Getting Your Office Space Post-Quarantine Ready

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Getting Back to Work

Looking forward to getting back to work after being cooped up for 70-something days? That would probably be the consensus across the board. With the thought of going back to the workplace, there are also concerns about the risks associated with returning to a building. Facility managers and owners must be proactive in ensuring that sites are safe, and minimize the risk for occupants. There is a great deal of information available in response to COVID-19 and it is hard to know which safeguards will work and those that are nothing but hype.

Here are some basic steps that apply to any facility, and some technologies available to reduce airborne infection vectors.

Virus & Bacteria Infection Transmission

Pathogens are all around us, and the human immune system has evolved to deal with most of them. Like multi-celled life forms, bacteria and viruses evolve and mutate creating new strains, which catch our immune systems off guard and make us sick. COVID-19, which is classified as a novel Coronavirus, has been devastating to the human population as we do not have any pre-existing antibodies to fend it off.

Pathogen Transmission Routes are:

1. Direct Contact (mucous membranes, wounds)
2. Fomite (contaminated surface transfer)
3. Aerosol (inhalation)
4. Oral (ingestion)
5. Vector-Borne
    a. Arthropods (insects, fleas, ticks, and spiders)
    b. Animals (rodents, birds, pets)
    c. Plants and Fungus

COVID-19 is transmitted primarily through the first three routes; however, a facility-level program should consider all routes.

Direct Contact

Transmission by direct contact occurs when an individual comes in physical contact with an infected individual's mucous membranes or bodily fluids. This transmission route poses the highest risk to healthcare personnel and is addressed with appropriate Personal Protective Equipment (PPE). In non-healthcare settings, social distancing is an effective compromise compared to strict isolation.

Strict Isolation/Enforced Quarantine

Physical separation with hard barriers and segregated HVAC systems are the strongest measures against all transmission routes, however, this creates several challenges in conducting normal daily activities. This measure is often implemented when personnel is traveling through an area of high infection rates to an area of lower infection.

Social Distancing

In non-healthcare settings, social distancing is an effective compromise compared to strict or partial isolation. In an office environment, reducing the density of occupants to allow them to maintain 2 meters/6 feet of separation while at their workstations is recommended. The use of face masks also helps reduce the spread of aerosol droplets.

Occupant & Visitor Screening

Another measure that has been implemented at many facilities involves screening people upon entry to determine if the person is sick. This non-contact temperature scanning is done using a pyrometer or IR Thermography device. Any persons with a temperature above 100°F (37.8°C) are refused entry into the facility. This may pose a challenge in public government facilities, but on private property, it should not be an issue.

IR Thermography systems can be effective and allow for screening greater numbers of personnel in a given time, however, IR sensors are prone to erroneous readings especially when natural and artificial light is reflected in the sensor from glossy surfaces.

Fomite (Contaminated Surface Transfer)

Many pathogens can remain contagious outside a host for days or weeks. Much of the research around COVID-19 indicates that it can be contagious outside a host for days. This route of transmission can be addressed on several fronts. The primary one is personal behavior (i.e., frequent handwashing, use of hand sanitizer, social distancing). The other method involved frequent disinfection of frequently touched surfaces.

Surface Treatment

There is a significant difference in the effectiveness of cleaning procedures regarding infection control. Let us begin with some definitions.

Cleaning: removes germs, dirt, and impurities from surfaces or objects. Cleaning works by using soap (or detergent) and water to physically remove germs from surfaces. This process does not necessarily kill germs, but by removing them, it lowers their numbers and the risk of spreading infection.

Sanitizing: lowers the number of germs on surfaces or objects to a safe level, as judged by public health standards or requirements. This process works by either cleaning or disinfecting surfaces and objects to lower the risk of spreading infection.

Disinfection: kills germs on surfaces or objects. Disinfecting works by using chemicals or radiation to kill germs on surfaces or objects. This process does not necessarily clean dirty surfaces or remove germs, but by killing germs on a surface after cleaning, it can further lower the risk of spreading infection.

Sterilization: application of high concentration chemical agent, intense radiation, high levels of thermal energy, or a combination of these to kill pathogens or render them inert. Poses a significant risk to humans.

Surface Cleaning and Disinfection

Modification of current cleaning procedures to incorporate effective disinfection is a required step for getting your facility ready for post-quarantine. Utilize the following steps to bring your cleaning program up to the task:

1. Ensure cleaning procedures are comprehensive and effective
2. Disinfect commonly touched and public surfaces frequently after they have been cleaned (daily)
3. Ensure disinfectant is being used safely and per manufacturer's instruction
4. Handle waste properly

Many products used as disinfectants require minimum contact time with the surface to kill the pathogens, and in many cases, the disinfectant is required to dry on the surface before being rinsed with clean water. So be sure to review the manufacturer's instructions and ensure your procedures comply.

Near Ultraviolet Radiation Disinfection (Blue Light)

Using ultraviolet light with wavelengths in the 100-254 nanometer (nm) range is an established and effective means of dealing with most pathogens, yet this is extremely hazardous to multicellular organisms. As a result, its application has been limited to the disinfection of water and air in closed systems. Light with a wavelength of around 405 nanometers has proved effective in inactivating bacteria.

Systems based on 405 nm light have been used in surgical suites in hospitals to reduce the occurrence of surgical site infections. Potential applications in commercial office environments would include conference rooms, public assembly areas, and other high traffic areas. However, this method doesn't impact virus-based pathogens and requires controls to allow the application of higher intensity of 405 nm light when the space is unoccupied.

UV-C Disinfection

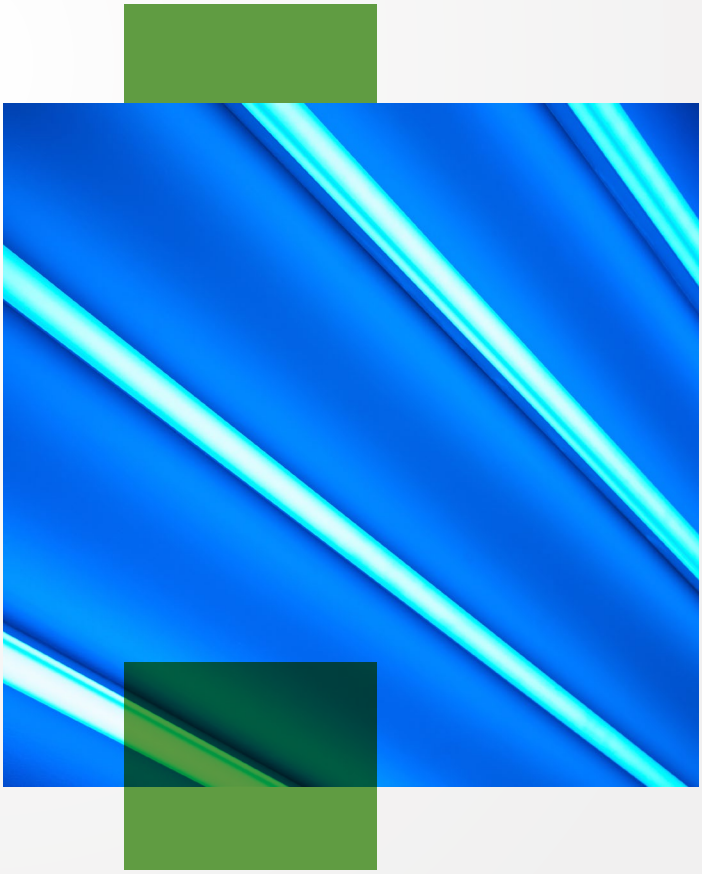
Sunlight contains three types of ultraviolet radiation, which is light just below the wavelength range visible to humans.

UV-A: This makes up most of the ultraviolet radiation reaching the Earth's surface. It is capable of penetrating deep into the skin and is attributed to skin aging, from wrinkles to age spots.

UV-B: This next band of wavelengths in the UV range is attributed to sunburn and skin cancer (caused by damage to skin cell DNA). Wear your sunscreen, people!

UV-C: This part of the spectrum consists of a shorter, more energetic wavelength of light. It is particularly good at destroying genetic material – whether in humans or viral particles. It isn't a problem for humans as the atmosphere filters it out with oxygen molecules in the stratosphere that create ozone.

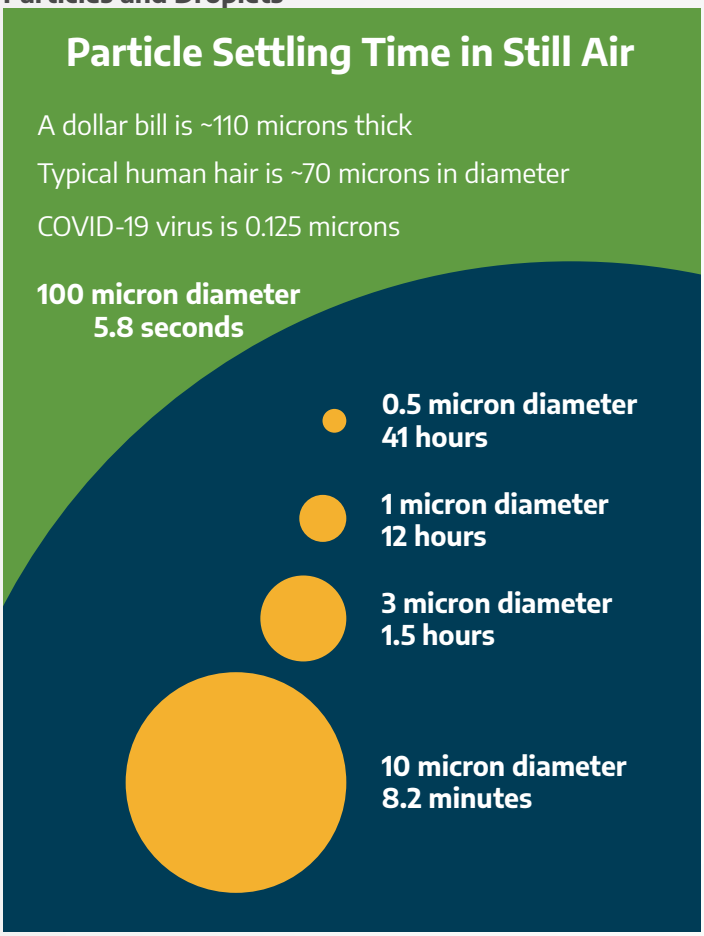
UV-C light has been in use to disinfect and sterilize materials for decades. It can be used to disinfect spaces during unoccupied periods, but its application must be properly engineered to ensure the safety and health of operators and personnel. Exposure to UV-C light will cause burns and blindness in seconds and increases the risk of cancer significantly. Application in spaces requires placing permanent or portable UV-C lamps in the space and then illuminating the area and surfaces for a fixed period to disinfect the space. A combination of intensity and exposure must be reached to be effective. If this fits into your approach to deal with infection control, please exercise extreme caution.



Aerosol Transmission

The method that is of greatest interest to building engineers is an aerosol transmission, where tiny particles and droplets from an infected person are released by breathing, speaking, coughing, or sneezing into the surrounding air. The use of non-surgical facemasks helps limit the volume of droplets released from those wearing them. Depending on the size of the particles or droplets, they either settle on surfaces supporting fomite transmission (large droplets) or they remain airborne in the space until carried through the return/exhaust ductwork or inhaled or walked through by occupants.

Particles and Droplets



Universal Accommodations

The challenge for building engineers is to facilitate the removal of these droplets and particles as quickly as possible. ASHRAE has issued several position papers and guidance documents on this epidemic. The core guidance revolves around increasing ventilation and filtration, which is effective but carries a significant energy cost.

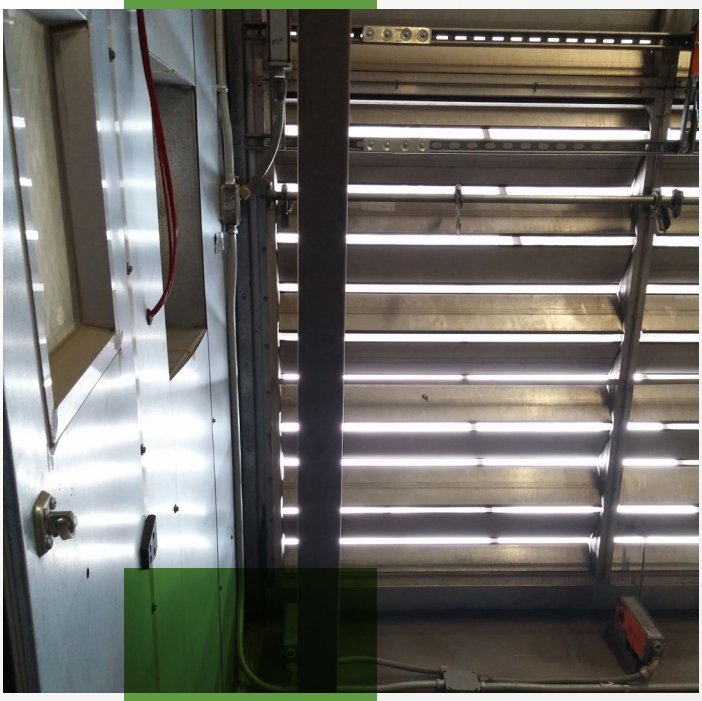
Actions most facilities can implement with minimal modification to their existing systems and risks involved:

Increased Ventilation Rates

Dilution is the solution: increasing the amount of fresh air from outside continuously forces potentially contaminated air out of the conditioned spaces, thereby reducing the risk of transmission. Sounds easy, you simply override your outside air dampers to fully open and you have a healthy facility. However, there is no free lunch. The outside air needs to be conditioned except for the hours where outside conditions are the same as supply air conditions in a typical year, typically a very low number. All other hours of the year you will have to condition that air, which requires significant energy. Many cities have aggressive carbon reduction programs that can exact a stiff financial penalty for increasing energy use. We need to strike a balance between health and energy use.

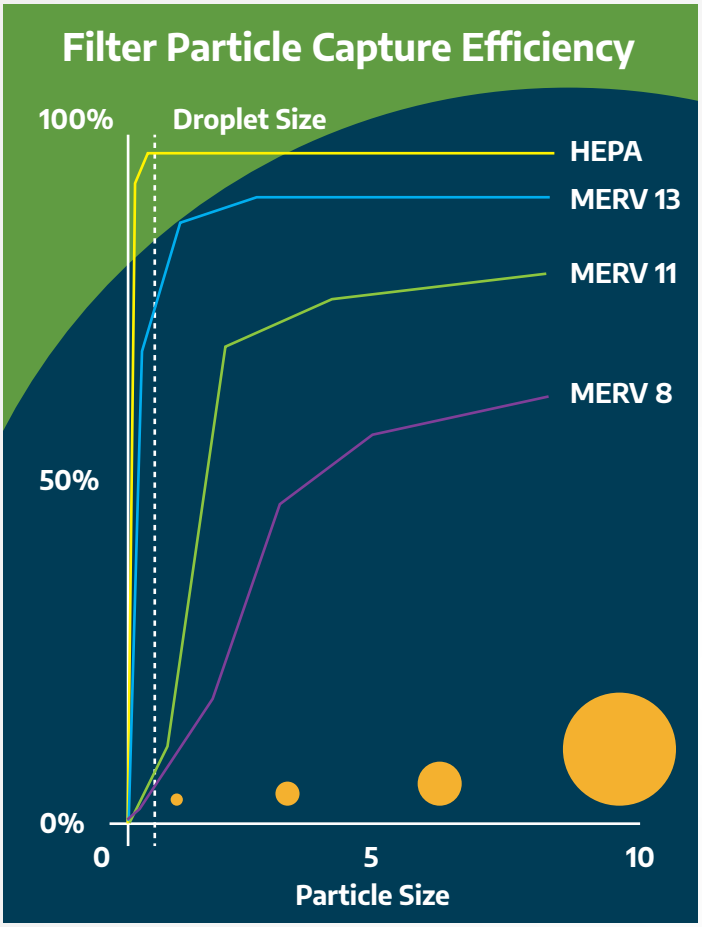
Another challenge to consider is many HVAC systems are designed around conditioning enough outside air to meet code minimum ventilation rates when not doing airside economizer. So, what are the ventilation limits imposed by cooling and heating coils? This will determine the tradeoff between thermal comfort and ventilation rates.

Having a solid understanding of the current state of your HVAC system and its capacity and constraints is fundamental to determining the appropriate ventilation strategy.



Increased Filtration

Another simple measure is to install higher efficiency filters in your existing HVAC systems. More efficient filters can capture a higher percentage of airborne particulate, including droplets carrying pathogens. Yet this also comes with added cost. The price of higher efficiency filters is increased fan energy. Your HVAC fans will have to work harder to overcome the additional resistance of the more effective filters. If your fans are already at their limit, the improved filters will cause a reduction in airflow, which will impact the comfort of your occupants.



Building Pressurization and Zone Control

Another practice that can be implemented without significant system modification is establishing pressure zones. This is common practice in healthcare and laboratory settings and can be loosely implemented in most buildings through rebalancing.

Zones that have clean areas will stay at a higher relative pressure than areas exposed to increased traffic and pathogen transmission routes. In the case of an office building, the areas where only employees are permitted would be maintained at the highest relative pressure, followed by areas where visitors to the office congregate, such as conference rooms, that would be maintained at a slightly lower pressure, followed by public areas such as the lobby. This maintains directional airflow from the cleanest to dirtiest spaces helping protect your occupants.

Implementing pressure zones may be limited by the design of your HVAC systems and the ability to regulate return airflow with balancing dampers.

Humidity Control

The humidity of the air in your building has a significant impact on the sustainability of aerosol droplets. Low humidity causes the water in droplets to evaporate, reducing the size of the droplets allowing them to stay aloft longer and making their removal through filtration more challenging. So higher humidity is better, but relative humidity levels above 60% promote mold growth. As a result, the target humidity levels to balance these two concerns are 40% RH to 60% RH. Maintaining humidity levels in this range also improves human health and immune system response.

If your building systems do not have humidification you may want to consider adding them before the winter.

Active Air Cleaning Technology

The mitigation measures we just covered can be implemented in most facilities without significant equipment or system modification. The following approaches are not typically installed in commercial office HVAC systems but can be retrofit in systems at a reasonable cost.

Ultraviolet Germicidal Irradiation (UVGI)

As previously discussed, UV-C light used for surface disinfection can also be used to render pathogens inactive in the air. The application of the UV-C system in HVAC systems is not new, and it has a proven track record of being effective when properly applied.

Coil Cleaning Systems

UV-C lamps have been installed in many AHUs adjacent to the cooling coils, where the UV-C light is used to prevent biological growth on the coils and condensate collection pans. These systems are effective in this capacity; however, they typically do not inactivate the pathogens suspended in the air stream. This is due to the short duration of time the airborne droplets are exposed to the UV-C radiation. Air velocities in AHU's at cooling coils are designed to maintain a maximum of 500 FPM, which means that a particle traveling in that air moves 1 foot in 0.12 seconds, or 8.3 feet in 1 second.

For UV-C to be effective in neutralizing viruses and bacteria, the combination of UV intensity and exposure time must meet a minimum threshold. The coil cleaning application doesn't meet this threshold in most cases. For organisms on the coil or in the pans, the exposure time is longer since they are not moving at the same speed as the air.

Air Cleaning Systems

To be effective in addressing airborne particles, the exposure time must be sufficient in conjunction with suitable UV-C intensity. We must exercise care on the intensity side of the equation as high-intensity UV-C light can react with common VOC compounds transforming them into more harmful compounds. The typical solution is the installation of UV-C fixtures in which the length of the lamp is parallel to the airflow in a section of the duct that will provide sufficient exposure time for the UV-C to neutralize the pathogens.

Occupied Space Systems

Another recent application of UV-C for air cleaning purposes is the installation of pendant fixtures that project UV light upwards towards the ceiling of occupied spaces to render airborne pathogens inactive. The use of circulation fans aids these systems in slowing air movement through the UV light to be neutralized. Another application is a ceiling grid fixture replacement which uses small fans to draw air into a UV chamber in the fixture and discharges the disinfected air back into space.

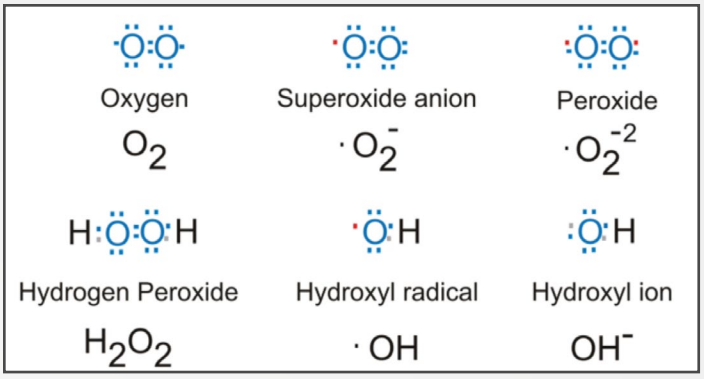
UV-C Safety

UV-C is hazardous to humans so these systems need appropriate interlocks, work procedures, and PPE must be employed if these systems are being considered. The system must be shut off if personnel will be accessing areas subject to UV-C radiation.

Air Ionization

Ions are molecules that have an electrical charge due to losing or gaining an electron. Losing an electron makes the molecule positive (+) and gaining an electron makes in negative (-). This process occurs in all matter and can be encouraged when energy or catalyst compounds are introduced.

The ions we are interested in are the Reactive Oxygen Species (ROS), which is a phrase used to describe several reactive molecules and free radicals derived from molecular oxygen. Atomic oxygen has two unpaired electrons in separate orbits in its outer electron shell. This structure makes oxygen susceptible to radical formation. The sequential reduction of oxygen through the addition of electrons leads to the formation of several ROS including superoxide, hydrogen peroxide, hydroxyl radical, and hydroxyl ion.



The increased presence of ROS ions in the air provides three benefits to Indoor Environmental Quality:

- **Sterilization:** ions interact with the surface of microorganisms, which rob the cell wall of hydrogen atoms, rendering them inert.
- **Agglomeration:** ions charge airborne particles binding together fine particulate matter (e.g. PM2.5) until they precipitate out of the air or are captured by filtration.
- **Oxidation:** ions change the chemical composition of noxious gasses, (e.g. VOCs), neutralizing the pollutant.

There are two technologies which are commercially available from various manufacturers:

Bi-Polar Ionization

This technology uses high voltage terminals to generate positive and negative ions of the oxygen passing over them. In HVAC applications the devices are installed in the air-handling equipment or ductwork and produce the ions which are carried with the supply air to the conditioned space where they can react with the particulate and pollutants.

Photocatalytic Oxidation (PCO) Ionization

This technology uses a photocatalytic coated surface that is illuminated with UV-C radiation to generate positive and negative ions of the oxygen passing over them. In HVAC applications the devices are installed in the unit or ductwork and produce the ions which are carried with the supply air to the conditioned space where they can react with the particulate and pollutants.

Electrostatic Precipitation

This technology doesn't ionize the air, rather it electrically charges particles in the air as they pass through the device. The charged particles are then collected on electrically charged plates, removing them from the air stream. This technology has been widely deployed as smoke eaters in kitchens and restaurants. They are effective filters but do not disrupt the microbial organisms' functions.

Oral (Ingestion) Transmission

Transmission by ingestion occurs when contaminated food or water is consumed. This often occurs when food handling and preparation sanitation practices are lacking. This is typically not a major concern for commercial buildings. However, if you have a cafeteria or pantry area in your building this transmission route should be considered and addressed.

Vector-Borne

Sometimes transmission occurs when other multicellular organisms (insects, rodents) carry the pathogens with them from location to location. This is the most common route for bloodborne pathogens in the case of blood-consuming insects and arachnids. Having an effective pest management program in place is the best defense against this transmission route.

Communication and Education

We have covered quite a bit on how you can prepare your facility to minimize infection risk and maintain a healthy indoor environment for your building's occupants. It is important to share with your tenants the significant effort that has gone into making the building safe and ready for business.

Education

Making your occupants aware of the measures that have been implemented and the method by which they hamper infection transmission can go a long way to easing their fears and concerns. This can take the form of a series of emails or a building newsletter.

Post signage and reminders to occupants on personal practices that can reduce infection transmission. Subjects such as social distancing, frequent handwashing, and use of hand sanitizer are important to help mitigate the spread of infection.

Monitoring

Continuous monitoring of system performance is a critical factor in establishing creditability with your occupants. Measurement of airborne pathogen levels is complex and costly, requiring air sampling pumps, sending materials to a laboratory to be cultured and the pathogens counted under a microscope. A good proxy for pathogen levels is monitoring several Indoor Environmental Quality (IEQ) parameters, which indicate the overall quality of the air in the space.

The following are standard IEQ measures that can be measured with fixed or handheld instruments in real-time:

Parameter	Typical (NYC) Outside Air Level	RESET Air Required Level	RESET Air Recommended Level
CO_2 (ppm)	400	< 1000	< 600
CO (ppm)	0 – 0.5	< 9	N/A
$PM_{2.5}$ (μg/m^3)	0 -36	< 35	< 12
PM_{10} (μg/m^3)	0 - 155	Not Specified	
TVOC	N/A	< 500	< 400
O3 (ppm)	0 – 0.604	Not Specified	
NO2 (ppb)	0 - 53	Not Specified	

Source: RESET Air: building standard https://www.reset.build/

Monitoring and maintaining the levels of these parameters will demonstrate the efficacy of your measures and have the benefit of improving occupant health and productivity.

Employee Satisfaction Surveys

Surveying your occupants on several facets of satisfaction is a great way to encourage feedback and ensure that the needs of the occupants are being addressed. Questions around IEQ and concerns over infection transmission will indicate how the measures are being perceived.

Ongoing Communication

Keeping the occupants informed is one of the best ways to manage concerns and fears. Signage and newsletters on progress and results keep people informed and connected. The ultimate in transparency is to make your monitoring data available to occupants in real-time via a web portal or kiosk in the lobby. These systems have become simpler to implement and give the building occupants confidence that the facility ownership and operations team are on task.

IEQ Economics

Indoor Environmental Quality (IEQ) has a tremendous impact on the health and well-being of human beings. When IEQ is high, people think more clearly and make better decisions. A Harvard study involved 24 people who worked in a test office for six days over two weeks. On two of the days, the IEQ of the office was maintained at IEQ levels seen in typical office environments. On two other days, the office maintained low levels of VOC, and on an additional two days, the ventilation rate was doubled from 20 CFM per person to 40 CFM, in addition to keeping low VOC levels. The results showed a 100% improvement in cognitive function between the baseline and the low VOC and increased ventilation rate days.

While you may think a 100% improvement in cognitive function might be a stretch, what if we knock that down to a 10% improvement in productivity. What would that mean to your organization? Let's run through a simple thought exercise to demonstrate the potential impact IEQ could have at your building.

	Baseline (20 CFM per Person)	High IEQ Environment (40 CFM per Person)
# of Employees	100	100
Average Revenue per Employee	$100,000	$110,000
Average Salary per Employee	$50,000	$50,000
Ventilation Energy Cost ($3/CFM/Year) per Employee	$60	$120
Total Revenue	$10,000,000	$11,000,000
Salary Costs	$5,000,000	$5,000,000
Ventilation Costs	$6,000	$12,000
Gross Profit	$4,994,000	$5,988,000
Delta	0	$994,000

This is an overly simplified example, but it does demonstrate the impact IEQ can have because staff costs are such a large portion of the business expenses. Providing a healthy environment for your building occupants pays in lower absenteeism, reduced medical costs, and higher productivity.

If you are the landlord, having a proven healthy building can differentiate your facility from others on the market. Proving you have a healthy building can be a challenge, but there are a handful of programs that provide a framework for certifying buildings as green and healthy.

Building Certifications

There are three primary certifying bodies related to IEQ, they are listed below in order of ease of certification.

RESET Air (reset.build)

This is a highly focused certification that addresses air quality in buildings. They have two types of certification: Core & Shell (CS) and Commercial Interiors (CI). Core & Shell addresses the central HVAC systems and CI monitors the air quality in occupied spaces.

The program is results-driven, allowing participants a great deal of flexibility in how the required results are delivered. This certification does require continuous monitoring and reporting of air quality to RESET and making the data available to occupants.

USGBC LEED (USGBC.org)

The granddaddy of green building certification programs addresses multiple facets of building design, construction, and operations, with IEQ being one area of focus. Getting a facility LEED certified requires an investment in time, money, and willingness to change your processes. There is data that supports LEED-certified facilities do command higher rents.

WELL (wellcertified.com)

Similar to LEED; WELL is more focused on human health and wellness, where LEED is more environmentally impact-focused. The standard does require performance testing as a step in the certification process.

About Enica Engineering

Enica Engineering was founded on the premise of quality and focus. While MEP Engineers are busy working on system sizing and equipment selections, no one is giving the dynamic nature of the design of any consideration. This is where Enica shines. We spend more time thinking about building automation and have solved more complex automation problems than your typical engineering firm. With that focus, we have proven processes that deliver successful outcomes for our clients.