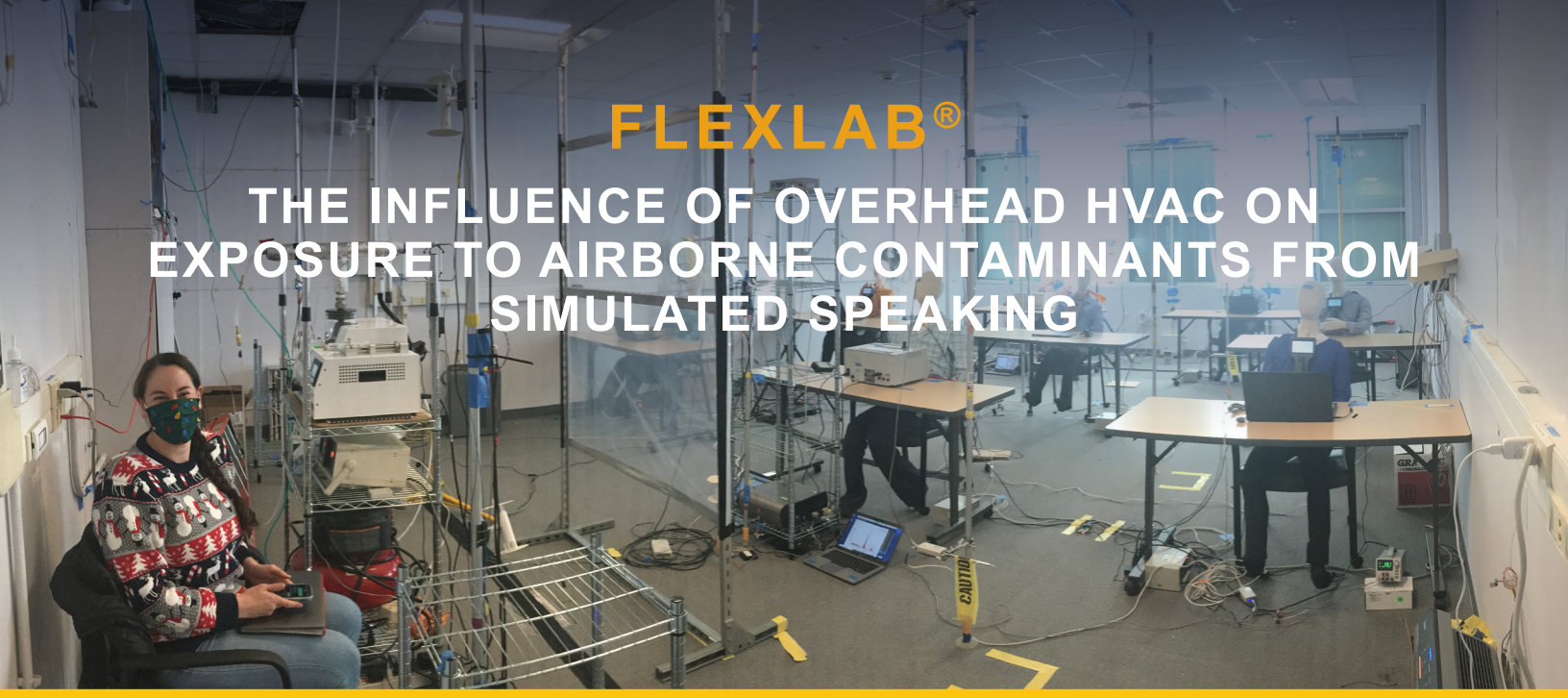

FLEXLAB®

THE INFLUENCE OF OVERHEAD HVAC ON EXPOSURE TO AIRBORNE CONTAMINANTS FROM SIMULATED SPEAKING

This FLEXLAB experiment advanced knowledge about the elevated exposure risks to airborne respiratory viruses in rooms with overhead heating.

THE CHALLENGE

Quantify the effect of room stratification from overhead heating on the mixing of respiratory aerosols emitted by people in meeting and classroom scenarios

The guidance to maintain a distance of at least six feet and to increase ventilation were core features of pandemic building operations. This distance was generally supported by studies of simulated emissions from one to two heated manikins in office-sized experimental chambers. Investigating the effectiveness of distancing in classroom and meeting room scenarios required a facility with advanced measurement tools and full control over the heat transfer processes that drive airflows.

THE SOLUTION

This research was supported by the U.S. Department of Energy Office of Science, through the National Virtual Biotechnology Laboratory, a consortium of DOE national laboratories focused on response to COVID-19, with funding provided by the Coronavirus CARES Act. Researchers at the U.S. Department of Energy's FLEXLAB® facility at Lawrence Berkeley National Laboratory experimentally investigated this challenge. The team conducted over 60 experiments to investigate the influence of supply air temperature on mixing of respiratory aerosols emitted by people speaking in a room that has forced air heating, ventilation, and air conditioning (HVAC) with supply and return registers mounted in the ceiling – which is common in schools and offices. The study used heated mixtures of carbon dioxide, air and generated aerosols to represent the emissions and heated manikins to represent occupants. The impact of portable air cleaners (PACs) was also studied.

> **This research provides valuable insight about risks for the common configuration of ventilation from overhead diffusers. The controlled but realistic conditions that were achieved with FLEXLAB® were extremely beneficial in providing quantitative results.**

Laureen Burton, Environmental Protection Agency, Indoor Environments Division

U.S. DEPARTMENT OF ENERGY
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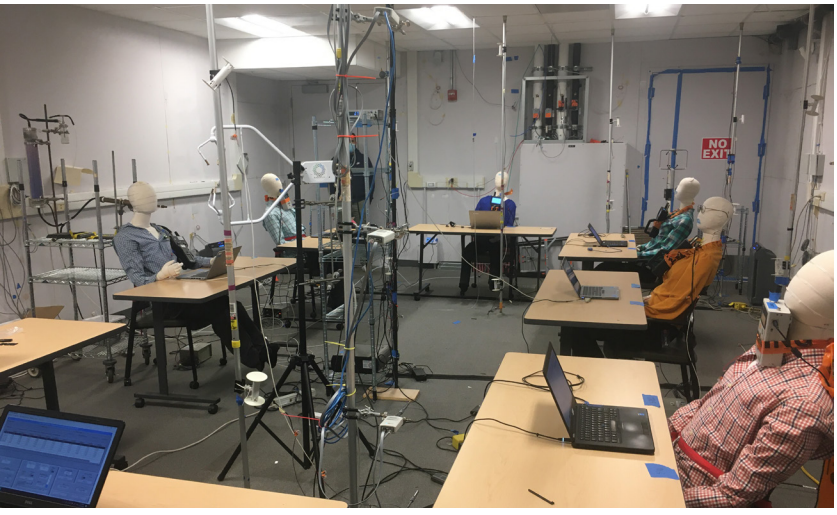
THE BOTTOM LINE

Overhead heating creates air stratification, leading to higher concentrations and exposures in the breathing zone compared to a completely well-mixed space.

In both simulated settings, the stratification from overhead heating created substantially higher exposures, compared to scenarios of no forced air, cool air, or air of a neutral temperature and reduced the benefits of outdoor air ventilation. Fortunately, there is a relatively simple solution. Fans or PACs can mix the air vertically and ventilation and filtration can be used to greatly reduce respiratory aerosol levels.

THE EXPERIMENT

- Room occupants were simulated with heated manikins seated at desks arranged in a meeting or classroom configuration with 7 feet of spacing.
- Respiratory aerosol emissions were simulated using heated mixtures of carbon dioxide (CO_2) as tracer gas, air and generated particles injected from a point adjacent to the head of a seated (student or meeting participant) or standing (teacher) manikin and measured at the breathing zone of each of seven other simulated occupants and at other locations spread throughout the room.
- The fully controllable forced air HVAC system was either turned off, to study the impact of mixing induced only by the simulated occupant body heat, or set to provide heated, cooled or air at room temperature.
- The variable frequency drive of the air handling unit (AHU) controlled the volumetric airflow, and outdoor air (OA) was controlled by setting outdoor, return, and exhaust air damper positions and monitoring flow rates separately at the intake, return, and exhaust. Two or four ceiling-mounted perforated face diffusers supplied air to the room.



THE RESULTS

- In both configurations, when the supply air was heated, mixing into the breathing zone was limited. Stratification interferes with dilution of emissions from people and reduces the effectiveness of ventilation that is intended to dilute and remove expelled respiratory aerosols that can carry infectious agents.
- In these experiments, stratification caused at least 25% of the manikins to have exposures 2.5 times beyond what would have occurred with perfect mixing.
- Cooled or neutral supply air led to good mixing of the simulated speaking emissions and low variability in the concentrations at each room height.
- The operation of portable air cleaners in the corners of the rooms helped both by removing the aerosols and also by mixing the air vertically to speed dilution.
- With the AHU off, mixing induced by the thermal manikins and equipment in the room was sufficient to avoid stratification, but with substantially more variability than with mechanical mixing.
- When ventilation is provided at the ceiling, it is critical that room air is mixed vertically to get the air quality benefits of the ventilation air. Occupant spacing is still helpful to reduce close contact exposures but mixing is also needed.

flexlab.lbl.gov
flexlab.lbl.gov/publications/measured-influence-overhead-hvac

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