Pioneering Ultrafine Particle Prevention Technology in Internal Combustion Engine Vehicles - Investigating the Pressure Release Valve

Hu, Neil (School: Temple City High School)

Significant ultrafine particle (UFP) exposure can cause serious health problems for individuals driving on-road. Despite this, internal combustion engine vehicles (ICEVs), which account for over 90% of all vehicles, do not include technology designed to effectively mitigate passenger UFP exposure. This study's purpose is to examine the influence of the pressure release valve (PRV) on infiltration and develop solutions to reduce UFP exposure. On-road cabin (Inside) and Outside UFP concentrations along with differential pressures (DP) between cabin and vehicle-exterior surface areas were measured for three modern vehicles. Extreme Outside and Inside UFP concentrations of 4.8×10^6 #/cm^3 and 4.2×10^5 #/cm^3, respectively, were observed, and Inside/Outside UFP ratios mostly ranged between 19.9%~71.8%, but reached an exceptionally low value of 1.3% in one non-ICEV vehicle operated under Biodefense. The PRV was identified as the primary contributor to infiltration as sealing it further reduced cabin UFP by over 50% in the ICEV. DP measurements indicated outside pressure near the PRV was higher than cabin pressure and that the PRV contributes approximately 87.5% of the ICEV's entire infiltration area. Opening a portion of the PRV can maintain a desired positive cabin pressure (PCP), thereby reducing infiltration. A novel PRV design is developed to sustain a desired PCP using weighted, inclined flaps. This study's findings demonstrate the possibility of reducing cabin UFP in ICEVs by controlling the PRV and creating PCP. These approaches offer a promising solution that addresses the lack of UFP-prevention technology in ICEVs, ultimately protecting millions of people's health by reducing UFP exposure.

Awards Won: