PROTECTION - SCIENCE AND TECHNOLOGY ADVANCES FOR CHEMICAL AND BIOLOGICAL PROTECTION

Extended Bioprotection Of Facilites

Mark Ginsberg ERDC-CERL

The recent COVID-19 pandemic led to widespread shelter-in-place measures globally. The rate and spread of infection during this period provided clues as to which heating, ventilation, and air conditioning (HVAC) systems either facilitate or hinder the spread of contaminants.
This report delves into applying advanced mathematical analysis to understand how biocontaminants spread through HVAC systems. We build on the methods introduced in Ginsberg & Bui [1], which initially described external biocontamination releases. These methods are expanded to cover internal releases, whether intentional, or from infected individuals. Our results outline the transmission of viruses through HVAC systems and estimate the cumulative viral dose inhaled by an uninfected person sharing the same building as an infected individual or other sources.
A key concept in our findings is the "protection factor," borrowed from gas mask design terminology. By employing state-space ordinary differential equations (matrix methods), we extend these results to create "lumped element models," which offer a more straightforward way to calculate results without matrices. Hand calculations suffice for almost all simple scenarios, while complex cases can be solved directly by machines without the complexity of solving state-space differential equations.
The outcome of these calculations provides the protection factor for each workstation in a building, offering a clear answer to the question of how long each workstation can be occupied without posing health risks to the occupant. This enables various "what-if" analyses to be conducted during design or rehab of HVAC systems and structures.
Additionally, our report introduces exact solutions to the underlying differential equations, replacing previous numerical approximations. These exact solutions maintain the same level of laboratory validation as older methods while enabling easy assessment of building safety based on HVAC design. Our analysis aligns with clues about which HVAC systems promoted or hindered the spread of contaminants during the recent pandemic, further aiding in maximizing protection while minimizing costs.
The results of this research will inform DoD building managers regarding how to design and rehabilitate structures to resist or defeat biological and other airborne threats.

This work is funded, in part, by the Defense Threat Reduction Agency as part of the Enhanced Bioprotection of Facilities project which is led by the Engineer Research and Development Center of the US Army Corps of Engineers.