Recommissioning for Reopening

Introduction

As states begin to loosen their stay-at-home orders in the wake of the COVID-19 pandemic, an increasing number of building owners, operators, and occupants are interested in ways to reduce risk of virus transmission in the buildings where they work, whether these facilities remained in use since the start of the crisis or are being readied for reopening. The latest available research from the National Academy of Sciences indicates that speech droplets caused by talking remain in the air for 8-14 minutes[1]. These droplets are thought to be the main transmission source for coronavirus transmission between people, but this has not yet been shown through research.

As building owners and operators consider upgraded operations and procedures, modifications to their building's ventilation systems to improve indoor air quality (IAQ) can be a key element in reducing the airborne risk of viral transmission and increasing occupants' confidence in buildings, systems, and operations. Such IAQ improvements are only one part of a comprehensive safety plan. For example, at this time, return to work before widespread immunity in the population has been achieved — either by prior infection or immunization — presents risks that could lead to a second wave of infection. Having a workplace plan in effect if and when this rebound occurs is clearly prudent. This white paper focuses on IAQ improvements and does not attempt to address overall safety planning.

The IAQ improvements discussed here are rooted in three key IAQ concepts: High-Quality Air Filtration, Increased Ventilation, and Directional Airflow. For example, typical return-to-work plans now include reduced occupant densities, which can inherently help improve ventilation rates per person and IAQ to some degree and should be one of the considerations when exploring options to improve IAQ.

The concepts presented in this article are applicable to a wide range of buildings with air handling systems and can be applied to new construction designs. A qualified HVAC engineer should review any field changes to ventilation system equipment or arrangement before implementation. Simple control and schedule changes are typically more straightforward and may not have unintended consequences, but some higher energy consumption and costs will likely occur after some of the changes discussed here. Before developing a plan to improve IAQ for COVID-19 concerns, be sure to assess of the existing HVAC system and identify any pre-existing IAQ issues. Interview operators and, if possible,

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[1] "The Airborne Lifetime of Small Speech Droplets and Their Potential Importance in SARS-Cov-2 Transmission", https://www.pnas.org/content/early/2020/05/12/2006874117?mod=article_inline

the building occupants. Any COVID-19 related HVAC modification plans should include a plan for reverting systems “back to normal” at some point in the future.

Returning to public buildings at this time poses some additional risk of infection. The methods described in this article should not be relied upon alone for managing that risk. These methods can be part of a larger, prudent strategy for reopening.

1. High-Quality Air Filtration

While direct evidence does not yet exist to prove that improved filtration reduces the risk of COVID-19 transmission, we can infer this from what we know about viruses similar to the SARS-CoV-2 virus (the virus which causes COVID-19 illness). For example, the SARS virus was more extensively studied prior to the current novel coronavirus. While information on active approaches to killing the SARS-CoV-2 virus particles with technologies such as UVC germicidal lamps continues to emerge, this white paper focuses on mechanical particle filtration since these provisions are already in place in most commercial and institutional buildings. Two types of improved particle filtration strategies are presented: existing air handler filter retrofits, and the addition of portable or local air “cleaners” in the space.

a) Existing Air Handler Filter Retrofit

What is the best central air handler filter for preventing the spread of COVID-19? Even if there was more research available about nature of the SARS-CoV-2 virus, it would still be difficult to provide a simple universal answer. No filter is perfect, but many air handlers present an opportunity for improving filtration.

Firstly, checking for any imperfections in the air sealing around the filter banks should be performed. Existing filter bank construction should also be reviewed for robustness to ensure undesirable air bypass around the filter is minimal. One simple approach is to access or enter the equipment safely, hold or place a light upstream of the filter bank, and look at the filter bank from the downstream side. Visible light around the edges of or between multiple filters should be identified and addressed to reduce air leakage. If deemed worthwhile, excessively large bypass openings around the filters could be sealed. Filter sections within a filter bank can be taped together to reduce the size of gaps between filters. According to the National Air Filtration Association, “A 10 millimeter gap (less than ¼ inch) between filters can lower a filter’s MERV rating by at least two levels, thereby taking a high efficiency filter and moving it to a medium efficiency filter.”

The size of individual SARS-CoV-2 is estimated to be at or just under 0.1 micron (µm). (A human hair is about 50 microns in diameter; a human red blood cell is about 5 microns.) Filtering for such miniscule particles – known as “fines” in the filter testing and IAQ world – is difficult, and the typical air handler fan is not capable of overcoming the increased pressure drop that is associated with the highest performance filters available for this particle size – true HEPA or ULPA filters (more on these in a moment). However, research on similar viruses has shown that while the virus particles can float in the air entirely on their own, the virus is usually embedded within a much larger water particle from a sneeze or cough. Even if low humidity conditions prevailed and were to dry the water particle before it reached the filter, research indicates that the virus is expected to still be attached to other larger particles within the droplet, and the aggregate size of this particle is significantly greater than the size of the virus alone. This particle would more likely be captured by filters that might not capture the virus alone.

In the United States, filter IAQ performance is rated in Minimum Efficiency Reporting Vale (MERV), ranging from MERV 1 to MERV 16. (Contact us for more information on ASHRAE Standard 52.2-2017 *Method Of Testing General Ventilation Air-Cleaning Devices For Removal Efficiency By Particle Size*, or ISO Standard 16890 and the corresponding European ePM rating.) A higher rating translates to cleaner air. Higher MERV filters are considered to be "high efficiency" filters. As a reference point, ASHRAE recommends MERV 6 or higher, the US Department of Energy recommends MERV 13, and LEED recommends MERV 8 at a minimum. As a filter "mesh" is made tighter to capture fine particles, that filter's resistance to airflow increases. This can be offset by extending the area of the filter face, as with pleated filters, or other means as with bag filters (which can also have very high "holding capacity" and useful life.

Since the highest suitable MERV rating for a given system is limited by the air handler fan's capacity to overcome the new filter's additional pressure drop, so the best strategy for determining the highest MERV rated appropriate for an air handler depends on the fan's capabilities. Increasing pressure drop will at some point decrease airflow, which in turn decreases heating/cooling capacity. This can be a major problem during extreme weather. Furthermore, when too much pressure drop exists for certain fans, the fan will fail and "stall" when it loses traction with the air and free-wheels. Over time, stalling would result in damage to the fan. Consult an HVAC engineer for guidance in exploring how much additional pressure drop your air handler fan may be able to accommodate. Some fans may be able to be adjusted (new pulleys and belts, for example); others may already be facing the maximum possible pressure drop.

Consider that higher pressure drop filters may not only have higher "clean" pressure drops, but they may also load more quickly (a sure sign they are working better than the old ones!), requiring more periodic filter changes. As the filter loads up, it increases the volume of air bypassing the filter due to imperfect air handler construction or filter installation.

Some central air handling units are equipped with two back-to-back filter banks, so that a prefilter bank can be changed more often. Eliminating the prefilters and using higher MERV filters in the other rack can allow improved filtration of fine particles without excessive pressure drop. Not every operator will be willing to do this since they will have to change the higher MERV, more expensive filters more frequently as a result.

Two related considerations: holistically thinking about the energy costs of pressure drop across two filter banks in addition to just the filter changing cost is helpful. The benefits of keeping coils and blower wheels cleaner and more efficient is an additional benefit of filtration upgrades that is also helpful to consider.

Pleated two inch filters are currently available with MERV ratings as high as MERV 14. Some of the best of these have an initial pressure drop as low as 0.3", which is quite close to the initial pressure drop of typical MERV-8 filters. Careful evaluation is required since many high MERV filters have much higher initial pressure drop than the "best in class."

Special care should be taken when installing and maintaining filters in air handlers. From a sense of precaution at this time, any time a filter is replaced it should be assumed that the filter has an active virus, especially if a person with a known case of COVID-19 has been in the building. Some version of the "bag in/bag out" filter change technique, which is typical for critical facilities, is prudent to adopt for now. Filters should be changed while wearing Personal Protective Equipment (PPE) and while the fan is turned off. Filters should be disposed of in a sealed bag.

b) Portable Air Cleaners

For some building spaces, portable air cleaners may be added to a space to provide "spot" filtration, either to supplement central air handling filtration or when system type makes central filter upgrades impossible. Many of the filtration principles described above for central air handlers also apply to portable air cleaners.

Portable air purifiers are rated in Clean Air Delivery Rate (CADR), and a higher CADR is more effective in filtering the air. Cleaner air can also be expected from units with high air-change rates, for a given room size.

Carbon or odor filtration stages are commonly provided in many air cleaners, but do not remove fine particles. The particle filter and the issues above relating to MERV rating and performance apply. No firm basis for selecting alternate filter technologies with respect to SARS-CoV-2 virus particles including ozonation, ion, or electrostatic precipitators is available at this time.

One advantage of portable or local air filtration over central air handler filtration is that many portable units offer high-efficiency particulate air (HEPA) filters, which can further reduce the levels of fine particles in indoor air than is possible with central air handlers alone. Since portable units are designed to work with the original manufacturer-supplied filters, carefully evaluate replacement filter expense and availability before purchasing.

Noise considerations should also be considered, since excessive noise can result in reduced use of the equipment. Portable air purifiers can be selected for use at low or medium fan speed to avoid noise issues, which is worst at high speed.

2. Increased Ventilation

Introducing more fresh outdoor air to your spaces is a simple way to prudently help address the risk of virus transmission. More outdoor air will dilute all IAQ contaminants, assuming that the outdoor air is cleaner than the indoor air. Energy increases can be expected, as conditioning outdoor air is more energy intensive than conditioning return air (consider that outdoor air economizers are intended to operate for a minority of hours during the year).

In some settings with outdoor air quality concerns, it is an oversight to simply assume outdoor air will always be cleaner for a particular building. Review locations of fresh air intakes for air handlers and operable windows for nearby exhaust terminals or other possible contaminant sources. Nearby contaminant sources ranging from cooling towers to highways to grease exhausts may affect the best tactics for increasing ventilation rates.

When weather allows, operable windows can be opened if the windows are deemed to be sufficiently distant from sidewalk or other places where people may travel or congregate. Opening windows can be the easiest strategy to achieve increased ventilation, but should still be considered with care. High pollen rates, vehicle exhaust, or other issues may limit the use of operable windows as an option for achieving increased ventilation rates. A benefit of increasing mechanical ventilation via an air handler is that the outdoor air would be conditioned and filtered before it is introduced to the space.

Regardless of how the additional outdoor air is introduced to the building, the heating and cooling systems will have capacity limits for conditioning the increased outdoor air volume. A trial and error process may be necessary to achieve increased ventilation rates while avoiding excessive heating or cooling loads on existing equipment. Again, increased outdoor air volume will result in an energy penalty in all but the mildest "economizing" weather. In some buildings with sufficient controls capability already installed, a more nuanced sequence for when to increase outdoor air intake can be developed and implemented. Any system changes should be overseen by qualified HVAC engineers.

For a quantitative perspective on this increased ventilation measure, Figure 1 shows typical code-minimum ventilation air rates per ANSI/ASHRAE Guideline 62.1 "Ventilation for Acceptable Indoor Air Quality". The table also shows 25% and 50% increased ventilation rate scenarios, as examples.

Occupancy Type	Estimated Maximum Occupant Load (persons per 1,000 sq ft)	Default Area Outdoor Air Rate (cfm per sq ft)	Default Person Outdoor Air Rate (cfm per person)	Default Outdoor Air Total Rate (cfm per person)	25% Improvement to Outdoor Air (cfm per person)	50% Improvement to Outdoor Air (cfm per person)
Private Office	5	0.06	5	17	21	26
Data Entry Office	60	0.06	5	6	8	9
Classroom	35	0.12	10	14	18	21

cfm means cubic feet per minute
ASHRAE 62.1-2019 is available for viewing-only online:
https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards

Figure 1 - Possible increases in airflow for several building space types

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3. Directional Airflow

Directional airflow concepts relate to both air distribution system configuration and seating of individuals within that air distribution system.

Not surprisingly, studies have shown that individuals downwind of a COVID-19 infected individual have the highest likelihood of being infected themselves[2]. Most air distribution systems designs intend to mix all the air in a given space. However, a careful review of supply and return air terminal locations could inform seating or circulation patterns of immunocompromised, older or otherwise high-risk individuals near “cleaner” supply air. If and when COVID-19 infection screening becomes more commonplace, and if research ends up showing that past infection indicates future immunity, then unscreened individuals could be located in the somewhat “cleaner” regions of the building. If worker health is prioritized over a visitor health, the workers could be located closer to the cleaner air, near the supply air diffusers. See Figure 2 and Figure 3, below.

Adjacent rooms in common buildings are not typically pressurized relative to one another, and as such, air flows back and forth as it may in an uncontrolled fashion between various rooms. However, slight modifications to supply and exhaust airflows may be possible to create a pressurization between areas of a building. That way, the air will tend to flow from the space at higher pressure to the space at lower pressure. Any system changes of this sort must be designed by an HVAC engineer and implemented by balancer, with care and documentation.

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[2] COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China,
https://wwwnc.cdc.gov/eid/article/26/7/20-0764_article

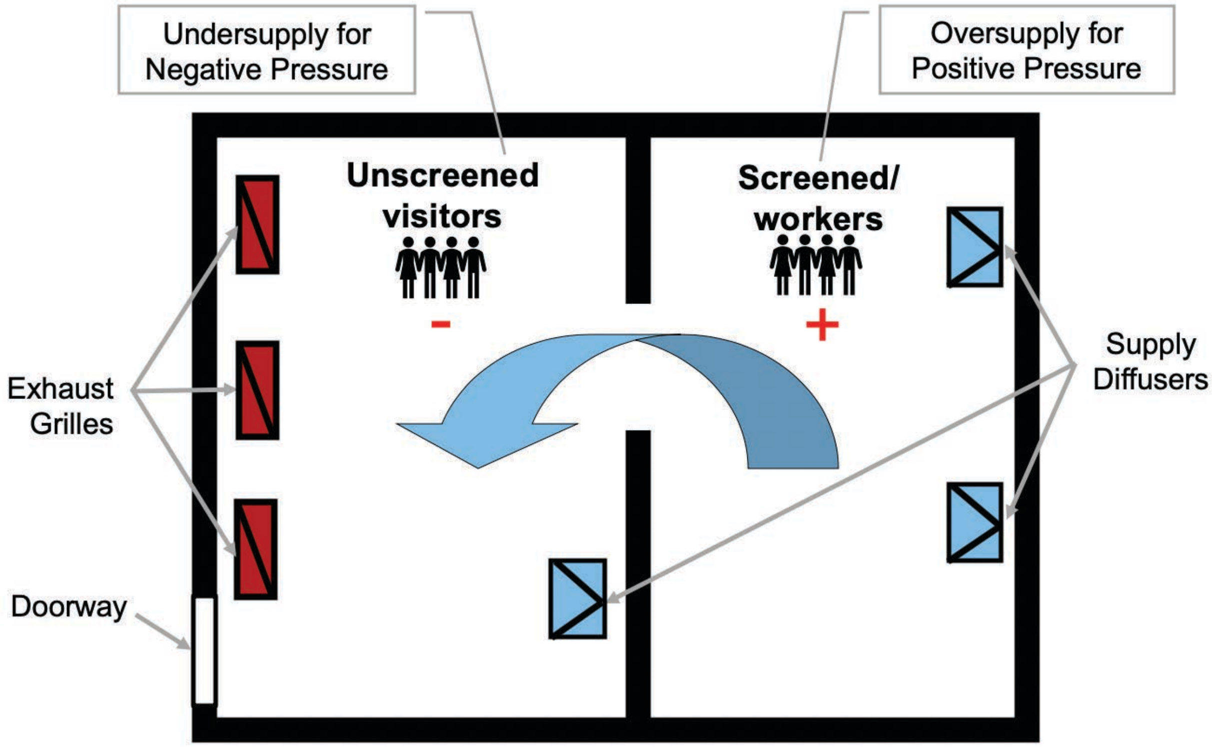

Figure 2 – Directional airflow example #1

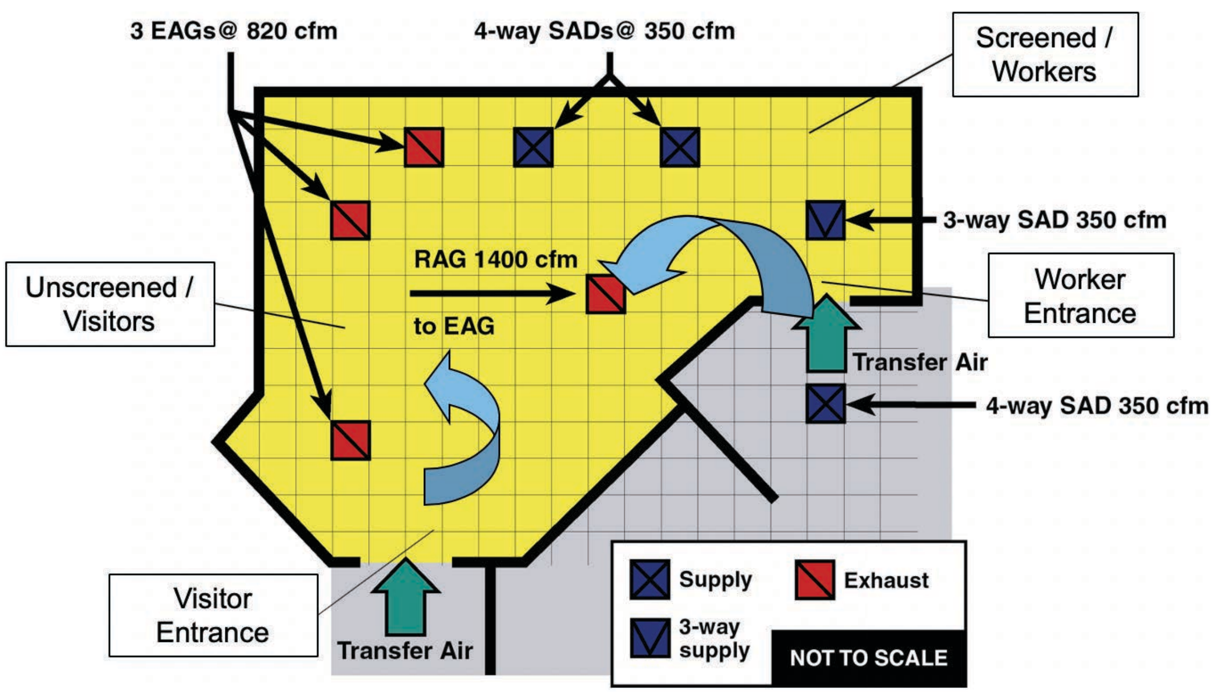

Figure 3 - Directional airflow example #2

As a building commissioning practice headquartered in Rhode Island with operations there and in Massachusetts, Connecticut, and Florida, our team has extensive experience helping owners plan and implement upgrades to existing facilities and systems. As a triple bottom line company with a commitment to community and the environment, we offer this COVID-19 assistance regardless of ability to pay to those who are trying to keep critical and occupied facilities through this crisis, and who are assessing appropriate engineered responses and options in all buildings whether currently in use or not. Our typical area of operations is largely Southern New England, but we have extensive experience on large projects throughout the world. Our team is engaged in developing codes, national standards, and international standards for the built environment. Clients include leading universities and colleges, cities, schools and school districts, and other owners of significant large institutional and commercial buildings.