LET'S NOT MAKE IT WORSE

DISCUSSING THE CDC AND ASHRAE RECOMMENDATIONS FOR HVAC SYSTEMS IN NON-HEALTHCARE BUILDINGS

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ABSTRACT

Research and understanding of COVID-19 continues to be a moving target. Many experts believe that HVAC systems, particularly those in most non-medical buildings, are just one factor when it comes to transmission of infectious diseases. However, this hypothesis is simply based on what appears to be reasonable assumptions based on available data which has not yet been validated. Just like we wouldn't (or shouldn't) take medications without fully understanding its side effects, one should not simply take generally made recommendations as a solution for all situations. While it is clearly understood that doing nothing and staying the course are not valid options; making the wrong decisions, particularly when it involves modifying a building's HVAC system, could have adverse effects not only to the building itself but also to public health. Many of these adverse effects which include, but are not necessarily limited to, higher moisture/humidity levels, continuous temperature fluctuations, condensation and/or microbial/mold growth build-up on surfaces, may not immediately come to light because everyone's focus is on the current COVID-19 crisis.

CURRENT CDC/ASHRAE GUIDELINES

Current guidelines from the Centers for Disease Control (CDC) and American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) have some general recommendations in place. The main points of their recommendations appears to be to reduce disease transmission by airborne particles by increasing outdoor air ventilation and filtration efficiency; however, the detail on how to best achieve this is vague to say the least. These recommendations appear to take a "one approach for all" method but do not consider the location and climate these facilities are located in. A facility located in Boston for example should not be designed the same as Miami. Weather, and more importantly, moisture in outdoor airflow is drastically different, particularly in the southern, warmer climates. Therefore, what may work for one location may not work the same for another.

CDC guidelines as they relate to modifying HVAC systems to handle the COVID-19 pandemic state as follows[1]:

[1] https://www.cdc.gov/coronavirus/2019-ncov/community/guidance-business-response.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fspecific-groups%2Fguidance-business-response.html

Consider improving the engineering controls using the building ventilation system. This may include some or all of the following activities:

- *Increase ventilation rates.*
- *Increase the percentage of outdoor air that circulates into the system.*

According to their website[2], "ASHRAE has developed proactive guidance to help address coronavirus disease (COVID-19) with respect to the operation and maintenance of heating, ventilating and air-conditioning systems." Their webpage lists a number of links to other websites and papers as well as publications of their technical standards. Some of which is discussed below.

ASHRAE has established an epidemic task force to respond to the global COVID-19 pandemic[3]. On the recommendation of the ASHRAE Epidemic Task Force, ASHRAE leadership has approved the following two statements regarding transmission of SARS-CoV-2 and the operation of HVAC systems during the COVID-19 pandemic:[4]:

> ***Statement on airborne transmission of SARS-CoV-2:*** *Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures.*
>
> ***Statement on operation of heating, ventilating, and air-conditioning systems to reduce SARS-CoV-2 transmission:*** *Ventilation and filtration provided by heating, ventilating, and air-conditioning systems can reduce the airborne concentration of SARS-CoV-2 and thus the risk of transmission through the air. Unconditioned spaces can cause thermal stress to people that may be directly life threatening and that may also lower resistance to infection. In general, disabling of heating, ventilating, and air-conditioning systems is not a recommended measure to reduce the transmission of the virus.*

ASHRAE also released a position document (PD) titled "ASHRAE Position Document on Infectious Aerosols."[5] This document primarily discusses approaches to mitigate airborne transmission of infectious diseases in healthcare facilities but recognizes infections are also transmitted in non-healthcare occupancies. It is assumed that most healthcare facilities have emergency response plans; however, it is likely that many non-healthcare facilities do not.

[2] https://www.ashrae.org/technical-resources/resources
[3] https://www.ashrae.org/about/news/2020/ashrae-epidemic-task-force-established
[4] https://www.ashrae.org/technical-resources/resources
[5] The revised position document (PD), originally titled *ASHRAE Position Document on Airborne Infectious Diseases*, was approved by the ASHRAE Board of Directors (BOD) on January 19, 2014 and Reaffirmed by the Technology Council on February 5, 2020. The BOD approved the revised PD titled *ASHRAE Position Document on Infectious Aerosols* on April 14, 2020.

Although ASHRAE provides general recommendations and air quality requirements in Standards 62.1, 62.2 and 170; "ASHRAE does not provide specific requirements for infectious disease control in homes, schools, prisons, shelters, transportation, or other public facilities."[6] However, the PD does discuss ASHRAE's position for non-healthcare buildings related to HVAC design and operation strategies which should be considered. These strategies, which are similar to their strategies for all building types, include the following:[7]:

- *Increase outdoor air ventilation (disable demand-controlled ventilation and open outdoor air dampers to 100% as indoor and outdoor conditions permit).*
- *Improve central air and other HVAC filtration to MERV-13 (ASHRAE 2017b) or the highest level achievable.*
- *Keep systems running longer hours (24/7 if possible).*
- *Add portable room air cleaners with HEPA or high-MERV filters with due consideration to the clean air delivery rate (AHAM 2015).*
- *Add duct- or air-handling-unit-mounted, upper room, and/or portable UVGI devices in connection to in-room fans in high-density spaces such as waiting rooms, prisons, and shelters.*
- *Maintain temperature and humidity as applicable to the infectious aerosol of concern.*
- *Bypass energy recovery ventilation systems that leak potentially contaminated exhaust air back into the outdoor air supply.*

The general consensus from both the CDC and ASHRAE appears to be that increasing both ventilation and filtration can reduce the risk of COVID-19 airborne transmission. While some of these recommendations may be able to be implemented with little to no effect on the current HVAC systems, it is important for a facility owner or manager to fully understand the costs and effects these recommendations may have on their specific systems before implementing them.

INCREASING OUTDOOR AIR VENTILATION

While studies have shown that increasing ventilation within a building can be an effective way of reducing the potential for airborne transmission,[8] simply doing so may have some unintended consequences. Depending on the climate, increasing ventilation into a building, either through mechanical means or simply opening a window, increases moisture infiltration into the building as well. The effects of moisture within a building depends on a variety of factors, which include but not limited to, current HVAC design and operation, exterior climate conditions, construction type and the types of building materials used. Before one can fully

[6] ASHRAE Position Document on Infectious Aerosols, Section 3.1
[7] ASHRAE Position Document on Infectious Aerosols, Section 4.1
[8] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6072925/

understand the effects of moisture, one needs to understand that moisture will still infiltrate into a building, even if an HVAC system is off.

Vapor Pressure and Relative Humidity

Vapor pressure is essentially the portion of atmospheric air pressure attributable to water vapor. In short, air is primarily made up of nitrogen and oxygen; however, several other small amounts of gases (usually less than 1%) also exist. In addition, the air molecules also include a portion of water vapor, the amount of which depends on the atmospheric conditions (i.e. temperature) in which it resides.

As air temperature increases, so does it ability to hold more moisture. The specific amount of moisture air can hold at a particular environmental condition is typically referred to as specific humidity. However, most people usually refer to humidity levels in a term called “relative humidity” or %RH. Relative humidity is the amount of moisture air can hold compared to the maximum amount of moisture the air can hold at a specific temperature. For example, air at 75 degrees F and 50% RH means the air is holding 50% of the total capacity of moisture it has the ability to hold while at 75 degrees F. Just as the ability to hold more moisture when air temperature is increased, if you decrease air temperature, the ability of the air at the cooler temperatures to hold moisture decreases also, however the relative humidity actually goes up while the specific humidity remains the same. When relative humidity reaches 100%, the air is considered saturated and condensation will form. The air temperature at this point is typically referred to as the “dewpoint” temperature. Dewpoint temperature is the temperature at which water vapor condenses in the air.

In addition, warmer air also has a higher vapor pressure than cooler air. The higher pressure of warmer air tends to move toward areas which have lower vapor pressures. This process is called “diffusion.” This is essentially the natural tendency of air to want to move from warm to cold. This is why one typically insulates buildings, in south Florida, to keep out the heat and moisture from the exterior and the indoor conditioned air within the interior spaces. Insulation and air conditioning will never stop the occurrence of vapor pressure and its tendency to want to infiltrate from the exterior as this occurs naturally in nature. However, the intent of proper HVAC design depends on the understanding of both the HVAC system and the building envelope in which it resides.

The diffusion process depends on many factors. Some of which include the construction of the building envelope, insulation properties and quality of the construction itself. In addition, the exterior environmental conditions and interior space conditions play an important role as well. As previously indicated, the higher the temperature and humidity, the higher the vapor pressure is at those conditions. The vapor pressure differential between the exterior and interior environments affects the rate and ability for warmer air to infiltrate into cooler spaces. The higher the pressure differential, the easier it is for warmer air and subsequent higher moisture quantities, to infiltrate a space. It is possible to elevate the vapor pressure differential by increasing the outdoor environmental conditions and maintaining a stable indoor environment, however, the opposite is also true. The vapor pressure differential may also be increased by decreasing the interior space temperature conditions while maintaining a stable exterior environment. Many people do not typically think about the latter, however, many indoor environmental problems occur for spaces that are potentially too cool just as they are when they are too warm.

An example of this is having a space located in an area where the exterior conditions are typical of South Florida in which they are approximately 91 degrees F dry bulb (DB) and 78 degrees F wet bulb (WB). Per air psychrometric charts, the vapor pressure at these conditions is approximately 0.83 inches of mercury. Typical indoor space conditions of 75 degrees F and 50% RH, translate to a vapor pressure of approximately 0.45 inches of mercury. This correlates to a vapor pressure differential of approximately 0.38 inches of mercury. If one was to decrease the indoor space conditions to 70 degrees F and 50% RH (vapor pressure – 0.34 inches of mercury, the vapor pressure differential would increase to 0.49 inches of mercury (0.83-0.34). See Figures 1 and 2 below.

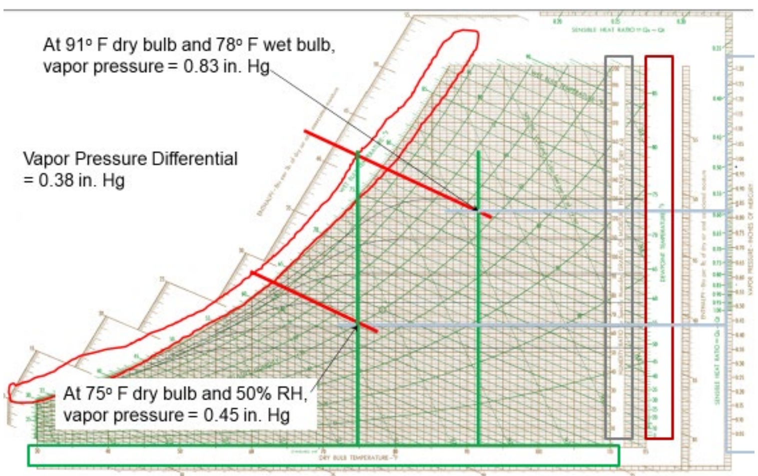

Figure 1: Vapor Pressure between 91°F DB/78°F WB and 75°F DB/50% RH = 0.38 in. Hg

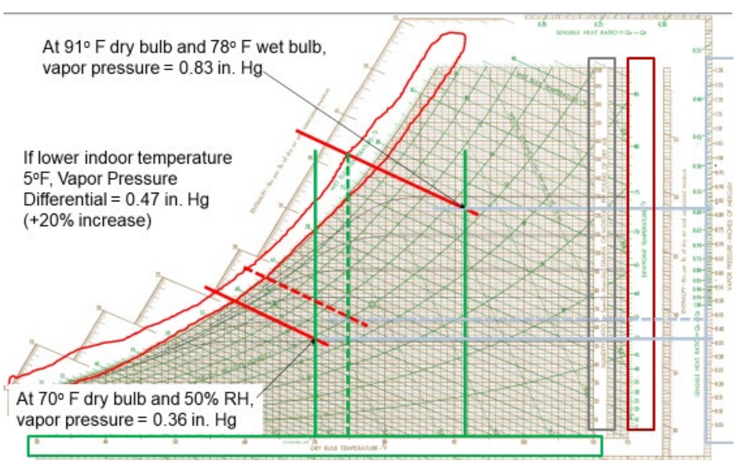

Figure 2: Vapor Pressure between 91°F DB/78°F WB and 70°F DB/50% RH = 0.47 in. Hg

The proper balancing of outdoor and exhaust airflows within a space is essential in maintaining a proper indoor environmental condition for both comfort and health/safety of indoor occupants. It is important to realize that if one were to increase ventilation within a space, this has the potential for also increasing relative humidity. According to ASHRAE standards[9], occupied-spaces should be controlled to limit the indoor humidity to a maximum dew point temperature of 60 degrees Fahrenheit (°F) which, assuming an ASHRAE recommended comfort level dry-bulb temperature between 72°F and 78°F[10], corresponds to a maximum relative humidity level of between 55 and 65% relative humidity (%RH). Therefore, the operation of HVAC systems should be controlled to achieve levels below the recommended dew point temperature at all times, regardless of COVID-19 or other potential similar threats, to prevent the potential for other adverse effects relating to moisture and condensation to occur. Spaces considered to be under "negative" pressure may introduce excess unconditioned outdoor air and associated moisture into the interior spaces thus increasing humidity levels causing discomfort to occupants. Most occupants unfamiliar with air properties would tend to lower the space temperatures via a thermostat or have their air conditioning systems run longer to remove the excess moisture. However, this sometimes can create an adverse effect as it may end up pulling more moisture into an interior space due to diffusion as previously explained. This may lead to the same or additional problems with regards to maintaining proper interior temperature and humidity levels and controlling interior moisture levels.

ASHRAE's PD "does not make a definitive recommendation on indoor temperature and humidity set points for the purpose of controlling infectious aerosol transmission. Practitioners may use the information herein to make building design and operation decisions on a case-by-case basis." [11]

Consider Your Environment and Building Systems

Regarding ventilation, ASHRAE's PD states "General dilution ventilation and pressure differentials do not significantly influence short-range transmission….generally speaking, designs that achieve higher ventilation rates will reduce risk. However, such buildings will be more affected by local outdoor air quality, including the level of allergens and pollutants within the outdoor air, varying temperature and humidity conditions, and flying insects."[12] Therefore, if you are adding non-conditioned ventilation into your building, you are adding moisture, the quantities of which depend on where your building is located and the exterior conditions. Therefore, the key is to control the ventilation and its associated moisture so it doesn't have an adverse effect on the building materials and personnel. Before simply running around and opening every outdoor damper 100%, consider the location of your building. Buildings located

[9] ASHRAE Standard 62.1-2019
[10] ASHRAE Standard 55-2017
[11] ASHRAE Position Document on Infectious Aerosols, Section 3.3
[12] ASHRAE Position Document on Infectious Aerosols, Sections 2.1 and 3.1

in warmer climates will typically have greater quantities of moisture in the outdoor air and therefore will have more moisture to control once its inside the respective building. That's not to say that buildings in cooler climates will not have similar issues as they will need to deal with moisture in warmer months and heating the extra outdoor ventilation in cooler months.

The types of HVAC systems are important as some systems are simply better than others with regards to controlling moisture. However, each system within a building was likely designed to handle a specific quantity of outdoor air ventilation per ASHRAE standards. Increasing the outdoor air ventilation for a specific air handling unit (AHU) system increases the mixed air temperature being delivered to the cooling coil, which in turn, increases the supply air temperature leaving the AHU and delivered into the space along with any excess moisture the AHU system was not able to remove. This excess moisture can not only make occupants feel uncomfortable but can lead to condensation/moisture issues which can settle on various building materials leading to microbial growth if not corrected. Specific AHU systems may have some ability to be adjusted in order to handle some excess outdoor air but this should be evaluated by a licensed mechanical engineer or vendor familiar with such systems before any changes to the systems are made. In addition, should additional outdoor air ventilation be able to be introduced into a building and controlled properly by the existing HVAC system, this excess outdoor air ventilation will need to go someplace. Therefore, exhaust system capabilities to handle this additional ventilation should be evaluated as well.

Example of excessive non-conditioned outdoor air effects into an outdoor air fan/duct system causing deterioration and corrosion of surrounding equipment and materials

It is important to remember that excess moisture from a warm environment into a cooler environment also brings the added potential for condensation to form. This is particularly apparent around areas where, for example, duct leakage may be occurring. Therefore, it is imperative to verify that insulation around ductwork, air devices, piping and air handling equipment is properly installed. In addition, insulation surrounding building envelope areas including attic spaces should be checked for proper consistent installation throughout and repaired/reinstalled as necessary. This would help assure that warmer moist air would not be able to settle on cooler surfaces thus allowing condensation to form leading to the potential for microbial growth in select areas under the right conditions.

Photo of moisture/condensation stains around supply diffuser due to lack of properly installed insulation.

If a building utilizes a plenum system[13], consideration should be given to providing a fully ducted system, even temporarily, to avoid the potential for the spread of airborne particles due to the difficulty to fully control the air movement within a plenum based system. However, it is understood existing building configurations may not allow for such a system to be constructed cost effectively. Outdoor air ventilation directly into a plenum space, above a ceiling for example, should be avoided, for many of the reasons noted above. If at all possible, outdoor air should be ducted directly to the return side of its respective AHU system and therefore, the return/outdoor air mixture can occur directly at the AHU and not in the plenum space. This way, the outdoor air ventilation, and its associated moisture will have a better chance to be conditioned and filtered before it enters the occupied spaces.

Photo of microbial growth along interior wall of a closet primarily due to vapor pressure diffusion from attic into plenum space above.

[13] A plenum system is a space within a building utilized for air circulation for HVAC systems. Typically plenum spaces are located above ceiling spaces, below floors or within mechanical rooms and are used as mixing chambers typically for return, outdoor air or both.

Photo of outdoor air duct stubbed into apartment AHU plenum closet. Not ideal. Duct outdoor air directly to return opening of AHU and provide volume damper for control

INCREASING FILTRATION

ASHRAE's PD states "The use of highly efficient particle filtration in centralized HVAC systems reduces the airborne load of infectious particles."[14] Most would agree that upgrades to filter efficiency would be an effective way to assist in filtering out unwanted airborne particles. However, careful consideration needs to be made when selecting the types of filters used for existing AHU systems. In general, filters with higher MERV[15] ratings have smaller openings in them which allow the higher MERV filters to capture more and smaller airborne particles; however, in doing so, can restrict the airflow passing through them. Increasing filter efficiency means increased resistance or static pressure[16] within a system which relates to a drop in airflow velocity across the filter itself. This can lead to an overall drop in total airflow being delivered to a space. In addition, if the velocity, particularly across a cooling coil, is too low, this can lead to coils freezing up. However, how the airflow behaves depends upon the type of HVAC system and specifically the fan serving it. Therefore, in order to counteract this effect, the system must have a way to make-up the difference of the greater pressure drop caused by the increased filter efficiency. In some larger AHU systems, simply increasing the speed of the fan or the even the horsepower (hp) of the fan motor may make-up for the added pressure drop within the system. However, for smaller AHU systems, such as those found in most residential, multi-family and light commercial buildings, the installed AHU systems likely do not have these capabilities due to the size and hp limitations of the supply fans themselves.

All filters have specific pressure drops associated with them which varies depending upon the type of the filter itself as well as the quantity of airflow across it. Pressure drops also increase as the filters become dirty. Installing a higher efficiency filter may work fine initially while the filter

[14] ASHRAE Position Document on Infectious Aerosols, Section 3.1.
[15] Minimum Efficiency Reporting Value (MERV) is a rating (on a scale from 1 to 20) developed by ASHRAE on the efficiency of the filter to trap airborne particles. For reference, clean room HEPA and ULPA filters are rated at between MERV 17 and 20.
[16] Static pressure or pressure drop is essentially air resistance within a fan or duct system which grows proportionally to airflow. The amount of static pressure in a system can be affected by a number of factors which includes, but not limited to, friction losses due to filters, ductwork configuration, valves, dampers, etc.

is clean but may not when the filter gets dirty because the AHU fan may then be outside of its performance range resulting in a decrease in total airflow.

Typical residential type AHUs may not be suitable for high efficiency MERV-13 or above filters. Verify the AHU performance including ductwork layout to determine if such filters are suitable for its intended application.

Therefore, as noted above, it is important to have each system evaluated by a licensed mechanical engineer or vendor familiar with such systems before any changes to the systems are made. This may include verifying the AHU system performance by a licensed test and balance or mechanical contractor to assure the system is performing in accordance with its intended design standards and also to verify what, if any, excess capacity the respective systems have before making temporary or permanent changes to their current operation.

In addition to selecting the proper filter and respective filter efficiency, careful consideration and protocols should be employed to removing and disposing of used filters. This includes, but not limited to, wearing the proper personal protective equipment (PPE) in accordance with CDC recommendations; protecting the surrounding work environment with proper drop cloths or similar enclosures to collect any particles which fall during filter extraction; cleaning and/or disinfecting/sanitizing the surrounding surfaces before new filters are installed; and properly bagging/disposing of all used filter media per CDC and related guidelines. Consulting with a licensed engineering firm for the development of such protocols and standards can be an option for those facility managers wishing to improve their standard operating procedures.

OTHER CONSIDERATIONS

ASHRAE's PD recommendation to "*Keep systems running longer hours (24/7 if possible)* may be warranted but not without its own concerns, namely the increased usage of energy and the potential for overcooling the space. Overcooling a building space can bring detrimental effects for many of the reasons noted above. Therefore, controlling the space temperatures by adjusting control settings, namely night setback settings, may assist with maintaining a proper indoor environment. Controlling energy usage, and the costs associated with it, has always been importance to any building owner or facility manager. Many, if not all, would agree that the safety of the public is on everyone's mind these days much more than energy savings.

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Nevertheless, if additional measures are implemented, it would be in the facility manager's and ownerships best interest to provide the additional measures in the most cost effective way possible without jeopardizing the health and safety of the building's occupants as well as their business continuity plan.

Portable room air cleaners with HEPA filters as well as UVGI systems may provide added protection for indoor occupants. As indicated in ASHRAE's PD, "while UVGI is well researched and validated, many new technologies are not."[17] ASHRAE's PD itself does not make a recommendation for or against the use of UV energy in air systems for minimizing the risks from infectious aerosols; however, the CDC has approved UVGI as an adjunct to filtration for reduction of tuberculosis risk and has published a guideline on its application.[18] Therefore, like any new system, the incorporation of these type of systems should be evaluated prior to installation to determine how and if operating these new systems will negatively affect the performance of the existing building's HVAC systems.

CONCLUSIONS

The reality is that there is always a way to do something better and this article is not, in any way, recommending that additional measures, like those proposed by ASHRAE and the CDC, not be implemented. It is important to remember that there are many factors related to HVAC performance which are not commonly thought of when trying to implement general recommendations, including building location, construction type, building envelope and how well the building was constructed in the first place. Therefore, it is always in the best interest of any facility/building owner, manager and tenant, to determine the pros and cons of any recommendation and how they will work specifically for their building and respective HVAC systems. It is much more valuable to spend time analyzing the proposed changes before spending the extra time and money to implement them and finding that the work performed to achieve a betterment in the short term may be detrimental in the long term to the facility.

[17] ASHRAE Position Document on Infectious Aerosols, Section 3.2.
[18] ASHRAE Position Document on Infectious Aerosols, Section 3.2.

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