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ASSESSMENT OF AIR QUALITY IN TERMS OF ODOUR ACCORDING TO SELECTED EUROPEAN GUIDELINES: GRID AND PLUME MEASUREMENTS

Methodology of odour measurements by field inspection in accordance with the guideline VDI 3940 prepared by the Association of German Engineers was described. The examples of plan for grid and plume measurements, scale and measurements of the odour intensity, and measurement data sheet with the identification of odour types according to the VDI were presented.

1. INTRODUCTION

In Poland, the methodology for measuring odour is included in the PN-EN 13725:2007 [1]. However, it refers to the characterization of emission concentrations. In the case of imission, despite the national proposals developed on the turn of the 20th century [2]–[4] and the surveys carried out [5]–[10], there are still neither regulations nor guidelines for assessing ambient odour intensity and hedonic tone of odour tone based on fieldwork. In Europe, such standards were developed by the Association of German Engineers (Verein Deutscher Ingenieure (VDI)) [11]–[12] and [13]–[16]. VDI 3883 [11], [12] concern the use of survey research for assessing odour nuisance and were adopted in Germany, Austria, France and the Netherlands. VDI 3940 standard series [13]–[16] describe the methodology for assessing the odour of ambient air around the selected sources in a grid [14] and in a plume [15].

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2. GENERAL PRINCIPLES OF FIELD ODOUR MEASUREMENTS

In odour field studies (imission measurements) the most important are: the selection of an experienced operator and the assessors (assessors are selected in accordance with the methodology described in the PN-EN13275 [1]), the acquaintance with operations of equipments used in the field (including stopwatch, map with clearly marked measurement points, a pocket compass, manual thermometer and anemometer), preparation of the test plan and strategy for writing up research results (measurement protocols) and the distribution of sampling points.

Before field tests, the team of assessors (odour inspectors) should also be trained in the odour intensity scales and the types of odours occurring in the area under study (defined in the protocol, depending on the odour source). Additionally, the members of the odour inspectors' team should have the opportunity to become well acquainted with the types of odour, for example, during a preliminary reconnaissance of the industrial plant or its surroundings. To evaluate the odour intensity in the field, the assessors should assign their odour annoyance to one of the terms of intensity referencing scale recommended in the VDI 3883 and given in the table [16]. The example of measurement data sheet (protocol) with the codification of odour types (characterization of odour qualities) prepared for the measurements carried out in July 2009 is shown in figure 1.

Table

Scale of odour intensity according to VDI 3883 [16]

Odour	The degree of intensity
Extremely strong	6
Very strong	5
Strong	4
Distinct	3
Weak	2
Very weak	1
No odour	0

Another important issue in field studies is to chose the optimum distribution of sampling locations. First of all, the assessors should not carry out their studies in the vicinity of houses, high walls, fences, edge of forest, roads with heavy traffic, railways, bus stops and taxi ranks [14], [15]. There should not be either pollutant sources such as shafts, manhole covers, snack bars and petrol stations in the vicinity of sampling points. Sampling points located in open areas should be clearly marked and visible even at night.

In the case of field studies conducted in the plume, it is necessary to make an ad hoc decision about the location of sampling points, because the meteorological conditions may change very quickly during the measurements.

Data record sheet

Assessor's Name: Date:

Research area : Location of the measurement point:

Start time of measurement:

End time of measurement:

1st Minute

0 10 20 30 40 50

2nd Minute

0 10 20 30 40 50

3rd Minute

0 10 20 30 40 50

4th Minute

0 10 20 30 40 50

5th Minute

0 10 20 30 40 50

6th Minute

0 10 20 30 40 50

7th Minute

0 10 20 30 40 50

8th Minute

0 10 20 30 40 50

9th Minute

0 10 20 30 40 50

10th Minute

0 10 20 30 40 50

Characterization of odour qualities

A – No odour

B - Farm odour(difficult to define)

C- Slurry

D – Farm odour: breeding pigs

E - Farm odour: breeding cows

F - Agricultural straw, corn odour

G - The smell of the bakery

H - The smell of exhaust from cars

I - The smell of coal burning

J - The smell of fermentation (rot)- to specify

M - Other: to specify

Weather data:

Wind force:

1. no wind 2. slight 3. moderate 4. strong 5. stormy

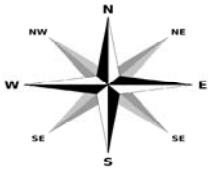
Cloud:

1. no cloud 2.light 3. moderate 4. heavy

Precipitation:

1. none 2. drizzle 3. rain 4.snow 5. mist 6. other

Wind blowing from:



Remarks:

ZE 2009

Fig. 1. Example of measurement data sheet (protocol) with the codification of odour types (characterization of odour qualities) used during field measurements in the area around the selected odour emission source

3. METHODOLOGY

As defined by the odour characteristics, the assessor must test ambient air to recognize the odour. Odour is detected, if the inspector is able to identify accurately its type [13]. A single measurement in field studies is defined as a odour concentration evaluated by the assessor at a receptor point in a certain period of time (at least 10 minutes). In order to determine the percentage occurrence of the odour tested in one cycle of measurements, the inspector tests ambient air at 10-second intervals and stores the identified type of smell (odour) in the protocol [14]. At the end of a 10-minute cycle, 60 ambient air samples are evaluated. In each 10-second time interval, the inspector describes the smell from only one breath, and not from an overall impression of 10 seconds. A total time of measurements should not exceed 20 minutes. The second recommended technique is to make each breath measurement and to start the stopwatch at the beginning and to stop it at the end of each period in which the assessor smells the odour. The percentage of odour occurrence is defined as a ratio of odour detection time to total measuring time.

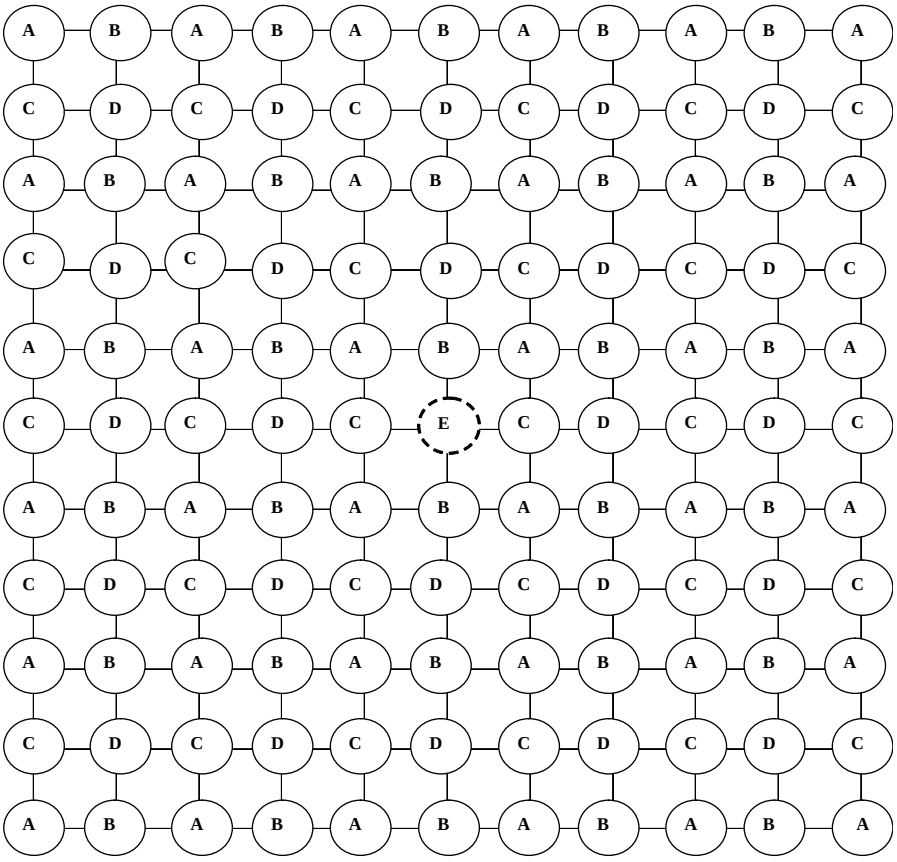
According to the VDI 3940 part 1 [14] field measurements should be carried out for at least 6 months, divided equally between very warm and very cold months. In the case of the industrial plant with variable annual emissions, one year-period of measurements is recommended. It is possible to limit the period of measurements to working-days only.

3.1. GRID MEASUREMENTS

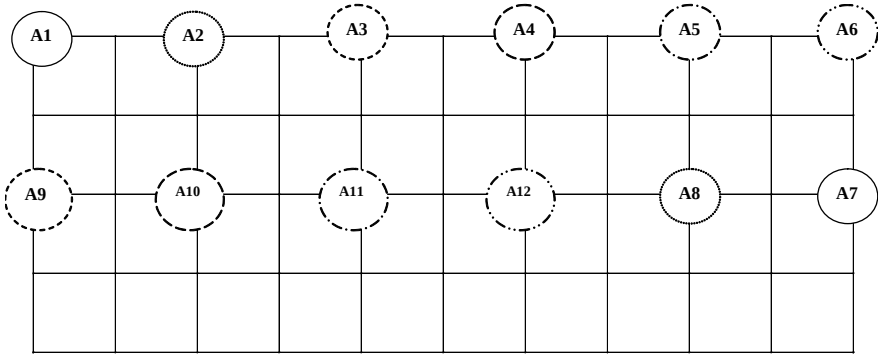
According to the standards adopted in Europe, part one of a VDI 3940 series, a grid measurement is a technique in which the team of assessors register odours in following measuring grids within the area under study for a fixed period of time (e.g. 6 months) [14]. The results obtained are used for assessing the impact of odours (the number of hours per year – odour hours) on air quality.

It is recommended that the area under study be a circle, with the source of odour emissions in its center [14]. Research area is covered uniformly with spaced grid points. Measuring squares are created by connecting 4 points. The grid step is very important for a proper evaluation of odour impact. It is recommended that the step set up initially be equal to 250 m. Depending on the conditions and needs, higher (up to 500 m) or lower (e.g. 125 m, 100 m and 50 m) steps are also acceptable.

In the case of high point sources, odour impact is determined at a distance of 250 m from the edge of the plant and it is recommended that a grid size be 250 m × 250 m. For low point and fugitive sources, located less than 250 m from the nearest buildings, it is possible to reduce the size of squares to cover all possible places where the odour distribution is not uniform. In such situations, the sizes of the squares are 50 m × 50 m. The longer the distance, the larger the size of squares.



(a)



(b)

Fig. 2. Examples of (a) grid measurement plan for total time of measurements and (b) theoretical measurement point/assessors position for two series of measurements carried out during one day of measurement: A – the first day of measurement, B – the second day, C – the third day, D – the fourth day, E – emission source; in part (b) the style of lines of circles refers to the position of exactly the same assessor (on the basis of [14])

According to the VDI 3940, standard measurements have to be carried out in different days and must be planned so that each single measuring point of all square points is independent of each other [14]. This can be possible if measurements are carried out in different days and no adjacent measuring points of a single assessment square are inspected for measuring round. To obtain the representativeness of test results, before starting the measurements, it is necessary to select regular and non-random days of measurements. Ultimately, 52 or 104 measurements should be performed in 6-month or in 12-month periods, respectively [14]. Apart from additional conditions described in detail in [14], it is important for an assessor to work with equal frequency. The involvement of individuals should be clearly specified.

The idea of grid measurement, according to part one of a VDI 3940 series, for different days and nonadjacent measuring points of the squares assessed is presented in figure 2.

3.2. PLUME MEASUREMENTS

A plume measurement (according to the VDI 3940 Part 2) is carried out in order to obtain information on the impact of odour within a plume range [15]. The study takes place under specified weather conditions. As compared to the grid measurements the percentage occurrence of odour in a single measurement (lasting minutes) is a variable for the calculation of odour impact.

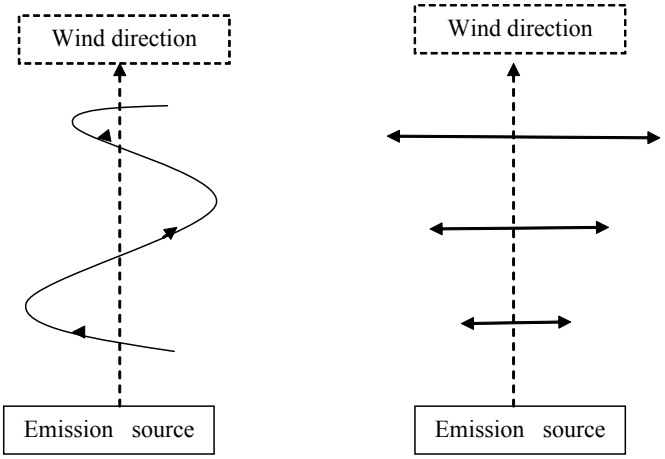


Fig. 3. Idea of localization of odour plume (on the basis of [13]): arrows (↔) indicate the direction of assessor moving in order to determine the approximate extent of odour plume

A plume measurement is related to a specific industrial facility. Therefore, before measurements it is necessary to gather information on manufacturing process and

product types as well as operating hours of the main emission sources discontinuous production processes [15]. Odour from the emitter permeates the air and this process is directly dependent on wind speed and direction and atmospheric stability. Hence, it is necessary to measure some meteorological parameters in a given area during the sampling period. According to German standards these parameters are as follows: wind speed and direction, air stability and ambient temperature. It is also important to register episodic events like rain, fog or snow during the measurements.

According to VDI 3940, part 2, before choosing the measurement points it is necessary to determine the extent of an odour plume [13]. Then, the approximate wind direction is determined. Assessors move away from the plant downwind to the end of a plume. Reaching the plant upwind they can assess the distance from an odour source at which it is perceptible. The plume boundary is reached when the percentage odour time reaches a predetermined percentage (10%) [15]. The idea of localization of odour plume extent is shown in figure 3.

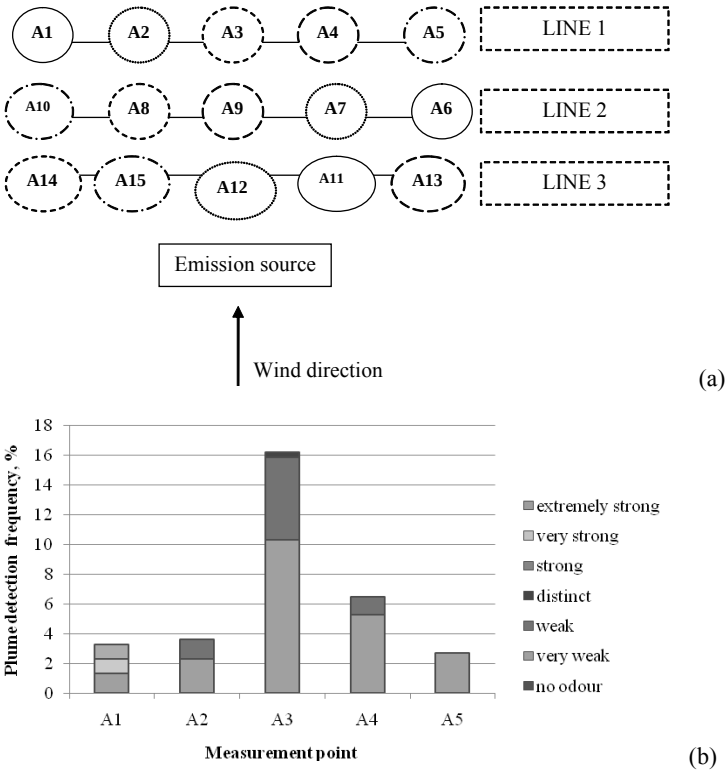


Fig. 4. Example of (a) plume measurement point plan with three intersection lines and (b) the results of plume measurements with investigation of odour intensity (on the basis of [15]): *A*1, *A*2…*A*15 – measurement points/assessor positions; in part (a), the style of lines of circles refers to the position of exactly the same assessor

According to the VDI standard a plume measurement should be carried out for three intersection lines at a minimum. An intersection line crosses at least five measurement points and is plotted by five assessors. The distances between intersections of lines and measurement points depend on the anticipated plume size, which can be affected by the height of emission source, by the odour of air flux, current weather conditions and topography. For consecutive measurements of intersection line, the positions of an assessor should be changed so that no single assessor takes the same position during plume measurements [15]. An example of the plan of plume measurements and results is presented in figure 4.

4. SUMMARY

Available and in-use European standards describe the methods and conditions of measuring odour concentration in the vicinity of the selected emission sources. These measurements are time-consuming and require the assessors, and meet the criteria listed in PN-EN 13725:2007. Conducting field investigations of the grid and plume it is possible to characterize the impact of odour emission source in terms of the percentage occurrence of odour.

The results from grid measurements characterize odour impact during a fixed period of time (e.g. 6 months). Plume measurements give the possibility of assessing the range of odour impact attributed to a specific meteorological situation.

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