School Ventilation and SARS-CoV-2 (COVID-19)

Building ventilation plays a critical role in the overall indoor air quality (IAQ) of school buildings, including the airborne spread of the COVID-19 virus. This guidance document provides schools and districts with important information and resources.

U.S. Centers for Disease Control and Prevention (CDC) Recommendations

The CDC website provides the following regarding school building ventilation:

> **"Ventilation:** Ensure ventilation systems operate properly and increase circulation of outdoor air as much as possible, for example by opening windows and doors. Do not open windows and doors if doing so poses a safety or health risk (e.g., risk of falling, triggering asthma symptoms) to children using the facility."

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Recommendations

ASHRAE is an internationally recognized authority regarding building heating, ventilating and air conditioning (HVAC) systems, energy efficiency, indoor air quality, refrigeration and sustainability. Its standards are incorporated in the International Building Code (IBC) and the International Energy Conservation Code (IECC). The IBC is the basis for the Kentucky Building Code (KBC).

ASHRAE has issued the following statements regarding transmission of COVID-19 and the operation of HVAC systems during the 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.

On May 28, 2020, ASHRAE stated, "Neither WHO nor CDC rule out the possibility of aerosol transmission under some circumstances and both recommend the use of engineering controls in some cases and cannot explain all incidents of community spread of COVID-19. ASHRAE's

position that engineering controls to reduce airborne concentrations of viral particles or droplets are warranted to mitigate this risk is not in conflict with WHO and CDC's positions." Subsequently, studies have determined that aerosol transmission does occur. Schools and districts should consider the information included in ASHRAE's Position Document on Infections Aerosols.

ASHRAE Reopening Guide for Schools and Universities

On July 22, 2020, the ASHRAE Epidemic Task Force released its updated Reopening Guide for Schools and Universities related to COVID-19.

ALL DISTRICT PERSONNEL RESPONSIBLE FOR THE OPERATION AND MAINTENCE OF HVAC SYSTEMS IN SCHOOL BUILDINGS SHOULD READ AND BECOME FAMILIAR WITH THIS DOCUMENT, WHICH ADDRESSES:

Recommendations and strategies for determining building readiness and operations for reoccupation after shut-down due to the pandemic:

- Summer checklist for fall start of classes
- Startup checklist for HVAC systems prior to occupancy
- Equipment and system-specific checks and verification during the academic year, including the following:
    - Daily flushing prior to occupancy
    - Monthly inspection of air-handling units, rooftop units, unitary and single-zone units related to operation, filters and other items

Recommendations regarding operation and retrofitting HVAC systems to improve indoor air quality and slow the transmission of viruses via the HVAC systems. Also included are design guidelines for the following:

- Temperature and humidity
- Ventilation
- Filtration and filtration upgrades
- Nurses office
- System maintenance and filter replacement during the COVID-19 pandemic
- Operation of occupied facilities
- Controlling infection outbreaks in school facilities

U.S. Environmental Protection Agency (EPA)

The EPA has indicated that a professional should interpret ASHAE guidelines for their specific building and circumstances.

Kentucky Department of Education (KDE)

KDE does not presume to possess the knowledge or expertise which the World Health Organization (WHO), CDC, ASHRAE, EPA and research institutions have at their disposal. The following should not be considered to supersede these recommendations or those of the governor's office and agencies such as the Kentucky Department for Public Health and Department of Housing, Buildings and Construction. Should KDE recommendations conflict with current or subsequent recommendations of these agencies, those of other agencies take precedent. The following recommendations, however, are based on our experience, observations and input from the engineering community that routinely serves Kentucky's K-12 schools, affiliated industry representatives and the State Fire Marshal's office.

Spread of COVID-19 via Room Air

The length of time the COVID-19 virus remains infectious in the air in a room after it was occupied by an infected person is not known. The concentration and spread of the virus is influenced by numerous factors:

- Number of occupants in the room
- Room area and volume
- Design, operation and maintenance of the HVAC and control systems
- Room temperature and humidity. Studies have indicated that maintaining a building's relative humidity at 50% discourages the spread of common viruses and decreases bacteria, fungi and allergens
- Air flow patterns related to the location of supply, return and exhaust vents

School HVAC Systems

Kentucky's K-12 schools have a wide variety of HVAC and control systems.

- HVAC systems vary by type, age, edition of the building code under which it was designed, any subsequent modifications and how well the system has been maintained.
- HVAC control systems also vary from thermostats providing individual room control to sophisticated Building Automation Systems (BAS) that may be controlled from a central location for district-wide applications.

Air Changes and Ventilation

The Kentucky Building Code (KBC) does not include a requirement for total air changes of the HVAC system, but it does include requirements for ventilation.

- The current design standard for classroom ventilation air changes per hour is ASHRAE 62. Table 6.1 provides the prescriptive method to meet the requirements, which include 10 cfm per person and 0.12 cfm/sq.ft.
- HVAC systems in older schools may have been designed under a code that might have required 15 cfm per person or less.

Understanding the building's HVAC and control systems is important when considering ventilation strategies to combat the spread of COVID-19.

Mitigation Strategies

Strategies to mitigate the spread of the virus can broadly be characterized as follows and are often used in combination:

Dilution

Flush (replace) the air in the building with large amounts of outdoor air to remove pathogens and residual cleaning agents using mechanical and/or natural ventilation.

Natural Ventilation

Open windows and doors when buildings are vacant for a period of time when occupant comfort is not a concern.

- Recommended when outdoor temperatures are moderate and the humidity level is low rather than during the heat of the day.
- Not recommended if doing so poses a health or safety risk to students using the facility for the following reasons:
    - Risk of falling,
    - Triggering asthma symptoms,
    - Security, and
    - Airborne pollution.

ASHRAE encourages opening windows 2 hours prior to occupancy in buildings without an outside air (OA) system.

Opening Doors and Windows When Buildings are Occupied:

KDE realizes existing life safety and school security policies may seemingly conflict with health guidance from the Kentucky Department for Public Health. For example, it is recommended that doors and windows be opened to promote air flow. This potentially conflicts with life safety

requirements that doors in fire-rated corridors are to be self-closing and self-latching (not necessarily self-locking). These doors are to have closers. The closing operation is not to be hindered by wood floor stops, tie-backs or other devices. Further, KRS 158.162 requires classroom doors to be closed and locked during instructional time for security purposes (unless exempted by the state school security marshal).

KDE recommends districts consult with their local health department, the local fire marshal and the school security marshal to assist districts in resolving these types of potential conflicts. For example, the fire marshal will know where to look for fire corridor doors and be able to determine if the door can be kept open.

Also, the Office of State School Security Marshal is available to assist districts with building security questions. Pursuant to KRS 158.162, the School Security Marshal may grant written exemptions to the requirement that classroom doors are to remain closed and locked during instruction time.

Mechanical Ventilation

Options depend on the type of system.

- Keep HVAC systems running for longer hours.
- Several ASHRAE publications recommend operating systems 24/7 without providing greater detail.
- This method provides the greatest number of daily air changes, but may significantly increase electricity costs.

<u>Buildings With Outside Air (OA) Systems:</u>

According to the CDC, an outside air system providing two air changes of outdoor air will flush airborne contaminants in a room as follows:

- 99% in 138 minutes
- 99.9% in 207 minutes

An outside air flush of the building is recommended to be performed after students leave each day and prior to their return. It may be advantageous to coordinate so that this flush occurs prior to wiping/disinfecting surfaces.

Based on this information, Kentucky's professional engineers are not recommending that buildings with outside air systems operate 24/7.

These professional engineers also are recommending the following:

Buildings With Outside Air (OA) Systems *AND* with MERV-13 (Minimum Efficiency Reporting Value) Filters:

- **Evening:** Flush by keeping OA system running for 3 hours, which typically provides at least six air changes with outside air and removes more than 99% of airborne contaminants per the CDC table. Sterilize surfaces as usual.
- **All day:** Program system to run terminal unit fans (classroom unit fans) continuously (don't cycle them on and off) to provide more than six air changes per hour of MERV-13 filtered air.
- **Morning:** Pre-flush with 1-2 hours of outside air (an additional two to four air changes of fresh outdoor air).

Recommendations will differ if the building does not have OA units, MERV-13 filters or is used with bi-polar ionization.

Buildings with Energy Recovery Wheels

Concerns have been expressed regarding running outside air units because most have an energy recovery wheel to help exchange energy and water vapor between outside air and exhaust air streams.

- Can the wheel transfer virus from exhaust air to outside air? The answer is yes.
- Is the benefit of dilution still worth running the unit? According to ASHRAE, yes – the benefit of dilution outweighs the risk of transferring.

Filtration

Filtration provided by HVAC systems can remove virus and bacteria and reduce the risk of airborne transmission.

- Filter efficiency and performance often is indicated by the filter's minimum efficiency reporting value (MERV) from 1 to 16, with the number serving as an indicator of how well the filter will remove material from the air.
- Filters should be changed regularly (possibly at shorter intervals than normal).
- According to ASHRAE, MERV-13 (the minimum rating needed for the COVID-19 virus) filters can be used on many standard pieces of equipment. Where possible, change to MERV-13 filters.
- MERV-13 filters often can be used on water source heat pumps and larger equipment, such as hydronic air handlers and larger rooftop units.

Not all equipment can withstand the additional air restriction created by these higher-efficiency filters.

- In general, MERV-13 filters are not compatible with variable refrigerant flow (VRF) and variable refrigerant volume (VRV) systems.
- Some equipment such as smaller split systems and even larger packaged units may trip unit safeties or simply not work.
- Generally, odds are better for proper function with MERV-13 if the unit can accommodate a 2- or 4-inch deep filter.

Consult equipment manufacturers before changing to MERV-13 filters. Filters should be treated as though they contain active virus. Proper personal protective equipment – including gloves and respiratory protection – is recommended when changing filters. Filters should be immediately bagged and safely removed from the school.

Purification

Ultraviolet Light

- Ultraviolet germicidal irradiation (UVGI) can kill bacteria, viruses and some molds. It traditionally has been used in healthcare settings.
- UVC refers to ultraviolet light with wavelengths between 200-280 nanometers (Nm).
- Air-handling units can be retrofitted with UVC lights if they were not originally designed with this capability or placed at strategic locations within the duct system.
- Placement is important because the coronavirus must be exposed for a period of time for the UVC light to be effective. Currently, there is not a consensus about the minimum time of exposure.

The district should work with its engineering consultant to ensure this technology is safely integrated into your system to prevent radiation exposure to occupants and maintenance personnel. Service the systems and ensure compliance with UL 2998 standard for zero ozone production so it is safe for school use.

Bi-Polar Ionization

- Bi-polar ionization releases positive and negative ions into the airstream.
- The ions latch onto and neutralize any contaminants they come into contact with.
- Charged particles are drawn together, forming clusters, which become heavy enough to drop out of the air.

- Does not remove the contaminant, but helps enhance the filtration system ability to capture the contaminant.
- Must constantly operate to maximize effectiveness.
- Systems must be UL listed for zero ozone production.

Humidity Control

- Studies have indicated that maintaining a building's relative humidity at 50% discourages the spread of common viruses and decreases bacteria, fungi and allergens.
- Although dehumidification occurs as the result of the air-conditioning process, most schools do not have a humidity control system. Humidity control is best accomplished at a system level. **Professional services are needed for the design of humidity control systems.**

Supplemental Systems

- Stand-alone air cleaners (air purifiers) with high-efficiency filters (such as MERV-14, HEPA, etc.) and a high clean air delivery rate (CADR) are available for use in spaces without filtration or to supplement existing systems.
- Stand-alone room humidifiers/dehumidifiers can be used if the existing building system does not provide sufficient humidity control.
- Portable UV units are available. They are most often used in hospitals to clean the air in a room known to be contaminated with pathogens such as MRSA. <u>They are not recommended in schools unless UL listed for zero ozone production.</u>
- Portable ionization units are also available. These must also be UL listed for zero ozone production.
- Portable fans, as a practical matter, should only be used when other options are not available. They should be located to avoid directing the air flow across occupants and facilitating the possible transmission of airborne pathogens between occupants.
- Occupants should not sit in front of wall-mounted return air vents.

Temporary Barriers

- Temporary barriers such as vinyl or plastic shower curtains, cloth fabric or other flammable materials that produce toxic gas when ignited are not allowable.
- If temporary barriers are utilized, they shall not:

  - Interfere with means of egress.
  - Be floor to ceiling and interfere with the operation of code-required systems such as fire suppression (sprinkler) and smoke detection, or limit the ability of occupants to see exit signs or emergency lighting. They also should not reduce the effectiveness of the building's HVAC system.
  - Be inconsistent with the building's construction type (wood studs are not allowed).
- Tabletop and desktop dividers should be constructed of a non-breakable material such as plexiglass.

- Tabletop and desktop dividers are not allowable if they are fabric-covered, constructed of flammable materials or produce toxic gas when ignited.
- Tabletop and desktop dividers should not have sharp corners.

Building Operation

- Maintain room temperatures between 68 and 78 degrees Fahrenheit during the cooling season.
- Maintain relative humidity levels between 40% and 60%.
- Ventilation systems serving communal spaces, toilet rooms and other rooms that are designed to operate under negative pressure should operated under the same extended schedule as the building's outside air system.

Statutory and Regulatory Compliance

If modifications to existing systems are needed or proposed, they may be subject to compliance with the Kentucky Building Code. Altering, modifying or changing the original characteristics of a HVAC system requires design by a licensed professional engineer pursuant to KRS 322.360. Such modifications also are subject to compliance with 702 KAR 4:160 .