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NATIONAL SOCIETY FOR CLEAN AIR
136 NORTH STREET – BRIGHTON BN1 1RG
–ENGLAND –
Telephone: Brighton (0273) 26313

CONTROLLING AIR QUALITY IN CAR PARKS

by
Dr. Malcolm F. Fox
School of Chemistry, Leicester Polytechnic

ABSTRACT

Pollution incidents in car parks occur in an acute but discontinuous manner. The factors which come together to cause such pollution incidents are analysed and a rough index described for analysing whether a car park will have such incidents or not.

Under certain circumstances, pollution incidents can occur in multi-storey car parks. The principal contributing factors are first, severe traffic congestion both within and without the car park, such that the rate of vehicles leaving the car park is very low. The actual rate is far less than the rate necessary for the number of people who wish to leave at that time. Second, when very stable weather conditions are allied to poor natural ventilation, the actual rate of ventilation of the car park can be very low. This situation can arise when a car park which has good ventilation is closely surrounded by further development which drastically reduces through draught. Third, congested, polluted conditions can arise in a car park due to a very slow rate of processing the charges. A large surge of vehicles may wish to leave at one time but only one kiosk is open. The situation worsens when there is no intervention by management.

Typical acute incidents involve 30-80 minutes exposure to carbon monoxide of up to 400-450 ppm for families ranging from the elderly to the very young. Car park attendants are also exposed to high carbon monoxide levels in some kiosks, in addition to high airborne levels of lead.

Survey results are presented and discussed in the context of

the design and construction of car parks. Proposals are made to reduce the incidence of air pollution in car parks and other enclosed spaces such as car ferries and customs posts.

A method for calculating an index of the pre-disposition of a given car park for sudden, acute, air pollution incidents is described which takes into account the flow capacity at peak times into the surrounding roads, the natural draught ventilation rate and the capacity of the management to respond to sudden peak flow rates of vehicles leaving the car park.

INTRODUCTION

There are many multi-storey car parks in redeveloped city centres, built as part of a plan to control road-side parking and aid traffic flow. These car parks are erected on sites which are either peripheral to a city centre or have built into, over or under shopping precinct developments. Such buildings are a common feature of developed countries; the literature shows a steady level of reports discussing air pollution arising from them. In addition, there are reports of air pollution arising from the use of internal combustion engines to power various unusual machines such as ice-polishers and miniature road sweepers within enclosed premises. Further, there are reports of high levels of vehicle fumes on car ferries and at relatively enclosed customs posts.

All of these reports describe high levels of carbon monoxide associated with very unpleasant exhaust fumes. A particular feature of air pollution incidents in car parks, whether they occur in the UK or other countries, is the sudden and acute nature of the incident. This work, conducted with Ivor Barker over a long period and encompassing a large number of car parks of different design and location, presents some of our results, analyses how these arise and what can be done to control and reduce these air pollution incidents.

RELEVANT LEGISLATION

The legislation on car parks is primarily concerned with their

design and construction, particularly with respect to fire precautions. They are covered by Section E2 (Structural Fire Precautions) of the Building Regulations, purpose group VIII (storage and general). Circular 17/68 of the then Ministry of Housing and Local Government also applies and further develops the fire precautions. The overall thrust is to safeguard car park construction and protect them from fire hazards. The problem of pollution from vehicles in the confined spaces of car parks does not appear in these regulations. The Institution of Structural Engineers has drawn the attention of its members to the need for considering vehicular pollution when designing multi-storey car parks.

AIR POLLUTION MONITORING

Carbon monoxide, as an indicator of air pollution in car parks can be measured reasonably accurately, to within 5%, using simple Draegar tubes, provided that a standard procedure is adhered to. The carbon monoxide tube is found to be particularly accurate when measured against standard gas mixtures. Lead in the air is determined by collection on a filter and analysed using atomic absorption techniques.

THE DIFFERENT TYPES OF CAR PARKS

The car park whose problems initiated this work was the most interesting of those investigated. It was designed and built to the relevant regulations and measures roughly 130 m x 130 m, with a clearance headroom of just over 2 m. It is situated on top of a shopping centre which occupies almost all of a central city block. The car park has two floors, the upper one being completely open. The lower floor has an extremely reticulated and obstructed configuration because of skylights, plant rooms, offices, service shafts and walls which protrude through from the development below. The lower is therefore a very thin sandwich, 130 m x 130 m maximum, with approximately 2 m headroom.

The draught movement for the lower floor was found to be at best only one-third of that measured for an identical position directly above it on the upper floor. However, the upper floor is the last to fill up and vehicles must return to

the lower floor via a conflicting junction with lower floor traffic to leave the car park.

Detailed surveys for busy and quiet days identified two areas of high pollution levels. For the first area, at the internal traffic junction, on a busy day, continuous levels of carbon monoxide in the region of 40-60 ppm were recorded. These did not occur on quiet days. The second area of high pollution was the exit ramp of the car park. As the car park is on the top of a shopping development, vehicles use a helical ramp to climb up to it. This ramp is intertwined with a separate exist ramp, both being enclosed within a glazed reinforced concrete drum. Exit from the car park was substantially hindered, and frequently stopped, by traffic congestion in the city centre street which it entered. When this happens, the enclosed exit ramp becomes a small enclosed space with stationary vehicles running their engines, generally with their chokes out. Background values of 130-210 ppm carbon monoxide for periods of over an hour, with peak values of 450 ppm. These levels of carbon monoxide are inhaled by people sitting in vehicles relatively immobilised for periods of up to 30-40 minutes. In extreme cases, even longer periods of exposure can occur. The longest time known to us for congestion-caused delay in leaving a car park is 105 minutes (but not from this car park) in a major city centre just prior to Christmas.

The second car park is constructed of a ground floor and four upper floors, mainly open at the edges, overall dimensions 70 x 38 m with an average height of 3.1 m. In comparison with the first car park described, this one has a relatively open deck structure. The exit from this car park is on to a quiet street, with no congestion, leading to a ring road.

The polluted area in this car park was the tunnel-like exit where the factor determining the rate of exit was the payment kiosk. This car park is used continuously, being close to the city centre and with a rate structure which encourages shorter stays. On busy days, a continuous stream of traffic entered and left. For long periods of time there was an unbroken queue of cars waiting to leave and, for shorter periods of time, vehicles waiting to enter, both within the tunnel-like entrance. Hourly averages of carbon

monoxide of between 130 and 50 ppm were found between 1000 and 1900 on busy days. Concurrent hourly atmospheric lead measurements showed levels ranging between 17 and 4 ugm^{-3} during this period.

Other car parks of this type surveyed showed good natural ventilation, less intensive use and very good road arrangements so as to move vehicles away. Their construction tended to taller, open deck structures, sometimes built over commercial developments such as car sales showrooms.

A different type of car park construction is the continuous ramp, either single or two ramps intertwined with separate entrances. These structures are usually massive, tall, buildings which stand alone and have good natural ventilation. The only areas of vehicle pollution found for this type of car park were the payment kiosk areas, again in a tunnel-like configuration at, or close to, ground level. Levels of carbon monoxide between 50 and 120 ppm were found in these areas on busy days as vehicles queued to leave the car parks. However, in each case, the exit from the car park was unhindered and traffic was able to disperse freely.

The final type of car park surveyed were those which are underground. The most interesting example of this type of car park used its site in a very complex manner. It was part of a comprehensive development of a railway station in a deep ravine. The lowest levels of the ravine were given over to a car park, approximately 400 x 80 m, the middle levels (at ground level) to a shopping centre development and, superimposed upon that, housing in upper levels.

At one end of the development, the car park on the lowest floor is the basement of a medium-size multi-storey car park sunk into the ground. As vehicles wend their way up through this car park, they eventually find their way up to ground level.

These two connected parts of the car park showed very different air pollution characteristics. The lowest level car park was positively ventilated through ducting. At peak times, the flow of vehicles within the car park was very positively organised by the management so as to maximise

traffic flow. (It is my observation that traffic left to its own devices in confined areas tend to minimise traffic flow). Further, whereas there were normally two pay kiosks, at peak traffic flow times a third payment point was established by setting up a portable table and a cash till. The lower car park exited on to a quiet street, away from the main city centre traffic, with no hindrance to the rapid dispersal of vehicles.

Vehicles leave the other, sunken, multi-storey, part of the car park at ground level by circulating through the various levels. The pay kiosks are at the end of a steeply inclined ramp. Final exit from the car park is to a main city centre street. Due to the complex configuration of the car park, ventilation is poor. At peak times, a queue of vehicles fills the roadways of this car park all of the way down to the lowest level. Steady carbon monoxide levels of 400-450 ppm were recorded in this car park, with exit times of 25-30 minutes. 100-170 ppm carbon monoxide was observed over several hours on the exit ramp with values of 200-270 ppm for the same period at the pay kiosks. The management of this end of the car park was conspicuous by its absence.

DISCUSSION

The three factors which come together to cause acute air pollution incidents in car parks are:

-> inadequate natural or forced ventilation,

-> hindered vehicle dispersal from the car park,

-> poor management response to the sudden occurrence of air pollution incidents.

The levels of carbon monoxide found in some of these car parks are well in excess of OEL limits, not that OEL considerations apply to these situations. We are dealing exposure to the general public and much lower exposure limits must apply.

It should be emphasised that most car parks do not have air pollution incidents. Concern should only be directed towards those which are perceived to have recurring problems,

particularly at peak times such as pre-holiday shopping times, post-Christmas sales and also after theatre performances.

Measures can be taken to relieve the problem of acute air pollution incidents in car parks. The first car park described had the position of the exit moved slightly relative to a pedestrian crossing. This small change enabled the vehicles to enter the main street traffic stream more readily. The glazing on the helical ramps leading to and from the car park was first removed (showing up some very rough concrete) and then replaced such that the ventilation was not hindered. Illuminated notices, activated by carbon monoxide sensors, were installed when the levels rose. The notices told motorists to turn their engines off, but were generally ignored and are now defunct. The management now responds to anticipated congestion by having both kiosks open when necessary. The early problems of air pollution from motor vehicles in car parks have been considerably reduced.

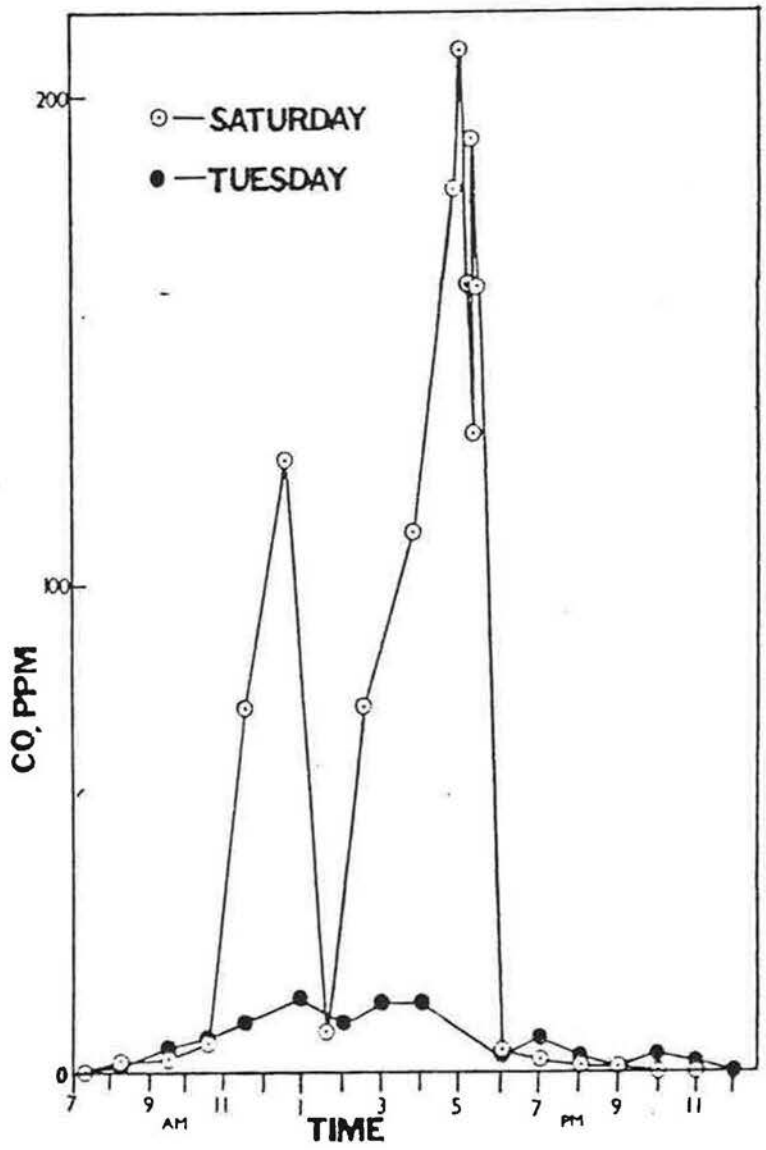
When development takes place close to car parks, the impact of the new building on the natural ventilation of those car parks should be considered. Changes in traffic flow caused by new building or revised road schemes should take into account any new hindrances to the ease of vehicles leaving the car park.

Management of car parks has to be aware of the problems that can arise and be prepared to respond to them. The exposure of car park employees to carbon monoxide over prolonged periods and also to lead particulates in the air can best be managed by ensuring a supply of clean air drawn from the outside of the car park to their kiosks. Car park employees often work very long shifts, so long as to render valueless the occupational exposure criteria of 8hrs/day, 5 days/week, etc.

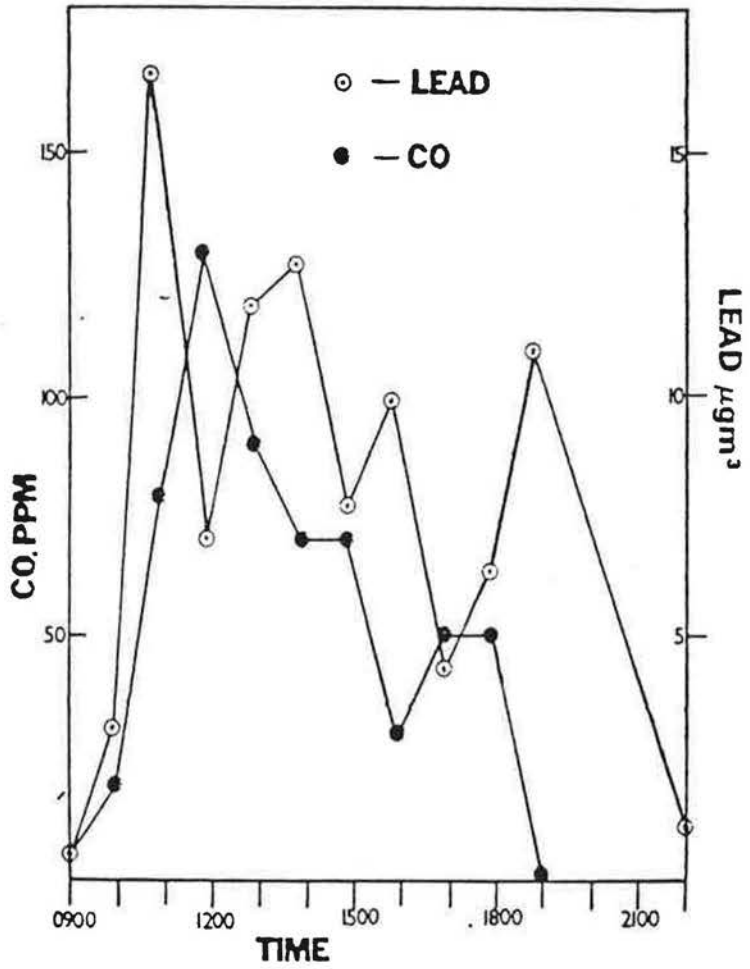
The diversity of car parks is such that when problems are encountered then an analysis of the form set out above should be undertaken. With careful thought, minor modifications can relieve or considerably reduce the problems of vehicular pollution in car parks.

REFERENCE

I.W. Barker and M.F. Fox, Royal Society of Health Journal, p.168, 1976.



1. Variation of carbon monoxide with time on the exit ramp of a car park for a Saturday and a Tuesday.



2. Hourly variations of lead and carbon monoxide within a kiosk of a car park.