Pepper Construction
Tomorrow Transformed

VENTILATION
OF THE FUTURE:

Protecting the Air We Breathe

Indoor Air Quality is the New Frontline

Among the many lessons learned from the COVID-19 pandemic, one of primary importance is that indoor air quality matters. Like drinking water, outdoor air pollution and the food we eat, the quality of indoor air is now under the microscope for future regulation.

Recently a global group of scientists published a manifesto in the journal Science, **urging governments to mandate higher standards for indoor air quality.**

"Governments have for decades promulgated a large amount of legislation and invested heavily in food safety, sanitation, and drinking water for public health purposes. By contrast, airborne pathogens and respiratory infections, whether seasonal influenza or COVID-19, are addressed fairly weakly, if at all, in terms of regulations, standards, and building design and operation, pertaining to the air we breathe. We suggest that the rapid growth in our understanding of the mechanisms behind respiratory infection transmission should drive a paradigm shift in how we view and address the transmission of respiratory infections to protect against unnecessary suffering and economic losses."

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> *SCIENCE*, MAY 2021

This follows the Centers for Disease Control (CDC) recent clarification of the real and lingering airborne threat the SARS-CoV-2 coronavirus presents. We now know with certainty that in an enclosed and controlled indoor environment like a school, senior living residence or office building, **the respiratory droplets via aerosol transmission from an infected person do in fact linger in the air over time and can travel well beyond six feet.** While physical distancing and wearing masks play important roles in reducing aerosol transmission at short distances, effective building ventilation serves a similar role at protecting people from transmission at further distances.

To protect our vulnerable populations and invigorate our economy, the health impact and science of indoor air circulation must be intimately understood and respected. For schools, health care facilities, commercial buildings and multi-family residences, achieving the ideal indoor air environment can be a complex scientific endeavor. Depending on the age and type of building, mechanical and ventilation system upgrades designed to bring in more outside air come with a hefty price tag and even environmental penalties. Fortunately, hundreds of billions of dollars in Federal grants (CARES Act & the American Rescue Plan) are currently available to schools, health care and senior living facilities to improve indoor air quality and reduce aerosol transmission risks in the built environment.

Commercial and institutional building owners, developers, architects and general contractors will be smart to consider and validate the efficacy of emerging technologies designed to clean their inside air. Those innovators that emerge with proven clean air solutions that also meet carbon-neutrality deadlines and maintain energy efficiency goals will be the heroes in this new public health frontier. Like prior public health mandates, clean indoor air protocols should drive innovation and eventually neutralize costs.

Protecting our students, elders and workforce from future airborne disease and subsequent economic disruptions without risking both environmental and financial progress is the ultimate frontline victory.

For school districts, building owners and developers interested in assessing and improving indoor air quality, this paper advances the proven strategies presented in the IAQ 1.0 article, "Improving the Air We Breathe," and suggests some emerging technologies that should be considered in the overall mix of a healthy building.

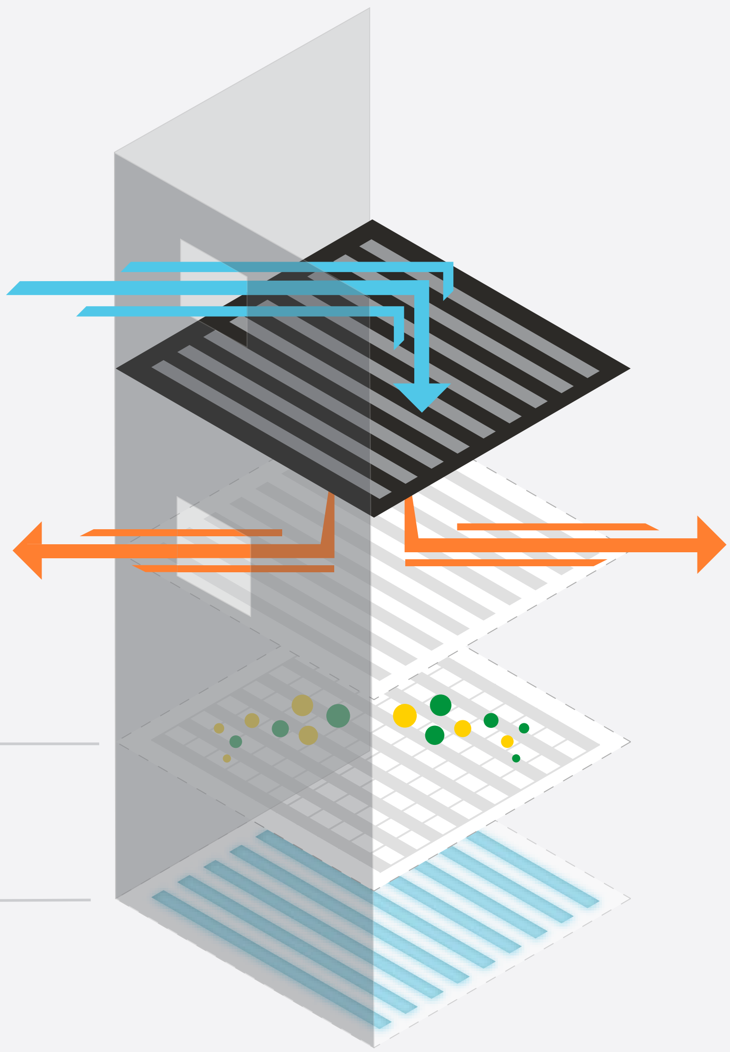
The approach to IAQ recommended by professionals at the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) involves layered levels of protection:

DILUTE
add outdoor air

EXHAUST
push recirculating exhaust air out of the building

CONTAIN
limit indoor aerosol mobility

CLEAN
using proven solutions such as filtration or UVC/UVGI lights in ductwork, or emerging technologies such as bipolar ionization, photocatalytic oxidation or reactive oxygen species air cleaners



What We Know

We now know just how quickly airborne disease can spread, just how vulnerable life and livelihoods can be, and the importance of scientific research and guidance.

In the mitigation of the small particulate and aerosol pathogens like respiratory droplets from indoor air (e.g., coalesced aerosols containing SARS-CoV-2 are predominantly in the size range of 1 μm to 3 μm), not all buildings and their mechanical systems are the same. No single strategy to control the indoor spread of infectious aerosols will work for all buildings. Additionally, each building operator has unique objectives and priorities. Budget, life cycle costs, and return on investment (ROI) are also important factors in a smart IAQ strategy.

For building owners, determining the safest, most effective, and sustainable IAQ strategy can be overwhelming.

"While this is a sound, tactical approach to a higher IAQ, a truly holistic and strategic approach to improving a building's IAQ will also consider all aspects of the building's operations, its envelope and core materials, in addition to the owner's building performance goals," explains Susan Heinking, AIA, LEED Fellow Vice President of High Performance and Sustainable Construction at Pepper Construction, one of the largest general contractors in the Midwest. "The environmental and energy impact of some upgrades can be costly to the building's operating budget and the planet. And some of the new air cleaning technologies can create unintended and hazardous byproducts like ozone."

Tactical consultants representing HVAC products will happily deploy additional systems but a holistic approach which considers all aspects of a building's operations and materials, and the owner's building performance goals will be most effective.

The science of IAQ under the lens of coronavirus threats is evolving and while we have several important and promising emerging technologies, more testing under real-world conditions is necessary before building owners invest to safely bring our workforce, our students, and our tenants back inside with confidence and scale.

How to Achieve a Higher IAQ

As recommended in an IAQ white paper from Pepper Construction, "*Improving the Air We Breathe*,," there are a number of proven strategies that can be layered together to create a healthier indoor environment. While it depends on the building's use as well as its mechanical systems and infrastructure, most common indoor air cleaning might include denser, higher-rated air filters (MERV-13 or higher), added humidity and increased outdoor air exchanges. Additionally, **promising emerging technologies can further improve a building's IAQ.**

For decades, the Pepper High Performance & Sustainability team has been innovating energy efficient, healthy, and environmentally-forward strategies and technologies on behalf of clients, their own workforce and the earth. This same dedication led them to conduct air quality testing at an active/in-progress Advocate-Aurora Christ Hospital Medical Center jobsite in 2019, while also collaborating with the hospital to ensure their patients and staff were breathing safely indoors.

Competing with a desire to bring people back to work is the persistent threat of airborne SARS-CoV-2 and its evolving mutations. Deploying a comprehensive IAQ management plan to combat infectious aerosols should be a priority of every operator. Early on during the pandemic Pepper immediately deployed proven IAQ strategies in their own offices such as increased ventilation, upgrading filters in air handlers to MERV-13, and CO2 sensors for demand-controlled ventilation. Pepper's Barrington, Illinois office is an example of how each office building is unique. Due to its age the specifications of the building envelope and windows, increasing humidity as an IAQ strategy was problematic. A more holistic approach to IAQ was necessary.

"In-person team collaboration and mentoring are woven into our company culture, and we believe it is important for our business and our local economies to bring everyone back to the office as soon as possible," said Stan Pepper, CEO, The Pepper Companies. "We also know from our research and project work, that a healthy building can enhance human performance and productivity without being a burden on our operating budget. In addition to proven strategies to ensure a high IAQ and earn our employees' trust, we are pilot testing emerging technologies that will further enhance operational efficiencies while improving the air our employees breathe."

Recently, Needlepoint Bipolar Ionization (NPBI) has gained traction as an emerging technology within the IAQ toolbox. While ionization technology has been used for decades, the needlepoint version is an evolution in design intended to prevent the formation of hazardous byproducts like ozone. According to manufacturer claims and third-party certification by Underwriters Laboratory (UL), the current market leader of NPBI devices uses "ozone free technology." While NPBI is a promising tool that does not seem to burden nonrenewable energy resources, the EPA considers NPBI to be an "emerging technology" and cautions prospective adopters that "little research is available that evaluates it outside of lab conditions."

Testing Assumptions About NPBI

"On paper, device manufacturers present Needlepoint Bipolar Ionization (NPBI) as an IAQ technology with a lot of upsides," explains Jacob Persky, MPH, CIH, Principal at RHP Risk Management Inc. "But with only laboratory testing under very specific conditions to validate efficacy, some of the performance claims for pathogen inactivation do not translate directly to real-world conditions as-installed in buildings. **We saw an opportunity to construct a controlled, real-world test on NPBI in the Pepper Construction office** to understand exactly how effective it is in meeting manufacturer performance claims for removing particles in various size ranges relevant to infectious aerosol transmission indoors. And a recent study suggests the technology may produce some unintended potential risks, like the formation of hazardous chemical byproducts. We looked at before vs. after installation changes for those hazards, formaldehyde and Total Volatile Organic Compounds (TVOCs)."

RHP Risk Management is a national research and consulting firm comprised of health scientists and public health professionals with a focus on regulatory compliance, health sciences, and product safety. RHP Risk Management is dedicated to helping facilities understand their exposure to potential airborne pathogens and help them prepare for a safe return to work by employing the most efficient procedures and technologies to mitigate transmission of COVID-19.

Needlepoint Bipolar Ionization (NPBI)

Much has been uncovered about NPBI from a laboratory studies, and most of the industry believes this technology works well as an additive air cleaning technology to neutralize and filter out ultrafine particulate and pathogens. However, NPBI is considered an emerging technology because it has not been scientifically evaluated in an actual office or institutional setting. Pepper and RHP just concluded the test of the efficacy of NPBI in virus mitigation in their Barrington, Illinois office.

NPBI releases positive and negative ions into the airstream of the building. These ions attract the ultrafine particulate to bond, forming clusters that are large enough to be filtered by MERV-13 filtration. In addition, laboratory testing suggests the pathogens are also neutralized as the ions changes the molecular structure, rendering the contagion harmless.

To test assumptions about NPBI, and to learn more about its effectiveness in a commercial environment at removing ultrafine particulates in the size range relevant to airborne pathogens like SARS-CoV-2 , a NPBI system was installed into each of the 15 roof top unit (RTU) air handlers at Pepper Construction's corporate headquarters in Barrington, Illinois in conjunction with robust, proven IAQ strategies: MERV-13 filtration, increased fresh outside air, and CO2 sensors for demand-controlled ventilation. **(To request a copy of the full RHP report on Barrington HQ Air Quality Testing, email info@pepperconstruction.com)**

"The pilot study revealed a 46% reduction in ultrafine particulate concentrations following ionizer installation," explains Persky. "This is meaningful from a SARS-CoV-2 risk reduction perspective in that research has shown that the particle size of the SARS-CoV-2 virus is around 0.1µm. It should be noted that the virus does not travel through the air by itself; because it is human generated the virus is trapped in respiratory droplets and droplet nuclei (dried respiratory droplets) that are predominantly 1µm in size and larger."

PARAMETER	BEFORE (12/23/2020)	AFTER (1/28/2021)	FINDINGS
Ultrafine Particulates (0.02 to 1 micron)	Indoors= 1500 pt/cc Outdoors = 4000 pt/cc	Indoors= 800 pt/cc Outdoors = 7600 pt/cc	46% reduction of ultrafine particulates.
Fine and coarse Particulates (PM_1, $PM_{2.5}$, PM_{10}, PM_{TOTAL})	Indoors= 4 ug/m^3 Outdoors = 13 ug/m^3	Indoors= 4 ug/m^3 Outdoors = 10 ug/m^3	No changes
Violatile Organic Compounds	None detected indoors and outdoors		No change
Formaldehyde	None detected indoors and outdoors		No change
Carbon Monoxide	None detected indoors and outdoors		No change

Testing was conducted using a DNA-tagged tracer to evaluate aerosol mobility throughout the building to provide a better understanding of how aerosolized respiratory droplets travel and migrate.

TEST PARAMETERS:

- 54,000-square-foot single-story building with single-pane curtainwall exterior
- Year Built: 1963
- Baseline testing: December 23, 2020
- Post-Ionization testing: January 28, 2021
- Monitoring of the ultrafine particulate levels was focused on one representative, open-concept cubicle area, both before and after NPBI installation
- Ion levels, formaldehyde, TVOCs and CO were measured
- Aerosol mobility was assessed throughout the building, before and after NPBI was installed using the DNA-tagged tracer.

CONCLUSION:

46%

Installation of NPBI devices improved indoor air quality by reducing ultrafine particulate concentrations by nearly half (46%).

The mobility of the tracer was well contained, primarily staying near the point of release. This is affirmation of the positive effect provided by the implemented IAQ strategies.

<1%

In this pilot test, we saw the energy use costs increased just under one percent with the MERV-13 upgrade, in conjunction with NPBI operation.

Phase Two Recommendations: Identifying a more energy efficient layered IAQ system

"This is a significant test of NPBI as one of the first documented, independent, scientific studies in an actual commercial indoor environment," explains Heinking. "The RHP test provides us confidence in the ability of NPBI to filter out the very fine pathogen-sized particulate from the air, but also reveals important information about how aerosol travels in an office of this size and ventilation. **This is a good scientific foundation; it is real, and we will be able to leverage this test and provide business and schools with well-informed counsel on IAQ before they invest in tactics that may not be effective or energy efficient."**

In addition to ensuring the safety of their own employees, Pepper and RHP are frequently engaged in IAQ consulting for their commercial and institutional clients and must understand the limitations and best applications for NPBI and other emerging air cleaning technologies. As a follow-on to the pilot-study work performed by Pepper and RHP at the Barrington office, plans are in progress to conduct additional evaluations and potentially assess the following:

- Repeat testing of the same NPBI system and test parameters but in conjunction with MERV-8 filters installed in the RTU air handlers.
- Repeat testing of the same NPBI system and test parameters but in conjunction with an emerging filtration technology, such as copper nanowire foam filters or reusable electrostatic filters, with NPBI providing a "pre-charge assist" to increase filtration efficiency.

Filtering Out Inefficiencies on Behalf of the Environment

Mitigating the spread of the coronavirus and future contagions in our built environments has shifted immediate attention and resources away from environmental and sustainability goals.

For example, increasing ventilation with a low relative humidity level requires a greater air exchange rate, which uses more energy. There has always been a battle between increased ventilation and operating efficiency, but especially today, health is the most important consideration. Particularly for clients seeking to achieve sustainability goals, there are ways to find efficiency elsewhere to rebalance the building's operations.

The CDC recommends filters that are rated MERV-13 or higher be considered for use in buildings, when feasible, to improve the capture efficiency of small particles and reduce the risk of indoor infectious aerosol transmission. Upgraded MERV filtration is a known, effective tool in the IAQ toolbox, but filters with greater filtration efficiencies also consume more energy. Further, MERV-13+ filters are currently in high demand, causing supply-chain shortages, long order delays, and driving increased costs.

"While we know the higher level MERV and HEPA filters will do a great job on the larger particulates, they are cost-prohibitive to procure, and they can add 2-4% to a building's energy budget," explains Heinking. "Intense research and innovation are needed before we start regulating or demanding more of the built environment. We need to prove the efficacy of new air cleaning tools that can clear the micro-particulate without breaking budgets or reversing environmental progress."

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> AIA, LEED Fellow
> Vice President of High Performance and Sustainable Construction at Pepper Construction

The challenge is determining the best recipe for each built environment, and for the global environment. A description and benefits of specific, proven strategies such as increasing ventilation rates, CO2 monitors, increasing humidity levels can be found in Pepper's IAQ 1.0: "The Air We Breathe."

Testing emerging technology will help drive innovation. Pepper and RHP are planning research to further evaluate additive air cleaning technologies in hopes of identifying new, safer ways of removing aerosolized pathogens in the air we breathe without backtracking on environmental progress or breaking building operation budgets. More focused, real-world research must continue before we can also achieve high performance and carbon reduction goals, at an accessible cost, while achieving a higher IAQ.