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U.S. DEPARTMENT OF ENERGY

Fact Sheet

OPERATING HVAC SYSTEMS IN COMMERCIAL OFFICE SPACES TO REDUCE RISKS OF AIRBORNE INFECTIOUS DISEASE TRANSMISSION

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and Center for Disease Control (CDC) have each released guidance related to operational changes in buildings for reducing disease transmission. Some of the general ASHRAE guidance might have different effects depending on the pressure configuration of the building. Separate from the heating, ventilation, and air conditioning (HVAC) changes, there will also likely need to be operational changes to limit a building's occupancy because of possible staff physical distancing requirements.

ASHRAE guidance recommends maximum outside air (OA) ventilation (whenever possible). Potential increase of outdoor air ventilation could result in:

- Increased moisture being introduced into the building as a side effect. Consider the climate of the building and the moisture in the outside air.
- Increased dust and pollens being introduced into the building as a side effect. Consider the impacts to HVAC filter loading and occupants.
- Increased cold air being introduced into the building as a side effect. Consider the impacts to HVAC system performance during cold weather.
- Increased hot air being introduced into the building as a side effect. Consider the impacts to HVAC system performance during hot weather.
- Stressed system causing component failure. Make sure conditions do not deviate too far from comfort ranges in terms of temperature and humidity. Adjust setpoints to accommodate more OA with less detrimental effect on central equipment.
- High humidity can lead to occupant discomfort and unwanted microbial growth.

The U.S. DOE ComStock platform analyzes the entire U.S. commercial building stock. ComStock analysis showed that that increasing the minimum outdoor air to ventilation in air handling units to 100% during occupied hours results in a 40% increase in energy consumption, 13% increase in electric consumption, 264% increase in gas consumption, and 37% increase in peak electric demand in the aggregated total of all the office buildings in the U.S. building stock.

Use the list below to mitigate the potential side effects of operational changes mentioned above:

- **Moisture Control:** Air-handling unit (AHU) or roof top unit (RTU) may not be able to remove excess moisture at cooling coils beyond original building design.
  - Cooling coils are designed with drain pans that provide a path for condensation to drain. Verify drain pans and piping are adequately designed and maintained (no blockages) to ensure that water is flowing to the designed drain connection – not down the ductwork, reintroduced into the airstream, or overflowing onto the mechanical room floor, etc.
- **Economizer:** 100% OA can be achieved via properly working economizer dampers.
  - Verify system is properly sequenced – e.g., the mixed air damper closes as OA damper opens.
  - Check economizer dampers – if failed, may limit the 100% outside air ventilation capabilities.
  - Increased exhaust (or relief) air needs to be considered along with increased outside air. An equal amount of air needs to be removed from the building. Most offices are designed with the bulk of the air going back to the return.

- Operating ventilation systems with maximum achievable OA during extreme weather may drive primary systems beyond their capacity. This could result in chilled water or hot water heating plants being unable to maintain adequate temperatures for comfort cooling and comfort heating. Consider the following strategies:
  - **Internal Load Control:** Communicate with occupants and see if the zone temperatures can be slightly increased or decreased without affecting acceptable comfort. Internal loads have different effects in heating versus cooling season. During cooling season, consider reducing internal loads that do not affect essential building functions. During heating season, the internal loads can be beneficial when more OA is brought into the building
  - **External Load Control:** The introduction of 100% outdoor air for dilution will drive cooling and possibly dehumidification loads higher than original design considerations. Chilled water plants that provide comfort cooling and serve process loads simultaneously may be forced to starve comfort cooling loads in order to maintain process loads (data centers, IT closets, elevator machine rooms, etc.) during extremely warm outdoor conditions. Consider installing automated shading devices to reduce heat gains during cooling season and allow the sun to warm office spaces during heating season.
  - **Hot Water Reconfiguration:** Hot water plants with the following characteristics may encounter unique challenges that need to be addressed if 100% outside air is being maintained:
    - Hot water loops that serve process heating loads (snow melt systems, etc.) may need to be reduced during cold weather to account for higher heating loads at the AHUs.
    - Hot water that is derived from heat pump chillers may result in heating loads beyond their original design parameters – resulting in cold spaces or the need to revert operations to gas-fired boilers (if they exist).
    - Hot water boilers that normally operate in a lower temperature region for efficiency may need to be configured to operate at higher temperatures.
- If there is an energy-recovery device, ASHRAE notes that some devices (i.e., energy wheels) have the potential of cross contamination between intake and exhaust air (ASHRAE 2020). This may necessitate the energy wheel being bypassed (if the energy wheel has bypass dampers) unless there is proper filtration downstream of the energy wheel.
- ASHRAE guidance includes HVAC air filtration based on "Minimum Efficiency Report Value" (MERV). The higher the MERV value, the more efficient air filtration. ASHRAE recommends that filters be MERV-13 or better. ASHRAE also recommends combining the effects of outdoor air, filtration, and air cleaners to exceed combined requirements of minimum ventilation and MERV-13 filters.

  According to ComStock analysis, upgrading to MERV-13 filters in central air handling units would increase energy consumption by 1%, increase electric consumption by 2%, decrease gas consumption by 2%, and increase peak electric demand by 1.08% on the aggregate total of office buildings in the U.S. commercial building stock.

  - **Air Velocity Control:** Filtration can result in increased resistance or static pressure which reduces airflow to the HVAC equipment and building space. For a direct expansion (DX) cooling system, if air velocity is too low, the cooling coil causes moisture on the coil surface to freeze because of low airflows. This may result in further airflow reduction with possible airflow blockage occurring as one unintended outcome.
    - Large AHUs may increase the speed of the fan to overcome the increased static pressure drop. Some AHUs or RTUs may not have the capability to automatically increase the speed of the fan (if not configured with a variable frequency drive or VFD).
    - Instead of more efficient filtration (which might result in other mitigation steps), consider increased outside air change rate with previously noted considerations for possible impacts to moisture removal systems and cooling and heating plant capacity impacts. This means the proportion of outside air to total supply airflow is increased without necessarily increasing the total circulating airflow.
    - Typically, the AHU or RTU comes with the ability to increase the fan speed by changing the mechanical sheave and pulley, which results in increased speed (and increased power consumption at the fan motor). This can only occur if the motor is oversized and is not already operating at its maximum power rating.

- **Filter Maintenance:** Filters will become dirty from use and the introduction of more outside air may likely require more frequent filter changes.
  - Before installing a more efficient filter than you are currently using, verify that your system can accommodate it (or plan on more frequent filter changes for better energy performance).
  - As particles accumulate, the AHU might operate outside of the performance range resulting in further air flow reduction. Filter replacement intervals will increase if system operation changes to either accommodate increased outside air recommendations or provide continuous operation of AHUs or RTUs.
    - At a minimum, replace filters if building occupant(s) are diagnosed with COVID-19. Filter replacement will probably occur at least twice as often, but plan for frequent (e.g., weekly, monthly) inspection of the filters because the frequency will vary based on each building.
  - Filter end-of-life also needs to be managed (may contain infectious disease particles). Wear personal protective equipment (PPE), protect the surrounding environment in case stray particles leave the filter during extraction, clean and disinfect the surrounding surfaces, and ensure proper disposal of all used filter materials.
  - Filters that may reside in the zone systems (fan powered VAV boxes, fan coils, etc.) may also need to be replaced more frequently and likewise be properly disposed of with attention to required cleaning and disinfection of surrounding surfaces.
- **Elevator Ventilation:** ASHRAE guidance suggests the following to reduce risk in elevators:
  - Turn on the cab ventilation fans where possible, allow elevators to run at higher speeds to minimize the time in elevator.
  - Consider local air treatment devices in frequently used elevators.
  - Consider closing elevator lobby vestibule doors, limiting the number of people in the elevator to maintain physical distancing, and encouraging more use of the stairs by occupants.
  - In a building with multiple elevators, consider reprograming the elevators to serve fewer floors than normal operations.
- **Demand Control Ventilation:** ASHRAE recommends that HVAC systems that use demand-controlled ventilation (DCV) be disabled during times when there is a concern about the spread of infectious disease. This may require the control sequences to be evaluated for proper operation without the DCV capability. DCV sensors (carbon dioxide – CO^2) could be used to validate the spaces are adequately ventilated with outside air, even if DCV is disabled. CO^2 readings below 500 ppm typically indicate a well-ventilated building.

  ComStock estimates that buildings using DCV constitute about 3% of all the building in the U.S. commercial building stock by area. There would be minimal aggregated impact due this measure on office buildings.
- **Operation Schedules:** The Centers for Disease and Controls recommends 2 hours of operations at maximum outdoor airflow rates prior to occupancy and after occupancy. ASHRAE similarly recommends 3 air changes and thus 2 hours of pre-purge and post-flush is long enough to cover the necessary air changes.
  - If the building has transitioned to multiple work shifts, then the use of highest OA that is still able to maintain comfort conditions is recommended during late nights and weekends (whenever the building is occupied).
  - Depending on the anticipated duration in response to infectious diseases in commercial office spaces, some of these considerations may be handled manually by the operations staff by overriding the building automation system (BAS) or better handled by updating control sequences in the BAS.
- **Equipment Maintenance:** Because of increased loads and continuous (or possibly extended) operations, equipment may fail prematurely, resulting in emergency repairs and/or replacements. Consider conducting more frequent preventative maintenance and re-commissioning and developing an emergency plan for unexpected equipment failure.

- **Floor Drains:** Each month prime all floor drains, especially where located in bathrooms, kitchen preparation areas, and other locations that may be overlooked. Priming a floor drain involves pouring at least one gallon of water into the floor drain each time.
  - Dried out floor traps allowed aerosolized fecal particles to back-flow into the occupied spaces, allowing cross contamination of viral particles from other bathrooms.
- **HVAC System Operation:** Implementation of HVAC system changes depend on all aspects of a HVAC system operating properly. General recommendations for HVAC operation include:
  - Review the modes of operation of HVAC system:
    - Sequence of operation, schedule, setpoint, which zones served by which type of HVAC system.
  - Check dampers, filter, and economizers seals and frames are intact and clean, functional, and responding to control signals.
  - Check the accuracy of zone temperature, humidity, and carbon dioxide (CO^2) sensor, and that air handling systems are providing adequate airflow.
  - Verify that there are no blockages in the duct system (e.g., closed fire/smoke dampers) and that exhaust fans are functional and venting to the outdoors.
  - Check outside air intake regularly for any potential risk such as exhaust nearby and provide proper clearance if accessible by pedestrians, etc.
- **Elevator Ventilation:** ASHRAE guidance suggests the following to reduce risk in elevators:
  - Turn on the cab ventilation fans where possible, allow elevators to run at higher speeds to minimize the time in elevator.
  - Consider local air treatment devices in frequently used elevators.
  - Consider closing elevator lobby vestibule doors, limiting the number of people in the elevator to maintain physical distancing, and encouraging more use of the stairs by occupants.
  - In a building with multiple elevators, consider reprograming the elevators to serve fewer floors than normal operations.
- **With regards to elevators, the CDC also recommends the following:**
  - Where feasible, designate certain stairwells or sides of stairwells as "up" and "down" to better promote social distancing.
  - Use floor markings in elevator lobbies and near the entrance to escalators to reinforce social distancing. Place decals inside the elevator to identify where passengers should stand, if needed.
  - Use stanchions (for lobbies only; not inside elevators) or other ways to mark pathways to help people travel in one direction and stay 6 feet apart.
  - Encourage the use of cloth face coverings by all elevator and escalator occupants. Ask elevator occupants to avoid speaking, when possible.
  - Consider limiting the number of people in an elevator and leaving steps empty between passengers on escalators, where possible, to maintain social distancing.
  - Post signs reminding occupants to minimize surface touching. They should use an object (such as a pen cap) or their knuckle to push elevator buttons.
  - Encourage elevator and escalator passengers to wash their hands and avoid touching their face after holding on to handrails or touching buttons.
  - Consider adding supplemental air ventilation or local air treatment devices in frequently used elevator cars.

Resources:

- ASHRAE Guidance for Re-Opening Buildings
- AHAM: 2015. ANSI/AHAM AC-1-2015, Method For Measuring Performance Of Portable Household Electric Room Air Cleaners. Washington, DC: Association of Home Appliance Manufacturers.
- ASHRAE. 2017b. ANSI/ASHRAE Standard 52.2-2017, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size. Atlanta: ASHRAE.
- CDC. Oct. 29,2020: Centers for Disease Control and Prevention COVID-19 Employer Information for Office Buildings

Notes:
Developed by the Pacific Northwest National Laboratory. This information is based on recommendations and guidance from ASHRAE and other sources. Energy analyses were performed by the National Renewable Energy Laboratory using the ComStock analysis tool https://comstock.nrel.gov. This is a quickly changing area of research and readers should review for any recent guidance. Each building in each climate type will differ and affect final implementation. Professional engineers who are familiar with each individual building should consider any changes as they impact a specific, unique building.