



# Ventilation Effectiveness Study

at

**St. Stephens Tavern, Westminster**  
**13th – 15th October 2005**

Report by:

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**These results are based upon the readings obtained between the 13th – 15th October 2005 and relate only to the data recorded on the dates when they were recorded.**

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## **1. Executive Summary**

A ventilation and filtration unit study was carried out at St. Stephen's Tavern, Westminster from the 13th – 15th October 2005.

Levels of Carbon Dioxide, as an indicator of ventilation effectiveness, and Carbon Monoxide and airborne particulates, both constituents of Environmental Tobacco Smoke, were recorded with the ventilation off and on.

The results indicate that with the ventilation on, there is a substantial reduction in the levels of the contaminants being monitored.

In conducting the study a number of limitations were identified, and suggestions made to improve the reliability and robustness of any future studies.

## 2. Introduction

This report presents the findings of a ventilation effectiveness study carried out at St. Stephen's Tavern, Westminster from the 13th – 15th October 2005.

St. Stephens Tavern is arranged as two interconnecting rooms with a non-smoking mezzanine level and is located opposite the Palace of Westminster. The venue is located in on a busy main road and due to its location is subject to security restrictions. The total floor area is approximately XXX m<sup>2</sup> with a total volume of XXXm<sup>2</sup> due to its high ceiling and mezzanine level.

The pub benefits from an installed conventional (high level supply and extract) ventilation system providing 12-15 air changes per hour. The equipment is arranged to allow a positive flow of fresh air from the bar counter area to the public area.

The approximate costs of upgrades to the ventilation for this test was £8,000.

There were no restrictions on smoking in the ground floor bar area at the time of the research, although the mezzanine remained non-smoking.

The aim of this report is to quantify the effectiveness of the ventilation system, using real time data recording of a sample of air quality and Environmental Tobacco Smoke (ETS) markers. The ventilation rate was lower than would be used if there were no filtration units fitted. The innovative use of fabric diffusers allowed the total air volume to be delivered to the bar serving area, optimising air quality in the serving area. These diffusers can deliver higher air volumes than conventional metal diffusers whilst avoiding noise and draught problems.

The airborne contaminants that were measured can be harmful in high concentrations. The levels of acceptable worker exposure are set out in Workplace Exposure Limits set by the Health and Safety Executive. There are also further levels at which discomfort can occur, these have been noted below.

### **3. Methodology**

The monitoring was conducted on a Thursday and Friday as these days were identified as busy days of the week, so avoiding periods of decreased activity. For a brief time on Thursday early evening the ventilation equipment was turned off.

Continuous real-time monitoring was carried out to ensure that peak exposure conditions were captured and to measure baseline levels of markers during the overnight period of no occupancy. The sampling devices were located in the bar serving area at a height approximating to the breathing zone. Additionally, readings for some markers were taken in a customer area during the busy periods.

This pub's layout is unusual in that it is divided into two interconnecting rooms on the ground, with a non-smoking mezzanine level, giving the venue a high total volume in relation to its floor space. Additionally, the building has Grade 1 listing and is bombproof due to its proximity to the Houses of Parliament. All of these factors complicate the task of ventilating effectively.

The sampling devices used were the Dustrak Aerosol Monitor Model 8520 by TSI Inc, using the 2.5 µm inlet conditioner and a flow rate of 1.7 l/min, and the Q-Trak Plus IAQ Monitor Model 8554 by TSI Inc.

During the busy periods an hourly cigarette count was taken. Levels of carbon dioxide, carbon monoxide and respirable suspended particles (PM 2.5) were recorded. Temperature and relative humidity were also recorded.

A number of other particle phase or vapour phase markers may be monitored when assessing ventilation performance in dealing with ETS, but to do so in this study would have extended the timescale and costs unacceptably. The aim of this study was to demonstrate the effectiveness of a ventilation system in dealing with ETS by monitoring a solid (PM 2.5) and a gaseous (CO) constituent. From these results it is possible to indicate the likely effectiveness of the system for a wider range of ETS constituents.

#### **3.1 Carbon Monoxide**

Carbon monoxide is a constituent of Environmental Tobacco Smoke (ETS) but is sometimes considered unsuitable as an ETS marker, as it has other sources such as gas fires. The advantages of ease of real-time recording and the existence of recognised occupational exposure standards for Carbon Monoxide outweighed this concern. Additionally any Carbon Monoxide from other sources will make the test conditions more onerous, not less.

The long-term exposure limit (8 hour time weighted average) for Carbon Monoxide is 30 parts per million (EH40/2002 Health and Safety Executive).

### **3.2 Carbon Dioxide**

Carbon dioxide is a product of respiration and occurs naturally in the atmosphere. It is therefore usual to use Carbon Dioxide as an indication of the effectiveness of the ventilation system in occupied buildings. For the purposes of this study it is important to establish that the ventilation is performing effectively.

A figure of 12000 ppm is identified by the World Health Authority as the level of concern (BSRIA Technical Note 2/2002). This is very unlikely to be reached in a building in normal occupation. The long-term exposure limit (8 hour time weighted average) for Carbon Dioxide is 5000ppm (EH40/2002 Health and Safety Executive). For comfort and adequate odour dilution, a CO<sub>2</sub> level of 1000 ppm is recommended.

It is also worth noting that Carbon Dioxide is present in fresh air at around 400ppm and so, unlike other indicators, Carbon Dioxide will not tend towards zero.

### **3.3 Respirable Suspended Particles (PM 2.5)**

Respirable Suspended Particles (PM 2.5) are a constituent of Environmental Tobacco Smoke and serve as a marker.

The long-term exposure limit (8 hour time weighted average) for respirable particles is 4 mg/m<sup>3</sup> (EH40/2002 Health and Safety Executive). However, figures for traffic related airborne particles currently under review by DEFRA suggest annual exposure limits of a mean value of 0.04 - 0.05 mg/m<sup>3</sup>. It should be noted that this figure relates to “fresh air” rather than indoor air and is an annual rather than an 8 hour average.

### **3.4 Temperature**

There are requirements under Health Safety legislation relating to the provision of a satisfactory thermal environment. Monitoring satisfies two objectives, firstly to establish that in improving the air quality the ventilation is not having a negative impact on thermal comfort, and secondly to establish whether it is actually enhancing thermal comfort. Ideally temperatures should be maintained between 19 °C and 24 °C, and relative humidity between 40 and 70%, (CIBSE Guide A, 1999).

### 3.5 Cigarette Count

The number of cigarettes consumed was measured on an hourly basis through a count of the cigarette butts collected in ashtrays to produce a measure of cigarettes/hour. To gain a fair comparison with other studies in venues of different sizes the cigarette count has been divided by the volume of the premises, to provide a measure of cigarettes/m<sup>3</sup>/hour. The highest level of smoking to date measured in these field trials was in this venue with a peak of 0.2 cigarettes/m<sup>3</sup>/hour.

## **4. Results**

### **4.1 Carbon Monoxide**

The results of the monitoring for CO can be seen in Figures 1, 2, 6 and 7. Figure 1 shows that when the ventilation is switched off contamination steadily rises but drops back to its previous level as soon as the ventilation is switched back on. Figure 2 shows that when the ventilation is run continuously, the CO levels are detected at a resolution of 0.2 ppm. Figure 6 shows that the CO levels dropped overnight to ambient levels.

The workplace exposure limit noted above is an average of 30 ppm over an eight-hour period.

### **4.2 Carbon Dioxide**

The results of the monitoring for CO<sub>2</sub> can also be seen in Figures 1, 2, 6 and 7. Figure 1 shows that with the ventilation off CO<sub>2</sub> rapidly rises to over 1600 ppm. Once the ventilation is reinstated the CO<sub>2</sub> level quickly falls to c. 700 ppm, below CO<sub>2</sub> comfort levels, even though this was the period of peak occupancy.

Figure 2 demonstrates that when the ventilation is switched on and run continuously the CO<sub>2</sub> is limited to a maximum of 750 ppm even when the outlet is very busy.

The workplace exposure limit noted above is an average of 12000 ppm over an eight-hour period as a cause for concern and 1000 ppm being the accepted level for comfort and odour control.

### **4.3 Respirable Suspended Particles (PM 2.5)**

The results for the monitoring for respirable suspended particles (PM 2.5) can be seen in Figures 3,4 and 6. Figure 3 shows that when the ventilation is out of service, the particle levels rise, on this occasion to over 1.8 mg/m<sup>3</sup>, but when the ventilation is re-instated, the readings return very quickly to their earlier levels. Figure 4 shows that the ventilation controls the rise in particle levels to 1 mg/m<sup>3</sup> at its very maximum. Figure 6 shows that particle levels overnight fall to values below 0.1 mg/m<sup>3</sup>

### **4.4 Temperature**

The results of the monitoring for temperature can be seen in Figures 5. Temperature is reasonably constant during the monitoring period although they fall slightly overnight when the building is unoccupied. The temperature is at the top of the acceptable range for comfort. During the period

when the equipment is off on the 13th, the temperature did rise. If this increase in temperature were maintained the room would become uncomfortably warm.

#### **4.5 Cigarette Count**

The level of smoking in St. Stephens peaked at a rate of 0.20/m<sup>3</sup>/hour on Friday early evening. Similar levels were counted on Thursday evening at the same time which also coincided with the ventilation being switched off.

## **5. Analysis of Results**

### **5.1 4<sup>th</sup> - 5<sup>th</sup> September 2003**

Although the original intention was to compare the results over the two evenings, the most striking results were obtained on the first evening when the ventilation was switched off in the early evening. In the absence of ventilation the concentrations of all three recorded markers were rising steadily and when the ventilation was turned on a very steep decay for both gases and particulate was observed, (Figures 1 and 3). It is also worth noting that levels of gases and particulates fell overnight to ambient levels. The fact that the three recorded markers, both solid and gaseous, responded in the same way suggests that the ventilation would have the same impact on other constituents of ETS.

## 6. Conclusions and Recommendations

This study clearly demonstrates the ability of the ventilation system in this building to limit and control the concentrations of the parameters under consideration.

The results add weight to the argument that appropriately designed ventilation systems significantly improve the air quality in buildings where smoking is taking place, meeting all available Health and Safety Executive Occupational Exposure Limits.

The study has a number of limitations both in terms of the range of markers recorded and the duration of the test period. It does however support the argument for the development of a more comprehensive study to determine the parameters for an acceptable standard for ventilation systems in buildings where there is smoking in or near the building. It is recommended that the following issues be considered in any such study:

- Determination of an appropriate range of ETS markers to be measured
- Determination of an appropriate number of monitoring points
- Determination of an appropriate smoking regime to test against
- Determination of appropriate short term and long term exposure standards.

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