The Role of Air Conditioning in Airborne Virus Transmission

Summary

What role does my air conditioner play in promoting or mitigating virus transmission? This is intended to be a hands-on guide to a topic that is quite complex. While Covid-19 is getting all the current attention, remember that "normal" influenza (the flu) falls under this category as well. Some are noticing sustained annual school closures that result from the flu. These closures have not always occurred. There was a time they never occurred. What is it about school classrooms and other similar spaces that are resulting in the transmission of viruses?

Closures did not occur in the past!

The Infectious Diseases Society of America has published a white paper entitled "It is Time to Address Airborne Transmission of Covid-19." Among those 239 scientists and engineers signing the paper was American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Society Past-President Bill Bahnfleth. The paper emphasizes that airborne transmission may be a significant transmission path. In simpler words, COVID-19 and other viruses may be and probably are transmitted by simply breathing the same air that others are breathing, even though distancing is in place.

With some thought, it is possible for a lay person to gain an understanding of how an air-conditioning unit can contribute to an indoor environment's well-being.

Ventilation Comes First

Most folks understand that warm or cool air will "blow" from a floor register or ceiling diffusers to accomplish heating or cooling. However, the journey really begins in the occupied space. During the summer, air that has been warmed within the space is drawn into a return grille. It may be on the wall or in the ceiling. That air then travels through a duct to an air-conditioning unit which cools the air and then pushes it, using a fan, through a supply duct and back out to the space. The air is constantly recirculated in this fashion, usually about once every five to ten minutes. So, the air that you are breathing right now may have been in your neighbor's office only ten minutes ago.

Popcorn vapor is a great example of an aerosol, or small particles suspended in air.

A good example of this is the fellow down the hall that makes microwave popcorn in the break room. It never fails, within five to ten minutes, usually less, the entire office smells like popcorn! This popcorn smell is actually an aerosol, consisting of very small particles of butter that get evenly distributed in the airstream. Perfume and cologne are other (usually) positive examples of aerosols. What happens though, if the aerosol contains a virus?

Well, if one goes back to the popcorn example, it is clear that the buttery smell eventually dissipates. Why? It dissipates because a fixed amount of butter is eventually diluted with enough surrounding air such that it becomes undetectable. Dilution may also occur partly because butter particles fall out of the air stream. A virus operates in a similar manner. Some portion may fall to surfaces like tables or the floor. But some may remain airborne.

If one is to mitigate an airborne virus, then dilution is the simplest method to accomplish it. For commercial buildings, there is possible good news - dilution should already be a part of your HVAC system!

Building codes have long required that a modest amount of fresh air should be introduced into an HVAC system. The exact amount is defined by within the code, but it is often about 10 to 15% of the overall airflow rate. It can be more for highly occupied spaces like classrooms and auditoriums. ASHRAE has determined through their Standard 62.1 that these dilution rates are appropriate to reduce concentrations of contaminants and maintain good indoor air quality.

So, we're okay, right? Well, maybe. In order to acquire this dilution air, a small duct has to be routed to a point where it can draw air from the outdoors. Usually, there is a wall louver or brick vent. An adjustment device (a damper) is needed as well. Finally, the fresh air flow rate needs to be measured, and the damper adjusted so that the correct amount is maintained.

Continuous ventilation is crucial during occupied periods.

If your system has this feature and has been properly adjusted, then it likely has the ability to dilute the recirculated air adequately. However, if your system lacks a fresh air duct, there is now a risk that airborne transmission of virus may become a problem. Unlike a bowl of popcorn, the production of virus is ongoing and constant, every time an infected person exhales. If there is no dilution, then the virus concentration will simply accumulate and build up over time, perhaps to dangerous levels, especially in high-occupancy spaces. The indoor air will become laden with virus, much like a movie theater becomes laden with the aroma of popcorn.

Supplemental HVAC Remedies

There are several technologies which claim to be effective at reducing or eliminate air contaminants, including viruses. Most of these have existed for some time. A short list would include the following:

- Enhanced Filtration
- Ultraviolet Light
- Bipolar Ionization

The first, enhanced filtration, is not likely practical for most buildings, short of the most acute areas of hospitals. To actually "capture" a small virus particle, the filter must be so dense that the cost of it and its penalty to the system is not practical. HEPA filters are the only types that will ensure effectiveness, and these cannot be readily installed most systems without a negative impact on its operation. Also, who wants to change a virus-laden filter?

There are two other technologies that seem to be popular on the market - ultraviolet light and bipolar ionization. These two are significantly different and while their core technologies are complex, some simple explanations can be offered.

Ultraviolet (UV) light operates on the principle that certain wavelengths of light can damage and even kill bacteria, viruses, and other pathogens. It is not difficult for most folks to understand that certain types of light can hurt or damage our own eyes. Sunburn is an even more intuitive example. The theory

is complex, but research has shown that ultraviolet light can be effective in killing viruses. The wavelength and intensity matter though. For HVAC applications, it is convenient that the dark cavities of an air conditioner can usually house such a light. Manufacturers claim a kill rate of 95 - 99% on each and every air pass, although one would expect that there will be inefficiencies in actual application of the lamp.

Bipolar Ionization (BI) operates much different than UV. This technology uses electrical charges (think static electricity) to cause particles small and large to become attracted to each other, like magnets. This process effectively reduces the overall number of particles, but they are now larger in size. The larger size particles are now able to be trapped by the HVAC unit's filter, even if it is one of relatively low efficiency. One might say that the method increases the efficiency of a cheap filter. This is generally a good thing, but what about viruses? BI does include a mechanism that will kill pathogens, but the time to do so is generally much longer than UV. Most are killed in about 30 minutes; some are less, but mold may take up to 24 hours. This should be compared to typical air change rates in HVAC systems - about 5 to 10 minutes.

Both technologies are subject to failure without regular inspections and maintenance. If the lamp (UV) or emitter (BI) fails in any way, there is not a tangible variable to recognize it, short of visual inspection. If inspection and maintenance are not rigorous, then overall effectiveness is reduced or eliminated.

In the past, one item that might encourage building owners to adopt either technology would be that ASHRAE standards allow some reduction of ventilation air requirements with their use. Heating and cooling fresh air does cost money, and many seek to reduce cost by reducing ventilation. For the COVID-19 pandemic, ASHRAE is recommending that such reductions be reversed; it is our position that implementing these technologies at anytime for that goal is not good practice.

Back To Ventilation

Ventilation paths and dampers should be checked.

Our first and primary recommendation to facility occupants, managers, and Owners is that an evaluation of their system's ventilation system be inspected and evaluated.

Does a ventilation path exist to the outdoors? If the unit is a rooftop type, then it will generally have an outside air damper. Check to see if it is open while the building is occupied. It does not have to be completely open, in fact for many units 5 to 10% open is adequate. Ideally, that damper was adjusted by a test and balance (T&B) technician at startup, but they are rarely checked and readjusted over the lifetime of the unit.

If the unit is an indoor type, then it should have a modest size duct that extends from a return duct near the unit to the outdoors. This duct will usually have a damper to adjust the airflow that can pass. Again, the damper should have been set by a T&B technician at startup.

Unfortunately, the state of most fresh air dampers is usually "closed." This results in the elimination of much needed ventilation. Why is this? Unfortunately, several factors combine here to create an undesirable result.

Several factors work to defeat proper ventilation in many buildings.

The test and balance process is often ignored or neglected when an HVAC system is completed, even though it is code mandated. Ignoring it improves the profit margin for the installing contractor, who often complains that the T&B firm inconveniently brings up items that remain incomplete on the project. The omission should be caught by the building official, but they generally don't show a tendency to enforce ventilation requirements. Further, in humid climates, the use of packaged equipment is prevalent, even for applications where it should not be considered. Packaged equipment usually performs poorly when fresh air values reach even modest limits. Owners and contractors have learned that leaving outside air dampers closed will improve "perceptions" of comfort, even as indoor air quality immediately suffers. Many owners understand that leaving the damper closed will result in lower utility charges. Finally, many owners and tenants simply don't understand the role of ventilation in proper operation of their system.

Ventilation systems, especially in the South deserve to be installed and maintained in a manner that promotes good indoor air quality. Sadly, they are not. In fact, some contractors go to great lengths to prevent it. One of our "favorites" loves to brag about immediately closing all outside air dampers as they leave the job site. Others are less obvious, but behind the scenes operate similarly. The following picture shows how one contractor went "above and beyond" in their effort to defeat ventilation by installing a sheet metal blank off plate.

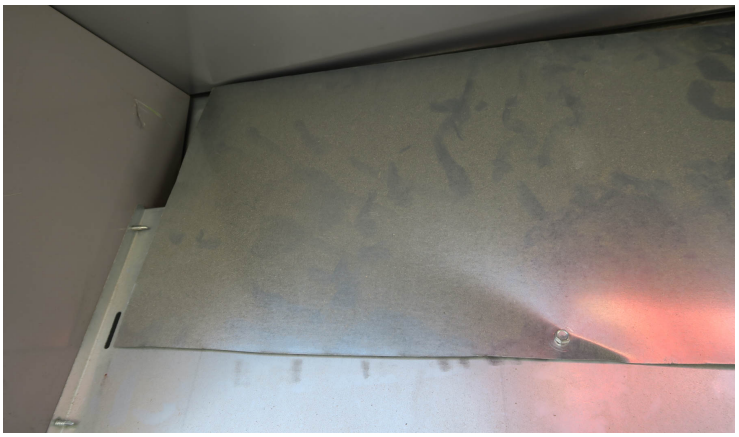

Figure 1 - Sheet Metal Plate Defeating Ventilation Intake

Conclusion

Air conditioning systems have the potential of spreading virus through airborne transmission. The extent to which transmission is severe is and will be studied further by many, we're sure. However it can be significant. Fresh air ventilation is an important component of minimizing air conditioning's impact on virus transmission. Unfortunately, it is not emphasized enough in the design, construction, maintenance, or operation of systems.

Building owners and operators should first evaluate the ventilation system within the building before spending capital money on supplemental remedies. Adjustments and corrections are often easy to

accomplish and offer the most "bang for the buck." At that point, additional system components can be considered for specific goals of disinfecting or cleaning the air stream.

References

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