a right angle towards an odour absence point on the other side of the plume direction

Note 1 to entry: The crossing shall cover similar distances at each side of the plume direction.

Note 2 to entry: When a crossing does not yield odour presence points it shall start at a distance similar to the estimated maximum plume width.

**3.4**
**experienced panel member**
panel member with the necessary experience to make valid observations for the dynamic method according to 6.2.2

Note 1 to entry: To become an experienced panel member a panel member shall participate at least five times in a measurement cycle with at least three different odour types.

**3.5**
**European odour unit**
amount of odorant(s) that, when evaporated into 1 cubic metre of neutral gas at standard conditions, elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one European Reference Odour Mass (EROM), evaporated in one cubic metre of neutral gas at standard conditions

[SOURCE: EN 13725:2003, 3.1.19]

**3.6**
**field inspection**
measuring odours in ambient air using panel members

**3.7**
**field observations coordinator**
individual responsible for the correct execution of the field measurement procedure

**3.8**
**field survey**
total of measurement sessions required to characterize an exposure level (see part 1 grid method) or plume extent (see part 2 plume method) in an area under study affected by one or more sources or emitting facilities

**3.9**
**hedonic tone (of an odour)**
degree to which an odour is perceived as pleasant or unpleasant

**3.10**
**intensity**
<sensation> magnitude of the perceived sensation

[SOURCE: ISO 5492:2008, 2.8]

**3.11**
**intensity**
<stimulus> magnitude of the stimulus causing the perceived sensation

[SOURCE: ISO 5492:2008, 2.9]

**3.12**
**intersection line**
intersection line is a line perpendicular to the plume direction along which panel members are placed for the stationary plume method

**3.13**
**maximum plume reach**
maximum distance downwind where an odour type can be perceived and recognized (under defined meteorological conditions)

**3.14**
**maximum plume reach estimate**
distance along the plume direction between the source and the point halfway from the furthest intersection line or crossing where odour presence points were recorded and the first intersection line or crossing where only odour absence points were recorded

**3.15**
**measurement cycle**
procedure of consecutive field observations required to determine the odour plume extent once, conducted by a panel under defined meteorological conditions

**3.16**
**measurement leader**
individual responsible for the quality assurance of the measurement

Note 1 to entry: The measurement leader can be the same person as the field observations coordinator.

**3.17**
**measurement point**
location where single measurement(s) are carried out

**3.18**
**measurement session**
set of consecutive measurement cycles conducted with one panel on the same day

**3.19**
**odorant**
substance whose volatiles can be perceived by the olfactory organ (including nerves)

[SOURCE: ISO 5492:2008, 1.35]

**3.20**
**odour**
sensation perceived by means of the olfactory organ in sniffing certain volatile substances

[SOURCE: ISO 5492:2008, 3.18]

**3.21**
**odour absence point**
measurement point at which the odour under study is not perceived and recognized as a result of a single measurement

Note 1 to entry: See also: odour presence point.

**3.22**
**odour detection**
to become aware of the sensation resulting from adequate stimulation of the olfactory system

[SOURCE: EN 13725:2003, 3.1.47]

**3.23**
**odour exposure**
contact of a human with a defined odour type, quantified as the amount of odorant(s) available for inhalation at any particular moment

Note 1 to entry: As odorants have no effect below the detection limit of the human subject, exposure to recognizable odours may be characterized as the frequency of occurrence of concentrations above a certain odour concentration (the recognition limit).

**3.24**
**odour hour**
odour hour is obtained by a single measurement when the percentage odour time reaches or exceeds 10 % by convention

Note 1 to entry: Only relevant for the stationary method.

Note 2 to entry: A test result of one single measurement can be positive for more than one distinct odour type.

**3.25**
**odour presence point**
measurement point at which the odour under study is perceived and recognized as a result of a single measurement

Note 1 to entry: See also: odour absence point.

**3.26**
**odour recognition (in ambient air)**
odour sensation in ambient air that allows positive identification of the odour type

**3.27**
**odour type**
odour that can be recognized and assigned to a certain installation or source

Note 1 to entry: Odour types are defined specifically for one survey. One installation can emit more than one odour type. Several facilities can emit the same odour type.

**3.28**
**olfactory**
pertaining to the sense of smell

[SOURCE: EN 13725:2003, 3.1.54]

**3.29**
**panel**
group of panel members

[SOURCE: EN 13725:2003, 3.1.59]

**3.30**
**panel member**
assessor who is qualified to perform field inspections according to 6.2

Note 1 to entry: See also: experienced panel member.

**3.31**
**panel selection**
procedure to determine which assessors are qualified as panel members

[SOURCE: EN 13725:2003, 3.1.62]

**3.32**
**percentage odour time**
quotient, expressed as a percentage, of positive observations for one or more odour types made for one single measurement

Note 1 to entry: One single measurement consists of 60 observations.

Note 2 to entry: Only relevant for the stationary method.

**3.33**
**observation**
assessment of the presence or absence of recognizable odour during a single measurement

**3.34**
**plume direction**
line from the source in the mean direction of dispersion projected to ground level

Note 1 to entry: The plume direction is typically derived from the wind direction.

**3.35**
**plume extent**
shape of the plume delineated by a smoothed interpolation polyline through the transition points, the source location and the location determined by the maximum plume reach estimate

**3.36**
**plume extent area**
surface area enclosed by a smoothed interpolation polyline through the transition points, the source location and the location determined by the maximum plume reach estimate

**3.37**
**plume width**
distance between two transition points perpendicular to the plume direction

**3.38**
**quality assurance**
all those planned and systematic actions necessary to provide adequate confidence that a product, process or service will satisfy given requirements for quality

**3.39**
**single measurement**
procedure to obtain recorded observations at a given moment at a given measurement point necessary to determine absence or presence of recognizable odour

Note 1 to entry: For the stationary plume method one single measurement results in the test result 'odour hour' or 'non-odour hour'.

Note 2 to entry: For the stationary plume method the absence or presence is determined based on the observed percentage odour time over a defined single measurement duration. For the dynamic plume method the absence or presence is based on the direct and instantaneous observation of recognizable odour or the lack of it.

**3.40**
**single measurement duration**
time required to conduct a single measurement

Note 1 to entry: The single measurement duration is 10 min (60 observations) for a stationary plume method. A single measurement duration of at least ten minutes is required in order to obtain a representative statement with at least 80 % certainty on the odour situation within an hour [1]. The single measurement duration for the dynamic plume method is the duration of one inhalation (one observation).

**3.41**
**sniffing unit**
minimal amount of odorant(s), present into 1 cubic meter of air, that generates a response of recognition of a certain odour type by an experienced panel member, under field conditions

**3.42**
**test result**
value of a characteristic obtained by carrying out a specific test method

[SOURCE: ISO 5725-1]

Note 1 to entry: In this European Standard the test result for a single measurement is the presence or absence of recognizable odour.

**3.43**
**transition point**
point halfway between the last absence point and the first presence point at the limit of the recognizable odour plume under investigation

## 4 Symbols and abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

| | |
|---|---|
| $L_+$ | Number of positive observations per measurement cycle and measurement point |
| $L_M$ | Monin-Obukhov Length in m |
| $ou_E$ | European odour unit |
| $P_{od}$ | Percentage odour time |
| $R$ | Total number of assessments per measurement cycle |
| su | Sniffing unit (see Annex G) |
| $z_0$ | roughness length in m |

## 5 Principle of plume extent measurement

The plume method is used to determine the extent of the area where the odour plume originating from a specific odorant source or an odorant emitting installation can be perceived and recognized, under specific meteorological and specific operating conditions.

The odour plume extent is described by points where a transition from absence to presence of the recognizable odour under investigation, occurs.

The results are typically used to determine a plausible extent of potential exposure to recognizable odours, or to estimate the total emission rate using reverse dispersion modelling. The plume extent measurement is particularly useful as a starting point for estimating emission rates for diffuse odorant sources where sampling at source is impracticable.

Panel members are used to determine the presence or absence of the specific odour under investigation at different points downwind of a source under well-defined meteorological conditions.

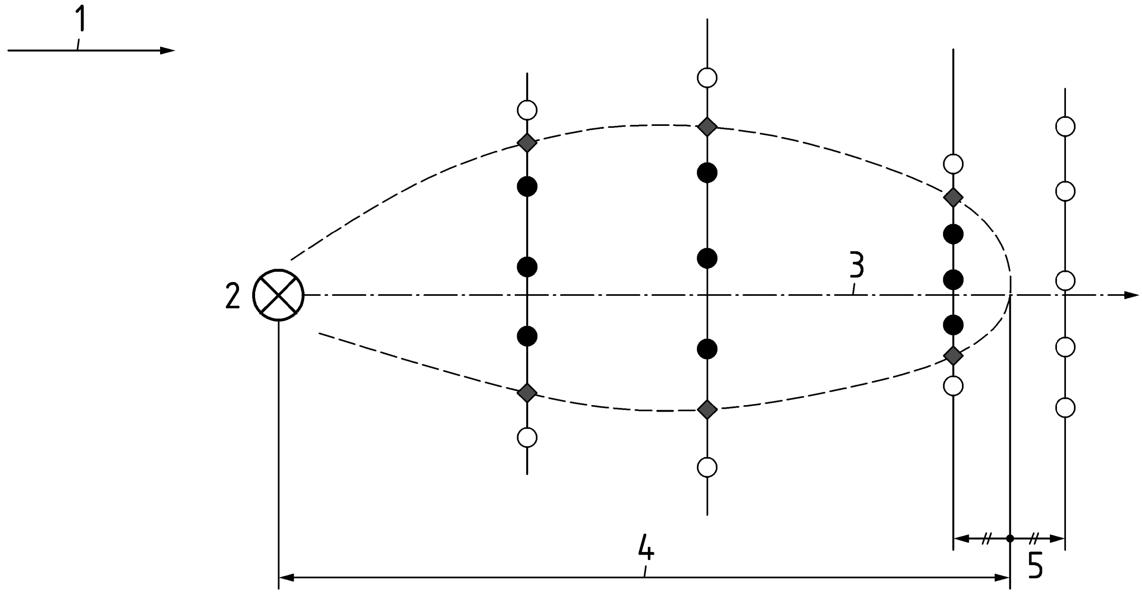
These conditions are chosen to ensure that the extent of the plume is well defined. The meteorological conditions during the field observations are measured and recorded.

Typically, the measurement is repeated to reduce uncertainty to an acceptable level. In this way variability due to random variations in meteorological conditions, panel member performance and odorant emission is averaged out. There are two versions of observation methods for plume measurement in this standard:

— stationary plume method (see 8.2),

— dynamic plume method (see 8.3).

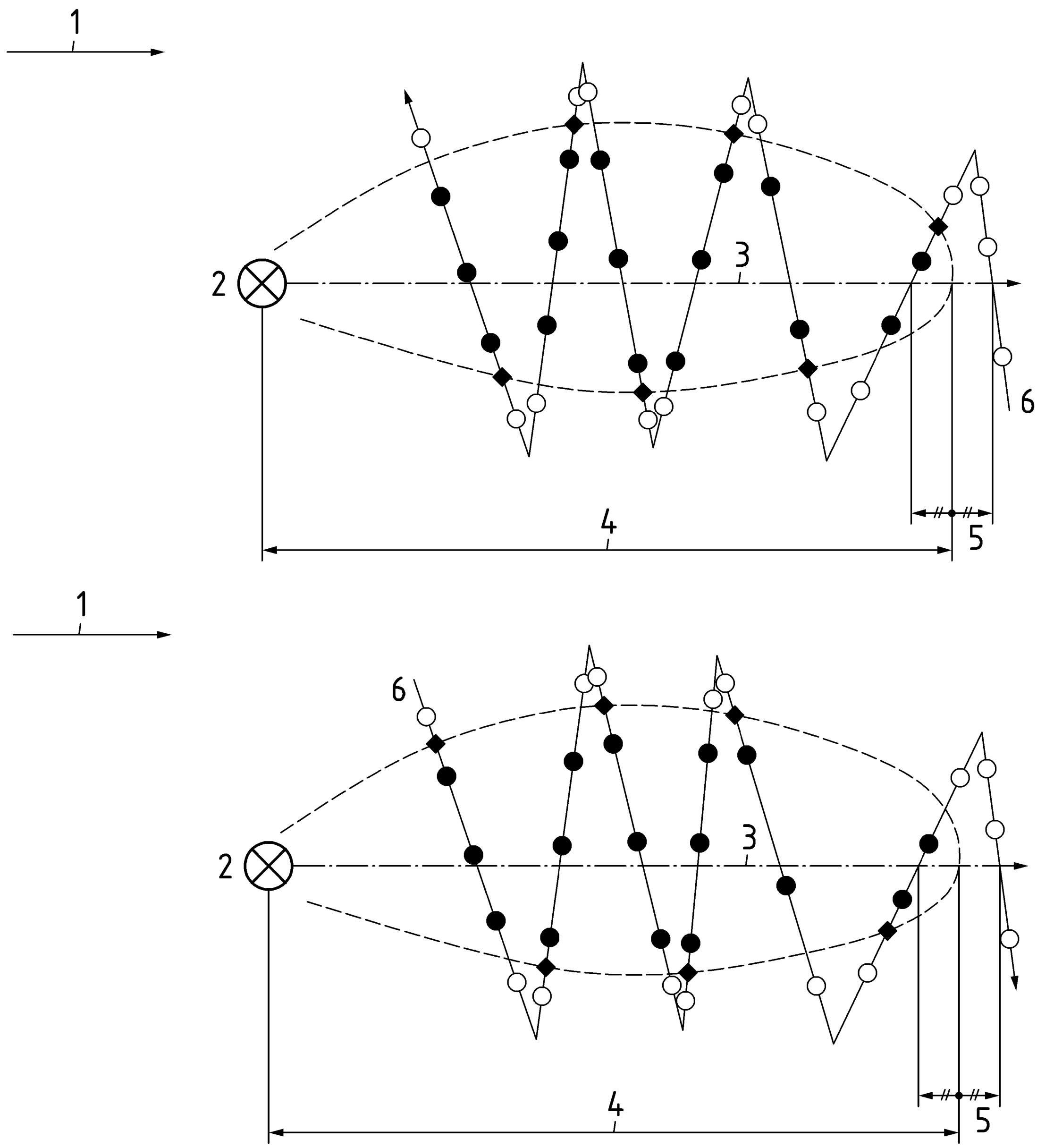
Using the stationary method, the panel members are located at specific intervals along intersection lines perpendicular to the plume direction. Several panel members are positioned at intervals along each intersection line to cover the estimated width of the recognizable plume. Each panel member determines the percentage odour time in the course of one single measurement. If the result of a single measurement reaches a percentage odour time < 10 %, the odour is considered as being absent; at higher values the odour is present. Single measurements at one intersection line are conducted simultaneously; intersection lines at different distances from the source are assessed subsequently assuming that the relevant meteorological conditions remain the same. At least one intersection line has to be at sufficient distance to ensure that no recognizable odour is present at any measurement point to be able to determine the maximum plume reach estimate.




**Key**

- ● single measurement: odour presence point
- ○ single measurement: odour absence point
- ◆ transition point
- | intersection lines
- ◌ plume extent
- 1 wind direction
- 2 source
- 3 plume direction
- 4 maximum odour plume reach estimate
- 5 equal distance between the last intersection line with and the one without recognizable odour

**Figure 1 — Schematic diagram of an example of stationary plume measurement**




**Key**

- ● single measurement: odour presence point
- ○ single measurement: odour absence point
- ◆ transition point
- Crossings
- plume extent

1 wind direction
2 source
3 plume direction
4 maximum odour plume reach estimate
5 equal distance between the furthest crossing with and the one without recognizable odour
6 start of measurement

**Figure 2 — Schematic diagrams of an example of dynamic plume measurement; in the first drawing the measurement commences moving towards the source; in the second drawing the measurement commences from the source**

Using the dynamic method, the panel members cross the plume, while conducting single measurements at frequent intervals. By successively entering and exiting the plume and in this way determining the transition between absence and presence of recognizable odour, the extent of the plume is defined. This approach helps to avoid adaptation. The plume direction is crossed at different distances from the source. This includes crossings at distances where no recognizable odour is detected.

The maximum plume reach estimate is defined as the distance along the plume direction between the source and the point halfway from the furthest intersection line or crossing where odour presence points were recorded, and the first intersection line or crossing where only odour absence points were recorded. This equal distance between the two intersection lines/crossings is indicated as point 5 on the schematic Figure 2.

For both the stationary and the dynamic method the plume extent is defined by the transition points. A transition point is the point halfway between adjacent odour absence point and odour presence point for the odour type under study. In order to prevent possible adaptation effects causing incorrect observations, the transition points in the dynamic plume method are only determined whilst entering the plume, and not while exiting.

The field of application and results (in terms of plume extent) for the dynamic and stationary plume method are considered to be equivalent.

# 6 Coordinator, assessors and panel members

## 6.1 Measurement leader and field observations coordinator

The measurements shall be conducted under the responsibility of a measurement leader, who is responsible for quality assurance. The measurement leader shall have experience conducting scientific field surveys and detailed knowledge of the contents of this standard. The measurement leader is responsible for the planning of the field inspections, and ensuring that all related measurements are conducted according to this standard. The measurement leader shall also ensure that the measurements and their results are recorded according to the requirements of this standard.

A field observations coordinator shall be responsible for correct execution and all practical aspects of the field inspections, including:

— instructing the panel members (see 6.3),

— organizing a general instruction on site for each measurement cycle with all panel members participate on that measurement cycle (see 6.3),

— surveying the study area,

— maintaining health and safety precautions (see 7.1),

— maintaining and checking the data record sheets for completeness and plausibility,

— recording source emissions characteristics, if accessible.

The field observations coordinator can be the same person as the measurement leader. In the dynamic method the field observations coordinator or measurement leader can also participate as a panel member in the observations for the current measurement.

The field observations coordinator has to be experienced in carrying out plume measurements. The field observations coordinator is viewed as sufficiently experienced if he/she has participated at least 10 times in field inspections (e.g. as panel member or coordinator assistant).

The measurement leader or other suitably qualified personal shall check the records of the observations and their plausibility.

If there are any indications that one or more panel members are not performing in compliance to the criteria set out in this standard, the measurement leader shall exclude them from further participation.

## 6.2 Assessors and panel members

### 6.2.1 Code of conduct for assessors and panel members

When recruiting panel members the following conditions shall be met:

— panel members shall be at least 16 years of age and willing and able to follow instructions.

To qualify as a panel member, assessors shall observe the following code of conduct:

— the panel member shall be motivated to carry out his/her job conscientiously;

— the panel member shall be available for the complete measurement session (series of measurements on a day, interrupted by short breaks only);

— from 30 min before and during measurement panel members shall not smoke, eat, drink (except water) or use chewing gum or sweets;

— panel members shall take great care to ensure there is no interference with their ability to perceive odours as a result of personal hygiene or the (inappropriate) use of perfumes, deodorants, body lotions or cosmetics;

— panel members shall not enter the installation under investigation prior to the field inspection in order not to be contaminated with the odorants;

— panel members suffering from a cold or any other affliction affecting their perception of smell (e.g. allergic reactions, sinusitis) shall be excluded from participating in measurements;

— during measurements panel members shall not communicate about their observations.

The measurement leader shall ensure that all panel members are aware of and understand the code of conduct. Enforcement of the code of conduct has a direct influence on the test results, and is therefore of great importance. The measurement leader shall ensure that the motivation of panel members is maintained throughout the measurements, and corrective action shall be taken when required.

### 6.2.2 Selection of assessors on individual variability and sensitivity

The initial selection of assessors is carried out according to EN 13725:2003, 6.7.2.

The olfactory acuity of panel members shall be checked at least every six months. A measurement history for each panel member shall be recorded and maintained by determining two individual threshold estimates for the reference odorant at least every six months. Each time an individual threshold estimate for the reference odorant is collected, the measurement history of the panel member in question shall be updated and evaluated. Evaluation shall be conducted by calculating the selection parameters as defined in EN 13725 from at least 10 and at most 20 of the most recent individual threshold estimates, and comparing the results with the selection criteria. If the panel member does not comply, he/she is excluded from all further measurements until compliance is established once again.

The panel selection shall be carried out before the field observations are conducted. The assessment of compliance with the panel selection criteria shall not be dated more than 6 months before the date of field observations.

Valid observations shall only be carried out by panel members. To become an experienced panel member for the dynamic method a panel member shall participate at least five times in a measurement cycle with at least three distinct odour types.

#### 6.2.3 Panel size and composition

For the duration of the survey period, a pool of qualified panel members shall be formed from which the panel members for the particular measurement session are selected.

The size of panel to be used in one measurement cycle shall be:

— For the stationary plume method a minimum of five panel members is required.

— For the dynamic plume method a minimum of two experienced panel members is required, to make measurements simultaneously.

### 6.3 Panel instruction

The purpose of the investigation, the code of conduct, the measurement method and the relevance of its results shall be explained to the panel members.

Before the start of the measurement, panel members shall be given general instruction on-site. Panel members shall be given the opportunity to become acquainted with the odour types occurring on-site.

Before the first single measurement, the panel member shall be explicitly instructed that the objective is not to achieve the most sensitive odour response but rather to obtain an immediate assessment of the presence of an odour beyond all doubt (clear recognition of the odour type).

## 7 Planning of measurements

### 7.1 Health and safety

When defining measurement points and assessing their accessibility, care has to be taken that panel members shall not be put at risk, e.g. from vehicle traffic. When working in the dark, panel members shall wear light-coloured or high visibility clothing and be issued with suitable personal equipment (e.g. torches, working lights, mobile phone). In dark or isolated areas, high priority shall be given to ensuring the personal safety of panel members

Panel members´ clothing and equipment should be suited to the weather conditions.

### 7.2 Personal equipment for panel members

Further items of equipment shall include:

— a timing device (for the stationary method a 10 s timing signal should be available),

— data recording tools (clipboard with data record sheets or a personal digital assistant),

— a positioning device (e.g. map, GPS).

Suitable protection should be provided to preserve the integrity of data record sheets or recording devices.

## 7.3 Planning of plume measurements

### 7.3.1 General conditions

The odour plume extent depends on the emission rate of the source, the characteristics of the odorant source and the current dispersion situation.

The following information on the operations of the source of the emissions is useful for planning field observations:

— Production process, products types;

— Characteristics of main emission sources:

  — Point sources: location, height of emission point and additional information e.g. temperature, flow velocity, diameter;

  — Area sources: location, area and additional information e.g. dimensions and height;

  — Fugitive sources: location;

  — Odour types of the emitted installation odour(s);

— Hours of operation, discontinuous operating processes, processing rate.

Additional information may also be relevant depending upon the nature of the source and process. It is advisable to document the actual operating conditions at the time of plume field inspection if access to this information can be obtained.

### 7.3.2 Accompanying meteorological measurements

#### 7.3.2.1 General

The dispersion of an exhaust air plume of an installation emitting odorants is directly affected by wind direction, wind velocity and stability of the atmosphere (e.g. dispersion category).

Therefore representative meteorological measurements of the installation site shall be carried out during the measurement cycle, of the following parameters:

— wind speed;

— wind direction;

— turbulence (e.g. Monin-Obukhov length);

— temperature.

Additional visual observations should be conducted for unusual features, e.g. precipitation, mist, snow, during each measurement cycle.

Meteorological measurements which are representative of the location shall be carried out using suitable meteorological equipment a suitable weather station. To be able to check the standard deviation in wind direction, the frequency of measurement should be sufficiently high. One minute mean values are recommended.

To achieve a meteorological data set that adequately describes the conditions determining odorant distribution in ambient air a digital ultra-sonic anemometer including a turbulence measurement

(Monin-Obukhov length) shall be used. This instrumentation is able to measure wind direction, wind speed, turbulence and temperature, at short measurement intervals (e.g. one minute average values).

Measurements by commercial or local authority weather stations (wind speed, wind direction, turbulence, temperature) can be used if the spatial conditions on-site are unsuitable for local meteorological measurements The applicability of measurement data of neighbouring wind measurement stations on-site should be examined with reference to following minimum requirements:

— height of measurement shall be 10 m,

— distance to obstacles, which could have any influence shall be minimum seven times of their height.

NOTE For reverse calculation, which is not part of the scope of this standard, other meteorological parameters can be relevant. For example, it may also be necessary to record the building layout and the orographic conditions to permit later digitization

#### 7.3.2.2 Measurements of meteorological parameters

Fulfilment of suitable conditions for the measurement has to be proven by measurements of the influencing meteorological parameters using an ultra-sonic anemometer 10 m high.

The limits for wind speed and direction according to 7.3.3 are based on mean values of 1 min. At least 10 single measurements have to be performed during one measurement cycle.

### 7.3.3 Suitable meteorological conditions

All measurement cycles should be carried out under the following meteorological conditions (measured by ultra-sonic anemometer):

— no significant precipitation (rainfall, snow, …);

NOTE 1 After rainfall, a break of 15 min is strongly advised before measurement recommences.

— ambient temperatures above 0°C ;

— standard deviation of wind direction less than 25° direction during one measurement cycle;

— average wind speed at 10 m height during the measurement cycle between 2 and 8 m/s;

Conditions for wind speed and direction have to be verified according 7.3.2.

— constant turbulence conditions (no changing dispersion class) during one measurement cycle; the atmospheric stability is specified by indicating the Monin-Obukhov length $L_M$, which can be measured by 3d-ultra-sonic-anemometer; the Monin-Obukhov length ($L_M$) shall be under −150 m or above 250 m (see Table 1 and Annex C);

— turbulence classes slightly stable, neutral or slightly unstable (for example Pasquill C or D or part of B and E).

NOTE 2 For estimating the stability classes a normal three cup anemometer with wind vane can be used (see C.2). To achieve the Monin-Obukhov length, an ultra-sonic anemometer is mandatory.

**Table 1 — Different stability classes and corresponding Monin-Obukhov length ($L_M$) for a roughness length $z_0$ = 1,5 m**

| **Stability class**[a] | | **Monin-Obukhov length (in m) for $z_0$ = 1,5 m** | |
|---|---|---|---|
| Klug/Manier | Pasquill | Intervall | allowed Intervall |
| I | F | $0 < L_M < 100$ | |
| II | E[c] | $100 \leq L_M < 500$ | $250 \leq L_M < 500$ |
| III/1 | D[b] | $500 \leq L_M$ or $L_M < -700$ | $500 \leq L_M$ or $L_M < -700$ |
| III/2 | C[b] | $-700 \leq L_M < -200$ | $-700 \leq L_M < -200$ |
| IV | B[c] | $-200 \leq L_M < -100$ | $-200 \leq L_M < -150$ |
| V | A | $-100 \leq L_M < 0$ | |

[a] These stability classes are comparable in a first approximation.

[b] Allowed meteorological range for plume measurements.

[c] Partly allowed meteorological range for plume measurements.

NOTE 3 Suitable meteorological conditions as defined above are necessary during the measurement itself but also necessary some time before the measurement starts in order to ensure a fully constant plume has developed. It is therefore advisable to observe these meteorological conditions at least during the time needed for a full plume to develop, 1 h before the start of the measurement.

#### 7.3.4 Assessing odour type in the field

Before the start of the measurement, all panel members shall be familiarized with the odour type under investigation.

Panel members assess the odour referring to a given list of odour types ("it smells of..."). The list can be adapted to the task in hand. It has to be defined before starting the survey and kept simple so as not to overburden panel members. If necessary, the list can be extended on the basis of incoming results.

A distinction between several odour types is necessary only if the installation under investigation has several sources emitting different odour types or if the plumes of several facilities are unavoidably superimposed.

# 8 Measurement procedure

## 8.1 General aspects

There are two methods to measure the plume extent, the stationary plume method and the dynamic plume method. In both methods a single measurement consists in the determination of the presence or absence of recognizable odour at a given moment and a given measurement point.

Transition points are defined as the location halfway between the last single measurement with absence and the first single measurement with presence of the recognizable odour under investigation. The different transition points determined during a measurement cycle define the plume extent.

The typical duration of one measurement cycle varies between half an hour and two hours, depending on the size of the plume and the accessibility of the terrain.

Before each measurement cycle some observations upwind of the source should be recorded to determine whether the observed odour really comes from the source and is not a background odour.

The **plume direction** is estimated from the wind direction. Suitable methods of estimation typically are using the data from the on-site weather station or using a weather vane, flag, balloon or smoke cartridge. In case of high emission points (e.g. stacks), one should be aware of the fact that the wind direction at emission height might be different from the wind direction at ground level. This can be checked by controlling the wind direction of the visible plume leaving the stack.

The minimum required data for describing the plume extent are the maximum odour plume reach estimate and the maximum plume width, usually located at a distance approximately halfway the maximum odour plume reach.

Additional points can be plotted on a map to graphically represent the plume extent for one measurement cycle.

The plume extent area can be calculated as the area enclosed by a smoothed interpolation polyline through the transition points, the source location and the location determined by the maximum plume reach estimate.

The result of a field survey can be expressed as:

— the median maximum plume reach (m);

— the median plume width (m);

— the median plume extent area ($m^2$).

NOTE For the purpose of reverse modelling (which is outside the scope of this standard), the actual separate results from the measurement cycles are used, in combination with the relevant meteorological data of each cycle.

## 8.2 Stationary plume method

The stationary plume measurement consists of several single measurements each lasting ten minutes at several intersection lines perpendicular to the current wind direction (**plume direction**). An **intersection line** consists of at least five **measurement points** chosen by the field observation coordinator; at each measurement point one panel member is positioned. The **transition point** is by definition the point halfway between the last single measurement with absence and the first single measurement with presence of the recognizable odour under investigation. Absence of odour is defined by a percentage odour time < 10 % during a single measurement; presence of odour is defined by a percentage of odour time ≥ 10 %.

A single measurement duration of at least ten minutes is required in order to obtain a representative statement with at least 80 % certainty on the odour situation within an hour [1].

Each measurement cycle shall comply with the minimum requirements as set out in 9.1.

The distance between the **intersection lines** and the distance between the measurement points depends on the anticipated plume extent. It is advisable to estimate the plume extent roughly beforehand, e.g. by car, as a guide for the measurement. The plume extent is affected by the structural height of the emission source, by the odorant flow rate, the current meteorological conditions and by buildings/vegetation (orography) and the topography. The position of the intersection lines and measurement points are entered on a map.

The first intersection line should be chosen as such that a clear recognition of the odour under investigation can be observed.

The single measurements at the first intersection line shall be carried out in such a way that allows the field observations coordinator to respond directly to unusual occurrences or uncertainty and answer any questions that may arise. For single measurements at consecutive intersection lines, the physical ranking of the panel members should be changed to prevent systematic errors.

It is usually necessary to decide ad hoc on the position of the **measurement points**, to adjust to the current dispersion conditions. Therefore, the field observations coordinator shall have sufficient experience (see 6.1).

When defining the measurement points, care shall be taken that the panel members can stand out in the open and not in the immediate vicinity of houses, high walls, hedges, the edges of forests etc. Heavily used roads are also unsuitable as measurement points (noise, traffic odours). The same applies to railway lines and stops for buses, taxis etc. If possible, the measurement points should not be situated within the impact range of other odorant sources. Locally delimited odorant sources such as exhaust air shafts, manhole covers, compost heaps, snack bars or petrol stations should be avoided when defining the measurement points.

To determine the percentage odour time in a single measurement duration, the following method is used.

The panel member sniffs the air every 10 s and records the identified odour type on a special data record sheet. At the end of the 10-min single measurement duration, the panel member has assessed 60 odour samples. At each 10-s interval, he assesses only the individual breath of air and not the odour impression gained during the preceding 10 s. In the event of disturbances during individual odour assessments within the 10 min, samples can be added immediately afterwards at 10 s intervals.

The percentage odour time is the fraction of the total number of odour assessments with a positive assessment result during the single measurement duration.

The start of measurement is indicated acoustically or visually by the field observations coordinator. If this is not possible, measurement can start at an agreed time. Watches should be synchronized beforehand.

Information about other odour types (not under investigation) also should be registered.

As an example, the procedure described above is presented in Annex D for an area source at ground level.

If interested passers-by disturb the measurement process, they should be requested to wait until the end of the single measurement for information on the project. Experience however has shown that individual panel members are rarely disturbed during plume measurement.

## 8.3 Dynamic plume method

A measurement cycle consists of at least 20 single measurements at different distances from the source by at least two experienced panel members in order to define at least 6 transition points and finally the odour plume extent (see also 9.1). These observations (single measurements) are to be done on foot or by bike.

It is advisable to estimate the plume direction and the rough plume extent beforehand, e.g. by car, as a guide for the measurement.

Before starting the observations, timing devices shall be synchronized.

The experienced panel members can begin a measurement cycle by starting observations either close to the source or at a certain distance downwind. In case of a complex source situation emitting different odour types, it is advisable to start at a distance downwind where the different odours can be clearly discerned. The objective of these initial observations is to familiarize the experienced panel members with the odour type(s) under investigation. The decision of where to start and which direction to go, is to be made by the field observations coordinator.

In order to prevent adaptation to the odour under investigation, panel members should regularly go in and out the plume preferably by crossing the plume axis in a zigzag pattern as shown in Figure 2.

In certain circumstances it is however allowed to cross only the edge of the plume in a zigzag way, e.g. when the complete crossing of the plume is not possible due to geographical restrictions.

The plume is then repeatedly crossed at different distances from the source in order to cover the whole estimated plume extent. The observations should include crossings at distances downwind where no odour is recognized, in order to ensure that the maximum odour plume reach can be determined.

Each measurement cycle shall as a minimum satisfy the quality criteria as defined in 9.1.

Each measurement point is chosen by the experienced panel member and is indicated on a topographical map or on a portable GPS-system by adding a waypoint. For each measurement point, the exact time is registered, and also whether or not the odour under investigation is recognized. Information about other odour types should also be registered.

An example of a typical observation form (map) of one panel member including the data record sheet is added in Annex E.

Panel members should work independently (e.g they should not do the same crossing at the same time). They should not communicate with each other during the single plume measurement in order to avoid mutual influences. The coordinator however can give additional instructions during the single plume measurement or decide to stop the measurement. This can be necessary when, for example, extreme changes in meteorological conditions occur during the measurement. For this reason, the coordinator shall have sufficient experience.

Panel members shall avoid communicating with members of the public when performing field observations. Information for interested passers-by shall be provided by the coordinator.

# 9 Quality requirements

## 9.1 General

There are several parameters which influence the determination of the plume extent and therefore have an effect on the uncertainty of the measurement (see also Annex B). Before providing a description of these parameters, it should be stated that the uncertainty of the total measurement using this standard cannot be fully defined. This standard therefore gives no overall uncertainty requirements which should be reached. This standard reflects current expert opinion on the best way to perform this type of measurement and on the minimum requirements needed to do this in accordance with the 'state of the art'.

The most important parameters influencing the uncertainty of a plume measurement are:

a) Meteorological parameters:

    1) wind direction and its variation in time,

    2) wind speed and its variation in time,

    3) turbulence and its variation in time.

b) Source parameters (process conditions):

    1) emission rate and its variation in time,

    2) variation of the odour type in time,

    3) configuration and location of the sources (incl. height, buoyancy).

c) Measurement parameters:

1) method applied and the degree of compliance to the standard requirements,

2) number and quality of panel members and experience of the coordinator,

3) time required to complete one measurement cycle.

In 7.3.2, the way to select and to check meteorological and measurement parameters have been established far as possible. Source parameters are not described here due to the wide variety of possible process conditions. The assumption is made that no relevant variations occur during a measurement cycle. It is therefore important to check that the process conditions are as constant as possible during performance of a measurement cycle. The minimum requirements for meteorological conditions are described in 7.3.3.

The meteorological conditions that prevail during a measurement cycle are very important. One of the main underlying assumptions of both plume methods is that meteorological conditions are considered as “constant” during one measurement cycle. That means that the duration of one measurement cycle should not exceed the duration of one “steady” meteorological condition.

NOTE In order to obtain an improved estimate of emission rate through reverse modelling (which is not part of the scope of this standard), the uncertainty of the mean emission rate estimate obtained can be reduced by increasing the number of measurement cycles, e.g. during different wind speeds or turbulence classes, to better characterize variations in meteorological conditions and take into account the variations in the source emission rate over time. Additional factors that affect the uncertainty of the reverse calculation are the details of the characterization of the meteorological conditions during the measurement and the dispersion model used.

## 9.2 Minimum requirements for the data collection during one measurement cycle

A measurement cycle shall consist of at least 20 single measurements, from which at least 6 transition points (absence to presence) can be determined.

The maximum plume reach estimate shall be determined from observations obtained from two intersection lines (stationary method) / two crossings (dynamic method), one of which includes at least one odour presence point observation, and another intersection line / crossing where only odour absence point observations are recorded.

The distance between the intersection line / crossing without odour presence point observations and the nearest intersection line /crossing with odour presence point observation(s) shall be less than 20 % of the maximum odour plume reach as determined from these observations.

At least 4 transition points (absence to presence), 2 at either side of the plume, shall be recorded at distances along the plume direction between 30 % and 70 % of the maximum odour plume reach.

The maximum plume reach estimate shall be determined from observations obtained during two crossings, one of which including at least one odour presence point observation, and another crossing where only odour absence point observations are recorded.

The distance between the crossing without odour presence point observations and the nearest crossing with odour presence point observation(s) shall be less than 20 % of the maximum odour plume reach as determined from these observations.

For the dynamic method, a measurement cycle shall be conducted by at least two experienced panel members who each contribute approximately equal shares to the single measurement results.

### 9.3 Number of measurement cycles for one field survey

A minimum number of ten measurement cycles have to be conducted for one complete field survey.

However, it is permissible to conduct less measurement cycles in some circumstances. For example, to confirm the presence or absence of odour at a certain point during or shortly after a complaint, or to assess the effect of switching off an odorant treatment system on the maximum odour plume reach in the field.

NOTE It is advisable to conduct the ten measurement cycles over at least five different days, in order to take possible variations (e.g. source emission strength, meteorological conditions) into account.

## 10 Data recording, calculation and reporting

### 10.1 General

During a single measurement, the panel member acknowledges and assesses his/her odour observations and records them. Information about other odour types (not under investigation) should also be registered. Commonly used collection methods and calculation of the results are described below.

### 10.2 Stationary plume method

#### 10.2.1 Data recording and calculating the percentage odour time

In addition to the data collected by the panel members, the field observation coordinator records the location of the intersection lines and measurement points with the corresponding identified panel member on a topographical map or on a GPS system.

The simplest method for determining the percentage odour time $P_{od}$ at a measurement point is with a clock or watch as a timer and with a data record sheet for recording the results of odour samples. A sample of such a sheet is added in Annex D. To determine the percentage odour time, the number of positive assessments is counted and divided by the total number of assessments according to Formula (1).

$$P_{od} = \frac{L_+}{R} \cdot 100 \quad (1)$$

where

$P_{od}$ is the percentage odour time at a measurement point (percentage of odour recognition)

$L_+$ is the number of positive responses per measurement cycle and observation point

$R$ is the total number of assessments per measurement cycle

NOTE If, outside the scope of this standard, odour intensity or other parameters have been investigated, this additional information can also be presented in the same record sheet.

The field observations coordinator records the general conditions of the measurement.

#### 10.2.2 Criterion for positive single measurements (odour hours)

The criterion of the positive single measurement (odour hour) is only employed for stationary plume measurements in order to define the plume

boundary.

For the purpose of reverse modelling (which is outside the scope of this standard), the actual percentage time of odour detection during the measurement cycle is required. It is calculated with Formula (1) given above (see example(s) in Annex D).

A single measurement equals an odour hour (which means odour presence) when the percentage odour time reaches or exceeds 10 % of the total number of timed olfactory samples during the 10-min measurement duration.

#### 10.2.3 Calculation

For each single measurement, the percentage odour time is calculated (see Formula (1)) and reported in a table. Odour presence or odour absence points are then determined and discriminated in the table.

The outcome of the plume measurement is the plume extent boundary. This boundary is represented by a smoothed interpolation polyline drawn on a map using the different transition points, including the transition point at the maximum plume reach estimate (see Figure 1).

### 10.3 Dynamic plume method

#### 10.3.1 Data recording

During a measurement cycle, each panel member indicates all of his measurement points on a (e.g. topographical) map by adding a number. As an alternative, the points can be registered on a portable GPS system with sufficient accuracy. Numbers corresponding to odour presence points should be different from those corresponding to odour absence points (e.g.by using different colours, circling the number or using different waypoints on the GPS). For clarity, the direction of the crossing can be specified on the map . This will facilitate the identification of the lines corresponding with entering the plume which are the only ones that allow the determination of the transition points. On a separate data record sheet, the exact time (if not registered by GPS), odour presence or absence and the odour type is registered for each measurement point. This means that information about other odour types should also be registered.

The field observations coordinator records the general conditions of the measurement.

NOTE If, outside the scope of this standard, odour intensity or other parameters have been investigated, this additional information can also be presented on the same data record sheet.

#### 10.3.2 Calculation

A transition point is determined as the point halfway between the last odour absence point and the first odour presence point for the odour type under investigation. For each crossing the transition points (if available) are determined.

The maximum plume reach estimate shall be determined from observations obtained during two crossings, one of which including at least one odour presence point observation, and another crossing where only odour absence point observation is recorded.

The outcome of the plume measurement is the plume extent boundary. This boundary is represented by a smoothed interpolation polyline drawn on a map using the different transition points, including the transition point at the maximum plume reach estimate (see Figure 2).

### 10.4 Reporting of results

The measurement report should present the results of the plume measurement logically and in a way that is verifiable by third parties. If for special reasons, e.g. because of an unusual task or inaccessibility of the installation, some methodological modifications were considered or some of the points listed below have to be omitted, this shall be mentioned explicitly in the report.

The following details are always essential:

a) commissioning organization identification and contact details,

b) organization responsible for carrying out the survey and publishing the report,

c) formulation of the objective of the study and the agreements reached, for instance with installation coordinators and public authorities,

d) description of the measurement method employed: stationary or dynamic plume method,

e) description of the meteorological station used and their location,

f) presentation of the results in figures (plume extents at each measurement cycle) with reference to maps,

g) table presentation of the maximum odour plume reach estimate for each measurement cycle, as well as the average value,

h) description of the measurement points on the intersection lines (stationary method) or on the crossing lines (dynamic method) on the site map,

i) details of how the requirements of the standard were implemented including reasons for any deviation from this European Standard,

j) a specimen of the data record sheet employed and of the differentiated odour types.

In addition, the reporting of the following details is recommended:

k) description of the installation(s), including odorant emission sources and existing odorant abatement measures, emitted odour types and operating hours during the survey period. Reference has to be made to operating conditions that generate particularly high emissions if relevant and available,

l) site plan or map with the relevant odorant sources marked on it.

The following details shall be retained and made available as required for at least five years from the date of completion of the survey (electronic or hardcopy):

m) Details of measurement planning and measurement results with the following items: date, time, panel member ID, identification of all measurement points with, for each of them, percentage odour time (number of positive observations for stationary plume method) or specification of presence or absence of odour (dynamic plume method), specified according to each odour type marking of any omitted and rescheduled single measurements,

n) measurement leader, field observations coordinator, institutions involved,

o) list of the panel members inclusive of an overview of their qualification as panel members,

p) list of the panel member IDs inclusive of an overview and detailed information of their qualification as panel members for that time period,

q) all completed data record sheets,

r) raw meteorological data measured during measurement cycles.

# Annex A
(informative)

## Overview and interaction of existing odour measurement methods

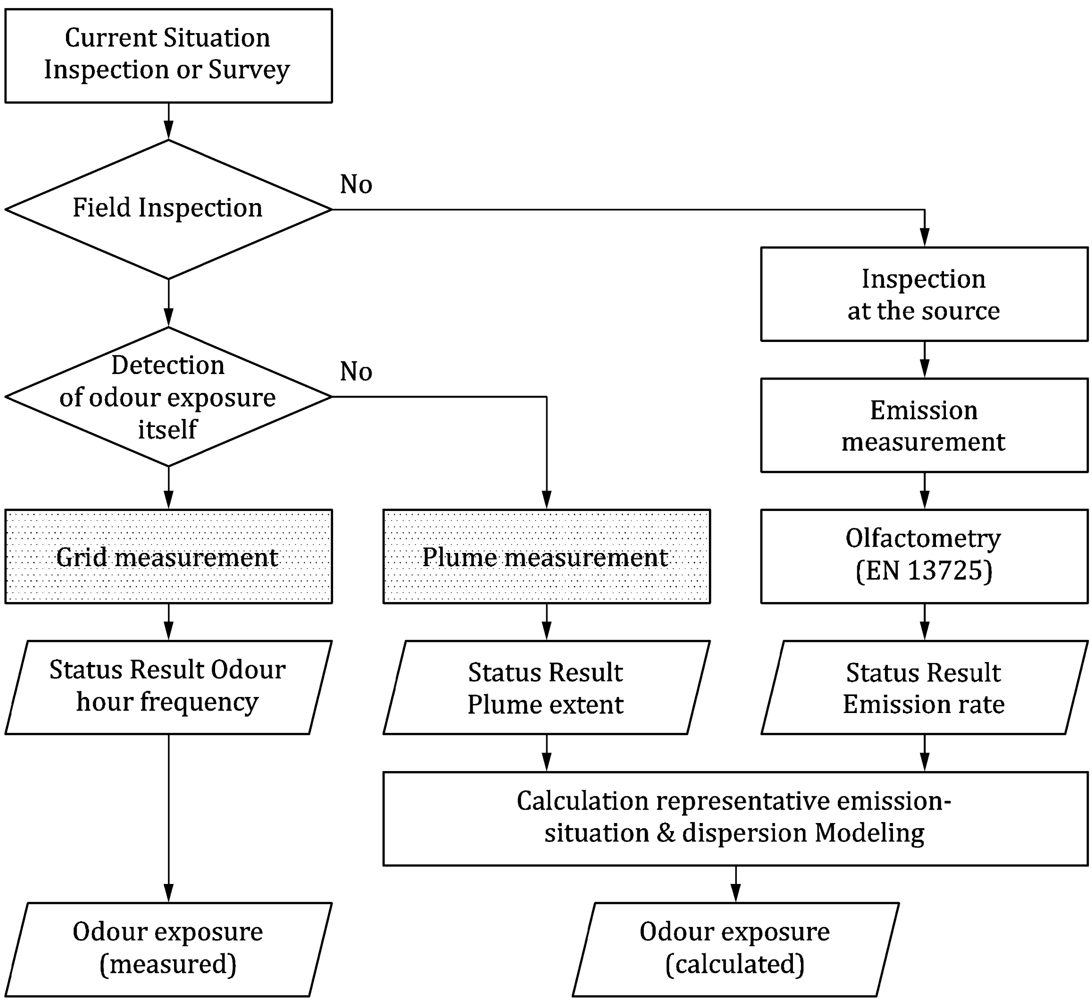



**Figure A.1 — Overview and interaction of existing odour measurement methods including grid method (Part 1), plume method (Part 2) and dynamic olfactometry according EN 13725**

# Annex B
(informative)

## Uncertainty of the plume method

The result of a plume measurement consists of the shape of the plume where at a given moment and under defined meteorological conditions, the odour type under investigation can be observed and recognized. This result can be expressed with a number of parameters: The maximum plume reach, the plume width at a certain distance and/or the plume extent area.

Uncertainty in the determination of the odour plume and thus in the description or quantification of the parameters referenced above, can be caused by a number of factors:

— uncertainty due to varying meteorological parameters during the plume measurement,

— uncertainty due to varying source parameters during the plume measurement,

— uncertainty due to the number and quality of panel members,

— uncertainty associated with the observations (i.e. estimation of transition points).

In order to reduce all these uncertainties, several restrictions are imposed in the standard.

The uncertainty caused by meteorological parameters is not quantifiable in a general way. For the meteorological parameters, 7.3.3 lists a number of minimal requirements under which a plume measurement can be conducted, in order to prevent plume determination during unsuitable conditions, where a good delineation of the odour plume is not possible. Besides this, 7.3.2 exiges the measurement and registration of different meteorological parameters in order to prove the suitability of the conditions afterwards.

The uncertainty caused by variability of the source parameters, is difficult to prevent and also not quantifiable in a general way. If possible, contacts with the operational management at the odorant source can give a more clear view on possible variations. These details can be used in the planning of the measurements. If variations of the source exist and if they cannot be excluded, it is recommended to repeat the single measurement. The uncertainty due to the panel members is being counteracted by using only human assessors fulfilling the requirements of EN 13725 and by using only experienced panel members, trained in distinguishing different odour types. Nevertheless, it cannot be excluded that certain panel members are much more or much less sensitive to a certain odour type than others. If this experience exists, it is advisable to exclude these panel members for measurements of this odour type. In practice however, most panel members start recognizing a certain odour type at more or less similar distances.

Finally, uncertainty in the delineation of the odour plume can be caused by estimating the transition points. This uncertainty can be defined by maximally half the distance between the last single measurement without the odour under investigation and the first single measurement with the odour under investigation.

In case of the stationary plume measurement, this distance is determined by the positioning of the different panel members. If the distance between the panel members is, e.g. 50 m the uncertainty is 25 m (half the distance between the last single measurement without the odour under investigation and the first single measurement with the odour under investigation).

In case of the dynamic plume measurement, this distance is very limited at the plume border and can be maximally around 10 m to 15 m. Panel members are moving on foot or by bike, thus at a maximum speed of 5 m/s. The time lap between two inhalations (two single measurements) is around 5 s to 6 s, which means that the distance between two single measurements is around 25 m to 30 m. Half the distance, being the maximum uncertainty for determination of the transition point, results in being maximally 15 m. The uncertainty of the plume width can thus be defined as twice this value, being maximum 20 m to 30 m.

At the end of the plume, the maximum plume reach estimate is defined as the distance along the plume direction between the source and the point halfway the furthest intersection line or crossing where odour presence points are recorded and the first intersection line or crossing where only odour absence points were recorded. The uncertainty is thus half the distance between these two points. In 9.1, it is defined that the distance between the crossing without odour presence point observations and the nearest crossing with odour presence point observations shall be less than 20 % if the maximum odour plume reach. The uncertainty on the maximum odour plume reach can thus be defined as maximum 10 % of the determined value.

The uncertainty for the plume area can be deducted from both uncertainties described above, but cannot be quantified in a general way.

# Annex C
(informative)

# Turbulence conditions

## C.1 Monin-Obukhov length

The atmospheric stability is specified by indicating the Monin-Obukhov length $L_M$. Table C.1 shows the classification of Monin-Obukhov lengths for a roughness of $z_0$ = 1,5 m [2].

**Table C.1 — Example for the relation between Monin-Obukhov length and Klug/Manier or Pasquill stablility classes for a roughness length $z_0$ = 1,5 m [2]**

| **Stability class**[a] | | **Monin-Obukhov length (in m) for $z_0$ = 1,5 m** | |
|---|---|---|---|
| Klug/Manier | Pasquill | Intervall | allowed Intervall |
| I | F | $0 < L_M < 100$ | |
| II | E[c] | $100 \leq L_M < 500$ | $250 \leq L_M < 500$ |
| III/1 | D[b] | $500 \leq L_M$ or $L_M < -700$ | $500 \leq L_M$ or $L_M < -700$ |
| III/2 | C[b] | $-700 \leq L_M < -200$ | $-700 \leq L_M < -200$ |
| IV | B[c] | $-200 \leq L_M < -100$ | $-200 \leq L_M < -150$ |
| V | A | $-100 \leq L_M < 0$ | |

[a] These stability classes are comparable in a first approximation.
[b] Allowed meteorological range for plume measurements.
[c] Partly allowed meteorological range for plume measurements.

The intervals of the Monin-Obukhov lengths were derived from an evaluation of meteorological measurement at the Kernforschungszentrum Karlsruhe (KFK). Therefore they are representative for a roughness length of about $z_0$ = 1,5 m. The default values were based on works of [3] and [4] for a roughness length of $z_0$ = 1,5 m.

The following estimate is applied for roughness length other than 1,5 m:

$$L_m = L_{m(1,5)} \cdot \sqrt{\frac{z_0}{1{,}5\,\text{m}}}$$

With this approach, the results of [4] are reproduced for the value range 0,01 m < $z_0$ < 1,5 m.

## C.2 Stability classes

In case that no data for the Monin-Obukhov length are available, as only information on wind speed and wind direction is on hand (e.g. because a normal three cup anemometer with wind vane is used), the stability classes can be derived from Table C.2 (daytime) or Table C.3 (at night) using the factors time of day, wind speed and surface coverage [5; 6].

**Table C.2 — Pasquill and Klug stability classes (daytime)**

| | | wind speed (m/s) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | > 6 |
| **Day (Winter)** | | | | | | | | | |
| Cloud cover | 8/8 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | 7/8 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | 6/8 | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | D - III/1 | D - III/1 | D - III/1 |
| | 5/8 | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | C - III/2 | D - III/1 | D - III/1 |
| | 4/8 | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | C - III/2 | D - III/1 | D - III/1 |
| | 3/8 | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | C - III/2 | C - III/2 | D - III/1 |
| | 2/8 | B - IV | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | D - III/1 |
| | 1/8 | A - V | A - V | B - IV | B - IV | B - IV | B - IV | C - III/2 | D - III/1 |
| | 0 | A - V | A - V | B - IV | B - IV | B - IV | B - IV | C - III/2 | D - III/1 |
| **Day (Spring)** | | | | | | | | | |
| Cloud cover | 8/8 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | 7/8 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | 6/8 | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | C - III/2 | D - III/1 | D - III/1 |
| | 5/8 | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | D - III/1 | D - III/1 |
| | 4/8 | B - IV | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | D - III/1 | D - III/1 |
| | 3/8 | A - V | A - V | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | D - III/1 |
| | 2/8 | A - V | A - V | A - V | B - IV | B - IV | B - IV | C - III/2 | D - III/1 |
| | 1/8 | A - V | A - V | A - V | B - IV | B - IV | B - IV | C - III/2 | C - III/2 |
| | 0 | A - V | A - V | A - V | B - IV | B - IV | B - IV | C - III/2 | C - III/2 |
| **Day (Summer)** | | | | | | | | | |
| Cloud cover | 8/8 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | 7/8 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | 6/8 | B - IV | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | D - III/1 | D - III/1 |
| | 5/8 | B - IV | B - IV | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | D - III/1 |
| | 4/8 | A - V | A - V | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | D - III/1 |
| | 3/8 | A - V | A - V | A - V | B - IV | B - IV | B - IV | C - III/2 | D - III/1 |
| | 2/8 | A - V | A - V | A - V | B - IV | B - IV | B - IV | C - III/2 | C - III/2 |
| | 1/8 | A - V | A - V | A - V | A - V | B - IV | B - IV | C - III/2 | C - III/2 |

| | | **wind speed (m/s)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **> 6** |
| | **0** | A - V | A - V | A - V | A - V | B - IV | B - IV | C - III/2 | C - III/2 |
| **Day (Fall)** | | | | | | | | | |
| **Cloud cover** | **8/8** | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | **7/8** | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | **6/8** | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | D - III/1 | D - III/1 | D - III/1 |
| | **5/8** | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | C - III/2 | D - III/1 | D - III/1 |
| | **4/8** | B - IV | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | D - III/1 | D - III/1 |
| | **3/8** | A - V | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | C - III/2 | D - III/1 |
| | **2/8** | A - V | A - V | B - IV | B - IV | B - IV | C - III/2 | C - III/2 | D - III/1 |
| | **1/8** | A - V | A - V | B - IV | B - IV | B - IV | B - IV | C - III/2 | D - III/1 |
| | **0** | A – V | A - V | B - IV | B - IV | B - IV | B - IV | C - III/2 | C - III/2 |

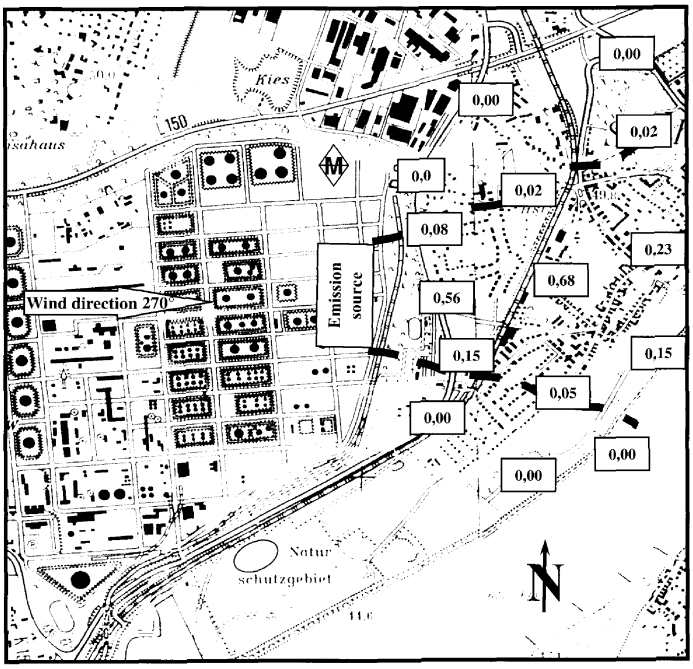
| Key<br><br>Pasquill classes | | | Klug Classes | |
|---|---|---|---|---|
| A | extremly unstable | | V | extremly unstable |
| B | unstable | | IV | unstable |
| C | slightly unstable | | III/2 | slightly unstable |
| D | neutral | | III/1 | neutral |
| E | slightly stable | | II | slightly stable |
| F | extremly stable | | I | extremly stable |
| G | foggy and misty | | I | foggy and misty |

**Table C.3 — Pasquill and Klug stability classes (at night)**

| **Cloud cover** | | **wind speed (m/s)** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **0** | **1** | **2** | **3** | **4** | **5** | **> 5** |
| | **8/8** | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | **7/8** | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | **6/8** | F - I | F - I | E - II | D - III/1 | D - III/1 | D - III/1 | D - III/1 |
| | **5/8** | F - I | F - I | E - II | E - II | D - III/1 | D - III/1 | D - III/1 |
| | **4/8** | F - I | F - I | F - I | E - II | D - III/1 | D - III/1 | D - III/1 |
| | **3/8** | F - I | F - I | F - I | E - II | E - II | D - III/1 | D - III/1 |
| | **2/8** | F - I | F - I | F - I | F - I | E - II | D - III/1 | D - III/1 |
| | **1/8** | F - I | F - I | F - I | F - I | E - II | E - II | D - III/1 |
| | **0** | F - I | F - I | F - I | F - I | E - II | E - II | D - III/1 |

# Annex D
(informative)

## Example stationary plume measurement




M Meteorological measurements:

wind direction: 270°

wind velocity: 3,0 m/s

stability category: AK III/1

| | Line 1 | Line 2 | Line 3 |
|---|---|---|---|
| Measurement points | Relative percentage odour time | Relative percentage odour time | Relative percentage odour time |
| 1 | 0 | 0 | 0 |
| 2 | 0,08 | 0,02 | 0,02 |
| 3 | 0,56 | 0,68 | 0,23 |
| 4 | 0,15 | 0,05 | 0,15 |
| 5 | 0 | 0 | 0 |

**Figure D.1 — Example of a plume measurement with three intersection lines**

| | | | |
|---|---|---|---|
| **Project-Nr.:** | **17 0815 11** | **Odour quality: foundry** | |
| **Panel member (ID): HOB** | | **Date: 12.11.2014** | |
| **Odour samples every ten seconds. The time between the ten seconds is disregarded** | | | |

| | **Point** | **1-1** | **2-3** | **3-5** |
|---|---|---|---|---|
| | Time | 10:35 | 10:45 | 11:10 |
| **1st min** | 0 | 0 | 0 | 0 |
| | 10 | 0 | 1 | 0 |
| | 20 | 0 | 1 | 0 |
| | 30 | 0 | 1 | 0 |
| | 40 | 0 | 1 | 0 |
| | 50 | 0 | 0 | 0 |
| **2nd min** | 0 | 0 | 1 | 0 |
| | 10 | 0 | 1 | 0 |
| | 20 | 0 | 0 | 0 |
| | 30 | 0 | 1 | 0 |
| | 40 | 0 | 1 | 0 |
| | 50 | 0 | 1 | 0 |
| **3rd min** | 0 | 0 | 1 | 0 |
| | 10 | 0 | 1 | 0 |
| | 20 | 0 | 1 | 0 |
| | 30 | 0 | 1 | 0 |
| | 40 | 0 | 1 | 0 |
| | 50 | 0 | 1 | 0 |
| **4th min** | 0 | 0 | 1 | 0 |
| | 10 | 0 | 0 | 0 |
| | 20 | 0 | [illegible] | 0 |
| | 30 | 0 | 0 | 0 |
| | 40 | 0 | 1 | 0 |
| | 50 | 0 | 1 | 0 |
| **5th min** | 0 | 0 | 1 | 0 |
| | 10 | 0 | 1 | 0 |
| | 20 | 0 | 0 | 0 |
| | 30 | 0 | 1 | 0 |
| | 40 | 0 | 1 | 0 |
| | 50 | 0 | 1 | 0 |

| | **Point** | **1-1** | **3-3** | **3-5** |
|---|---|---|---|---|
| | Time | 10:35 | 10:45 | 11:10 |
| **6th min** | 0 | 0 | 1 | 0 |
| | 10 | 0 | 0 | 0 |
| | 20 | 0 | 0 | 0 |
| | 30 | 0 | 1 | 0 |
| | 40 | 0 | 1 | 0 |
| | 50 | 0 | 1 | 0 |
| **7th min** | 0 | 0 | 1 | 0 |
| | 10 | 0 | 1 | 0 |
| | 20 | 0 | 1 | 0 |
| | 30 | 0 | 1 | 0 |
| | 40 | 0 | 1 | 0 |
| | 50 | 0 | 0 | 0 |
| **8th min** | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 |
| | 20 | 0 | 0 | 0 |
| | 30 | 0 | 0 | 0 |
| | 40 | 0 | 0 | 0 |
| | 50 | 0 | 1 | 0 |
| **9th min** | 0 | 0 | 1 | 0 |
| | 10 | 0 | 1 | 0 |
| | 20 | 0 | 1 | 0 |
| | 30 | 0 | 1 | 0 |
| | 40 | 0 | 1 | 0 |
| | 50 | 0 | 1 | 0 |
| **10th min** | 0 | 0 | 1 | 0 |
| | 10 | 0 | 1 | 0 |
| | 20 | 0 | 0 | 0 |
| | 30 | 0 | 0 | 0 |
| | 40 | 0 | 0 | 0 |
| | 50 | 0 | 0 | 0 |

| **Scale of intensity** | |
|---|---|
| 0 | no odour |
| 1 | very weak |
| 2 | weak |
| 3 | distinct |
| 4 | strong |
| 5 | very strong |
| 6 | extremely strong |

Panel member: ______________________________

**Figure D.2 — Example of a data record sheet for stationary plume measurements**

# Annex E
(informative)

## Example dynamic plume measurement

**Key**

- ◆ transition point
- — plume extent
- odour source

**Figure E.1 — Example of results of a dynamic plume measurement (map)**

Each measurement point is indicated by a number. Odour presence points are indicated in black, odour absence points are indicated in grey.

**Table E.1 — Example of a data record sheet for dynamic plume measurements (panel member No. 1)**

| Measurement point | Time | | Odour under investigation ? | Remarks | Measurement point | Time | Odour? | Odour under investigation? | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 09:05 | - | | | 30 | 09:38 | - | | |
| 2 | 09:06 | - | | | 31 | 09:39 | X | yes, soap | |
| 3 | 09:07 | - | | | 32 | 09:33 | - | | |
| 4 | 09:08 | - | | | 33 | 09:34 | - | | |
| 5 | 09:09 | - | | | 34 | 09:35 | - | | |
| 6 | 09:09:30 | X | yes, soap | | 35 | 09:36 | X | yes, soap | |
| 7 | 09:10 | - | | | 36 | 09h37 | X | yes, soap | |
| 8 | 09:11 | - | | | 37 | 09:38 | X | yes, soap | |
| 9 | 09:12 | - | | | 38 | 09:39 | X | yes, soap | |
| 10 | 09:13 | X | no | exhaust gasses | 39 | 09:40 | - | | |
| 11 | 09:14 | - | | | 40 | 09:41 | X | yes, soap | |
| 12 | 09:15 | - | | | 41 | 09:42 | - | | |
| 13 | 09:16 | - | | | 42 | 09:43 | - | | |
| 14 | 09:17 | X | yes, soap | | 43 | 09:44 | X | yes, soap | |
| 15 | 09:18 | X | yes, soap | | 44 | 09:45 | X | yes, soap | |
| 16 | 09:19 | - | | | 45 | 09:46 | - | | |
| 17 | 09:20 | X | yes, soap | | 46 | 09:47 | X | yes, soap | |
| 18 | 09:22 | - | | | 47 | 09:48 | X | yes, soap | |
| 19 | 09:23 | - | | | 48 | 09:49 | X | yes, soap | |

| Measurement point | Time | | Odour under investigation ? | Remarks | Measurement point | Time | Odour? | Odour under investigation? | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 20 | 09:24 | - | | | 49 | 09:51 | - | | |
| 21 | 09:25 | - | | | 50 | 09:52 | - | | |
| 22 | 09:26 | X | yes, soap | | 51 | 09:54 | X | yes, soap | |
| 15 | 09:27 | | | | 52 | 09:56 | - | | |
| 14 | 09:28 | | | | 53 | 09:57 | X | yes, soap | |
| 13 | 09:29 | | | | 54 | 09:59 | - | | |
| 12 | 09:30 | | | | 55 | 10:00 | - | | |
| 23 | 09:31 | - | | | 56 | 10:02 | X | - | exhaust gasses |
| 24 | 09:32 | X | yes, soap | | 57 | 10:03 | - | | |
| 25 | 09:33 | X | yes, soap | | 58 | 10:05 | - | | |
| 26 | 09:34 | X | yes, soap | | 59 | 10:08 | - | | |
| 27 | 09:35 | X | yes, soap | | 60 | 10:11 | - | | |
| 28 | 09:36 | X | yes, soap | | 61 | 10:12 | - | | |
| 29 | 09:37 | X | yes, soap | | 62 | 10:13 | - | | |

# Annex F
(informative)

# Calculation of the odour emission rate by reverse modelling – stationary plume measurement (example)

Plume measurements can be used for ascertaining the impact range of odour emissions, and in connection with an odour dispersion model, to ascertain the source strength (odorant flow rate e.g. in $ou_E/h$) from inaccessible emissions or emissions not amenable to reliable direct measurement (e.g. fugitive sources).

For a good description of the plume a sufficiently large number of intersection line measurements are necessary (see 9.1).

A possible reverse calculation method is described below to obtain the potential odorant flow rate from a facility on the basis of plume measurement data.

To obtain sufficiently informative data, plume measurements are necessary downwind of the emission source with a variety of wind directions and wind velocities and with readily describable meteorological conditions. The basic conditions specified in 7.3.2 and 7.3.3 shall also be complied with.

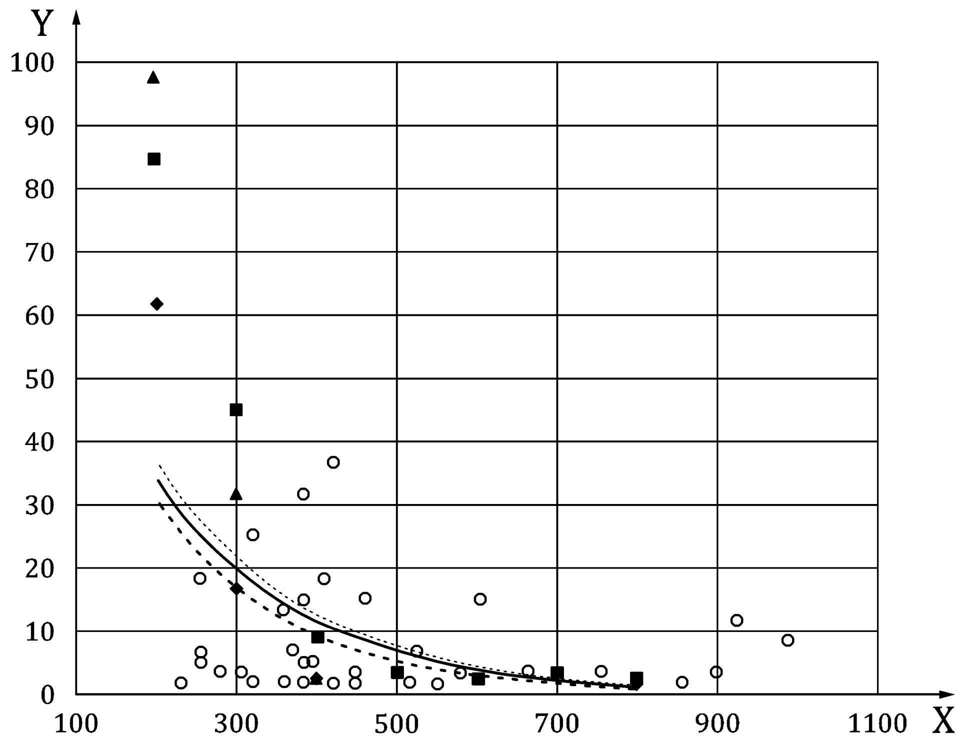
As an example, the procedure described above is presented in Figure F.1 for an area source close to the ground. The open circles indicate all the facility-relevant measured percentage odour times and are marked in relation to distance from the source.

The continuous black line shows a regression curve from the measured percentage odour times of all intersection line measurements. From the meteorological conditions during the intersection line measurements, the dispersion category statistics are estimated, which are then entered in the subsequent dispersion simulation calculation. This means that the dispersion calculation is performed with the weather conditions and percentage odour times that simultaneously prevail during the field inspections.

To derive the necessary source strength, the field inspection results are simulated by means of the dispersion calculation.

With the aid of an estimated source strength, e.g. from olfactory measurements serving as a guide, it is then possible to iteratively adapt the source strength by calculating its dependence on odour frequency (percentage odour time) and source distance in the course of the dispersion calculation (broken lines), until the calculated percentage odour times coincide sufficiently with those obtained by plume measurement.

Once this iteration process has been completed, it can be assumed that the odorant flow rate obtained in this way corresponds to the odorant flow rate at the time of plume measurement. A comparative study [7] has shown that this method yields comparable results even when applied by different laboratories.




**Key**

| | |
|---|---|
| X | Distance from source, preliminary waste water clarification, in m |
| Y | Detection frequency, in % |
| ○ | frequency in % (measured) |
| ▲ | (%) 30 Mou/h (calculated) |
| ◆ | (%) 25 Mou/h (calculated) |
| ■ | (%) 35 Mou/h (calculated) |
| .......... | exponential ((%) 25 Mou/h) |
| ______ | exponential ((%) 30 Mou/h) |
| - - - - - - | exponential ((%) 35 Mou/h) |

**Figure F.1 — Graphic representation of odour detection frequency per measurement point in relation to distance from source (Mou = Mega odour units; ou x $10^6$)**

# Annex G
(informative)

# Calculation of the odour emission rate by reverse modelling – dynamic plume measurement (example)

The primary application of the plume measurement is to estimate the total odour emission rate using reverse dispersion modelling. Although this is not within the scope of the European Standard, examples of the reverse modelling are given in this annex.

The odour emission rate is calculated on the basis of the recorded plume extent, the source characteristics and the local meteorological conditions during the plume measurement.

NOTE To underline the differences between the field measurement and the olfactometric measurement, the odour emissions calculated on the basis of the plume measurement are expressed as sniffing units per second (su/s) instead of odour units per second.

One sniffing unit per cubic meter can be defined as the odour concentration at the border of the plume. This means that every transition point the odour concentration can be defined as 1 su/$m^3$.

It is not possible to quantify higher concentrations (e.g. 5 su/$m^3$) by observation in the field.

A fundamental difference with the European odour unit is the fact that sniffing units are determined by recognition of odour whereas European odour units are determined by detection and not necessarily recognition of the odour type. Typically 1 su/$m^3$ corresponds with a concentration of 1 $ou_E/m^3$ to 5 $ou_E/m^3$.

The method of reverse modelling is applied as follows:

In a first step the plume extent is determined as described in 8.3. Figure E.1 gives an example of a recorded plume extent in the surroundings of an odour source. Each measurement point is indicated by a number. Odour presence points are indicated in black, odour absence points are indicated in grey. The plume extent (indicated by the dotted curve) is determined by the transition points halfway between the last odour absence point and the first odour presence point. For reasons of clear presentation, not all 20 transition points are indicated on the map. Table E.1 gives the data recording sheet of one panel member.

In a second step a dispersion model is used to calculate the average ambient odorant concentrations in the surroundings of the odorant source under investigation. This is done on the basis of the source characteristics (emission rate, height, temperature, flow etc) and the local meteorological data (wind speed, wind direction and stability class) during the measurement. Since the odour emission rate is not known, a fictitious emission rate of for example 5000000 'model units' per second is assumed. The calculated ambient odorant concentrations are expressed in terms of model units per $m^3$.

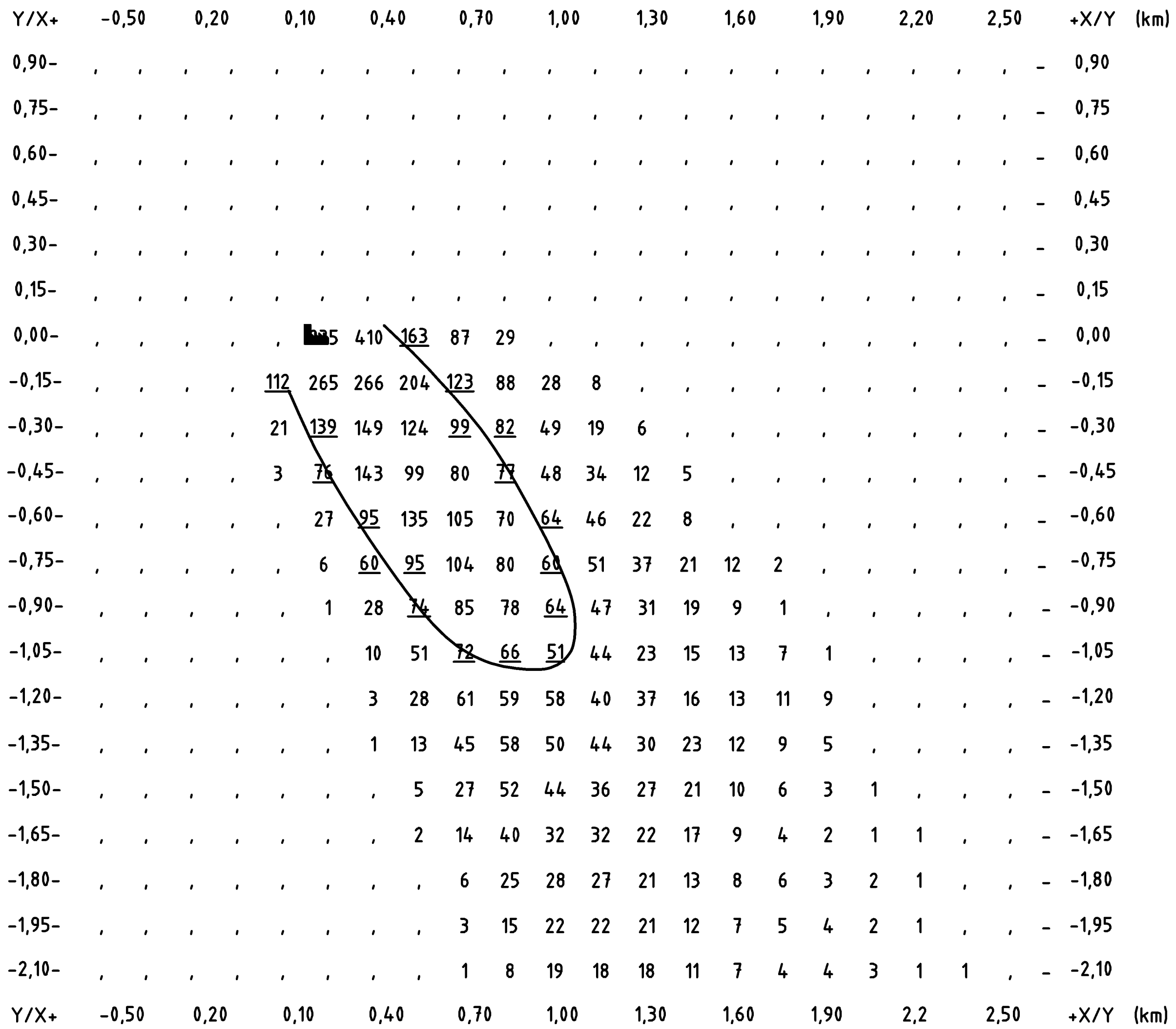
Figure G.1 gives an example of the calculated average ambient odorant concentrations in the surroundings of the odorant source.

After calculating the ambient air concentrations (in model units per $m^3$), the plume extent recorded during the plume measurement is input on the calculated ambient odorant concentration distribution grid and the grid points on the edge of the plume are ticked. By definition, the odour concentration at these edge points is equal to 1 sniffing unit per $m^3$ (su/$m^3$). The average of the ambient odorant concentrations (in model units per $m^3$) of all edge points is calculated. This average value gives the number of model units corresponding to one sniffing unit. The odour emission rate in sniffing units per $m^3$ is finally calculated by dividing the fictitious emission rate by this average value.

Figure G.2 gives an example of the comparison of the calculated average ambient odorant concentrations with the recorded plume extent and of the calculation of the odour emission rate in sniffing units per m³. In the example the fictitious emission rate was 5000000 model units per second. The average of the calculated odour concentrations on the edge points of the plume is 87,33 model units per m³. So the emission rate, calculated by dividing the fictitious emission rate of 5000000 model units per second by the number of 87,33 model units per sniffing unit, is equal to 57254 sniffing units per second.

| Y/X+ | -0,50 | | 0,20 | | 0,10 | | 0,40 | | 0,70 | | 1,00 | | 1,30 | | 1,60 | | 1,90 | | 2,20 | | 2,50 | +X/Y (km) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0,90- | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | - 0,90 |
| 0,75- | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | - 0,75 |
| 0,60- | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | - 0,60 |
| 0,45- | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | - 0,45 |
| 0,30- | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | - 0,30 |
| 0,15- | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | , | - 0,15 |
| 0,00- | , | , | , | , | , | [illegible]5 | 410 | 163 | 87 | 29 | , | , | , | , | , | , | , | , | , | , | , | - 0,00 |
| -0,15- | , | , | , | , | 112 | 265 | 266 | 204 | 123 | 88 | 28 | 8 | , | , | , | , | , | , | , | , | , | - -0,15 |
| -0,30- | , | , | , | , | 21 | 139 | 149 | 124 | 99 | 82 | 49 | 19 | 6 | , | , | , | , | , | , | , | , | - -0,30 |
| -0,45- | , | , | , | , | 3 | 76 | 143 | 99 | 80 | 77 | 48 | 34 | 12 | 5 | , | , | , | , | , | , | , | - -0,45 |
| -0,60- | , | , | , | , | , | 27 | 95 | 135 | 105 | 70 | 64 | 46 | 22 | 8 | , | , | , | , | , | , | , | - -0,60 |
| -0,75- | , | , | , | , | , | 6 | 60 | 95 | 104 | 80 | 60 | 51 | 37 | 21 | 12 | 2 | , | , | , | , | , | - -0,75 |
| -0,90- | , | , | , | , | , | 1 | 28 | 74 | 85 | 78 | 64 | 47 | 31 | 19 | 9 | 1 | , | , | , | , | , | - -0,90 |
| -1,05- | , | , | , | , | , | , | 10 | 51 | 72 | 66 | 51 | 44 | 23 | 15 | 13 | 7 | 1 | , | , | , | , | - -1,05 |
| -1,20- | , | , | , | , | , | , | 3 | 28 | 61 | 59 | 58 | 40 | 37 | 16 | 13 | 11 | 9 | , | , | , | , | - -1,20 |
| -1,35- | , | , | , | , | , | , | 1 | 13 | 45 | 58 | 50 | 44 | 30 | 23 | 12 | 9 | 5 | , | , | , | , | - -1,35 |
| -1,50- | , | , | , | , | , | , | , | 5 | 27 | 52 | 44 | 36 | 27 | 21 | 10 | 6 | 3 | 1 | , | , | , | - -1,50 |
| -1,65- | , | , | , | , | , | , | , | 2 | 14 | 40 | 32 | 32 | 22 | 17 | 9 | 4 | 2 | 1 | 1 | , | , | - -1,65 |
| -1,80- | , | , | , | , | , | , | , | , | 6 | 25 | 28 | 27 | 21 | 13 | 8 | 6 | 3 | 2 | 1 | , | , | - -1,80 |
| -1,95- | , | , | , | , | , | , | , | , | 3 | 15 | 22 | 22 | 21 | 12 | 7 | 5 | 4 | 2 | 1 | , | , | - -1,95 |
| -2,10- | , | , | , | , | , | , | , | , | 1 | 8 | 19 | 18 | 18 | 11 | 7 | 4 | 4 | 3 | 1 | 1 | , | - -2,10 |
| Y/X+ | -0,50 | | 0,20 | | 0,10 | | 0,40 | | 0,70 | | 1,00 | | 1,30 | | 1,60 | | 1,90 | | 2,2 | | 2,50 | +X/Y (km) |

**Figure G.1 — Example of calculated odorant concentrations (in model units per m³) in the surroundings of an odorant source**




**Key**

average odour concentration at the edge points = 87,4 model units per m$^3$ = 1 sniffing unit per m$^3$

fictitious emission rate = 5 000 000 model units per second

emission rate = 5 000 000/87,4 = 57254 sniffing units per second

**Figure G.2 — Comparison of the recorded plume extent with the calculated odorant concentrations to calculate the odorant emission rate**

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**BSI Group Headquarters**

389 Chiswick High Road London W4 4AL UK

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