Car Parks

#7425

Carbon monoxide levels in a car park

– a case study

A complaint was received by the environmental health department of a city council from the National Union of Public Employees that fumes from vehicle exhausts were too concentrated in one of the car parks where their members were employed by the council as attendants.

The investigation and actions which followed illustrate the lack of information generally available about the design of ventilating systems for car parks. The investigation also showed the success of a joint approach between the employing authority, the enforcing authority and the employees to quantify the position, assess the risk and provide remedies, and demonstrated the pertinence and interaction of sections 2, 3 and 7 of the Health and Safety at Work Act.

Background

In the early planning stages the city environmental health officer was involved in advising on the design aspects of a large, pedestrianised shopping complex in the centre of the city. The development of the complex was undertaken by a large private developer and comprised approximately 300000 square feet of new shopping space, 20000 square feet of office accommodation and two car parks for 800 vehicles, arranged within a five and a half acre site.

On completion, the car park in question was operated by the city council on a "pay and display" basis.

The car park

The car park, with a capacity of 453 vehicles, is built on two levels with the upper level open to the air. The lower level is approached via a curved ramp providing access to the partially enclosed portion at first floor level.

Each level is rectangular (178 m × 32 m) and the first floor level has a height from floor to ceiling of 2.6 metres. It is open to the air along the length of the north west elevation and 19 pairs of air extraction grilles are located on the opposite wall. The north east wall is totally enclosed whilst the south west wall is open for the majority of its length.

Having entered the car park, traffic reaches a junction where it can turn right to park on the same level or left to reach further parking spaces via a short ramp. This same ramp is used by vehicles travelling to and from the roof section of the car park to which access is gained by way of a further ramp.

Access to the offices used by the car park attendants is adjacent to this junction and ventilation to those rooms is provided largely by diffusion of air from the car park through airbricks. The windows were kept closed for security reasons.

Design factors

It was initially proposed to rely solely on natural ventilation, from the two adjoining open sides, to disperse the vehicle exhaust fumes from the lower level but the city environmental health officer, with the support of the petroleum officer, required the provision of mechanical extract ventilation.

The standard of ventilation specified was six air changes per hour with a split of one-third high level and two-thirds low level extraction. This standard was believed to be the nationally accepted standard and appeared in a Greater London Council's code of practice[1]. In fact, when the ventilation system was finally commissioned, seven air changes per hour were achieved.

It was assumed on opening that, as the mechanical ventilation system was achieving more than six air changes per hour and two of the sides of the car park were open, the levels of exhaust pollution, in particular carbon monoxide, would be satisfactory. Further, if the environmental pollution levels in the car park were satisfactory, then it followed that the ambient air in the offices, connected with the car park by airbricks, would also be acceptable. The investigation which followed the complaint proved that these assumptions were wrong.

Standards

During the investigation, the standards for atmospheric pollution which were being used as a reference were those published by the American Conference of Governmental Industrial Hygienists. This list of acceptable exposure limits for industrial pollutants has been republished by the Health and Safety Executive in its series of environmental hygiene guidance notes. The latest such publication, EH 15/80[2], reproduces a comprehensive list of pollutants and their respective threshold limit values (TLVs).

With respect to the concentration of carbon monoxide, EH 15/80 gives a figure of 50 ppm as the time weighted average (TWA) and 400 ppm as the short term exposure limit. The first figure is the TWA concentration for a normal eight hour day or forty hour week, while the second is considered the maximum allowable concentration (MAC) which should not be exceeded and which should not be attained on more than four occasions per day, with a maximum period of fifteen minutes per excursion.

Whilst the quoted TLVs have no strict basis in law, it was accepted that the council as employer should have regard to the quoted standards contained in the current document. Indeed, in the absence of any other relevant information from the HSE, both regarding pollution levels or the design of ventilating systems for car parks, there was no other information available to the responsible employer.

Investigation

Soon after the initial complaint, staff of the environmental health department

sampled the air within the lower level of the car park by means of a Dräger hand-held pump and detector tubes.

Those initial tests, whilst only spot samples, demonstrated that the level of carbon monoxide was reaching a concentration at least twice the TLV-TWA and appeared unacceptably high. The level of pollution seemed worst along the rear wall containing the air extraction grilles.

During the tests, the air extraction rate was tested using an anemometer. This exercise ruled out any breakdown or imbalance in the system of mechanical ventilation.

Advice sought

Having identified a possible hazard, it was decided to seek advice for three main reasons:-

1 Lack of information generally available concerning car park ventilation;

2 The extract ventilation provided was fulfilling its design criteria but apparently not overcoming the emission of carbon monoxide from the vehicle exhausts;

3 Lack of information on the effect of elevated carbon monoxide levels on the general public, in particular infants, the elderly and infirm.

The Home Office, Fire Research Station and HSE were not able to provide any real immediate help but an offer of specialist assistance from the HSE was made and, through the Factory Inspectorate and the Employment Medical Advisory Service, a mobile laboratory was provided. The test equipment was located in a caravan parked beneath the access ramp to the car park. The equipment consisted of an ecolyser carbon monoxide analyser connected to a chart recorder. Four sampling units were used and samples taken from various positions in the car park for periods of from five to twenty minutes. At the same time, a vehicle counting unit was used to observe vehicle movements.

The results obtained indicated that with one exception the carbon monoxide levels varied widely and fluctuated rapidly. Maximum levels from 42 ppm to 275 ppm were recorded. The slow diffusion of air through the airbricks between the superintendent's office and the car park accounted for the only sampling point from which the results remained fairly steady. On one day the carbon monoxide within the office was above the TLV-TWA for a continuous period of six hours.

During the same period blood samples were taken from the test team working in the car park and from the car park attendants. Analysis of the blood for carboxyhaemoglobin demonstrated clear evidence of carbon monoxide inhalation. The "normal" level of carboxyhaemoglobin in the blood of a non-smoker is around one per cent whilst a heavy smoker can achieve levels of ten per cent without apparent ill-effect[3].

The results did not indicate a serious health hazard, neither did they prove that there was no problem at all, particularly if elderly persons suffering from cardio-respiratory disease remained in the car park for prolonged periods. Although the mean carbon monoxide level exceeded the TLV-TWA, this required evaluating against:

1 The superintendent spent up to 50 per cent of his time in the office at the car park and the sampling point in this office recorded the highest average level of carbon monoxide.

2 The attendants spent no more than two hours per day in this particular car park, some in the areas of low pollution – the remaining time being employed travelling between and at other car parks.

3 The maximum permitted period for a car to remain in the car park was four hours per day. It seemed unlikely that an elderly person or baby would be left in the car park for such a long period although one elderly person was observed sitting in a car for two and three-quarter hours.

As the car park, although in fairly heavy use during this period, was not being subjected to the extreme pressure experienced during peak use, it was decided to repeat a series of tests in the immediate pre-Christmas period. In the meantime, immediate steps were taken to produce a scheme for introducing fresh air into the offices to overcome the unacceptably high concentrations of carbon monoxide found there. The initial recommendations from the HSE required an increase in the rate of air extraction from the car park (no optimum rate was forthcoming) but was challenged on the basis of limited exposure time, cost and lack of information as to what improvement would be achieved by a given increase in air extraction rate.

It seemed likely, from observation, that the higher pollution levels arose when the majority of all of the parking spaces were occupied and cars slowly circulated within the car park while the drivers sought vacant parking spaces. It became obvious, as the investigation progressed, that the sign positioned at the bottom of the curved access ramp which displayed "Full" when all the parking spaces were occupied was either not being seen or ignored and this was the important factor in the elevated carbon monoxide levels.

The tests carried out by the city council and EMAS volunteers during peak use involved the use of a Dräger polymeter personal air sampler, a battery operated device worn by the volunteers, which delivers a steady supply of metered air to a glass detector tube. On four days, including a Saturday, the volunteers remained in the car park in the most polluted section (rear wall) for three-four hours. At the end of this time, the average carbon monoxide exposure was calculated and a sample of blood taken. All the volunteers were non-smokers and blood samples were taken both before and after exposure in order to ensure that any elevated carboxyhaemoblobin levels would be directly attributed to vehicle exhaust fumes.

The results again clearly illustrated that the exposure of the non-smoking volunteers led to significantly elevated carboxyhaemoglobin levels, particularly in the case of the Saturday exposure which also produced the highest carbon monoxide levels within the car park. An additional analysis for blood lead levels found no abnormal results.

The solution

An improved system of ventilation to the offices was provided, consisting of mechanical admission of fresh air equivalent to four air changes per hour. At the same time, a system of vehicular control comprising a set of traffic lights controlled by the traffic counting mechanism was installed on the car park access ramp.

Results subsequently obtained demonstrated dramatic improvement in the pollution levels such that there was now no significant health risk to the attendants or to members of the public. Similarly, blood samples showed a blood carboxyhaemoglobin level well within "safe" limits.

Conclusions

1 Early consultations on design are essential.

2 A standard based on specified ventilation rates takes no account of two vital factors:-

a) traffic management measures which in this case permitted overloading of the ventilating system, especially during peak shopping periods;

b) the effect of wind speed and direction on a partially enclosed car park.

3 In view of this, it might be more effective to specify maximum levels of pollution which should not be exceeded rather than ventilation rates.

4 The first remedy offered in this case was the most expensive and lacked a guarantee of success whereas the problems were eventually overcome in a fairly simple way.

5 At no time was any information withheld from the enforcing authority. The problem-solving exercise, carried out jointly by the enforcing and employing authorities was of mutual benefit and overcame the hazard.

6 No comprehensive guidelines are available to assist in the assessment of proposed ventilation systems for car parks. It is essential that a code of practice is produced as a matter of urgency in order to reduce the health risk to which the general public as well as employees may be exposed.

References

1 GLC Code of Practice: London Building Acts (Amendment) Act 1939 – Section 20.

2 Guidance Note EH 15/80. HMSO.

3 Encyclopaedia of Occupational Health and Safety 1971. International Labour Office, Geneva.

Note: Readers wanting full data on monitoring results will be sent a copy on receipt of a written request.