BRITISH COLUMBIA
Ministry of Education and Child Care

GUIDANCE FOR

HVAC SYSTEMS

This version of the document supersedes all previous versions

VERSION	SECTION AMENDED (ex. 1.2 or all)	TYPE OF REVISION (annual review, update, addition)	ISSUED ON
1.0	–	New Guidance	August 08, 2022
2.0	2.1	Update	December 13, 2022

CONTEXT AND PURPOSE OF THIS DOCUMENT

This document is intended to provide some considerations to school districts with regards to improving Heating Ventilation Air Conditioning (HVAC) system performance given the recent pandemic situation.

Note that this document is not intended to supersede any requirements from ASHRAE or other regulatory bodies.

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MAINTENANCE FOR SCHOOL HVAC SYSTEMS/EQUIPMENT

1.1. VERIFICATION OF OUTDOOR AIR DELIVERY

Delivery of at least minimum ASHRAE recommended amount of outdoor air is the target of a correctly functioning ventilation system. Air handling units are typically equipped with dampers intended to modulate introduction of outdoor air, typically connected to the school's digital control system.

Whether dampers are correctly functioning is important to verify. Control systems are programmed to modulate dampers, typically based on readings from building carbon dioxide (CO2) levels and, whereas less sophisticated controls may be based solely on outdoor temperature.

Dampers and their associated control mechanisms do go out of calibration or experience component failures. What the controls system indicates on a controls graphics display screen cannot be assumed to be true at the damper location. Linkages break, slip or become disconnected. Or become seized due to lack of maintenance.

Periodically, damper operation should be verified by physically witnessing how dampers respond to control signals. Under normal circumstances this is recommended to occur every three years, but when situations such as the current pandemic occur, a district wide damper review should be performed.

1.2. VERIFICATION OF OVERALL CONTROLS FUNCTIONALITY

As an extension of the above, it is recommended a review of controls programming, and a re-commissioning exercise be performed, as per manufacturer's/mechanical engineer's recommendations.

This exercise will identify energy saving opportunities such as HVAC equipment operating outside school occupancy schedules, incorrect temperature setpoints, elevated heating plant water temperature setpoints and variable speed motors running at higher speed than necessary.

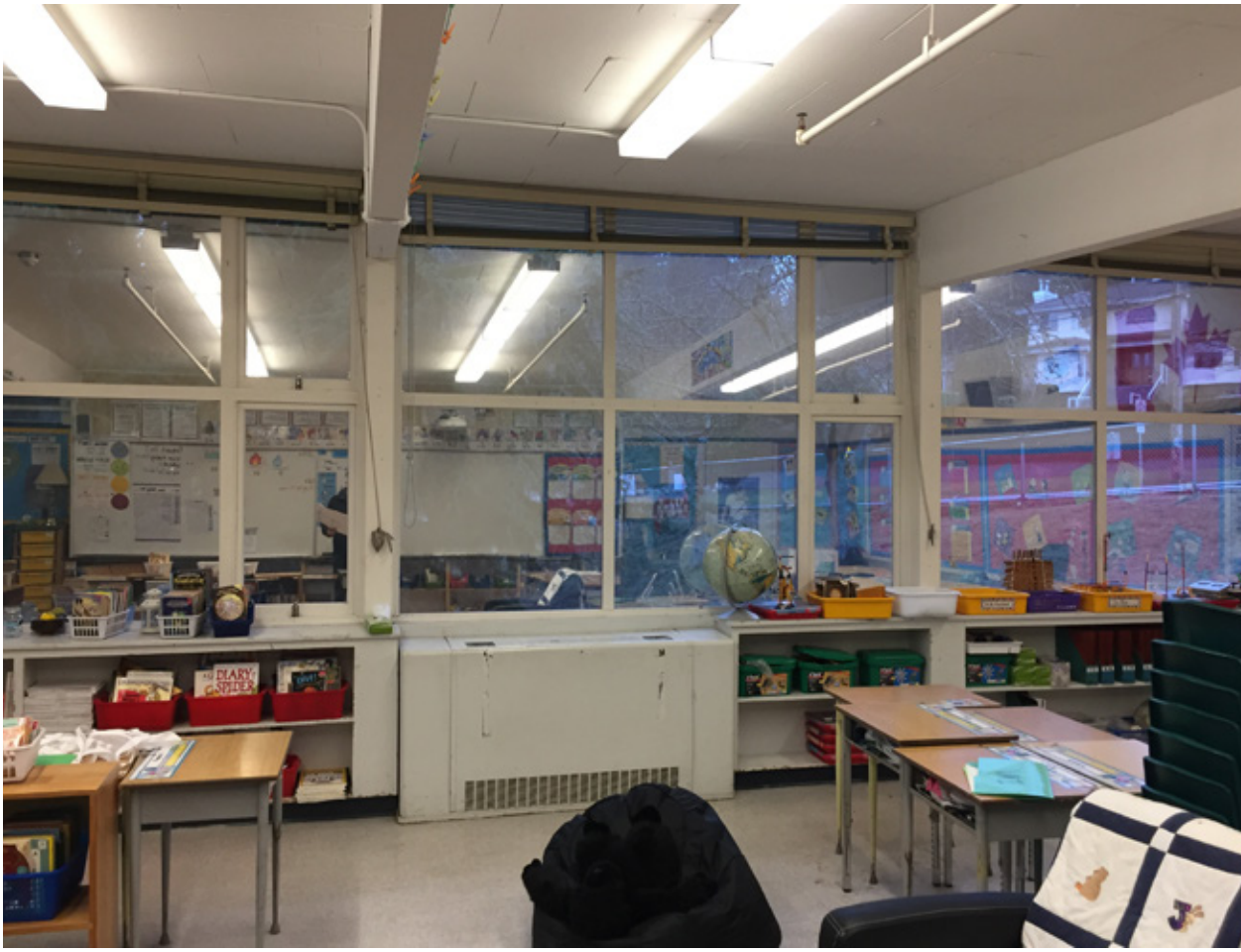
1.3. DUCT CLEANING

It is recommended that school districts have a plan in place that involves a routine schedule of duct cleaning for all facilities.

1.4. FILTERS

It is recommended that school districts replace or clean filters as recommended by the filter manufacturer, or at least three times annually. In cases where electro-statically charged filters are used to increase MERV-rating, the charge will deteriorate over time. Changing filters on a regular basis will mitigate this issue.

Maintenance staff should also review filters and how they fit into their holding racks. Instances where air can bypass the filter media results in a reduced overall MERV rating, as any air that does bypass does not get filtered at all.



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UPGRADE CONSIDERATIONS FOR SCHOOL HVAC SYSTEMS/EQUIPMENT

2.1. VENTILATION

When planning for future HVAC upgrades with a particular focus on ventilation improvements, School Districts should consider upgrades based on an analysis of the type and condition of existing systems.

Age of any type of system and/or equipment, along with performance, will be factors supporting need for upgrades. Consideration should also be given to the potential of repair and/or re-commissioning systems.

The highest priority projects should be for spaces and/or schools with no mechanical ventilation.

At a minimum, ventilation systems serving standard sized classrooms should have the ability to deliver around 450 cubic feet per minute (CFM) of outdoor air, per ASHRAE Standard 62.1 "*Ventilation for Acceptable Air Quality*". This equates to roughly 3 air changes per hour (AC/hr).

Some ventilation systems mix outdoor air with air recirculated from the room. Others are strictly outdoor air systems. The latter category may be heat recovery type units and are sometimes categorized as dedicated outdoor air systems (DOAS).

Mixing systems with capacity to deliver 6-8 AC/hr were more useful than DOAS systems during the pandemic, with the ability to deliver greater quantities of outdoor air. Many school districts implemented pandemic mode ventilation operation to deliver greater amounts of outdoor air than the ASHRAE minimum, even during colder (or warmer) weather, as long as heating (or cooling) plant capacities could support heating (or cooling) the additional outdoor air.

When outdoor temperature was suitable, systems could provide outdoor air up to 100% of their airflow capacity. Logically, therefore, mixed air systems provided more benefit than DOAS systems for pandemic response.

Beyond the pandemic, providing enhanced amounts of outdoor air runs counter to energy targets. It is anticipated, however, that ASHRAE will be publishing updated standards for classroom ventilation in Fall 2022, which may recommend increasing capacity of ventilation systems to a level greater than pre-pandemic values.

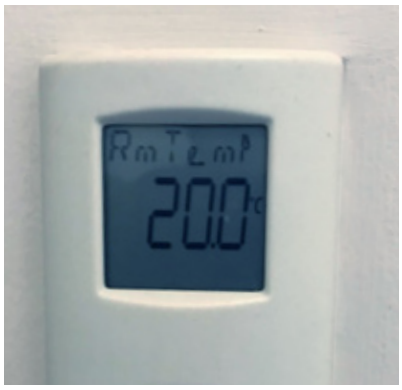
Heating and cooling plant equipment will not need to be sized for anything more than the new level of enhanced ventilation, and under normal circumstances should not be operated using this incremental capacity increase. The updated capacity should be reserved for times within the year where there is a higher than normal rate of respiratory illness transmission.

The increase in new ASHRAE recommended outdoor air rates will apply equally to mixing and non-mixing ventilation systems, so either system type can be considered for future HVAC capital upgrade projects. Mixing systems may be viewed as more useful, however, in light of their ability to deliver more outdoor air than DOAS systems when ambient temperature is mild.

In light of the above, the Ventilation Technical Advisory Panel has categorized ventilation systems in the following order from most effective to least effective, which School Districts may choose to use as a guide toward future ventilation upgrades. Applicable system enhancements that would improve overall effectiveness of each categorized ventilation system have also been provided for consideration.

CATEGORY 1: Mixing systems with capacity to provide a total air flow (combination of outdoor and recirculated) of 6-8 air changes per hour (AC/hr).

- 8 AC/hr when relying on ambient outdoor temperature for free cooling (east / south / west facing rooms)
- 7 AC/hr when relying on ambient outdoor temperature for free cooling (north facing rooms)
- 6 AC/hr when mechanical cooling is provided

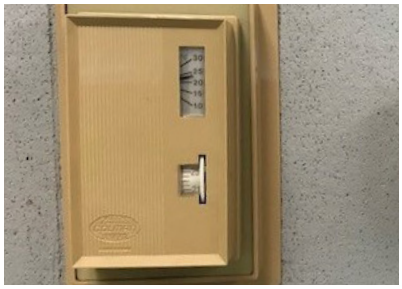


CATEGORY 1(A): Systems with capacity to provide 6-8 air changes per hour (AC/hr) of total air flow and equipped with digital controls.

> ***Enhancement*** *– None necessary. The optimal category for pandemic operation, with ability to provide greater amounts of outdoor air than code requirement, as well as digitally programmed operation that does not compromise occupant comfort or risk damage to heating equipment during colder weather*

The following, 1(b), 1(c) and 1(d), have fan capacity to provide 6-8 AC/hr of TOTAL airflow, but have restrictions that limit ability to introduce and/or properly control OUTDOOR air.

> *Depending on system/equipment condition, these can potentially be made equivalent to Category 1(a) systems with upgrades to controls, damper operability, or increased size of outdoor air ducts and louvres.*



CATEGORY 1(B): Systems with capacity to provide 6-8 AC/hr, but without digital controls

No associated digital controls. Enhanced outdoor air can be provided, but potentially in a manner not controlled as to time of day and/or maintaining interior comfort. Excessive energy use could potentially be an unintended consequence.

Enhancement *– Consider upgraded or new digital control system*

CATEGORY 1(C): Systems with capacity to provide 6-8 AC/hr, but with non-functional outdoor dampers

Where damage of component failure has occurred, resulting in non-functional dampers due to broken linkages, seized actuators or dampers being out of alignment.

Also, with older unit ventilators, outdoor air dampers are sometimes controlled in an "either/or" manner in parallel with heating valves, as with some older unit ventilators.

Enhancement *– Consider replacement or repair of failed or damaged dampers and/or damper actuators*

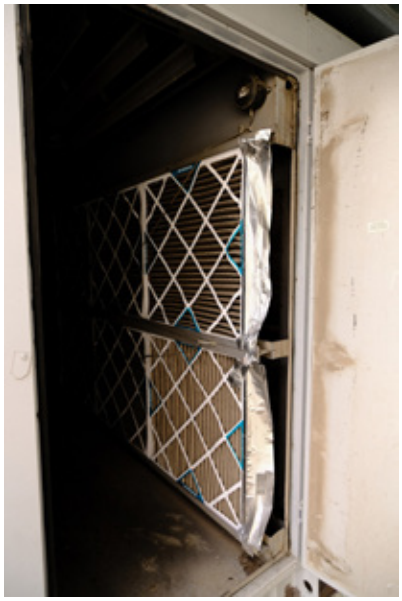
CATEGORY 1(D): Systems with overall capacity to provide 6-8 AC/hr, but with restricted OUTDOOR AIR paths

Often seen with furnaces provided for classrooms and portables.

Enhancement *– Consider replacement of outdoor air ducts, with larger ducts capable of delivering 100% outdoor air. This would not only allow increased amounts of outdoor air as a response to future periods of increased respiratory illness transmission, but would also allow the ventilation system(s) to be operated in free cooling mode when outdoor temperatures are suitable (for climatic areas that do not have mechanical cooling)*

CATEGORY 2: Outdoor Air Systems with capacity to provide 1-5 AC/hr of TOTAL airflow.

- Outdoor air systems with total airflow capacity of 4-5 AC/hr do meet or exceed current ASHRAE ventilation rates and have ability to deliver enhanced amounts of outdoor air.
- Outdoor air systems with total airflow capacity of 3 AC/hr meet current ASHRAE ventilation rates, but do not have ability to deliver enhanced amounts of outdoor air.
- Outdoor air systems with total airflow capacity less than 3 AC/hr do not meet current ASHRAE ventilation rates.



CATEGORY 2(A): Outdoor air systems with capacity of at least 4 AC/hr of OUTDOOR air

Where outdoor air systems are sized for at least 4 AC/hr of outdoor air, these already have ability to deliver enhanced amounts of outdoor air, if required for any future events of concern.

> ***Enhancement*** *– None necessary.*

CATEGORY 2(B): Outdoor air systems with capacity of 3 AC/hr of OUTDOOR air

Common in schools that qualify for full cooling, where make-up units deliver outdoor air to modular heat pumps or fan coil units.

> ***Enhancement*** *- when upgrades are carried out, an increase of airflow capacity of the make-up air unit(s) should be considered, along with appropriate amounts of pre-heating and/or pre-cooling capacities.*
>
> *This will also allow replacement of the make-up equipment and the modular indoor units independently, allowing HVAC capital funding to be carried out over multiple years, with a clear delineation between phases.*

These systems are also common where DOAS ventilation systems are installed, where providing code minimum outdoor air was done strategically to minimize energy use. These systems were designed to minimize energy use and are NOT viewed as wrongly designed. These schools will likely be equipped with newer equipment, which should not yet need renewal based on age or condition. These sometimes include Heat Recovery Ventilators (HRVs), which although typically not providing any more outdoor air than code minimum, do have the benefit that they do not re-circulate any room air.

Such designs often are also associated with terminal heating/cooling equipment, such as fan coils, heat pumps, chilled beams and/or radiant floors

> ***Enhancement*** *– It is expected that ASHRAE will be recommending increased minimum ventilation rates for Classrooms. Considering the current pandemic, and potential for future events of concern, increasing outdoor air capacity in future should be considered.*

CATEGORY 3: Mixing Systems with capacity to provide 1-5 AC/hr of TOTAL airflow.

- Mixing systems with total airflow capacity between 1-5 AC/hr of TOTAL airflow likely do not have capacity to provide ASHRAE recommended ventilation rates of OUTDOOR air.

CATEGORY 3(A): Mixing systems with capacity to provide 1-5 AC/hr of TOTAL supply air

Common in older schools. These likely do not have capacity to meet the current ASHRAE standard of 3 AC/hr of OUTDOOR air.

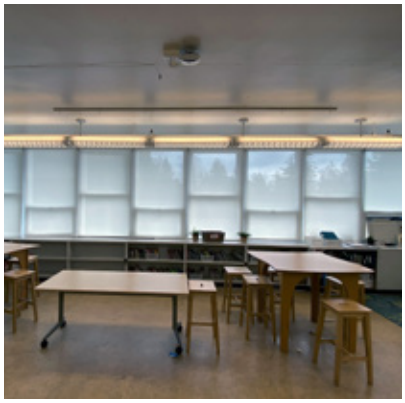
Enhancement *- Consider new equipment with increased ventilation capacity.*

CATEGORY 4: No Mechanical Ventilation

CATEGORY 4(A): Schools designed to use Natural Ventilation

These utilize windows or other means of introducing outdoor air, such as trickle vents. Air is diverted to the highest level(s) of the building, where it is expelled. If these are operating as intended, then no upgrades to these are necessarily required.

Enhancement *– None required unless the natural ventilation system is not providing an adequate quantity of outdoor air or maintaining indoor thermal comfort. Funding was provided by government to school districts during the pandemic to purchase HEPA filter units for all classrooms that don't have mechanical ventilation systems.*



CATEGORY 4(B): Schools with heating but no mechanical ventilation. Typically, with operable windows for ventilation.

It is rare to find these in districts that qualify for mechanical cooling, which by default use ventilation air as the cooling medium.

Enhancement *- Category 4(b) systems should be considered as the least effective. An upgrade of the heating plant will also likely be required as part of such an HVAC upgrade, since no capacity for heating of ventilation air would have been included in the original design. Funding was provided by government to school districts during the pandemic to purchase HEPA filter units for all classrooms that don't have mechanical ventilation systems.*

Design for Climate Resiliency

In all cases of replacement ventilation systems, consideration of equipment with capacity to deliver more outdoor air than code minimum is recommended. Most new motor driven fan and pump equipment is available with variable speed motors, so amounts of outdoor air can be adjusted to provide optimal indoor air quality based on prevailing conditions, in the interest of energy savings.

In cases where schools currently provide heating, but not cooling, with ventilation as the delivery medium, consider future provision of at least partial cooling. This could include pipe and duct insulation with vapour barriers, and condensate drain pans in air handling units, to minimize potential future costs.

The provision of separate heating and cooling pipe loops, with cooling lines installed in future can also be considered. 2-pipe switchover systems are also an alternative. Partial cooling may also be considered acceptable, with heat pumps sized to meet heating demand, and not increased in capacity to meet peak cooling load.

Heating and cooling pumps and pipes should be considered for enhanced outdoor air capacity, with the caveat that pumps are provided with variable speed motors, which can be adjusted to provide optimal indoor air quality based on prevailing conditions, to minimize energy use.

2.2. FILTRATION

Standard Filter Capacity

HVAC equipment not compatible with installation of MERV-13 (or higher) filters should also be considered for renewal, to provide improved indoor air quality during times of need.

The ability to easily switch between MERV-13 and filters with lesser MERV rating provides flexibility to respond to prevailing conditions, allow reduced fan energy opportunities and minimize potential equipment degradation bases on prevailing conditions.

Filter efficiency should not be viewed in isolation of outdoor air delivery. The efficiency of the filter is deemed to be relative to re-circulated air, whereas outdoor air is assumed to be virus free, unless drawn from an exterior location where people may congregate.

The differences in efficiency between different MERV-rated filters is therefore mitigated, the more outdoor air is mixed with re-circulated air.

At the point where 100-percent outdoor air is introduced to an air handling unit, the filter efficiency is effectively a non-factor. The conclusion being that enhanced rates of outdoor air should be provided while we are in pandemic mode, within the boundaries of occupant comfort and the risk of damage due to freezing of heating pipes.

HEPA Filter Application

HEPA filter units have an application for rooms that do not have ventilation systems. Self-contained HEPA units have limitations on the rate they can recirculate air, due to fan noise constraints. HVAC systems should be viewed holistically, however, with consideration of the combined benefit of filtration and introduction of outdoor air.

2.3. ENERGY PLANTS

In cases where requested HVAC upgrades include new heating/cooling plant equipment, equipment with capacity to support delivery of more outdoor air than code minimum should be considered. Motor driven fans and pumps, as well as heating and cooling equipment, are available with options for variable speed operation.

Operation of system components can therefore be adjusted to provide optimal indoor air quality based on prevailing conditions, in the interest of energy savings.

2.4. CONTROLS

For HVAC upgrades where digital controls are currently not installed, include for such in planning for renewed or replacement systems. Correctly commissioned and operating controls are a necessity to ensure HVAC equipment operates correctly, depending on building occupancy status, outdoor temperature, and indoor ventilation requirements.

Future HVAC infrastructure may have enhanced heating/cooling plant, ventilation fan and heat transfer medium pump capacities, which can be scaled back during non-emergency times. Ensuring these do not consume any more energy than necessary will be paramount to reducing energy consumption and carbon emissions.

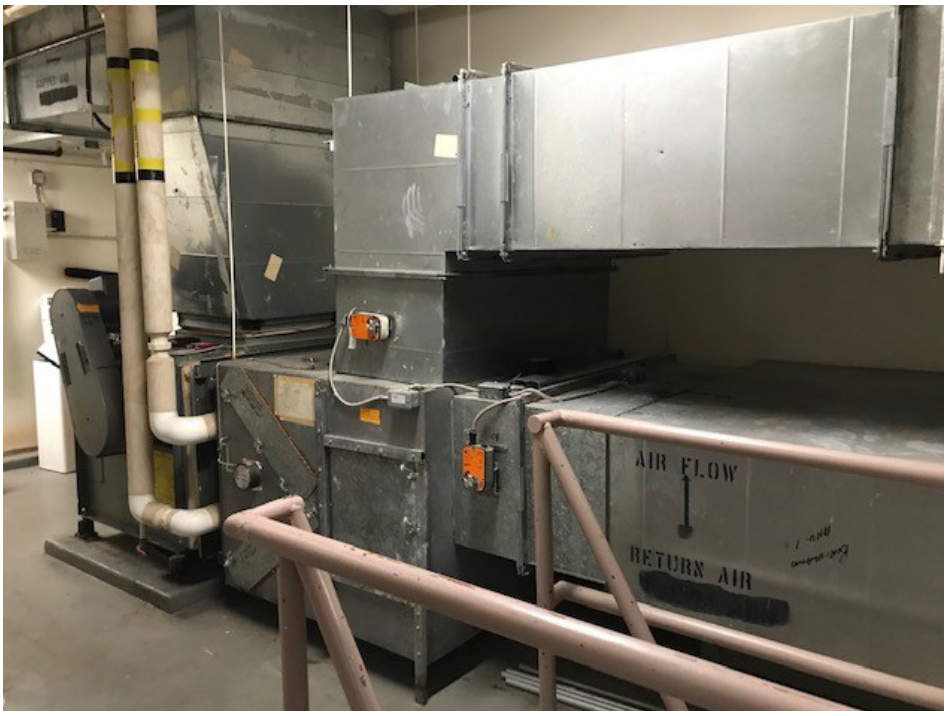
Many systems also will, at least in the short term, not be equipped with enhanced capacity. Nevertheless, these can currently deliver enhanced quantities of outdoor air during non-peak heating or cooling weather. Properly commissioned and operating controls can support increased outdoor air rates during shoulder seasons, without compromising the thermal comfort of building occupants, or risking freezing of heating systems as outdoor temperatures drop to a level where increased outdoor air cannot be supported.

Programmable controls systems should be provided with simple 'toggles' to allow building operators a straightforward method to switch between 'normal' and 'enhanced' modes. Enhanced mode should also have sub-categories, whereby increased outdoor air delivery can be put into operation during scenarios like the current SARS-CoV-2 pandemic, but minimal outdoor air is introduced during wildfire smoke seasons.

2.5. ENERGY USE

It is obvious that, in spite of consideration for enhanced capacity of future HVAC systems, minimization of energy utilization and carbon emissions must remain an important aspect to planning of renewed or replacement infrastructure.

Design of all HVAC systems is to be from the perspective of higher capacity equipment but intended to operate only as necessary to maintain thermal comfort and required ventilation.



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ASHRAE RESOURCES

(American Society of Heating, Refrigeration & Air-Conditioning Engineers)

Established HVAC Standards (pre-dating the SARS-CoV-2 pandemic)

- ANSI/ASHRAE STANDARD 52.2
  "METHOD OF TESTING GENERAL VENTILATION AIR-CLEANING DEVICES FOR REMOVAL EFFICIENCY BY PARTICLE SIZE"
- ANSI/ASHRAE STANDARD 55
  "THERMAL ENVIRONMENTAL CONDITIONS FOR HUMAN OCCUPANCY"
- ANSI/ASHRAE STANDARD 62.1
  "VENTILATION FOR ACCEPTABLE INDOOR AIR QUALITY"

Standards/Documents in Response to the Pandemic

- BUILDING READINESS (2020)
  https://www.ashrae.org/technical-resources/building-readiness
- FILTRATION & DISINFECTON (2020)
  https://www.ashrae.org/technical-resources/filtration-disinfection
- ASHRAE EPIDEMIC TASK FORCE (2022)
  "Understanding and Applying ASHRAE Core Recommendations for Mitigating Aerosol Infection Risk"
  https://attendee.gotowebinar.com/recording/4538704157456640268
- ASHRAE TECHNICAL COMMITTEE 9.7
  "Design Guidance for Education Facilities: Prioritization for Advanced Indoor Quality"
  Expected to be released by ASHRAE in Fall 2022

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