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Indoor air quality in a multi-car garage

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Abstract

Multi-car garages under residential and public buildings become more and more popular nowadays. People do not spend much time there but even short exposure to harmful conditions could be harmful. The paper describes the results of the indoor air parameters study in a multi-car garage. The tested site was located below a five-storey multi-family residential building. The CO₂ and CO measurements were conducted. All of the recorded measurements data of CO₂ and CO concentration were below the maximum recommended values. The calculations of essential air ventilation flow were done

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1. Introduction

Nomenclature

| | |
|------|---|
| A | the cars movement coincidence factor (garages with small movement– 0.6, garages in public buildings – 0.8–1.5 (Regulation of the Minister of Labor and Social Policy of Poland) |
| Cdop | acceptable concentration of CO in the garage [kg/m ³] |
| Cz | CO concentration in a supply air stream [kg/m ³] |
| E | pollutants emission [mg/h] |
| Ec | emission from one car [kg/h] |

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|-----|---|
| e1 | CO emission during idle run [m ³ /h/car] |
| e2 | CO emission while passing the garage [m ³ /h/car], with speed of 10 km/h |
| V | air ventilation stream [l/h] |
| M | CO emission [l/h] |
| np | number of parking places |
| s | the distance travelled in the garage [m] |
| S | CO ₂ concentration in the calculated room/garage [ppm] |
| Sm | maximum acceptable concentration of pollutants in the room NDS [mg/m ³] |
| Sn | CO ₂ concentration in air supply [ppm] |
| Sn1 | concentration of pollutants in air supply stream [mg/m ³] |
| T | starting time of a vehicle [s] |

The present study was inspired by the publication of measurements made in cars [1, 2] and other places [3–6]. Emissions from vehicles could be dangerous. Nitrogen and water vapor are not harmful to humans, however CO₂ (12 %) and CO (2 %) from the flue gas are not neutral for human health.

Large residential and public buildings are more and more popular in cities all over the world due to rising land prices and population growth. The necessity of creating enough parking spaces for tenants leads to increased popularity of underground parking lots. This kind of parking could be harmful for people using it if the ventilation system is not sufficient. Fans working during a normal garage usage should protect users from air pollution generated by the car engines' combustion process, as it causes significant health issues and can be deadly. In Poland, the main control standards that should be met in the garages are included in the Regulation of Minister of Infrastructure [7]. The air exchange rate should be provided to ensure the safety of users during normal operation of the facility and in case of fire hazard.

The gas emissions depend on the garage location and its usage profile, but ventilation system pays a significant role. According to Recknagel et al. [8] there are different types of usage profile: the low frequency of cars in and out of the lot movement should be taken into account when not more than 60 % of cars enter or exit the garage per hour. High frequency designation implies entry and exit movement of cars higher than 80 % [9, 10].

Some studies have been carried out around the globe to understand the impact on human health of CO₂ concentration in garages. The Batterman et al. [11] studies showed that residential garages have high concentrations of gasoline vapours due to the storage of gasoline-powered vehicles. The authors paid attention to the possibility of numerous sources of pollution migrating from the garage into living spaces. Similar problems were discussed by Nirvan et al. [12]. The results of studies of two buildings showed a high concentration of indoor pollutants for typical leaky garage-house interface. Authors' calculations indicated a design of mechanical exhaust systems can cause higher infiltration of contaminants from the garage to the house. The motor vehicles are in fact emitters of harmful and hazardous gases and dusts that could also be a huge problem for the environment. In the enclosed space of the garage it is easy to exceed pollutant concentration, for instance odorless CO which is dangerous to humans, or other toxins in car exhaust gases: hydrocarbons, sulfur compounds, and lead. CO₂ is emitted during the combustion of fuels. CO is also a product of combustion and appears in the mixture with CO₂ in the same volume percentages [13]. The mixture is heavier than air, so it could be dangerous for small children and animals.

In the design of rooms, the minimum hygiene criteria, which defines the maximum limit of CO₂ concentration on 1000 ppm (0.1 %) must be met [14–16]. To keep the concentration of CO₂ at a lower level, it is necessary to supply adequate flow of fresh air to replace the exhaust air [17]. The interim maximum CO concentration was set at 158 ppm, while the CO concentration boundary value by 8 hours of exposure is 26 ppm. According to UNE 10001191 [18] it is 50 ppm per 8 hours and 400 ppm per 15 min. The necessary air stream for the mechanical ventilation system controlled variable, dependent on the CO₂ concentration can be calculated with the formula [19]:

$$V = \frac{m}{10^{-6}(S - S_n)} [l/h] \quad (1)$$

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