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Enhancing VDI3940 Grid Method via In-Field Olfactometry to Obtain Complete Odour Impact Assessment

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This study describes an enhanced method for the measurements of odour impact as per VDI3940 (VDI, 2006), part 1. The methodology incorporates the use of the SM100i in-field olfactometer within the panel of assessors to determine the odour concentration in the assessed site. The results from this enhanced method will allow not only to understand the total odour load determined as per VDI3940 (VDI, 2006), but will also allow us to determine the odour concentration in terms of Odour Units obtained through a reliable in-field olfactometry protocol.

1. Introduction

Odors have been subject of regulation in diverse countries including Canada. Nowadays, odor specialists are studying a variety of factors to determine the impact of odours. These factors are commonly known by the FIDOL acronym *(Naddeo, 2013):*

- Frequency
- Intensity
- Duration
- Offensiveness
- Location

The most common approach used for assessing ambient odour concentrations is source sampling with dispersion modelling analysis *(Bokowa, 2012).* Another approach for assessing the odour impact is conducting field inspections by recording some of the FIDOL factors *(DEFRA, 2010).* In the European Union a common approach for assessing odours in the field is described German Guideline VDI 3940 (VDI, 2006), parts 1 and 2. The proposed VDI 3940 (VDI, 2006), part 1 enhanced method considers the collection of odour samples using a grid to determine the total odour load and the odour concentration in terms of OU_E/M^3. The inclusion of field olfactometers lay on the limitation of the laboratory based instruments to quantify odour concentrations below laboratory detection level (estimated between 20 OU_E/m^3 to 50 OU_E/m^3) (*Gostelow et al, 2003).*

2. Study General Principles

This study was developed for the Environmental Protection Department of a refinery. The refinery had been receiving a large number of complaints due the proximity to urban developments. Plant's location and Grid nodes (sampling points) are showed in Figure 1

3. Assessor Selection

For this study, the panel members were selected in accordance to section 3.3 of the VDI 3940 part 1 guide and according the methodology described in the EN 13725:2003 (CEN, 2003) Standard.

4. Instruments Used

The instruments used for field assessments according the VDI 3940 part 1, were: Digital chronometer, GPS device, and field sheets. To assess field odour concentrations at grid points, SM100i portable olfactometers

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were used by 2 panel members. The instrument was set up to conduct Yes/No tests according the EN13725:2003 (CEN, 2003). Weather data was gathered using a portable Davis Vintage Pro Plus meteorological station.

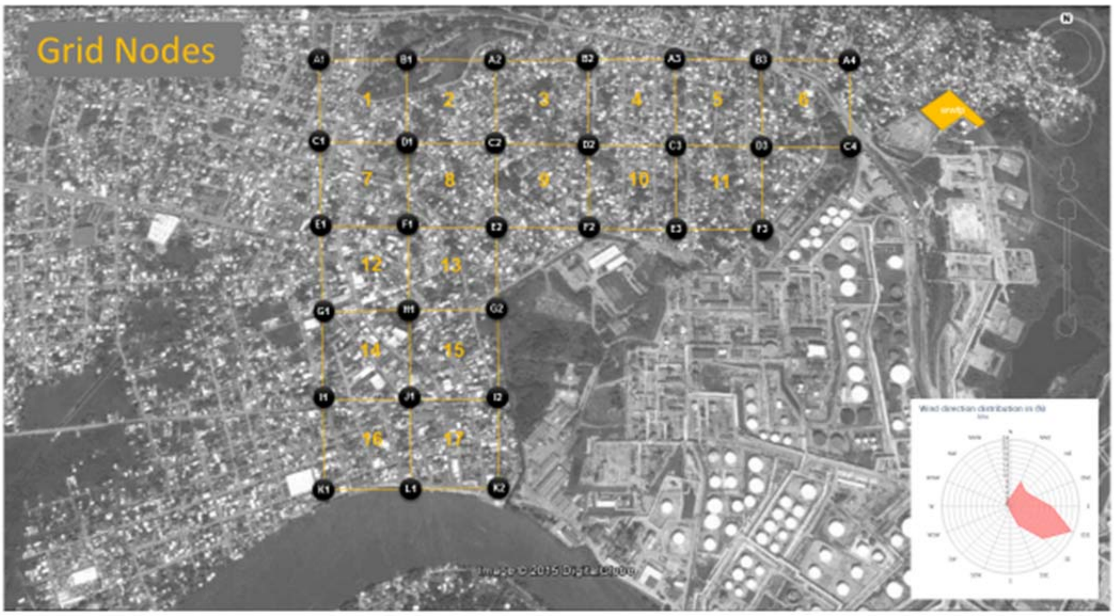

Figure 1 Refinery location and grid points

5. Data collection

An initial protocol was carried out inside the plant to identify potential odorous sources and to establish the baseline for this study. An initial survey was carried out to identify and determine the odour characteristic using Curren's odour wheel (Figure 2). The most representative odour characteristics were: Chemical (Gasoline/ Oil), Sulphur (Rotten Egg, Natural Gas), Burnt (Exhaust, Burnt Rubber).

Figure 2 Refinery odour wheel (Curren 2012)

6. Measurement principles

To assess odours from each assessing point, a team of 1 administrator and 3 assessors was created. The assessor (A) was responsible to carry out the measurements according the section 4.1 of the VDI3940 part1. The two assessors (B) used the SM100i portable olfactometer to evaluate odour concentration. The assessors were in parallel and close to the assessor (A). The assessors (B), analyzed the ambient air in 5 duplicated events within a period of ten minutes. The portable olfactometers were preset in auto mode (Figure 3), to say, the equipment produces automatically dilution ratios until the odour is detected by the assessor. During the assessment, the equipment presents blanks randomly. This presentation method is known as Yes/No and is described in the EN13725:2003 (CEN, 2003) standard.

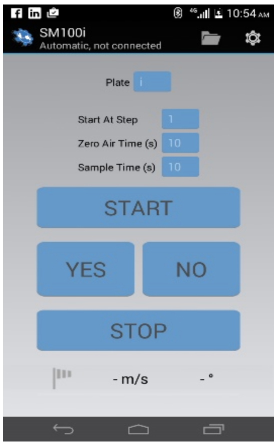

Figure 3 SM100i yes/no method user interface

7. Protocol for data collection

The assessments were carried out according (Figure 4) per grid node:

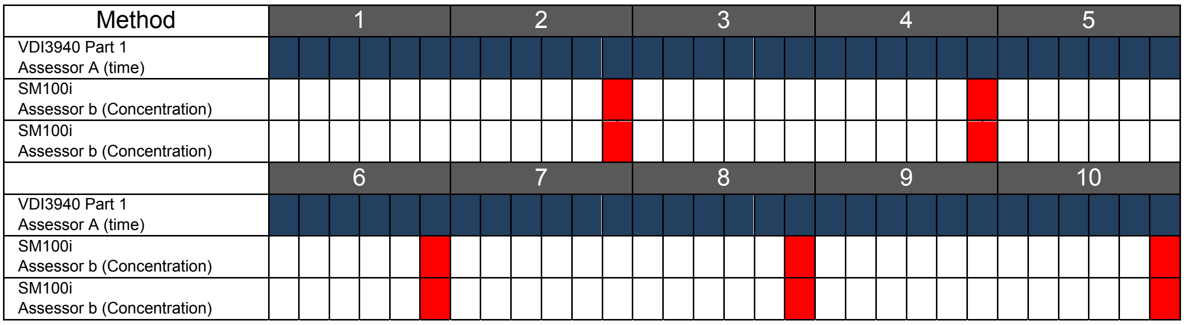

Figure 4 Data collection schedule per grid node.

From figure 4 Blue squares represents the evaluation of ambient air every 10 seconds that was carried out by the assessor (A) and according the methodology of the VDI3940 (VDI, 2006), part 1. Red squares represent the assessments carried out by the assessors (B) to verify the odour concentration using the portable olfactometer.

For time data collection in the assessment points the assessors followed the criteria determined by the VDI 3940 (VDI, 2006), part 1. A total of 14 assessors were evaluated and used for this study. For odour concentration evaluations the administrator and the assessors (B) followed this protocol.

Previous to data collection

- Administrator activities
- Prepared the forms to collect the data in the field that were used by the assessors (A)
- Verified correct operation of the weather station wireless console, verifying the hour, battery state, and the correct reception of the data transmitted form the weather station.
- Verified the power state of the tablet and the SM100i servo controller.
- Verified the state and the pressure of the SM100i making sure the pressure in the gauge showed 80psi as per the operating manual.
- Verified that the cylinders were filled completely to reach the required duration.
- Reviewed that the SCBA tanks were filled in the case that a recharge was necessary in the field.

During the data collection

The assessor (B) initiates the procedure turning ON the servo controller and testing the SM100i face masks and verify proper sealing. This operation was performed before the assessor reached the assessing point to avoid exposure to predominant odours and to prevent sensitivity loses before the test started. The assessor initiates the SM100i application on the tablet once he/she reaches the assessing point, the application was configured with the sample presentation time of 10 seconds. The assessor starts the test indicating if he/she perceived the odour to record their response in the tablet, the assessor continues until the application recognizes 2 positive responses to thereafter calculate the odour concentration in OU.

8. Results and discussions

The odour impact study was performed in 29 nodes, which were used to create 17 assessment squares according figure 1. A total of 52 in field inspections were carried out per grid square for a period of 6 months, therefore a 3120 measurements using the VDI3940 (VDI, 2006), part 1 methodology and a total 520 odour concentration readings per assessed square were performed.

Odour impact characteristic

To calculate the exposition percentage time for each assessing point equation (1) was used.

$$Pod = \left(\frac{\mathrm{L+}}{\mathrm{R}}\right) X100 \quad (1)$$

Where:

P_{od} = percentage odour time at a measurement point

L_{+} = number of positive responses per measurement cycle and measurement point.

R = number of odour samples.

The time percentage evaluation results obtained (13 per node) in which the refinery odour characteristic were present in more than 10% of the time are showed in Figure 5.

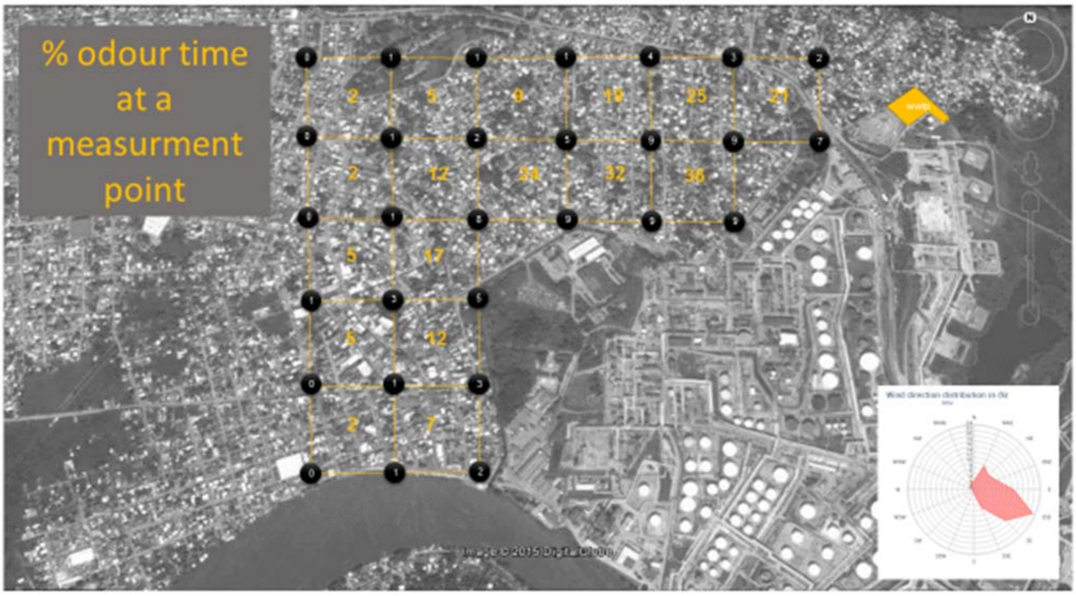

Figure 5 Percentage odour time per node and grid squares.

Once all the positive measurements were obtained as percentage time in which the odour was present in the assessed point (P_{od}), the odour impact characteristic was calculated. To calculate the odour impact characteristic per assessment square, it was considered the number of hours that each assessed square was evaluated divided by the total number of samples that were taken, this was to obtain the odour impact characteristic as the relative frequency of odour hours. The results are shown in the image that follows.

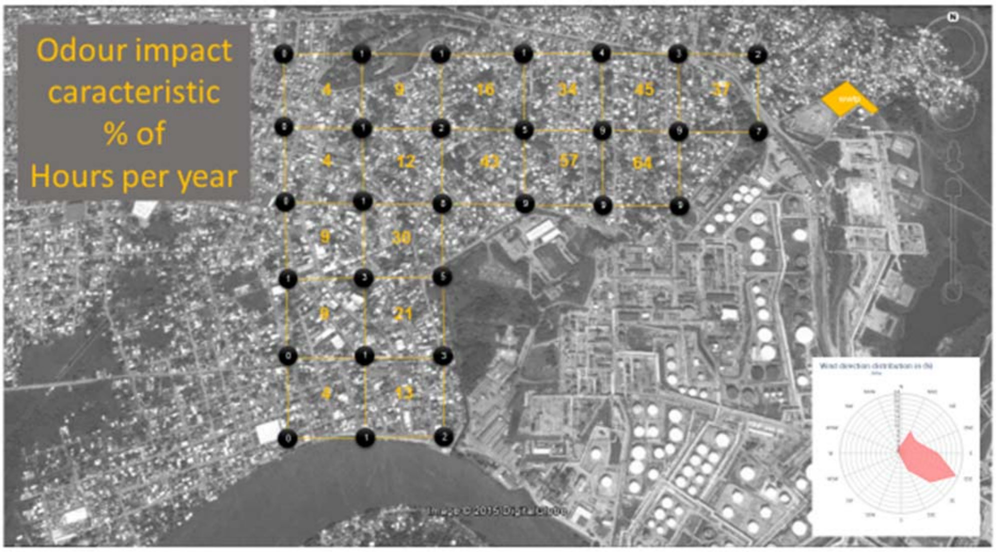

Figure 6 Odour impact characteristic per node and grid squares.

Odour Concentration calculation

The results for odour concentration were calculated automatically in OU/M^3 by the SM100i application. Each node (measurement point) a total of 13 measurement cycles were performed (10 Min/ each). All cycles are compounded by 10 odour concentration evaluations expressed in OU/m^3 obtained from the 2 assessors (B). A total of 130 measurements were carried out per square node, totalizing 520 evaluations per grid square.

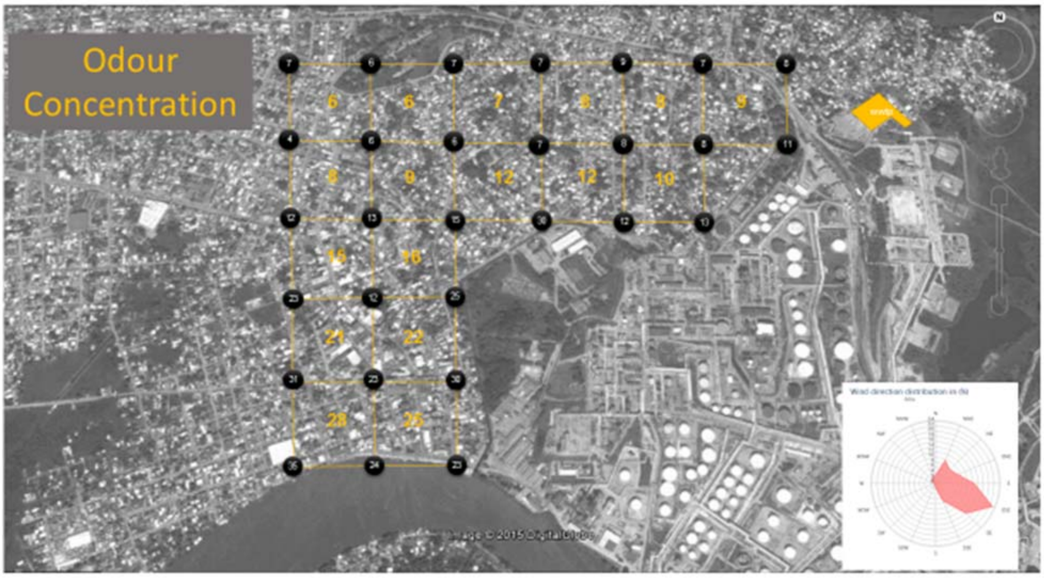

Figure 7 Ambient odour concentration per node and grid squares.

9. Conclusions

FIDOL factors are used typically for odour impact assessment. The main objective of this study was to propose an enhanced method to the VDI3940 for a more comprehensive impact assessment. VDI 3940 guideline does not consider the measurement of odour concentration within the assessed area, therefore the utilization of the field olfactometer was a significant contribution for odour impact assessment.

From the results of this study, it can be concluded that according to the numbers shown in Figure 5, grid squares numbers 8, 9, 10, and 11 were the most impacted with the presence of characteristic odors related to refinery operations. In the aforementioned grid squares, is observed a significant presence of odors of up to 64% of the time (Figure 6), which might be supposed as a potential problem due to the presence of odors. Among the odour characteristic of the refining of crude oil, the most common was the smell of burning from incinerators (2 units), chimneys (2 units) and one high burner corresponding to the Sulphur recovery plant.
The analysis of odor concentration was a valuable contribution to observe certain phenomena related to irregular emissions. Effects of gas flaring impacted significantly the node F2, which reached 30 OU/m^3. It is important to notice that within the measurement cycle for node F2, levels of 240 OU / m^3 were encountered, and as a consequence this levels affected the average obtained for that node. For the nodes in the square grids numbers 14, 15, 16, and 17, high odour concentrations were detected. These concentrations appeared intermittently but they did not exceeded the percentage of odour time P_{od} in more than 10%, and therefore they were not considered as positive measures for the annual impact characteristic. Within the square grids 14, 15, 16, and 17, concentrations ranging from 21, 22, 28, and 26 odor units were encountered, respectively. From the above we conclude that even though the square grids number 9, 10 and 11 showed the high percentages of odour impact (high frequency of appearance), the average concentration was between 10-12 OU /m^3. On the other hand, squares 14, 15, 16 and 17 presented the highest odour concentration.

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