# WHITE PAPER

## Volume Matters for Optimal Indoor Air Quality

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**Volume Matters for Optimal Indoor Air Quality**

Whether you're a private residence, a commercial space, or a communal area (like a school or hospital), optimizing your indoor air quality is crucial. This is especially important during a global pandemic, but indoor air can affect health at any time.

To approach indoor air quality most effectively, your strategy should include a means of reducing indoor air pollutants, a way to optimize HVAC processes and overall building comfort, and a means of monitoring all the relevant factors that go into that strategy. Having a robust monitoring plan is crucial but often overlooked. It's important to remember that when it comes to indoor air quality and outside air intake, volume matters, and you need quantifiable data to assess those volumes.

**The Role of Outdoor Air Intake in Your Indoor Air Quality**

While many people think about air pollution in terms of smog, haze, and outdoor conditions, indoor air pollution should be of equal or even greater concern.

According to the EPA[1], indoor air is routinely two to fives times more polluted than outdoor air. In some circumstances, these levels of indoor pollutants can be up to one hundred times greater. The EPA also notes that people spend roughly 90 percent of their lives indoors. T

In order to maintain acceptable levels of indoor air quality, it requires the simultaneous managing of several factors:

- Airborne pollutant control
- Adequate outdoor air introduction
- Adequate outdoor air distribution
- Recommended temperature and humidity maintenance

ASHRAE defines acceptable indoor air quality as "air in which there are no known contaminants at harmful concentrations, as determined by cognizant authorities, and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction."[2]

Introducing outdoor air into your indoor space is an effective and important strategy to dilute any airborne pollutants that are present. Common indoor air pollutants[3] can range from asbestos, formaldehyde to particulate matter and biological pollutants (bacteria, viruses, dust, pollen). This includes aerosolized SARS-CoV-2.

The introduction of outdoor air into an indoor environment also plays a critical role in the maintenance of adequate building pressure, as well as the control of humidity and temperature levels.

[1] https://www.epa.gov/iaq-schools/why-indoor-air-quality-important-schools#:~:text=EPA%20studies%20of%20human%20exposure,times%20%E2%80%94%20higher%20than%20outdoor%20levels.&text=These%20levels%20of%20indoor%20air,percent%20of%20their%20time%20indoors.
[2] https://ashrae.iwrapper.com/ASHRAE_PREVIEW_ONLY_STANDARDS/STD_62.1_2019
[3] https://www.epa.gov/indoor-air-quality-iaq/indoor-pollutants-and-sources

**It Matters How Much Outdoor Air You Introduce**

Simply introducing outdoor air at an arbitrary rate is not the most effective way to mitigate poor indoor air quality. This frequently leads to one of two problems: over-ventilation or under-ventilation.

With **under-ventilation**, you do not introduce enough outside air. These low levels of outdoor air are not enough to dilute the contaminants or pollutants present in the indoor air. This can lead to everything from a nuisance (reduced occupant comfort) to more serious health and safety concerns (headaches, fatigue, upper respiratory irritation).

When many occupants experience these negative health effects, it's commonly attributed to a condition known as sick building syndrome.[4]

With **over-ventilation**, you're not concerned with the health and safety of those inside the building. Rather, you'll see negative effects on building operations and all relevant operational expenses. Whenever outdoor air is introduced into an interior space, that air must be treated by the HVAC system. This includes filtration, as well as temperature control. (Warm air must be cooled to a comfortable level; cold air must be warmed up.) These processes require energy and strain on the HVAC system.

If you're routinely taking in more outdoor air than is needed to achieve adequate indoor air quality, you're putting expensive and needless load on your HVAC system, likely shortening its overall life span, and paying more in operational energy costs.

**The Role of Humidity and Temperature in Indoor Air Quality**

When taking in outdoor air, it's vital that air is properly treated through your HVAC system. This includes filtration, but it also entails ensuring the proper temperature and humidity levels.

**Humidity** should be kept below 60 percent and would ideally be between 30 and 50 percent.[5] Higher levels can promote mold or mildew growth, which can have adverse health effects. Having humidity that's too low can be an eye or skin irritant. It can also dry out mucous membranes, which reduces one's resistance to upper respiratory conditions that may include infections, irritation, cough etc.

**Temperature** plays an important role in overall indoor air quality as well. To prevent the drying of nasal passages and susceptibility to viruses, temperatures should be kept somewhere between 66 and 75 degrees Fahrenheit. Research suggests[6] virus transmission is significantly less at 68 degrees Fahrenheit compared to 39 degrees Fahrenheit. It also suggests the influenza virus is blocked or highly inefficient in an environment with an air temperature of 86 degrees Fahrenheit. This suggests a direct link between air temperature and virus transmissibility.

[4] https://www.epa.gov/sites/default/files/2014-08/documents/sick_building_factsheet.pdf
[5] https://www.epa.gov/iaq-schools/moisture-control-part-indoor-air-quality-design-tools-schools
[6] https://journals.asm.org/doi/pdf/10.1128/aem.02291-09

**A Constantly Evolving System**

When a building is first designed, its HVAC unit is calibrated using several assumptions. These assumptions dictate the unit's operation, with the aim of generating acceptable levels of indoor air quality. These assumptions include the following:

- Intended use of the facility
- Suggested occupancy rates
- Current building codes
- Current operating conditions

This often works initially, but there's an inherent problem within this system. None of those assumptions are static. Building codes and best practices evolve over time. Occupancy rates can fluctuate. HVAC units degrade. Even the intended use of the building can change from when it was first constructed. The global COVID-19 pandemic also illustrates that recommended operating conditions can change dramatically as well.

This makes the continual monitoring of your indoor air quality more important to ensure it continues to be optimally effective as factors shift, evolve, and change.

**Controlling Airborne Pollutants**

Beyond outdoor air intake, the EPA recommends airborne pollutant control as another simultaneous method to maximize indoor air quality.

One way to accomplish this is through the introduction of ions into the indoor space. According to Dr. Qingyan Chen, a professor of mechanical engineering at Purdue University, mask wearing indoors could reduce SARS-CoV-2 infection rate by 50 percent. Coupling those measures with bipolar ionization could further reduce transmission rates by another 20 to 30 percent.[7]

**The Relationship between Ions and Particulate Matter**

Devices that introduce air ions into the occupied space have been shown to significantly reduce the amount of airborne particulate matter.[8] A recent study compared the cleaning efficiency of an ionizer and a HEPA filter based cleaner. It demonstrated that the ionizer was up to 2 times more effective than HEPA filter in particle removal efficiency for rooms larger than 25 $m^3$.

The removal of particulate matter is important to the health of anyone exposed to indoor air. The EPA notes that particulate matter, or PM, becomes more dangerous for smaller particles. Particulate matter of 2.5 microns or less present the largest potential hazard because these particles are small enough to lodge into the lungs or even to enter into the bloodstream.[9]

[7] https://engineering.purdue.edu/Engr/rising-to-the-challenge/Events/covid19-impacts-and-strategies-for-buildings
[8] https://shg-cleanair.co.il/wp-content/uploads/2021/04/Efficiency-of-ionizers-in-removing-airborne-particles_2017_Journal-of-Electr-1.pdf
[9] https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

**Volume Matters for Air Ions Too**

Just as the amount of outdoor air intake matters, it also matters how many ions you're introducing into the indoor space. In this case, the greater the volume of ions, the cleaner you can expect that air to be.

The cleanest air in nature, such as you'd encounter on a mountaintop or on a beach near a large body of water, coincides with areas of high naturally occurring ions. These locations routinely have anywhere from 3,000 to 21,000 ions of both polarities per cubic centimeter.[10] The volume of indoor ions, on the other hand, is often only a few hundred ions per cubic centimeter.[11]

Introducing large amounts of ions into the indoor space helps that indoor air replicate clean natural outdoor air.

The more ions introduced into the space, the more likely those ions are to interact with the particulate matter suspended throughout the indoor air. That interaction sparks a process known as agglomeration.[12] Charged ions attach to suspended particulate. These particles then attract other particles of opposite polarity, thus making them larger and more easily captured in a standard HVAC filter.

In this way, higher ion generation and distribution are directly correlated with a greater reduction in indoor particulate matter.

**A Note about Ozone Production**

If you are considering ionization as an indoor air quality improvement solution, be cognizant of whether the device generates ozone or not. There are multiple technologies that generate ions for the purpose of air quality improvement, and ozone is a byproduct created by some of those solutions. The EPA has well documented the negative health effects related to ozone exposure.[13]

Always ensure the technology can provide documented proof of minimal ozone production.
A UL-867 certification ensures independent testing confirms it produces less than 50 ppb of hazardous ozone.[14] Technologies like needlepoint bipolar ionization can provide this certification.

**Battling Uncertainty with Continuous Monitoring**

One of the most difficult challenges to navigate with indoor air quality is that improper ventilation isn't immediately obvious. Most people usually don't even know it's a concern until they've experienced one of the negative effects—medical or financial.

Coupled with the continuously evolving and changing building dynamics, this is why accurately and continuously monitoring and measuring your air volume intake is crucial.

[10] https://inspiredtecllc.com/wp-content/uploads/2017/12/Daniels-report-on-MCI-for-VOCs.pdf
[11]https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4661648/#:~:text=A%20high%20concentration%20of%20air,5%2C6%2C7%5D.
[12] https://www.sciencedirect.com/topics/chemistry/agglomeration
[13] https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics#effects
[14] https://www.ul.com/news/revised-standard-ul-867-electrostatic-air-cleaners

To achieve the greatest health benefits and to see the most positive return on investment, an HVAC system should incorporate both an advanced indoor air quality improvement system and a continuous monitoring system to measure volume of outdoor air intake.

**Common Challenges of Monitoring Airflow**

There are several options available for airflow measuring stations. These can help you determine if your outdoor air intake is at an optimal level. There are, however, some common problems and challenges to consider before committing to any given system:

- These systems often have placement restrictions, needing to be installed within the HVAC ductwork. In some challenging HVAC applications, that isn't always feasible or easy.
- Many systems have low-flow limitations, making them ineffective or inaccurate in those environments.
- Some airflow measurement methods are subject to pressure drop issues. This compromises on accuracy.

For the greatest efficacy, accuracy, and ease of installation, choose a system that installs in the perimeter of an HVAC duct or in an outdoor air opening and is designed to normalize the turbulent airflow inherent in HVAC ductwork.

**Measuring Air Ion Levels**

If your indoor air quality improvement solution involves ion production, you also want a system in place to accurately measure and monitor the performance of that system. This will provide immediate and verifiable confirmation that the requisite ions are being both generated and distributed throughout the occupied space.

Your options for ion monitoring vary from simple and inexpensive to more robust and costly:

- **Handheld ion counter**. This is a simple, intuitive, inexpensive solution for getting single-point data about ion production. It will display positive ion count, negative ion count, and positive and negative ion differential.
- **Permanently installed ion counter**. These devices are installed directly into the HVAC or air handling unit. They often have sensitivity settings that can be adjusted based on installation location and specific application.
- **Plenum-mounted ion detector.** These types of devices are also permanently installed. They have the advantage of wiring into a building management system. This allows an alarm relay to be triggered if ion production is no longer detected. This is more tailored to commercial buildings rather than private residences.
- **Wall-mounted ion detector.** This is a good solution if installation within ductwork or plenums isn't feasible. They continuously take air samples.

**Indoor Air Quality in a Pandemic-Influenced Landscape**

Indoor air always has the ability to affect the health, safety, comfort, and well-being of anyone within an occupied space, but living in the middle of a pandemic heightens the importance of these indoor air quality issues.

It's more important than ever for private residences and commercial or communal spaces to not only address indoor air quality but to accurately and consistently monitor those air-improvement systems.

Real-time monitoring allows you to make adjustments as needed. This can boost air quality while simultaneously minimizing negative health effects and the costs associated with energy consumption, utility bills, and HVAC equipment wear and tear.

In addition to effectively diluting pathogens and particulate matter, the appropriate amount of outdoor air intake can also help ensure your HVAC operations are optimized.

In certain specialized environments, such as a laboratory or a clean room, this is crucial. Positive pressure, for example, is created when the volume of air pulled from the building is less than the entering supply air. This positive pressure ensures irritants, pollutants, and particulate matter do not enter that space. Should there be a leak somewhere, such as an opened door, clean air will leave the space and contaminated air will not enter.

Minimizing this kind of infiltration also minimizes heat loss or gain. Even in less specialized environments, this can offset the costs associated with treating outdoor air.

**Conclusions and Key Takeaways**

Achieving acceptable indoor air quality is a complex and interconnected process, but here are some key points to consider:

- Outdoor air intake is an important factor in improved indoor air quality.
- Taking in too much outdoor air leads to premature and costly wear and tear on HVAC equipment, as well as higher-than-necessary energy bills.
- Taking in too little outdoor air does not provide the necessary dilution of indoor pollutants and can have negative health effects.
- When optimizing your indoor air environment, humidity and temperature should not be neglected. They play integral roles in overall indoor air quality.
- There are many systems and methods to control indoor particulate matter, including needlepoint bipolar ionization.
- When it comes to ion production and particulate control, the more ions created, the more PM is removed.
- Monitoring your indoor air quality solution and measuring factors like how much outdoor air you take in are vital to optimizing your health results and return on investment. This step is often shortchanged or overlooked entirely.
- ASHRAE, the CDC, the EPA, and various regulatory bodies do not recommend a single-system approach for indoor air quality improvement. They all recommend a layered, multiprong plan that involves particulate matter control, dilution with outdoor air, and pandemic-related best practices.