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Memo

To: Clients of Mueller Associates, Inc.

From: Paul P. Czajkowski, P.E., Chief Mechanical Engineer

cc: Principals and Project Managers of Mueller Associates, Inc.

Date: May 11, 2020

Subject: SARS-CoV-2 / COVID-19 - HVAC Considerations and Recommendations

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This memorandum briefly summarizes current considerations and recommendations for heating, ventilation, and air-conditioning (HVAC) systems relative to reducing the potential for airborne transmission of infectious aerosols including Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) which is the virus responsible for coronavirus disease 2019 (COVID-19). The considerations and recommendations herein have been compiled primarily (but not exclusively) from publications and communications of the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). Much of the information that follows has been taken directly from ASHRAE's published materials, including from their website and their publications. As such, what appears below is made without citation or quotation marks. Information has been re-arranged in some situations to suit the brief summary in this memo. Unless otherwise noted, ASHRAE is hereby acknowledged as the primary source of information in this memo.

ASHRAE recently announced the creation of the ASHRAE Epidemic Task Force to help deploy ASHRAE's technical resources to address the challenges of the current pandemic and future epidemics as it relates to the effects of heating, ventilation, and air-conditioning systems on disease transmission in healthcare facilities, the workplace, home, public and recreational environments.

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:

> 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.
>
> 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.

A major source for the considerations and recommendations of this memorandum is the *ASHRAE Position Document on Infectious Aerosols*. This document was developed by the Society's Environmental Health Position Document Committee. It replaces the *ASHRAE Position Document on Airborne Infectious Diseases* which was originally approved by ASHRAE's Board of Directors on 6/24/2009. ASHRAE's Technology Council approved reaffirmation of *Airborne Infectious Diseases* February 5, 2020. On April 14, 2020 *Infectious Aerosols* was approved and replaces *Airborne Infectious Diseases*. *Infectious Aerosols* contains this note:

> "ASHRAE position documents are approved by the Board of Directors and express the views of the Society on a specific issue. The purpose of these documents is to provide objective, authoritative background information to persons interested in issues within ASHRAE's expertise, particularly in areas where such information will be helpful in drafting sound public policy. A related purpose is also to serve as an educational tool clarifying ASHRAE'S position for its members and professionals, in general, advancing the arts and sciences of HVAC&R."

The position document, as well as other ASHRAE resources and publications related to COVID-19, is available on-line through ASHRAE's COVID-19 page at https://www.ashrae.org/technical-resources/resources. The following information was taken from the *ASHRAE Position Document on Infectious Aerosols* (not necessarily in the order it appears in the publication):

- Design engineers can make an essential contribution to reducing infectious aerosol transmission through the application of the strategies included in the *ASHRAE Position Document on Infectious Aerosols*. The design and construction team, including HVAC designers, should engage in an integrated design process in order to incorporate the appropriate infection control bundle in the early stages of design.

- Facilities of all types should follow, as a minimum, the latest published standards and guidelines and good engineering practice. ANSI/ASHRAE Standards 62.1 and 62.2 (ASHRAE 2019a, 2019b) include requirements for outdoor air ventilation in most residential and non-residential spaces, and ANSI/ASHRAE/ASHE Standard 170 (ASHRAE 2017a) covers both outdoor and total air ventilation in healthcare facilities. Based on risk assessments or owner project requirements, designers of new and existing facilities could go beyond the minimum requirements of these standards, using techniques covered in various ASHRAE publications, including the ASHRAE Handbook volumes, Research Project final reports, papers and articles, and design guides, to be even better prepared to control the dissemination of infectious aerosols.

- With infectious diseases transmitted through aerosols, HVAC systems can have a major effect on the transmission from the primary host to secondary hosts. Decreasing exposure of secondary hosts is an important step in curtailing the spread of infectious diseases. Ventilation is not capable of addressing all aspects of infection control. HVAC systems, however, do impact the distribution and bioburden of infectious aerosols. Infectious aerosols can pose an exposure risk, regardless of whether a disease is classically defined as an "airborne infectious disease." ASHRAE's position document covers strategies through which HVAC systems modulate aerosol distribution and can therefore increase or decrease exposure to infectious droplets, droplet nuclei, surfaces, and intermediary fomites in a variety of environments.

- Depending on environmental factors, larger droplets (100 um diameter) may shrink by evaporation before they settle, thus becoming an aerosol (less than approximately 10 um diameter). The term droplet nuclei has been used to describe such desiccation of droplets into aerosols. While ventilation systems cannot interrupt the rapid settling of large droplets, they can influence the transmission of droplet nuclei infectious aerosols. Directional airflow can create clean-to-dirty flow patterns and move infectious aerosols to be captured or exhausted.

- Aerosols smaller than 10 um can stay airborne and infectious for extended periods (several minutes, hours, or days) and can travel long distances and infect secondary hosts who had no contact with the primary host. Infectious diseases can be controlled by interrupting the transmission routes used by a pathogen. The potential for airborne dissemination of infectious pathogens is widely recognized, although there remains uncertainty about the relative importance of the various disease transmission routes, such as airborne, droplet, direct or indirect contact, and multimodal (a combination of mechanisms). Transmission of the disease varies by pathogen infectivity, reservoirs, routes, and secondary host susceptibility. The variable most relevant for HVAC design and control is disrupting the transmission pathways of infectious aerosols.

- Infection control professionals describe the chain of infection as a process in which a pathogen is carried in an initial host or reservoir, gains access to a route of ongoing transmission, and finds a secondary susceptible host. Ventilation, filtration, and air distribution systems and disinfection technologies have the potential to limit airborne pathogen transmission through the air and thus break the chain of infection. Facility operations and ventilation systems are important in interrupting disease transmission. HVAC professionals play an important role in protecting building occupants by interrupting the indoor dissemination of infectious aerosols with HVAC and local exhaust ventilation systems.

- Even the most robust HVAC system cannot control all airflows and completely prevent the dissemination of an infectious aerosol or disease transmission by droplets or aerosols. An HVAC system's impact will depend on source location, the strength of the source, distribution of the released aerosol, droplet size, air distribution, temperature, relative humidity, and filtration. Furthermore, there are multiple modes and circumstances under which disease transmission occurs. The design and operation of HVAC systems can affect infectious aerosol transport, but they are only one part of an infection control bundle. The strategies for prevention and risk mitigation require collaboration among designers, owners, operators, industrial hygienists, and infection prevention specialists.

- Healthcare facilities have criteria for ventilation design to mitigate airborne transmission of infectious diseases – ASHRAE 2013, 2017a, 2019a, FGI 2010. For ordinary occupancies in the community (non-healthcare) ASHRAE provides general ventilation and air quality requirements in Standards 62.1, 62,2, and 170 (ASHRAE 2019a, 2019b, 2017a). ASHRAE does not provide specific requirements for infectious disease control in homes, schools, prisons, shelters, transportation, or other public facilities.

- The *ASHRAE Position Document on Infectious Aerosols* covers the dissemination of infectious aerosols and indirect transmission by resuspension but not direct-contact routes of transmission such as bodily contact. Also, non-HVAC measures for breaking the chain of infection are beyond the scope of the position document.

- Mitigation of infectious aerosol dissemination should be a consideration in the design of all facilities, and in those identified as high-risk facilities, the appropriate mitigation design should be incorporated.

The HVAC strategies listed below have the potential to reduce the risks of infectious aerosol dissemination. While the exact level of ventilation effectiveness varies with local conditions and the pathogens involved, ASHRAE believes that these techniques, when properly applied, can reduce the risk of transmission of infectious diseases through aerosols. These considerations can be used as criteria in the design of new and replacement HVAC systems and can be used to evaluate and make recommendations for modifications to existing HVAC systems in buildings to reduce the potential for transmission of the coronavirus. An essential contribution to reducing infectious aerosol transmission can be made through the application of these strategies.

For existing buildings (with existing HVAC systems), the options that are practical for implementation will be influenced by the constraints of the existing conditions, similar to any modification or alteration

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project. Existing systems may not have the spare capacity or controls infrastructure to fully implement strategies; careful assessment of existing systems capacity, infrastructure, and controls should be undertaken to evaluate which strategies could be implemented or what upgrades to existing systems are required to avoid operational shortcomings. The following are some examples of potential operational shorcomings that need to be avoided. These are given as illustrations of why careful assessment of existing systems capacity, infrastructure, and controls should be undertaken prior to deciding which strategies to implement, and to what extent their implementation is practical. Some of the strategies will impose additional loads on equipment. For example, for increased ventilation rates, under certain outdoor temperature and humidity conditions the heating and cooling loads imposed on air handling unit coils might exceed coil capacities. This potentially could result in loss of environmental control (space temperature and relative humidity), which could result in loss of code-mandated comfort conditions, mold growth, coil failure, and other problems. Another example pertains to the increased air pressure drop generally associated with enhanced filtration. If the system fans do not have adequate static pressure capability to accommodate the additional pressure drop associated with more efficient filters, the system could experience a decrease in air flow rate. This in turn could lead to issues with maintaining required air change rates, space temperature and relative humidity, and other issues. Designing new systems generally affords greater flexibility concerning the selection of options.Based on risk assessments, the use of specific HVAC strategies supported by the evidence-based literature should be considered, including the following:

1. **Ventilation**:
    a. Temporarily increase outdoor air ventilation (above code minimums) and verify outside air is accurately measured. Temporarily disable demand-controlled ventilation and open outdoor air dampers as much as indoor and outdoor conditions permit; explore other ventilation and dilution strategies. Note: The extent to which this can be done depends on several factors including but not limited to the size of the outside air intake and ductwork, capacity of the AHU heating coil and cooling coil, and outdoor temperature and humidity. If the outdoor air is cold or hot/humid, increasing its rate might cause a load on the AHU coils that they cannot satisfy. In that case, the extent to which the outside air is increased is limited by the current outside air temperature and moisture content. Consider permitting slightly higher cooling and slightly lower heating space set points to permit higher levels of outside air.
    b. Consider personalized ventilation systems/units.
    c. Consider extraction ventilation (source capture, local exhaust, general exhaust).
2. **Enhanced filtration of air**:
    a. Increase to MERV 13 (as a minimum) or the highest level achievable.
    b. MERV 14 and 14A are recommended by some sources.
    c. HEPA filters are even higher efficiency.
    d. Note: The extent to which this can be done depends on a number of factors such as the air pressure drop of the proposed filters and the static pressure capability of the existing fan(s). Generally, the more efficient the filters, the higher the pressure drop, and the

more often they must be changed. There are extended media filters available that can reduce the impact of higher pressure drop from higher efficient filters.

e. Add portable room air cleaners with HEPA or high-MERV filters with due consideration to the clean air delivery rate.

3. **Add ultraviolet germicidal irradiation (UVGI) devices**. These can be added in ducts, air handling units, and upper room, as well as portable type at an intensity level suitable for disinfection. The type selected depends on many factors, including occupant density and available space in ductwork and air handling units. Many existing systems have UVGI installed, but it may have been installed for coil cleaning and not disinfection. The intensity level required for disinfection is higher than for coil cleaning, so if a system has UVGI do not assume it is adequate for disinfection without evaluation. While ultraviolet germicidal irradiation (UVGI) is well researched and validated, many new technologies are not (ASHRAE 2018).
4. **Maintain temperature and humidity** as applicable to the infectious aerosol of the room. Generally, maintaining 40%-60% relative humidity is appropriate. Generally, air conditioning systems will dehumidify to 60% RH or less in the summer. In the winter, and without humidifiers, most buildings will be at less than 40% RH. Many systems do not have humidifiers. Adding humidifiers should be considered where appropriate. Among the considerations are increased occupant comfort, protection of finishes/materials, energy consumption, maintenance, system capacities, and space requirements.
5. **Maintain Pressure Differentials** based on risk assessments between rooms or between zones comprised of multiple rooms, as well as overall building pressurization.
6. **Airflow Distribution Patterns, Directional Air Flow**. Based on risk assessments, consider designs that promote cleaner airflow patterns for providing effective flow paths for airborne particulates to exit spaces to less clean zones and use appropriate air cleaning systems.
7. **Keep systems running longer hours** (24/7 if possible, with outside air).
8. **Inspect seals of energy recovery ventilation systems:** If seals cannot be adjusted to mitigate concern of leaking potentially contaminated exhaust air back into the outdoor air supply, bypass energy recovery systems.
9. **Anterooms:** Where a significant risk of transmission of aerosols has been identified by infection control risk assessments, design of airborne infection isolation rooms (AIIRs) should include anterooms.

Additionally, the ASHRAE Epidemic Task Force has developed guidance on mitigating potential health risks during reopening of buildings closed during the COVID-19 pandemic. ASHRAE's recommendations for reopening buildings are outlined in two locations of its COVID-19 Resources webpage.
<https://www.ashrae.org/technical-resources/frequently-asked-questions-faq>
<https://www.ashrae.org/technical-resources/resources>, then click on "Reopening".
The reopening recommendations go beyond HVAC and should be reviewed with appropriate parties. The following is a partial summary of the ASHRAE HVAC reopening recommendations:

1. **Follow Above Guidelines.**
2. **Systems Evaluation:** Check setback and setup modes, space temperature and humidity levels are controlled within tolerance, each system component is working properly, and sensors are within calibration; perform tactical commissioning.
3. **Outside Air Flushing:** Before and after occupancy (outside air and exhaust).
4. **Garage Exhaust:** Before occupancy.
5. **Unoccupied Mode:** Operate systems with minimum outside air.
6. **Legionellosis:** Follow ASHRAE Standards 180-2018 and 188-2018.
7. **Filters:** Verify condition and consider increasing filtration levels or provide portable units as stated above.
8. **New Control Mode:** Consider adding a building manual control mode for epidemics to incorporate HVAC strategies to reduce virus transmission for future events.
9. **Plumbing Fixtures:** Run water to ensure water quality, verify traps are wet.
10. **Domestic Hot Water:** Keep systems circulating, keep water above 140 deg F, do high temperature flush if system was down.
11. **Life-Safety Systems:** Verify if official inspection is required or consider inspection by contract service professionals for fire sprinkler, fire alarm, emergency lighting, and other life-safety systems.
12. **Battery Backup:** Check equipment provided with battery backup (fire alarm, IT, OIT, BAS, etc.)
13. **Standby/Emergency Generator:** Test in accordance with AHJ and manufacturer's recommendations.

This memo is a brief summary of considerations and recommendations for HVAC systems relative to Coronavirus and COVID-19. Recommendations are current as of the release date of the memo. We encourage readers to refer to the actual ASHRAE publications for latest recommendations because they are subject to updates and changes as more knowledge is gained in the developing pandemic.