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Mitigating Airborne Disease Transmission for K-12 and Higher Education
Best Practice Recommendations for Breathing Air

Discussion

The primary mechanism of person-to-person infection of viral diseases such as COVID and influenza in public space is through the sharing of infected respiratory aerosols (airborne droplets). Specifically, when an infected person contaminates the breathing air by exhaling infected respiratory aerosol and the next person inhales and ingests these infected aerosols to the extent that they ingest the minimum infectious dose (MID) of virus particles (virions). While the MID of common viral disease is in the 1000's, limited studies to date suggest that COVID is highly contagious with an MID of less than 1000 and perhaps closer to 700 virions.

Given the above, it is intuitive that the objective of any plan to mitigate the transmission of airborne disease in occupied space is to control or minimize the respiratory aerosols in the breathing air. The following summary of plan elements is intended to demonstrate why *Ventilation Control* is essential to any disease transmission mitigation plan.

Face Masks: The intent of the face mask is to filter respiratory aerosol inhaled/exhaled from the breathing air as well as reduce the projection of respiratory aerosol. While they may be effective in reducing the projection of respiratory aerosol, they do little to filter or reduce the quantity of respiratory aerosol that is inhaled or exhaled as the majority of respiratory aerosol is respired around the edges of the mask and not filtered through the mask. Additionally, the *effectiveness* of plans that depend on face masks as the primary element of mitigation is directly proportional to adherence. While high levels of adherence may be achievable in professional working environments such as those in the medical field, social behavior in K-12 and higher education groups undermines adherence enforcement efforts rendering such plans substantially less effective by comparison.

Summary Statement: Masking should be considered a supplemental practice recommended for higher risk environments.

Ionization: Many pathogens are neutralized or destroyed by direct contact with negatively charged particles. This is the case with surface decontamination and pathogens that are left from dehydration of respiratory aerosol. However, flooding occupied space with ionized atmospheric air does very little to reduce respective contamination level. The density of active ionization byproducts such as OH, Hydrogen Peroxide and Ozone required for human safety is typically less than 1 part per million (1ppm). Simple arithmetic suggests that such a low ratio precludes the direct interaction of these byproducts with airborne pathogens. Given that the virions in infected breathing air are contained in respiratory droplets, the active ionization byproducts are more likely to react with the droplet's electrolytes than directly with the pathogen. Moreover, chemical treatment of breathing air can create additional hazardous byproducts depending on the actual composition of the air and other sources of air contamination. Specifically, the formation of formaldehyde has been identified as a common byproduct.

The use of ionization as an internal component of an air purification device is similar if not identical to the above considerations given that these byproducts migrate by diffusion and cannot be contained.

UL Standard 867 addresses safe levels of Ozone. It does not assure safe levels of other chemicals, namely, Hydrogen Peroxide.

Summary Statement: Ionization is NOT recommended under any circumstance primarily due to risks associated with continued hazardous chemical exposure.

UV Light: UV-C is effective for surface disinfection. The integration of UV in air handlers is recommended to control surface contamination and improve the overall biological integrity of the HVAC system. However, UV is not effective in disinfecting airstreams within an air handler. The neutralization of any organism by UV requires the absorption of a requisite amount of energy. Given that the velocity of pathogens in airstream typically exceed 600 feet per minute, exposure time for sufficient energy absorption is not achieved.

Summary Statement: UV installed in HVAC air handlers is medium priority and recommended as supplemental practice.

Increase Ventilation and Upgrade HVAC Filters: "Ventilation" is synonymous with "outdoor air" and "make up air" in the engineering vernacular. Effectively, outdoor air is introduced to dilute the breathing air in a populated space. Uncontrolled ventilation or simply increasing ventilation rates can exceed the design capacity of the system and reduce the capability to control temperature and humidity while decreasing energy efficiency. Replacing MERV 8/9 filters with higher efficiency filters such as MERV 13 can significantly decrease recirculation rates and performance as well as decrease energy efficiency.

Summary Statement: Uncontrolled increased ventilation is not recommended.

Recommended Best Practice: Controlled Ventilation

- Install CO2 Sensors and Continuously Measure CO2 Levels
  - Ventilation rate standards have been established to control the CO2 levels in a given type of populated space. Given that CO2 is a product of respiration, there is a direct correlation between respiratory aerosol density and CO2 density in a given space. Install CO2 Sensors in each classroom and defined occupied space. Using CO2 as a proxy for respiratory aerosol density, set an alert at 1000 ppm and an alarm at 2000 ppm.
  - **Capital Cost < $16/Student. Operating Cost < $0/Student**

- Assure Proper Filtration
  - Install system recommended filters for existing HVAC System design to assure effective level of filtration while maintaining full design capacity volumetric air flow. Use antimicrobial treated filters if available.
  - **This is high priority recommended practice. Capital Cost < $0/Student. Operating Cost < $1/Student/year**

- Balance Air Handlers to CO2 Levels
  - Balance individual HVAC air handlers to provide uniform CO2 levels during hours of peak occupancy.
  - **This is high priority recommended practice. Capital Cost < $0/Student. Operating Cost < $1/Student/year**

- Increase Ventilation Rate to Control CO2
  - Increase make up air or ventilation rate to achieve CO2 levels below 800 ppm during peak occupancy. Provide additional conditioning capacity as required to maintain design level temperature and humidity.
  - **This is high priority recommended practice. Capital Cost < $1/Student. Operating Cost < $1/Student/year**

- Install HEPA Filter Air Purifiers with High Velocity Directional Air Flow
  - Install discrete HEPA air purifiers specifically designed to displace respiratory aerosols from the breathing zone and dilute respiratory aerosol density. Purifiers should have minimum effluent velocity of 400 fpm directed 3-6 feet above floor level to displace, dilute and remove respiratory aerosols.
  - Installed purifier capacity must match or exceed the ventilation rate as provided by ASHRAE Standards. Accordingly, the dilution coefficient should be between 1 and 2 using the following equation:

    Coefficient of Aerosol Dilution = Air Purifier Flow Rate/ASHRAE Ventilation Rate.
  - Use Computational Fluid Dynamics (computer simulation) if available for air purifier placement to optimize room air dynamics for breathing zone displacement and vertical directional air flow.

  - Selected purifiers MUST carry the following credentials and be labeled accordingly:
    - UL listed
    - EPA Registered Manufacturing Facilities
    - FDA Compliant listing specific Pathogen Efficacy > 99.99%
    - HEPA filters should be Certified to IEST Standards
  - **This is high priority recommended practice. Capital Cost < $250/Student. Operating Cost < $15/Student/year.**

- Install UV Light Module in Air Handler
  - The integration of UV in air handlers is recommended to control surface contamination within the air handler and improve the overall biological Integrity of the HVAC System. Selected components must meet UL Standard 867 and be labeled accordingly.
  - **This is medium priority and recommended as supplemental practice. Capital Cost < $30/ Student. Operating Cost <$1/year/student.**

- Install In-duct HEPA Air Purifiers in Return Air
  - The integration of in-duct HEPA air purifiers in return air is recommended to eliminate pathogen migration and maintain the overall biological integrity of the HVAC System.
  - **This is medium priority and recommended as supplemental practice (for existing buildings). Capital Cost < $100/ Student. Operating Cost <$5/year/student.**

General Guidance for New Construction (Abridged)

- Include In-duct HEPA Air Purifiers in Return Air
  - The integration of in-duct HEPA air purifiers in return air is recommended to eliminate pathogens and pathogen migration while maintaining the overall biological integrity of the HVAC System.
  - **This is high priority and recommended practice (for new construction). Capital Cost < $100/ Student. Operating Cost <$5/year/student.**

- Floor or Low Wall Return
  - HVAC design should provide for in-floor or low wall return such as required to maintain vertical downward air flow.
  - **This is high priority and recommended practice (for new construction).**

- Air Handler Capacity
    - Air handler capacity shall be specified to meet or exceed ASHRAE Standards AND provide a minimum air exchange rate as required to maintain vertical air flow in each classroom and defined occupied space with floor or low wall return configuration.
    - **This is high priority and recommended practice (for new construction)**

About Am Technical Solutions

AM Technical Solutions, Inc. (AMTS) is arguably the world leader in aerosol particle measurement, trace gas analysis and associated micro-contamination. As a world leader in clean room design, construction and certification, AMTS engineers are experts in room air dynamics.

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