Experimental Investigation of an Advanced System to Prevent Pollutant Ingress Into Vehicles

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Due to high ultrafine particle (UFP) concentrations on freeways and the lack of effective UFP prevention technologies in vehicles, passengers may be exposed to elevated cabin UFP levels during driving, potentially leading to adverse health effects. To address this, a novel $22 cost-effective pressure release valve (PRV), incorporating weighted flaps and an inclined angle, was developed to reduce infiltration while maintaining pressure-release functionality. A prototype PRV was installed in two vehicles, combined with a high-efficiency particulate air (HEPA) filter to remove UFP in ventilation air. On-road tests were conducted measuring outside and cabin UFP concentrations under three common ventilation modes—AC On, All Off, and Fan On—and three configurations: baseline, HEPA filter only, and HEPA filter plus PRV. With the new PRV, both vehicles achieved positive cabin pressure under Fan On mode. With the HEPA and new PRV, a 91% reduction of UFP I/O ratio was achieved in one vehicle operated under AC mode. All average I/O ratios were substantially reduced: from 0.319 to 0.038 under AC On, 0.275 to 0.149 under All Off, and 0.418 to 0.210 under Fan On, corresponding to reductions of 88%, 46%, and 50%, respectively, compared with baseline. Notably, the system under AC On achieved a comparable UFP I/O ratio to the Biodefense, a state-of-the-art cabin air filtration technology in electric vehicles (0.038 vs. 0.013) and substantially outperformed it under All Off (0.149 vs. 0.712). These results demonstrate that the combined new PRV–HEPA system offers a promising solution to reduce UFP ingress into vehicle cabins and enhance passenger health protection during daily commutes.

Awards Won:
Fourth Award of $600