Ventilation Effectiveness Study

at

The Speaker Public House, Westminster

6th–7th November 2003

Report by:

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December 2003

These results are based upon the readings obtained between the 6th – 7th November 2003 and relate only to the data recorded on the dates when they were recorded.

INVESTOR IN PEOPLE

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1. Executive Summary

A ventilation study was carried out at The Speaker from the 6th – 7th November 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 Speaker Public House, Westminster on the 6th and 7th November 2003. The Speaker benefits from a ventilation system designed to provide 12 – 15 air changes per hour.

The ventilation system comprises two sets of supply and extract fans in the customer area each under the control of an air quality sensor. There is also a manual boost facility. A ducted supply system provides fresh air delivery to the rear of bar area.

The Speaker is a long narrow single bar establishment serving meals at lunch time.

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 from Thursday lunch time to Friday lunch time as this was identified as a busy time 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

After the first 2 hour period of monitoring, results were viewed to ensure that all instruments were operating satisfactorily. The early results suggested that the ventilation was not performing effectively. On further investigation it was discovered that one of the air quality sensors was not working and the fans at that end of the room were only running on low speed. This was the end of the room where the customer side monitoring was taking place.

The sensor could not be replaced until the following morning and so monitoring was conducted under the following three conditions:

Thursday lunch time – one fan set under automatic control, one fan set on minimum setting.
Thursday evening – one fan set under automatic control, one fan set operated on manual boost at regular intervals.
Friday Lunchtime – both fan sets under automatic control.

The rear of bar supply was constant throughout the test period.

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 in the absence of automatic air quality sensing on the first day the levels rise to 2.5 mg/m^3. This is higher than would be expected, and later in the day when the fans are being boosted by manual control, levels are restricted to 2 mg/m^3 despite higher levels of smoking. The results for Friday lunch time confirm that with the automatic sensors functioning correctly there is a greater degree of control with levels restricted to just over 1.2 mg/m^3 , approximately half the value for the previous day.

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. As before there is an improvement in performance once the sensor fault has been identified. The benefit is not as pronounced for Carbon Dioxide as this is produced by all of the occupants not just smokers, and there were more people in the room on the second day although smoking levels were similar.

4.3 Carbon Monoxide

The results of the monitoring for CO can also be seen in figure 2. As with the particulates, following the repair of the automatic sensor the Carbon Monoxide levels are 50% lower on the Friday lunchtime than on the Thursday lunchtime.

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.

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. The problems described above with the automatic air quality sensor are illustrated in these results in the same way as figure 2. This is to be expected as the instrument was located at the same end of the room as the faulty sensor. When compared with figure 2 it can be seen that although the trends match those of figure 2, the values are consistently higher with Carbon Monoxide peaking at 10 ppm compared to 6 ppm for figure 2.

This higher level in the customer area may be partly the result of the rear of bar air supply and partly 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

In the bar area, and with the automatic sensors operating the recorded values for Carbon Dioxide during the busy lunch time period are slightly in excess of 1000 ppm. Although this is higher than would be anticipated in a well ventilated building, the occupancy level was very high and the level of Carbon Dioxide control was satisfactory in these circumstances.

The particulates at this time were limited to 1.2 mg/m^3, and the Carbon Monoxide to 2 ppm. These values are higher than reported in similar studies but are within published guidelines and demonstrate the effectiveness of the ventilation in the challenging circumstances of a small and crowded area with a relatively low ceiling

6. Conclusions and Recommendations

The problems with the air quality sensor have inadvertently provided an opportunity to observe the improvement in performance provided by the automatic sensors. There is a difference noted between the air quality behind the bar and in the customer area, with the air quality in the customer area being poorer. This may be expected as this is where the smoking is taking place, but may be of concern where there is no segregation for smoking and non-smoking customers.

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
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for and on behalf of UGCS Ltd

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.

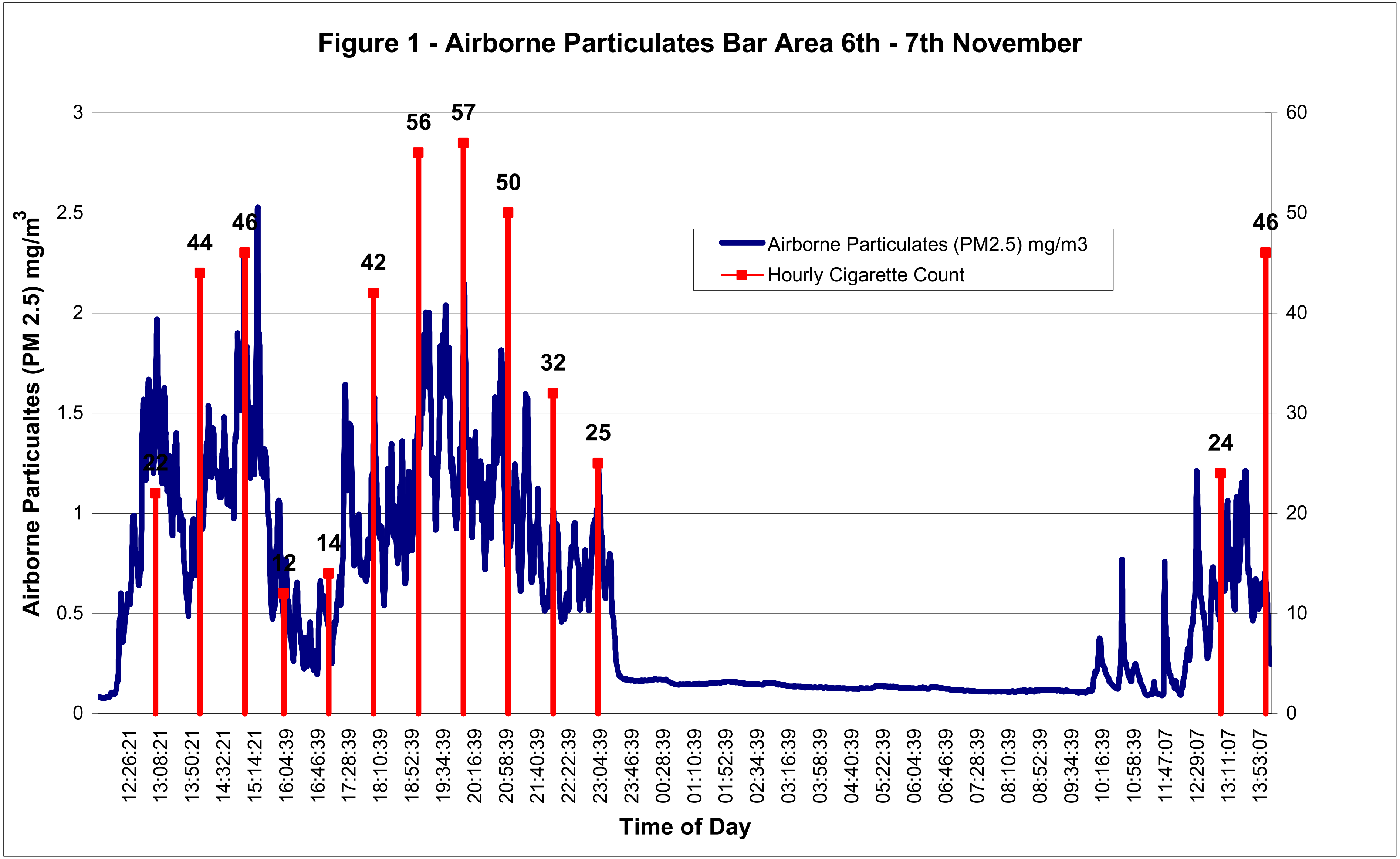

Figure 1 - Airborne Particulates Bar Area 6th - 7th November
Airborne Particualtes (PM 2.5) mg/m3
Time of Day
Airborne Particulates (PM2.5) mg/m3
Hourly Cigarette Count
0
0.5
1
1.5
2
2.5
3
0
10
20
30
40
50
60
22
44
46
12
14
42
56
57
50
32
25
24
46
12:26:21
13:08:21
13:50:21
14:32:21
15:14:21
16:04:39
16:46:39
17:28:39
18:10:39
18:52:39
19:34:39
20:16:39
20:58:39
21:40:39
22:22:39
23:04:39
23:46:39
00:28:39
01:10:39
01:52:39
02:34:39
03:16:39
03:58:39
04:40:39
05:22:39
06:04:39
06:46:39
07:28:39
08:10:39
08:52:39
09:34:39
10:16:39
10:58:39
11:47:07
12:29:07
13:11:07
13:53:07

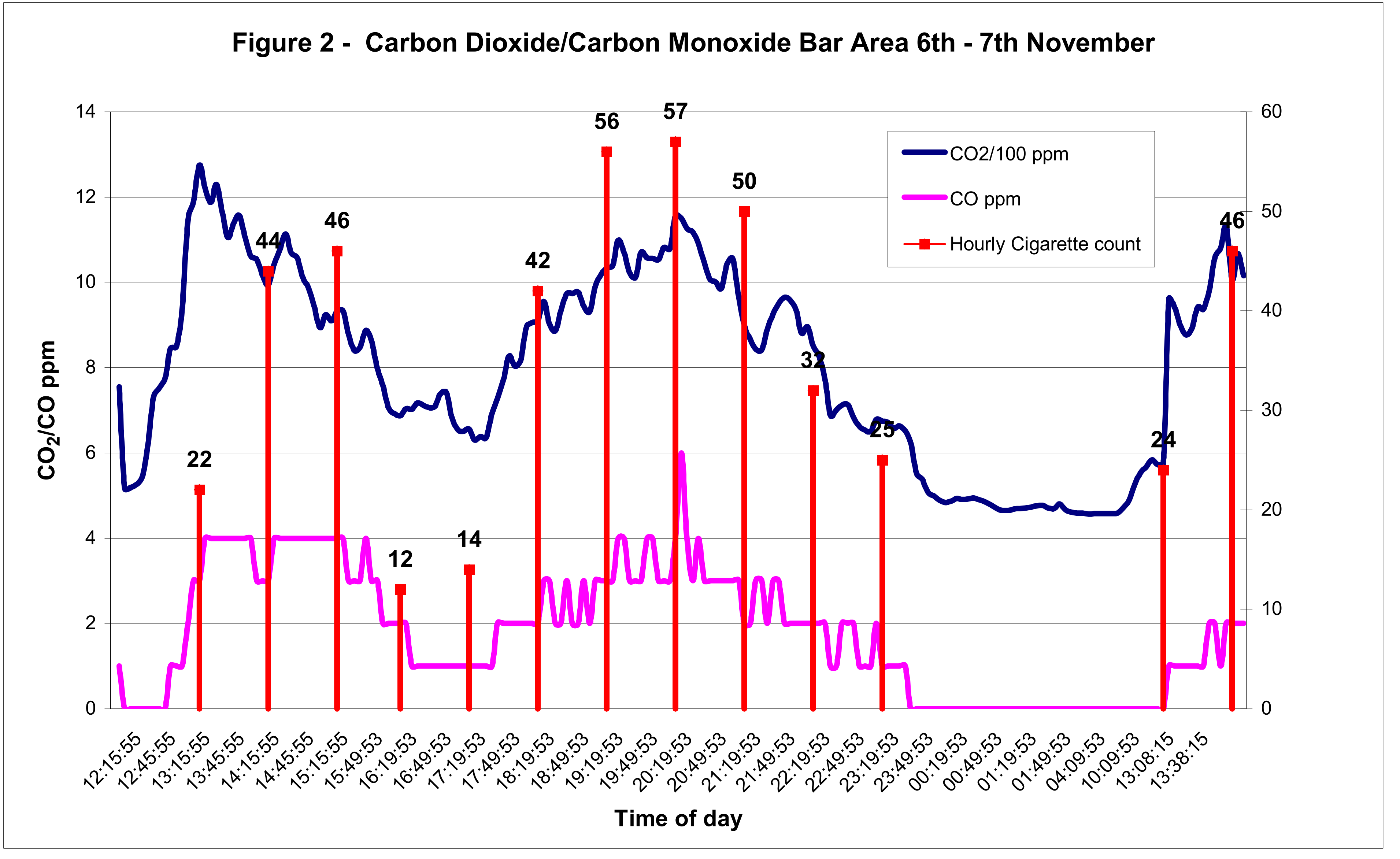

Figure 2 - Carbon Dioxide/Carbon Monoxide Bar Area 6th - 7th November
CO2/100 ppm
CO ppm
Hourly Cigarette count
CO_2/CO ppm
Time of day
14
12
10
8
6
4
2
0
60
50
40
30
20
10
0
22
44
46
12
14
42
56
57
50
32
25
24
46
12:15:55
12:45:55
13:15:55
13:45:55
14:15:55
14:45:55
15:15:55
15:49:53
16:19:53
16:49:53
17:19:53
17:49:53
18:19:53
18:49:53
19:19:53
19:49:53
20:19:53
20:49:53
21:19:53
21:49:53
22:19:53
22:49:53
23:19:53
23:49:53
00:19:53
00:49:53
01:19:53
01:49:53
04:09:53
10:09:53
13:08:15
13:38:15

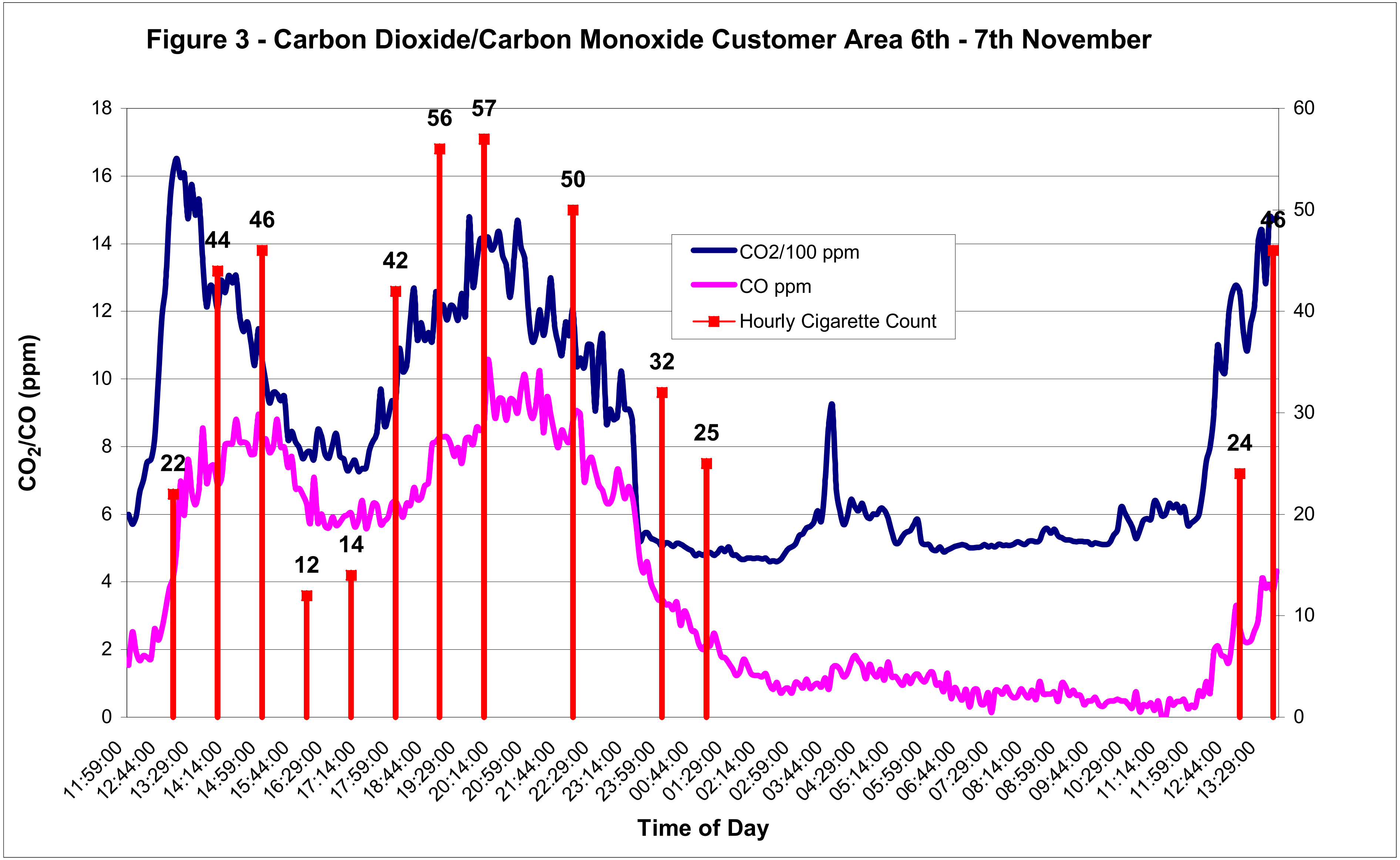

Figure 3 - Carbon Dioxide/Carbon Monoxide Customer Area 6th - 7th November
CO2/100 ppm
CO ppm
Hourly Cigarette Count
CO2/CO (ppm)
Time of Day

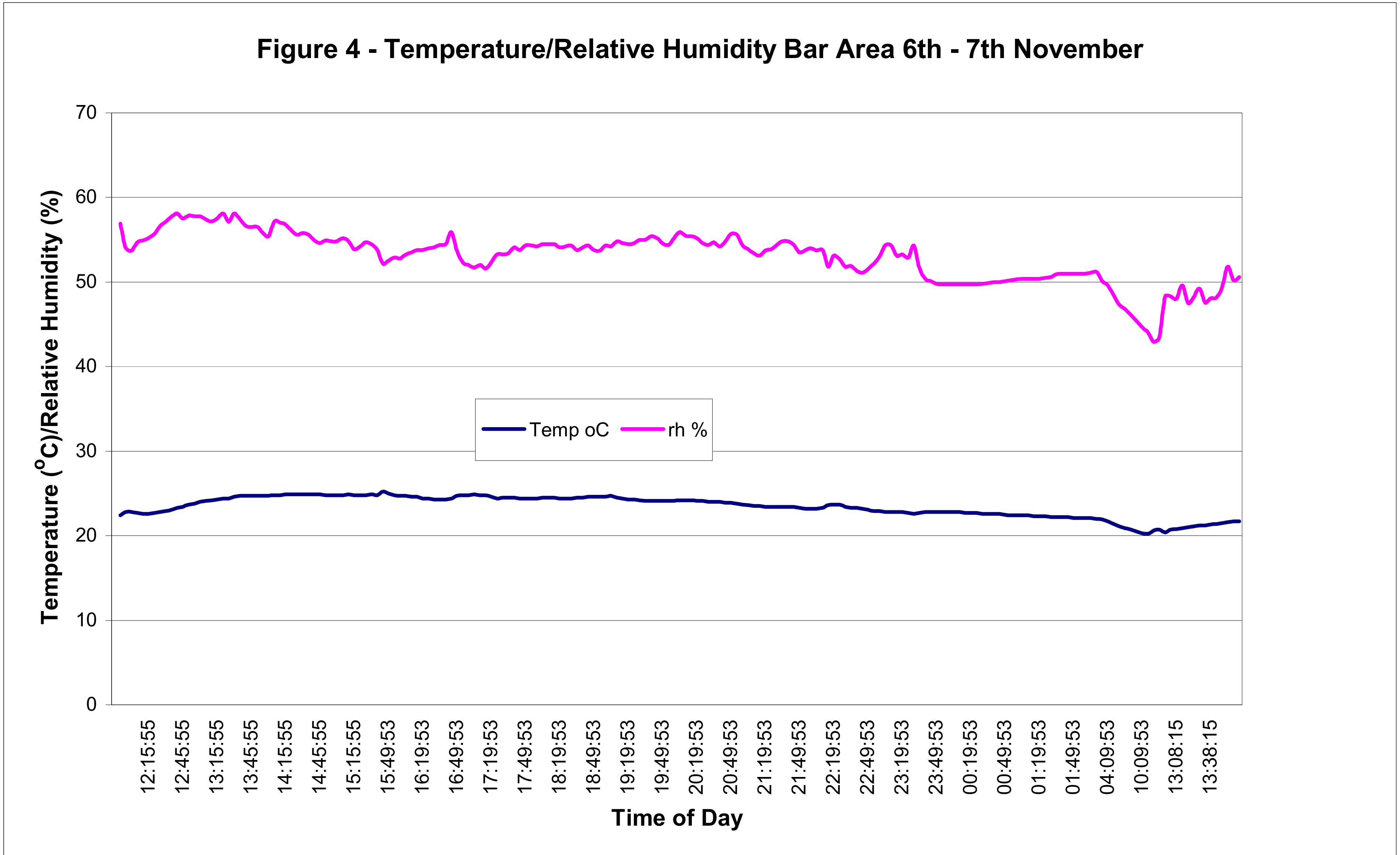
Figure 4 - Temperature/Relative Humidity Bar Area 6th - 7th November
Temperature (°C)/Relative Humidity (%)
70
60
50
40
30
20
10
0
Temp oC
rh %
12:15:55
12:45:55
13:15:55
13:45:55
14:15:55
14:45:55
15:15:55
15:49:53
16:19:53
16:49:53
17:19:53
17:49:53
18:19:53
18:49:53
19:19:53
19:49:53
20:19:53
20:49:53
21:19:53
21:49:53
22:19:53
22:49:53
23:19:53
23:49:53
00:19:53
00:49:53
01:19:53
01:49:53
04:09:53
10:09:53
13:08:15
13:38:15
Time of Day

UGCS

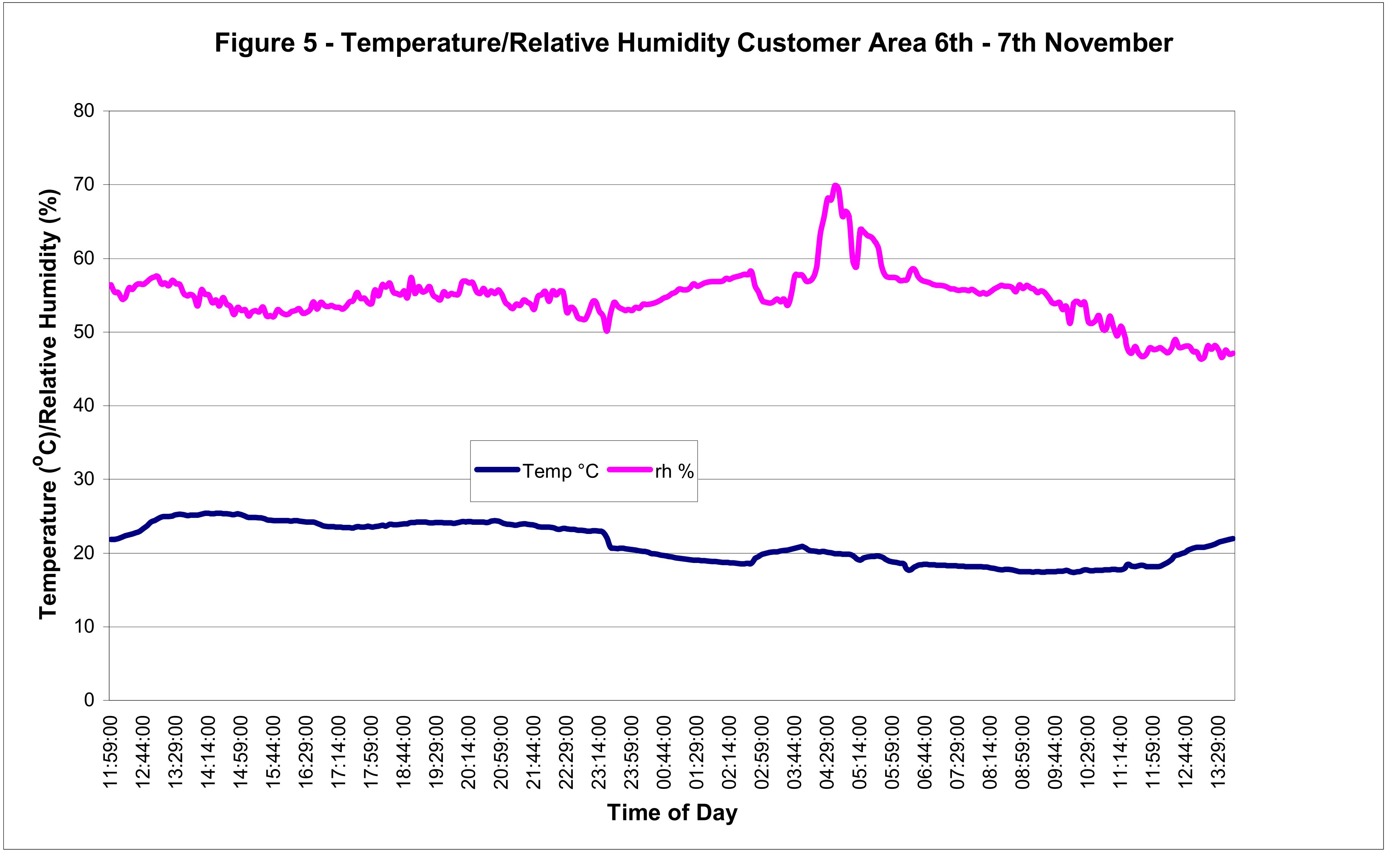

Figure 5 - Temperature/Relative Humidity Customer Area 6th - 7th November
Temperature (°C)/Relative Humidity (%)
80
70
60
50
40
30
20
10
0
Temp °C
rh %
11:59:00
12:44:00
13:29:00
14:14:00
14:59:00
15:44:00
16:29:00
17:14:00
17:59:00
18:44:00
19:29:00
20:14:00
20:59:00
21:44:00
22:29:00
23:14:00
23:59:00
00:44:00
01:29:00
02:14:00
02:59:00
03:44:00
04:29:00
05:14:00
05:59:00
06:44:00
07:29:00
08:14:00
08:59:00
09:44:00
10:29:00
11:14:00
11:59:00
12:44:00
13:29:00
Time of Day