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Filtering Efficiency of Pollutants in Heavy-Duty Vehicle Cabins

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Quality of air in the cabin of transportation vehicle is of high importance due to increase in globalization that hinders rise of transportation of goods worldwide. The largest source of street pollution in urban areas is vehicular combustion, constituted mainly of gaseous pollutants such as CO_2, CO, oxides of nitrogen (NO_x), ozone (O_3), and particles comprising ultrafine particulate matter (UFP). Drivers of heavy-duty vehicles (HDV) are spending both their working and free time in vehicle cabins, rendering them highly exposed to toxic gases and hazardous aerosols. Intensive industrial development is more concentrated in metropolitan areas, and since it still relies on fossil fuel energy for goods transportation, it results in high pollution of air with traffic-related air pollutants (TRAPs). Primary sources of UFPs in the urban environment near road sites are thus strongly related toHDVs, and they enter cabin air through windows, accumulating in the cabin air and on the surfaces, resulting in up to three times higher concentration of TRAPs in the cabin than outdoor air. Exposures to high CO_2, $NO_x$and UFP can significantly reduce decision-making performance and is considered a contributory cause of premature deaths of HDV drivers. Development focus is to improve use of human-machine interactions. However, sedimentation and/or collection of UFP onto filter surfaces, long filter exposure times, and high temperatures within cabins in turn cause decrease of air-flow within the filter and drastically decrease filtering efficiency. By combining experimental results obtained from in-field measurements performed in the city of Belgrade, during peak traffic hours, for air filtration systems (AFS) placed at different positions within the cabins, we obtained master data representing the functional role of air filtration systems. Following analytical study of experimental results, we propose a mathematical model to describe AFS efficiency in cabin pollution mitigation. Predicted results are in close agreement with the experimental data showing that knowing the levels of outdoor to cabin pollutant concentrations itis possible to estimate the efficiency, depending on design and local terrain, filtration exposure time and thermodynamic parameters within the cabin. We hope that this research raises organizational attention to the health and welfare of HDV drivers and will result in reduced levels of human exposure to harmful vehicle pollutants.

Keywords: heavy-duty vehicle, HDV, air filtration system, AFS, HDV cabins