pilot study to investigate airborne benzene levels in service station kiosks

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SUMMARY

This report describes the results of a small pilot study which was carried out in two service stations in the UK. The purpose of the study was to compare the concentrations of benzene in the forecourt air with that in the kiosk at each of the service stations and possibly identify reasons for any observed differences.

The results showed that the ambient concentrations of benzene on the forecourts of the two service stations differed significantly. A possible explanation for this observation is that the service station with the lower ambient benzene concentrations had a stage I vapour balancing system installed, thereby reducing releases of hydrocarbons into the air during tanker discharging.

The results also showed that for each service station, the benzene concentration inside the kiosk was similar to that immediately outside. It was also shown that increases in ambient benzene concentrations following forecourt activities, was followed by a corresponding increase inside the respective kiosk.

1. INTRODUCTION

During the period 1990-1992, CONCAWE carried out a study of airborne benzene levels around a number of European service stations (CONCAWE, 1994a). Whilst conducting the study, air samples were also taken from inside the service station kiosks, and the benzene levels were found to be less than 320 µg/m^3 (i.e. <100 ppb) (CONCAWE, 1994b). Although these levels are far below current occupational exposure limits for benzene, they are higher than those recorded at the boundary fence.

To study this further, CONCAWE carried out a pilot study at two service stations during March-April 1996 to investigate the presence of benzene and other hydrocarbon vapours and to ascertain their possible routes of entry into the service station kiosks. The results of the pilot study are presented in this report.

2. THE SURVEY

2.1. SELECTED SERVICE STATIONS

Two high throughput service stations in the United Kingdom, both open 24 hours a day, were selected for the pilot study:

Station A

This is a modern station, which had an average daily throughput of gasoline of approximately 15,000 litres during the survey. The kiosk, situated on one side of the forecourt on the opposite side to the gasoline storage tanks, has windows which could not be opened and is fitted with an air recirculation system. As far as could be ascertained (from the engineer), the make-up air is provided via the entry door as customers enter and depart. Vapour balancing is utilised during bulk fuel deliveries whereby vapour from the gasoline storage tanks is displaced to the delivery tanker. The dispenser pumps are located between the tanks and the kiosk, and approximately 11.5 metres from the latter (**Diag. 1**).

The station is situated in a semi-rural location, adjacent to, and with direct access from, a main road.

Station B

This is an older station and had an average daily throughput of gasoline of approximately 17,200 litres during the survey. The kiosk, situated between the dispensing pumps and the tank vents, (approximately 5.4 metres from the kiosk), (**Diag. 2**), had no mechanical ventilation system and was fitted with opening windows to improve the natural ventilation. Vapour balancing was not installed and the storage tanks vented directly to atmosphere. Storage tank vent lines are attached to the outer left hand wall of the kiosk (as viewed when facing the front of the kiosk).

The station is situated on a major cross-roads and traffic passes on two sides of the kiosk. As a consequence, there is a greater potential for vehicle exhaust emissions to influence the overall level of hydrocarbons on the service station forecourt. From photographs, it appeared that buildings are located on at least two sides of the perimeter.

Neither station was equipped with a Stage II vapour recovery system.

The benzene content of the gasolines dispensed was in the range 3.0 - 4.6 (leaded) and 4.6 - 4.8 (unleaded), on a percent weight/weight basis.

2.2. MEASUREMENT OF BENZENE LEVELS

Ambient benzene levels (µg/m^3) were measured, inside and immediately outside the kiosks, using diffusive samplers for 14 day periods. The samplers were packed with 200 mg of Chromosorb 106 and fitted with diffusive heads containing a silicone membrane. Samplers were in positions where they would not interfere with normal kiosk activities and where they would be out of reach of customers. Generally, they were located close to, and parallel with the kiosk ceiling (see **Diags 1** and **2** for disposition of the samplers). One sample was taken directly outside the kiosk; for this the sampler was fixed onto the outside of the kiosk wall.

After collection of the air samples, the diffusive samplers were thermally desorbed to recover the adsorbed material and analysed using a gas chromatograph fitted with a flame ionisation detector (BP)[1]. Data on other hydrocarbons present, in addition to those for benzene, were also recorded on the chromatograms.

2.3. MEASUREMENT OF TOTAL HYDROCARBONS

Ambient total hydrocarbon levels (ppm) were determined using:

- continuous monitoring equipment at two fixed points, one inside and one outside the kiosk. Air from the two locations was sampled by means of a PTFE tubing assembly and pump, fitted with a switching unit in the sampling train, allowing air to be drawn alternately from each location, every 60 seconds. The air was analysed by a Research Engineers AUTOFID instrument which was calibrated against air/methane standard mixtures and the output connected to a chart recorder. The instrument response was adjusted to ensure that all the readings indicating total hydrocarbon levels (methane equivalents) remained on the chart recorder.

- A Century Systems Organic Vapour Analyser (OVA), which is a direct-reading instrument, was used to determine instantaneous hydrocarbon levels at selected positions on the service station forecourts and inside the kiosks. The purpose was to identify possible points of ingress of hydrocarbon into the kiosks and to study the decay of peak levels of airborne hydrocarbons within the kiosks.

- Wind speed and direction, and temperature data were recorded.

1 BP Method MT-HSE-06. The collection and determination of volatile organic compounds in air using diffusive tubes. (This method is based on UK MDHS 43, 50, 63 & 66 ISO Standard TC/146/SC2/WG4)

3. RESULTS

3.1. BENZENE IN AIR

14-day benzene-in-air samples were collected from seven sampling points inside each of the kiosks at the two service stations (samples 1-7) and from a single sampling point directly outside each kiosk (sample 8). The results are shown in **Table 1.** The benzene levels inside the kiosks ranged from 9.3 to 13.6 µg/m^3 (mean 10.9 µg/m^3) at service station A and 74 to 99 µg/m^3 (mean 87 µg/m^3) at service station B. The corresponding benzene levels outside the kiosks were 11.5 µg/m^3 and 96 µg/m^3 respectively. For each kiosk, the levels inside and outside the kiosk (averaged over a 14 day period) were essentially the same.

Table 1 Airborne Benzene Levels (µg/m^3) Inside and Outside the Service Station Kiosks

	Inside Kiosk								**Outside Kiosk**
Sample No. / Service Station	1	2	3	4	5	6	7	Mean (1 - 7)	8
A	9.3	9.9	10.2	10.2	10.9	11.5	13.6	10.9	11.5
B	74	84	84	87	87	90	99	87	96

3.2. HYDROCARBON PROFILES

Service Station A

The gas chromatograms for all seven diffusive air samples within the kiosk indicated that there was a higher proportion of higher boiling point hydrocarbons in the kiosk atmosphere than in the ambient air outside. Typical chromatograms for inside and outside air are given in **Fig. 1**.

Service Station B

Gas chromatograms for the air samples from both inside and outside the kiosk of service station B were similar, indicating a similar hydrocarbon composition in each environment.

3.3. TOTAL HYDROCARBONS-IN-AIR

3.3.1. Continuous monitoring

Figures 2-6 show the relative hydrocarbon levels inside and outside the kiosks during periods of continuous monitoring including a time for which there was a delivery of fuel to one of the service stations.

Service Station A

Figure 2 indicates the relative hydrocarbon levels during a period of low activity, in circumstances where the kiosk was upwind of the fuel dispenser pumps. The levels (maximum 3 ppm) were consistently higher inside the kiosk, the differences ranging from less than 1 ppm up to 2 ppm.

Figure 3 illustrates the relative hydrocarbon levels in circumstances where the kiosk was downwind of the fuel dispenser pumps. The outside measurements showed several transient peaks (approx. 10 seconds) up to 6 ppm. Some fluctuations also occurred within the kiosks but to a much lesser extent.

Figure 4, also corresponding to downwind conditions, demonstrates an 'expanded' set of airborne hydrocarbon data showing that the ambient hydrocarbon levels inside the kiosk are generally higher than outside (by about 0.8 ppm), and relatively constant, during each sampling period. In contrast, the lower ambient readings outside the kiosk vary considerably, both during and between the sampling periods.

Service Station B

Figure 5 illustrates similar trends to those seen at service station A (cf. Fig. 2) but the variation in the levels within the kiosk was slightly less.

Figure 6 indicates the effect of a delivery of bulk fuel to the service station. High levels of hydrocarbon vapour (>> 100 ppm) were initially recorded, both inside and outside the kiosk after delivery. The rate of decrease of hydrocarbon levels was similar inside and outside the kiosk, but the level inside remained slightly higher.

3.3.2. Direct-reading measurements

In general, measurements of total hydrocarbons taken downwind of a vehicle refuelling gave short peaks in excess of 1000 ppm, although typically the hydrocarbon levels in the forecourt areas were less than 20 ppm.

At service station A, where direct-reading measurement were undertaken on seven consecutive days, the levels measured in the public areas of the kiosk peaked at 100 ppm during tanker unloading at station B but were generally less than 5 ppm. There was little or no difference in airborne concentrations between different locations in the kiosk.

In service station B it was noted that when all the kiosk windows and doors were open in kiosk B, there was a steady increase in the hydrocarbon levels within the kiosk.

A thorough survey of the possible points of ingress of hydrocarbon vapour at the two service stations, e.g. via ducts containing cables that connect the dispensing pumps and the console, showed no evidence of elevated levels of hydrocarbon vapour.

4. DISCUSSION

The 14-day sampling results (**Table 1**) show that the benzene levels inside and outside the kiosks are similar. However, corresponding levels at the two kiosks differed considerably, those at service station B being far higher (87 and 96 µg/m^3 respectively).

There was no indication in either kiosk that hydrocarbon vapours were "tracking" into the kiosks via cable or other ducting, although this situation had been identified at one service station in a previous CONCAWE study (CONCAWE, 1994a).

Main Influences

The large differences in the benzene levels between the two service stations is associated with the differing service station layouts, gasoline delivery technologies, adjacent road networks and associated traffic volumes. Service station A (mean kiosk benzene level 10.9 µg/m^3) had the greater distance between the dispenser pumps and the kiosk and a functioning vapour balancing system installed for gasoline deliveries. By comparison, for service station B (mean kiosk benzene level 87 µg/m^3) there was a slightly greater sales volume, the distance between the dispenser pumps and the kiosk was half that of service station A and there was no vapour balancing system for utilisation in connection into gasoline deliveries.

Kiosk Ventilation

In these cases, the kiosk ventilation appeared to have a relatively minor influence on benzene levels in the kiosks in this particular study. One depended on recirculation ventilation (A) the other (B) on natural ventilation, but both kiosks experienced airborne levels of benzene which were very similar to their relevant external levels.

5. CONCLUSIONS

5.1 The mean airborne benzene levels recorded in the two kiosks (11 and 87 µg/m^3) were within the range of benzene-in-air concentrations measured in service station kiosks in previous CONCAWE studies (CONCAWE, 1994a, CONCAWE, 1994b). Moreover, the results for the air samples taken from different locations within the same kiosk indicated little spatial variation on the airborne benzene levels.

5.2 In general the pattern - and the magnitude - of the airborne hydrocarbon levels within the service station kiosks were similar to the ambient levels recorded immediately outside the kiosks. Neither kiosk ventilation system (i.e. natural and recirculation) was capable of preventing the ingress of benzene/other hydrocarbons into the kiosks.

5.3 The major influence on the average ambient levels of benzene/other hydrocarbons on the service station forecourts appeared to be directly related to the use, or otherwise, of a vapour balancing or vapour return system during gasoline deliveries to service stations;

5.4 The average levels at the service station with vapour balancing were similar to outdoor ambient benzene levels (approx. 6 µg/m^3) expected in an urban area (CONCAWE, 1994a). Although floors and cable ducting are potential sources of ingress of hydrocarbon vapour into service station kiosks, in this study, both were effectively sealed.

5.5 The increase of heavier hydrocarbons in kiosk A may have arisen from the presence of consumer goods within the kiosk (e.g. newspapers) and/or possibly from customers' clothing/shoes contaminated with hydrocarbons present in the service station forecourt environment.

6. REFERENCES

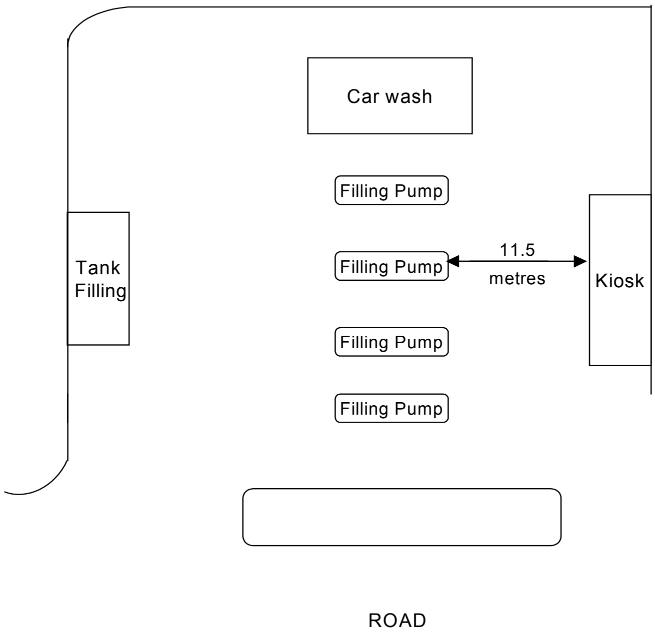
CONCAWE (1994a) A preliminary study of ambient air concentrations of benzene around service stations and distribution terminals in Europe. Report No. 94/53. Brussels: CONCAWE

CONCAWE (1994b) Review of european oil industry benzene exposure data (1986 - 1992). Report No. 7/94. Brussels: CONCAWE

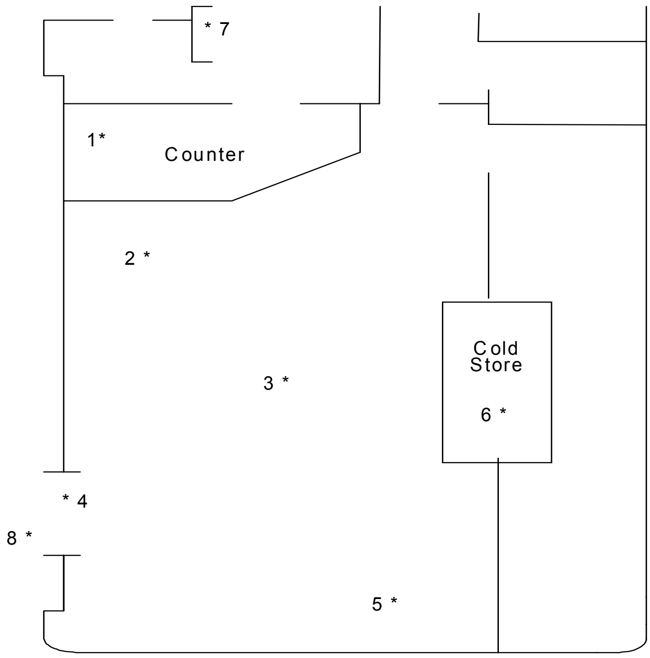
Deutscher Bundestag (1993) Hydrocarbon emissions from newsprint. Drucksache 12/4459. 12. Wahlperiode 03.03.93

Diag. 1 Service Station A (not to scale)

Site Layout



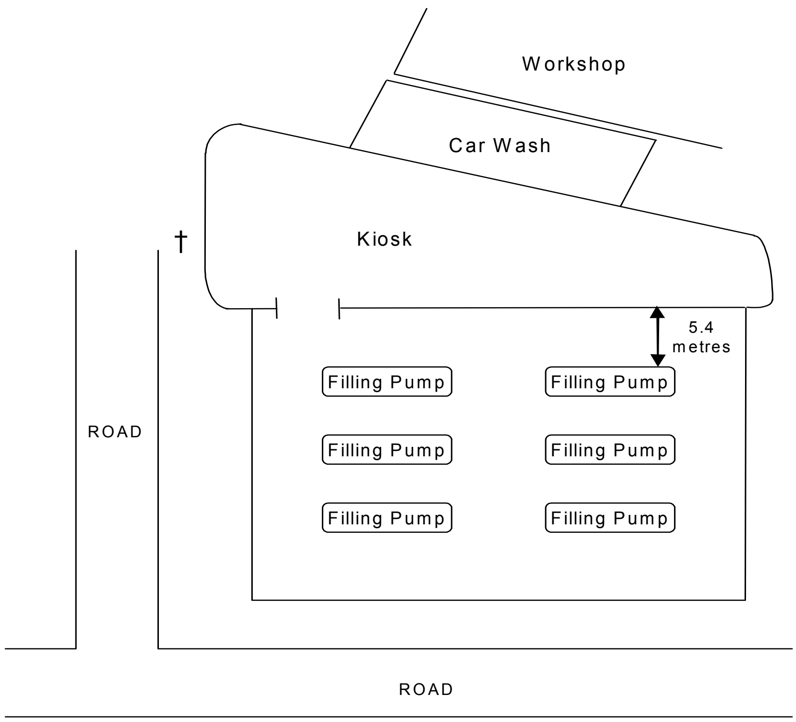
Layout of Kiosk



Numbers indicate sampling positions

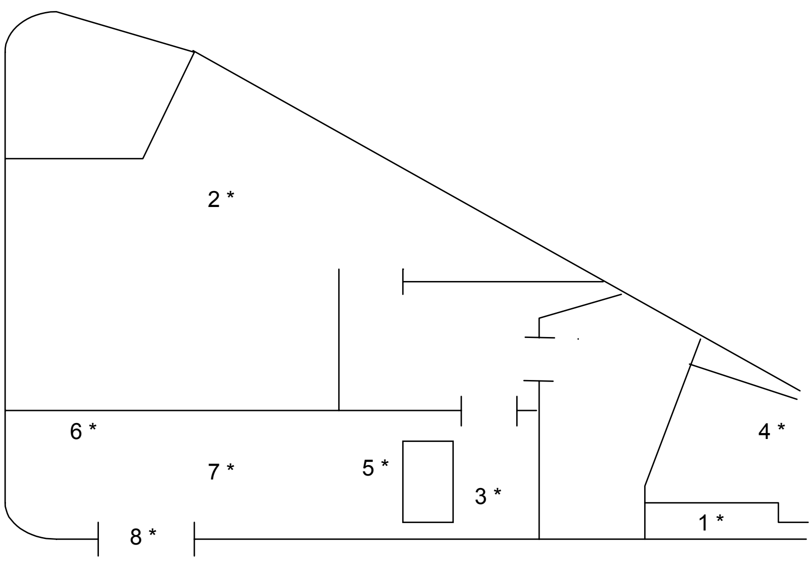
Diag. 2 Service Station B (not to scale)

Site Layout



† Storage tanks believed to be in this vicinity

Layout of Kiosk



Numbers indicate sampling positions

Figure 1 Gas Chromatographic Traces from Air Samples taken inside and outside the kiosk (A)

Figure 2 Relative hydrocarbon levels during a period of low activity, in circumstances where the kiosk was upwind of the fuel dispenser pumps

Figure 3 Relative hydrocarbon levels in circumstances where the kiosk was downwind of the fuel dispenser pumps

Figure 4 An ‘expanded’ set of airborne hydrocarbon data

Figure 5 Relative hydrocarbon levels during a period of low activity (service station B)

Figure 6 Relative hydrocarbon levels associated with the delivery of bulk fuel to service station B

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