Carbon Monoxide Exposures in Parking Garages

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Introduction

With the enormous year by year increase in automotive vehicles in this country there are ever more instances of occupational exposure to carbon monoxide and other deleterious materials in automotive exhaust emissions. Since carbon monoxide is the most abundant of these as well as the easiest to detect and measure, its concentrations serve as a reliable index for indications of other automotive exhaust constituents such as nitrogen oxides, lead, and the polynuclear hydrocarbons. In fact the correlation of CO and 3, 4- benzopyrene in gasoline engine exhaust has been shown to be high (1).

In respect to ambient air CO in cities there are occasional reports of concentrations above 100 ppm, particularly in specific locations such as large traffic intersections (2), but such a concentration as well as those exposed are both transient entities and therefore equilibrium with the blood is not established. However, in enclosures or partial enclosures where engines run, not only should the CO concentration be somewhat more stable but the other variable, the exposed employee, is confronted by the exposure for a work day which is more than ample time to establish equilibrium.

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Many surveys for CO concentrations have been conducted in automobile service garages. In twenty six such garages in Italy (3), the concentration of CO ranged from 10-300 ppm with a mean of 93 ppm. In France CO concentrations in service garages have approached 1 per cent in exceptional instances (4). In this country 100 ppm of CO may be reached in service garages in a relatively short time where there are no control measures (5). In respect to other types of automobile garages, Trompeo, et al. (6), found a range of 10-300 ppm of CO with a mean of 98 ppm in twelve underground garages, and Hofreuter, et al. (7), reported an average of 50 ppm (range 10-150 ppm) in an auto inspection garage.

Nothing in the literature could be found in reference to CO in parking garages of the type in this study. In Dayton, Ohio there are about ten parking garages of the enclosed type; i.e., the only ventilation is from street air through the entrance. Most of these garages have a 300-500 automobile capacity and four decks or floors. Though motors may not be left running as long as in service garages, the number of vehicles is appreciably greater. Seven such garages were selected for study.

Objectives

The overall objective was the elucidation of the degree of potential occupational hazard this type of parking garage poses in reference to carbon monoxide exposure. More specific objectives involved: the determination of the daily average of CO

concentrations and the degree of CO fluctuations throughout the day; the comparison of CO concentrations among garages and the comparison of CO levels on different days at the same garage; a comparison of garage CO in summer with that in winter; and the comparison of CO on weekdays with that on Saturdays. Plans were made for later studies on the carboxyhemoglobin of the employees.

Methods and Procedures

The potassium pallado sulfite method was employed for the detection and measurement of carbon monoxide. The calibration for the 112 cubic centimeter volume (7 strokes) was employed. My efforts to establish the degree of accuracy have shown the error for most of the range to be within ± 2 ppm. Silverman (8) provides an excellent evaluation of the method.

A sample of air was taken each hour beginning at 8 A.M. and ending at 5 P.M. Each sample was taken at the same point within the garage (a point where attendants are found most frequently).

Four of the seven garages were so studied on four different days, two days in summer and two in winter. One garage was frequented five times and two others twice each. In all, twenty five days were spent; twelve during July and August, and thirteen during November and December. One Saturday's sampling was included from each garage.

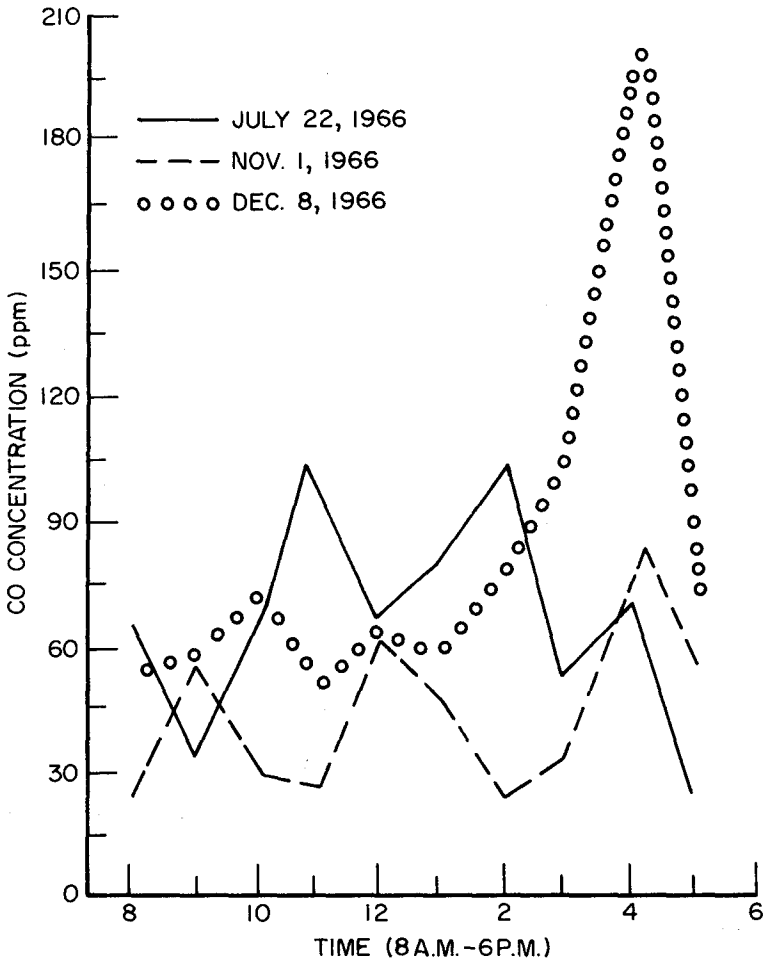

Figure 1. Three Diurnal Patterns of CO from Garage 1.

Results

Figure 1 exemplifies the fluctuations of CO throughout the day. Further indication of hourly fluctuation is shown by the standard deviations for each of the 25 daily means. These range from ± 9.59 to ± 94.71 with an average of ± 32.44. Goldsmith, et al. (9), imply that CO exposures from most sources are quite fluctuating. Furthermore, Gadaskina, et al. (10), show experimental proof that fluctuating CO is more harmful and produces more COHb than constant concentrations.

It would appear that the basis of the hourly fluctuation is the difference in the number of cars with engines running at the time of sampling.

Table 1 presents the summarized values. It is obvious that the CO concentrations vary from day to day in the same garage and that some garages consistently average higher than others. These differences reflect the extent of auto volume on different days and in different garages. The range among individual samples is 7-275 ppm and the average of the 25 daily means (which reflects the mean for all samples) is 58.1 ppm S.D. ± 23.15.

The mean for 12 days of summer readings is 63.2 ppm S.D. ± 15.90 and that for the 13 days of winter readings is 53.1 ppm S.D. ± 26.42. This is not the case in ambient air (2) where greater air turbulence and a more prominent adiabatic lapse rate maintain lesser concentrations of pollutants in summer,

than during autumn and winter. But then velocity of air movement in the garages is always somewhat independent of that of ambient air.

Weekdays averaged a little more than Saturdays; 59.6 ppm S.D. ± 24.95 to 53.7 ppm S.D. ± 20.13 respectively.

TABLE 1.

Concentrations of CO
in Seven Dayton Parking Garages

Garage	Sampling Days	Range (ppm) of Daily Means	Average (ppm) of Daily Means	S.D.
1	4	42.1 - 75.5	61.2	± 13.9
2	4	46.2 - 94.0	72.5	± 22.4
3	4	22.5 - 82.8	48.9	± 27.7
4	4	22.4 - 51.9	34.2	± 12.6
5	5	39.7 - 95.0	66.4	± 21.5
6	2	36.9 - 53.3	45.1	± 11.6
7	2	72.0 - 88.1	80.0	± 11.4
Totals	25	22.4 - 95.0	58.1*	± 23.15

* An average of all 25 daily means. Standard Error = ± 4.63 ppm

Discussion

As to the potential significance of these findings it is necessary to consider how the mean exposure of 58.1 ppm relates theoretically to the carboxyhemoglobin of the employees, and what such levels of COHb mean in terms of a health hazard. At equilibrium 58 ppm of CO would result in 9.3% saturation of the blood with the gas (from this source alone). Of course these proportions are derived from experimental data in which a definite,

non-fluctuating concentration is inhaled (11). Most of the parking garage attendants are smokers and this would constitute an additional source of CO.

COHb levels of 8-10% saturation are not enough to produce many symptoms in most healthy subjects (12). However the oxygen tensions of arterial and mixed-venous bloods have been known to decrease 7.3% and 13.3% respectively when the COHb amounted to a range of 5-10% saturation (13). Furthermore it has been shown that functional impairment of the higher centers of the central nervous system increases proportionally with greater percentages of COHb, impairment being detectable by psychological tests at levels of 5% and below (14).

Though 10% COHb is often given as the level significantly affecting oxygen transport, half this value has been observed as a standard (30 ppm CO exposure) for community air pollution in view of the added potential harm and possible synergistic effects from NO_2, Pb, and polynuclear hydrocarbons that are certain to be in the same air (15).

Finally 30-40 ppm of CO to equilibrium (5-7% COHb) in itself, without other air contaminants, may well pose a health problem in those already hypoxemic from other causes, e.g. anemia, cardio-respiratory conditions, and heavy smoking (15).

Conclusions

Twenty five days of hourly air sampling at seven parking garages of the enclosed type indicated a mean carbon monoxide

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concentration of 58.1 ppm (S.D. ± 23.15, and S.E. ± 4.63). This degree of exposure for eight hours each day poses a potential occupational hazard to those already having some degree of impairment of tissue oxygenation.

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