Development and Evaluation of an Exhaust-Assisted Toilet for Aerosol Control

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Abstract

Toilet use has been linked to the dissemination of both infectious agents and chemical residues, primarily due to aerosol generation during flushing. Studies have consistently detected contaminants on nearby surfaces and fixtures, highlighting the potential for environmental exposure. Therefore, this study aims to investigate the factors influencing particle escape and to enhance the design of existing toilet systems.

A commercially available toilet was installed inside an acrylic testing chamber to prevent interference from external particles, with clean air supplied at 200 LPM. At the exhaust end of the chamber, a CPC was used to measure the total number of particles generated during each flush. The operational parameters included the exhaust flow rate, the shape and position of the air exhaust port, and the area of the air inlet and outlet.

To evaluate the sealing effectiveness of the toilet lid, the coverage area of the lid was adjusted. Results demonstrated that as the coverage area increased, the exhaust flow rate required to achieve a same particle capture efficiency decreased accordingly. Notably, even under very low airflow rate (20 LPM), a capture efficiency of 90% was attained. Under all conditions, approximately 99% capture efficiency was reached at 120 LPM. Furthermore, it was found that approximately one minute was sufficient to achieve a 99.9% particle displacement efficiency within the toilet bowl.

By applying engineering control approaches to modify toilet design and air exhaust mechanisms, we can actively capture particles generated during flushing and effectively reduce particle escape, thereby lowering users' exposure risk.

Keywords: Particle control device; Particle capture efficiency; Toilet lid redesign.