# Ventilation Effectiveness Study

at

# The Ivy House, Chalfont St. Giles

## 4th–5th October 2003


**Report by:**

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**These results are based upon the readings obtained between the 4th – 5th October 2003 and relate only to the data recorded on the dates when they were recorded.**



INVESTOR IN PEOPLE

# Contents


**Page No.**

| | | |
|---|---|---|
| **1.** | **Executive Summary** | **3** |
| **2.** | **Introduction** | **3** |
| **3.** | **Methodology** | **4** |
| | 3.1 Respirable Suspended Particles (PM 2.5) | 4 |
| | 3.2 Carbon Dioxide | 5 |
| | 3.3 Carbon Monoxide | 5 |
| | 3.4 Temperature and Relative Humidity | 5 |
| **4.** | **Results** | **6** |
| | 4.1 Respirable Suspended Particles (PM 2.5) | 6 |
| | 4.2 Carbon Dioxide | 6 |
| | 4.3 Carbon Monoxide | 6 |
| | 4.4 Temperature and Relative Humidity | 6 |
| | 4.5 Monitoring in the Customer Areas | 7 |
| **5.** | **Analysis of Results** | **8** |
| **6.** | **Conclusions & Recommendations** | **9** |


## Figures


| | | |
|---|---|---|
| Figure 1 | Airbourne Particulates – 4th – 5th October 2003 | 10 |
| Figure 2 | Carbon Dioxide/Carbon Monoxide – 4th – 5th October 2003 | 11 |
| Figure 3 | Carbon Dioxide/Carbon Monoxide Customer Area – 4th – 5th October 2003 | 12 |
| Figure 4 | Temperature/Relative Humidity – 4th – 5th October 2003 | 13 |
| Figure 5 | Temperature/Relative Humidity Customer Area – 4th – 5th October 2003 | 14 |


## Appendices


Appendix A Photographs of Site

Appendix B Glossary of Terms

# 1. Executive Summary

A ventilation study was carried out at The Ivy House from the 4th – 5th October 2003.

Levels of Carbon Dioxide, as an indicator of ventilation effectiveness, and Carbon Monoxide and airborne particulates, both constituents of environmental tobacco smoke, were recorded over a 24 hour period.

The results indicate that with the ventilation running the increase in the levels of the contaminants monitored is substantially less than would be expected in a non-ventilated smoking area.

In conducting the study a number of limitation 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 the Ivy House Public House, Chalfont St. Giles on the 4th and 5th October 2003. The Ivy House benefits from a ventilation system designed to provide 12 – 15 air changes per hour.

The ventilation system incorporates a Sigma HRV2000 air handling unit with heat recovery.

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 markers.

# 3. Methodology

The monitoring was conducted on a Saturday as this was identified as a busy day of the week, so avoiding periods of decreased activity.

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 on a continuous basis.

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. The sampling device for the customer area was a Testo M450 IAQ Monitor.

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. The rationale for this is as follows:

## 3.1 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 $mg/m^3$ (EH40 2000 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 $mg/m^3$. This figure relates to "fresh air" rather than indoor air.

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 and by monitoring a solid, (PM 2.5), and a gaseous, (CO) constituent it is possible to indicate the likely effectiveness of the system for a wider range of constituents. Ultimately it is recommended that a more comprehensive study is undertaken to determine absolutely, the effectiveness of a ventilation system in dealing with ETS.

## 3.2 Carbon Dioxide

Carbon Dioxide is produced wherever people are present in buildings, as a product of respiration. It is therefore usual to use Carbon Dioxide as an indication of the effectiveness of the ventilation system. For the purposes of this study it is important to establish that the ventilation is performing effectively. Levels of $CO_2$ are not likely to reach levels of health concern for a building in normal use, a figure of 12000 ppm is identified by the World Health Authority as the level of concern (BSRIA Technical Note 2/2002). For comfort level/odour dilution, a $CO_2$ limit of 1000 ppm is recommended.

## 3.3 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). 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 ppm (EH40/2000 Health and Safety Executive).

## 3.4 Temperature and Relative Humidity

There are requirements under Health Safety legislation relating to the provision of a satisfactory thermal environment. Monitoring of these parameters 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 $^{o}$C and 24 $^{o}$C, and relative humidity between 40 and 70%, (CIBSE Guide A, 1999).

# 4. Results

## 4.1 Respirable Suspended Particles (PM 2.5)

The results for the monitoring for respirable suspended particles (PM 2.5) can be seen in figure 1. This figure shows that with the ventilation running the rise in particulate levels is generally limited to less than 1.0 $mg/m^3$. The higher levels that coincide with the periods of heavy smoking are very short term as the high air changes rates rapidly dilute the contaminated air. Time weighted average levels will therefore be substantially lower than these peaks.

## 4.2 Carbon Dioxide

The results of the monitoring for $CO_2$ can be seen in figure 2. These results indicate that $CO_2$ levels overnight fall to ambient levels in fresh air as would be expected. These figures show that with the ventilation running, the $CO_2$ levels are limited to less than 1300 ppm at the busiest times.

## 4.3 Carbon Monoxide

The results of the monitoring for CO can also be seen in figure 2. These results show that the ventilation controls the rise in CO levels during the busy evening period to between 4 ppm.

## 4.4 Temperature and Relative Humidity

The results of the monitoring for temperature and relative humidity can be seen in figure 4. Temperature and relative humidity are reasonably constant during the monitoring period. The temperature and relative humidity are both dropping out of the comfort range overnight, which would be expected.

### 4.5 Monitoring in the Customer Areas

The instrumentation for this monitoring was located at a slightly lower position than the equipment behind the bar and hence slightly lower than the breathing zone in order to remain unobtrusive. The installed ventilation system is designed on the principle of mixing and therefore the height difference should not significantly influence the results.

The results of the monitoring for $CO_2$ and CO can be seen in figure 3. When compared with figure 4 it can be seen that the $CO_2$ levels are slightly lower in the customer area and the CO levels are slightly higher, reaching 6 ppm at the busiest time. This lower $CO_2$ level in the customer area may be the result of the designed air distribution pattern, with higher CO levels the result of the location of the smokers.

The results of the monitoring for temperature and relative humidity can be seen in figure 5. As was the case behind the bar, temperature and relative humidity are reasonably constant during the monitoring period. The temperature is at the bottom of the acceptable range for comfort whilst relative humidity levels are satisfactory. The lower temperatures are probably due to the proximity of the instrument to a window.

## 5. Analysis of Results

Although it is not possible to make direct comparisons between studies in different buildings, the results from this study do show higher than expected values for Particulates and Carbon Monoxide, given the level of smoking.

The recorded values for Carbon Dioxide at the busy times are in excess of 1000 ppm, also higher than would be anticipated in a well ventilated building,

As the Carbon Dioxide is being used as an indicator of ventilation effectiveness, it is reasonable to question the performance of the ventilation system. It is likely that either the design air supply rate is not being achieved, the room air distribution pattern is poor, or that the exhaust outlet is very close to the fresh air intake.

All of these possibilities should be investigated before conclusions can be made.

## 6. Conclusions and Recommendations

This study is inconclusive on the ability of the ventilation system in this building to limit and control the concentrations of the parameters under consideration, as discussed in 5.1 above.

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.

**Dr Andrew Geens**
Centre for Continuing Professional Development
University of Glamorgan
*for and on behalf of UGCS Ltd*

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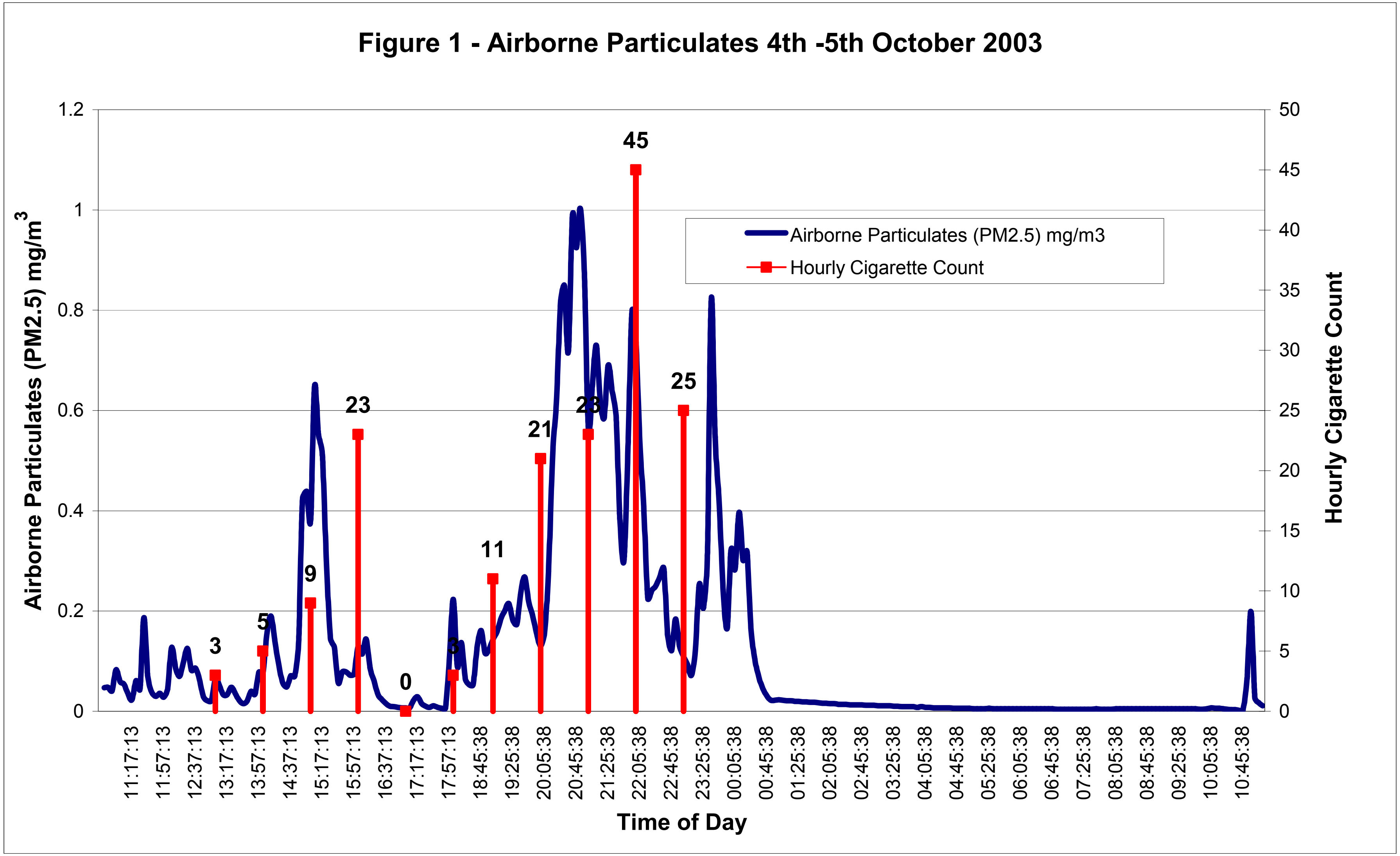
Figure 1 - Airborne Particulates 4th -5th October 2003
Airborne Particulates (PM2.5) mg/m3
Hourly Cigarette Count
Airborne Particulates (PM2.5) mg/m3
Hourly Cigarette Count
Time of Day
1.2
1
0.8
0.6
0.4
0.2
0
50
45
40
35
30
25
20
15
10
5
0
3
5
9
23
0
3
11
21
23
45
25
11:17:13
11:57:13
12:37:13
13:17:13
13:57:13
14:37:13
15:17:13
15:57:13
16:37:13
17:17:13
17:57:13
18:45:38
19:25:38
20:05:38
20:45:38
21:25:38
22:05:38
22:45:38
23:25:38
00:05:38
00:45:38
01:25:38
02:05:38
02:45:38
03:25:38
04:05:38
04:45:38
05:25:38
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08:45:38
09:25:38
10:05:38
10:45:38

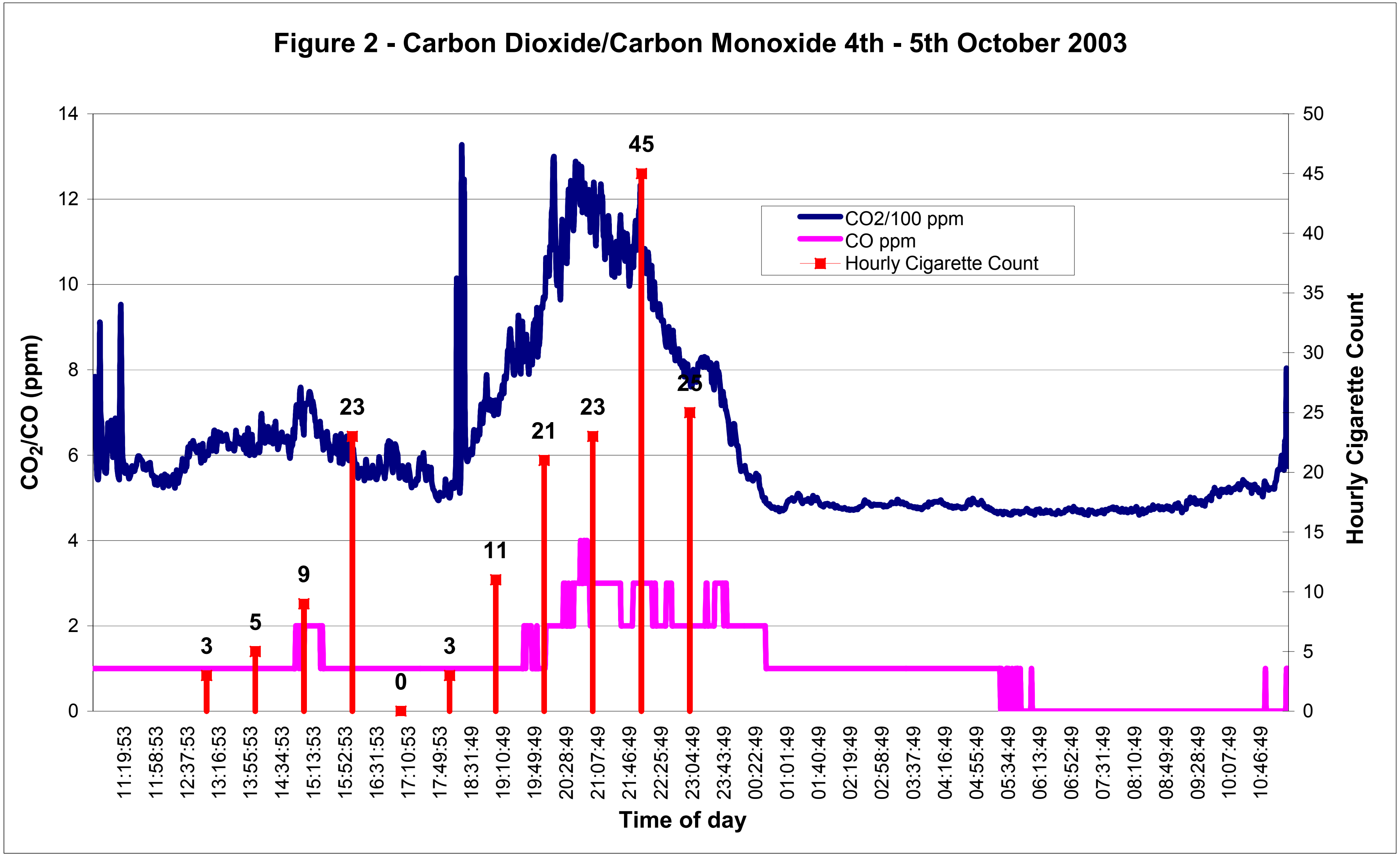
Figure 2 - Carbon Dioxide/Carbon Monoxide 4th - 5th October 2003
CO2/100 ppm
CO ppm
Hourly Cigarette Count
$CO_2$/CO (ppm)
Hourly Cigarette Count
Time of day
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
45
50
3
5
9
23
0
3
11
21
23
45
25
11:19:53
11:58:53
12:37:53
13:16:53
13:55:53
14:34:53
15:13:53
15:52:53
16:31:53
17:10:53
17:49:53
18:31:49
19:10:49
19:49:49
20:28:49
21:07:49
21:46:49
22:25:49
23:04:49
23:43:49
00:22:49
01:01:49
01:40:49
02:19:49
02:58:49
03:37:49
04:16:49
04:55:49
05:34:49
06:13:49
06:52:49
07:31:49
08:10:49
08:49:49
09:28:49
10:07:49
10:46:49

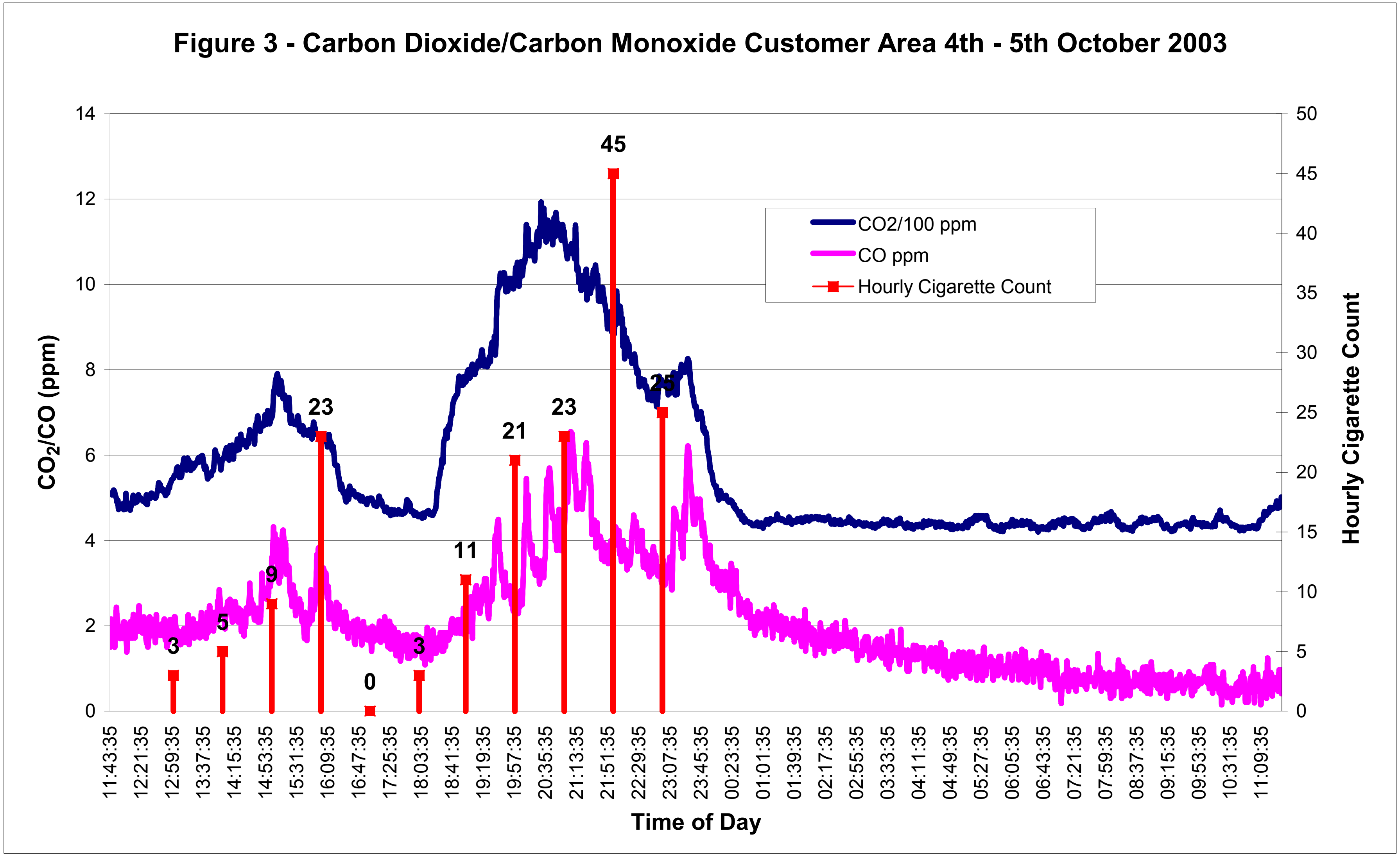

Figure 3 - Carbon Dioxide/Carbon Monoxide Customer Area 4th - 5th October 2003
CO2/100 ppm
CO ppm
Hourly Cigarette Count
CO2/CO (ppm)
Hourly Cigarette Count
Time of Day
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
45
50
3
5
9
23
0
3
11
21
23
45
25
11:43:35
12:21:35
12:59:35
13:37:35
14:15:35
14:53:35
15:31:35
16:09:35
16:47:35
17:25:35
18:03:35
18:41:35
19:19:35
19:57:35
20:35:35
21:13:35
21:51:35
22:29:35
23:07:35
23:45:35
00:23:35
01:01:35
01:39:35
02:17:35
02:55:35
03:33:35
04:11:35
04:49:35
05:27:35
06:05:35
06:43:35
07:21:35
07:59:35
08:37:35
09:15:35
09:53:35
10:31:35
11:09:35

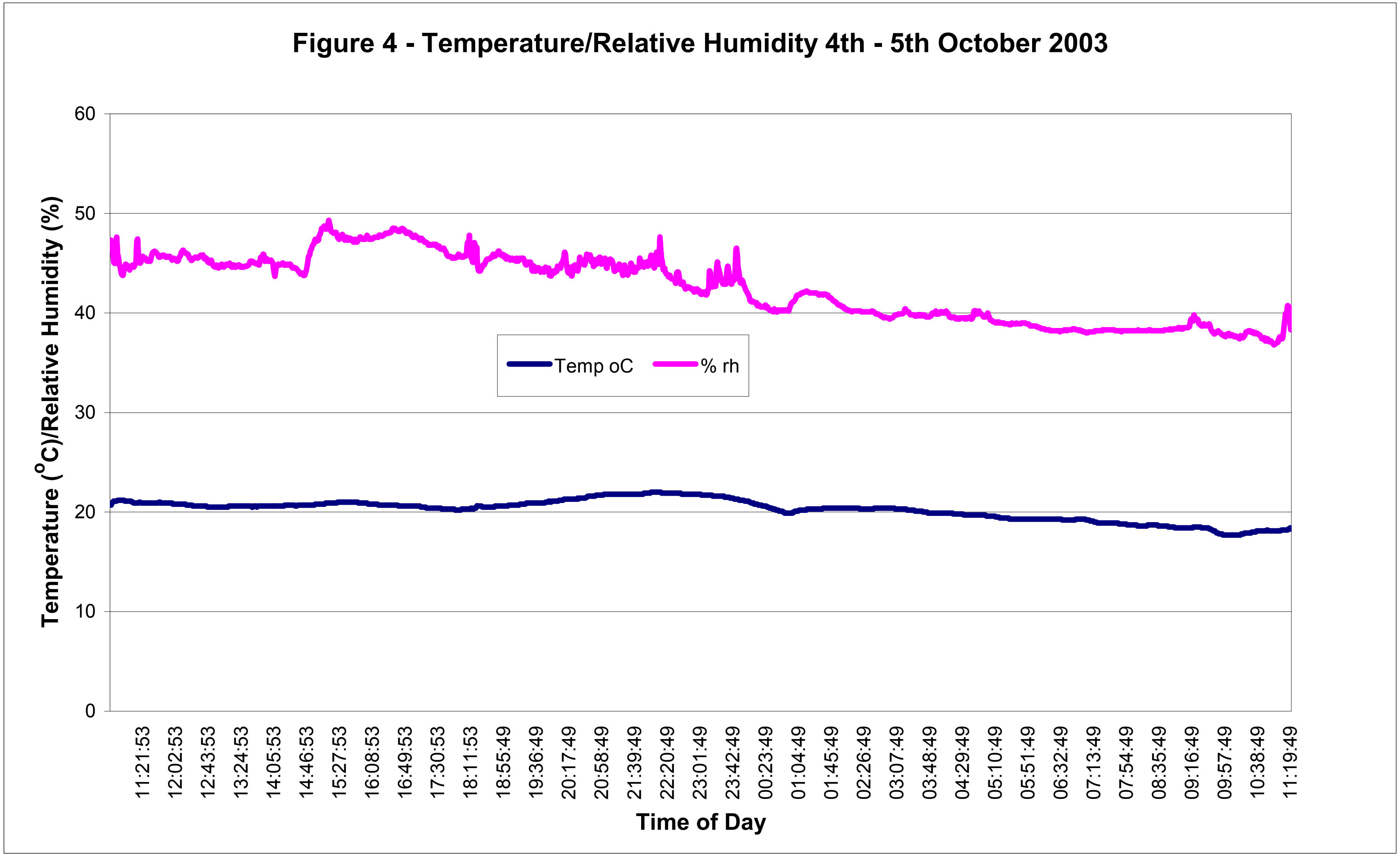
Figure 4 - Temperature/Relative Humidity 4th - 5th October 2003
Temperature (oC)/Relative Humidity (%)
60
50
40
30
20
10
0
Temp oC
% rh
11:21:53
12:02:53
12:43:53
13:24:53
14:05:53
14:46:53
15:27:53
16:08:53
16:49:53
17:30:53
18:11:53
18:55:49
19:36:49
20:17:49
20:58:49
21:39:49
22:20:49
23:01:49
23:42:49
00:23:49
01:04:49
01:45:49
02:26:49
03:07:49
03:48:49
04:29:49
05:10:49
05:51:49
06:32:49
07:13:49
07:54:49
08:35:49
09:16:49
09:57:49
10:38:49
11:19:49
Time of Day

# Figure 5 - Temperature/Relative Humidity Customer Area 4th - 5th October 2003