DENNIS-YARMOUTH SCHOOLS
HVAC COVID-19
BUILDING VENTILATION ASSESSMENT

PREPARED FOR

Dennis-Yarmouth Regional School District

PREPARED ON:
December 08, 2020

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1. Executive Summary

Preface

This document was prepared in the midst of the Covid-19 pandemic. Much of the country's medical research efforts into the epidemiology of the virus is producing daily results. The opinions expressed in this report are based on the information available at the time of publication. New research, products, and regulations are being released daily. In the ever-changing backdrop of information, readers are advised to avail themselves of the results of current study and research. The latest information can be found at the CDC Website at www.cdc.gov/coronavirus/2019-nCoV.

Recommendations and suggestions from ASHRAE, Mass. Dept. of Ed. and other recognized agencies concerning the ventilation, facility operation or other protocols to mitigate transmission of COVID virus. The requirements are called 'suggested' as it is recognized that the measures taken to increase ventilation or any other measures, are beyond code requirements during the pandemic. Post pandemic operation may revert back to code minimum values. (Ventilation – generally refers to the amount of outdoor air that is being provided to a space as opposed to the total rate of air flow being circulated.)

Procedure

ENE Systems was asked to assess three (3) schools against guidance documents prepared by various authorities. We did so under the outline below:

Classrooms Spaces (no special circumstances): Inspect and assess 100% of ventilating and air circulating equipment. Identify equipment that is inoperable or needing repair. Identify strategies for increasing air dilution if possible.

Gym / Café / Library Spaces (no special circumstances): Inspect and assess 100% of ventilating and air circulating equipment. Identify equipment that is inoperable or needing repair. Identify strategies for increasing air dilution if possible.

Special Spaces (Nurses Office, Holding Areas for potentially Sick Occupants): 100% of these spaces will be inspected and assessed. Extra time will be spent gathering information on the layout, intended use, and current capabilities. It is likely that additional design efforts outside of this report will need to be spent in order to meet the guidance documents.

A calibrated air balancing hood was used to measure the supply air, ventilation (outside) air, and exhaust air values for each occupied space. Other information recorded includes the space volume, number of occupants, and occupancy type, i.e. classroom, office, etc. From this information we can determine whether each space is able to meet the COVID guidelines through existing HVAC means and/or by supplementing with HEPA filtration. The COVID guideline is to provide 150% of the ASHRAE 62.1 ventilation rate. The data can be viewed in its entirety in Appendix 3.

Office Locations: 480 Neponset Street, Canton, MA – 19D Star Drive, Merrimack, NH – 17 Virginia Avenue Providence, RI

Assessment Summary

ENE completed the assessment of the three (3) schools on Thursday November 05, 2020 and immediately began to compile the data and develop this report. We hope to present the Dennis-Yarmouth School District with the information they need so that resources can be focused on making the schools safer to open and lessen the risk of spreading the virus.

ENE Systems assessed 119 (85%) of the 140 occupied building spaces. 39 (33%) of the spaces assessed currently meet the COVID guidelines for increased ventilation (150% of ASHRAE 62.1 Std.) and would not require any further action. It was determined that 90 HEPA filtration units would need to be deployed to bring 116 of the 119 assessed spaces (97%) into compliance with the guidance documents. The remaining 3 spaces are the three COVID Isolation rooms which require additional design considerations discussed later in this report. Office spaces have not been included in the recommended HEPA filter count under the assumption that they will be occupied by only 1 person at any time.

There are 63 spaces (53%) identified that would benefit from having their HVAC equipment repaired or modified to increase the amount of ventilation air. This information was turned over to the ENE Systems Service Team on November 16th, after which they immediately began addressing each item. At the time that this report was prepared, most items had been addressed by the service team. Their work has likely reduced the amount of HEPA filtration units needed, however, the ENE Systems Assessment team will need to return to the schools to verify. The summary information shown in the table below can be viewed in detail in Appendix 3 – Assessment Results.

Date: 12/08/20

School Building	Total Spaces	Spaces with Operable Window for Natural Ventilation	Number of Spaces Assessed	# of Spaces That Currently Meet ASHRAE 62.1 Std	# of Spaces That Currently Meet COVID Guidance 150% of ASHRAE 62.1 Std	# of HEPA Filter Units Required	Total # of Spaces That Currently Meet Guidance or Will Meet Guidance After HEPA Filter is Installed.	# of Spaces That Are Unable to Meet Guidance With a HEPA Filter Installed	# of Spaces That Would Benefit From HVAC Equipment Repairs and/or Modifications	Does the School Have a Glycol Freeze Protection System?	Building Automation System Type
Baker	45	42	30	14	9	21	29	1	16	Steam - N/A	DDC - Pneumatic Hybrid
Wixon	59	53	54	32	21	39	53	1	25	Hydronic - No	DDC - Pneumatic Hybrid
Station Ave	36	33	35	15	9	30	34	1	22	Hydronic - No	DDC - Pneumatic Hybrid
Total Number	140	128	119	61	39	90	116	3	63		
Total Percent	100%	91%	85%	51%	33%		97%	3%	53%		

Notes:
1. If space does not meet COVID Guidelines, no more than one person should occupy the space at any time or it shall be supplemented with natural ventilation via operable window.
2. Results based on reduced hybrid space occupancy as determined by the school district. Results not valid for normal full space occupancy.
3. All offices have been treated as passing COVID Guidelines under the assumption that each will be occupied by only 1 person at any time.
4. The total number of HEPA filter units needed may decrease if repairs and/or modifications described in assessment form are performed.

These assessment results are only valid under a reduced hybrid occupancy. The hybrid occupancy was determined by counting the number of chairs in each space, typically no more than 12 chairs per room. The ventilation requirements increase when the number of occupants increase. For many of the assessed spaces, the existing ventilation equipment would not be able to meet COVID guidelines under normal occupancy, typically 25-30 occupants per classroom. This is because much of the equipment has exceeded the useful life expectancy or was not originally designed to do so. A HVAC capital improvement plan could address these shortcomings and ensure the district is prepared for any future emergencies that require increased ventilation.

It is recommended that the district consider retrofitting glycol freeze protection on the hot water heating systems. Glycol allows hot water piping to operate at lower outside air temperature without freezing, bursting, and leaking. This safety feature will be crucial as the amount of cold winter ventilation air is increased under the new guidance. The Wixon and Station Ave schools both have hydronic systems without glycol protection. The Baker school utilizes a steam system in which glycol would not be applicable.

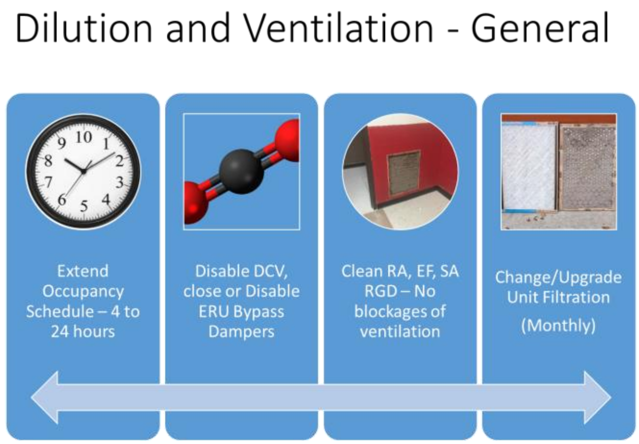
Lastly, a Direct Digital Controls System (DDCS) allows facilities staff to modify mechanical equipment operation using a computer. DDCS saves time compared to a pneumatic system which requires changes to be made physically at the unit. The DDCS also allows equipment operation to be monitored remotely from a computer which can be helpful for troubleshooting and repairing. None of the three assessed schools are equipped with a full DDCS system. Each school has a DDCS head end which controls equipment scheduling only, the remaining controls are pneumatic. The district should consider upgrading to a complete DDC system to improve system robustness and ease of operation as the new COVID guidelines place added demands on the equipment.

2. General Recommendations

The overall goal of this project is to lessen the transmission efficacy of the virus. This can be accomplished in many ways. The most effective way to accomplish this is to dilute contaminated indoor air with clean outside ventilation air. HVAC equipment that does not present a “positive” impact on that effort will be recommended for discontinued use until such time that the pandemic is under control. A “positive” impact in our definition is the unit is either diluting the indoor air to ASHRAE 62.1 required levels or filters the indoor air to a MRV 17/18 (HEPA). Equipment such as split system ACs, Window ACs, Fans and Cabinet Unit Heaters do not provide ventilation air. These types of equipment should not be operated during this time because they can recirculate contaminated air keeping the virus airborne and increase the rate of transmissivity.

Recommendations for District application have been summarized in the Dilution and Ventilation Chart to the right.

Extending Occupancy run times for all ventilating equipment, disabling Demand Control Ventilation (DCV), disabling ERU/ERV bypass dampers, cleaning of registers, heating/cooling coils, grilles, and diffusers, and increasing frequency of changing filters in HVAC equipment.



The issues and recommendations for each assessed space have been identified in Appendix 3 - Assessment Results. The basic recommendations are:

- All HVAC equipment should be operational (Exhaust Fans, Unit Ventilators, Roof Top Units, Energy Recovery Units, Dedicated Outside Air Systems).
- Adjust equipment minimum outside air damper positions to meet COVID ventilation guidelines.
- Consider modifying the heating system to utilize glycol so that issues caused by conditioning increased amounts of cold outside air, i.e. freezing coils, is mitigated.
- Supplement General Areas with HEPA filtration to make up for deficiencies. Supplemental HEPA filtration consists of a standalone unit that is plugged into a 115VAC receptacle outlet.
- Turn off Demand Control Ventilation, and close ERU bypass dampers.
- Clean fixed equipment registers, grilles, and diffusers
- Replace HVAC filters monthly.
- Extend the operational schedule of all equipment 4 -24 hours,
- Refrain from using cooling and heating equipment (Fans, Mini Splits, Window AC, Space Heaters, Cabinet Unit Heaters, Fan Coils units) that does not provide a “positive” impact on reducing the spread of virus and may even contribute to the spread.
- Treat “Special Areas” differently than General or Standard Nurses Areas. Care and design considerations need to be carefully assessed to ensure spread of the virus is limited.

In the event that a space is unable to meet the COVID ventilation guidelines through existing HVAC and/or supplemental HEPA filtration means, box fans may be used in the windows with one blowing into the room and one exhausting out of the room to assist in the implementation of natural ventilation. It was observed that 128 of the 140 total spaces (91%) have operable windows, see Table 1 on page 3.

The natural ventilation/box fan method should only be relied upon as a last resort as it does not provide any means of conditioning the ventilation air and will undoubtedly cause occupant comfort issues. ENE Systems strongly suggests that the COVID guidelines first be met by existing mechanical HVAC system and/or supplemental HEPA filtration means rather than relying on natural ventilation. However, natural ventilation can and should be used whenever outside air conditions allow as this will only further increase the ventilation and space air dilution rates.

Any alteration or operation of an HVAC System requires Companion Mitigation Efforts with the intent to provide a healthy environment for school building occupants through a multitude of methods:

- Avoid or minimize instances where the virus may spread with sanitization protocols.
- Constant vigilance and procedures for detecting signs of infection among the school building occupants.
- Social distancing, contact tracing, minimizing size of gatherings, cohort grouping, surface sanitizing, hand washing, and other protocols are firmly in place and well-practiced.

General Areas

Room by Room recommendations for General Areas will follow the chart developed below. This chart was developed to provide consistent guidance for each space assessed.

Dilution, Ventilation and Filtration - Room by Room

Has 150% OA Design Vent Capability per ASHRAE 62.1

- Goal is to increase dilution of potentially contaminated air. Add a EMS control sequence that allows facility operator to select an enhanced ventilation mode bringing units to 150% of ASHRAE 62.1 150% OA, with the ability to select normal mode if situation allows. Make sure boiler/heat systems can support the increased heat load.

Meets 100% OA Design Capability per ASHRAE 62.1

- Add EMS control sequence to run equipment at maximum OA allowable, supplement space OA with HEPA filtration in the range of 200-300cfm (2 ACH) to make up any deficiency. Operate with window open until supplemental filtration is in place.

Less than OA Design Capability per ASHRAE 62.1

- Attempt to repair unit deficiency to bring to design. Add EMS control sequence to run equipment at maximum OA allowable, supplement space OA with HEPA filtration in the range of 500-1000cfm to make up any deficiency. Operate with window open until supplemental filtration is in place.

Not OA Ventilating per ASHRAE 62.1

- Repair or replace unit, when replacing design for 150% OA per ASHRAE 62.1 and Guidelines. Space occupancy should be kept to 1 person or less until issues are resolved.

Special Areas

Most schools have an area designated as the Nurse's Area. With Covid-19, the Nurses Area becomes critical in the containment of the epidemic. School Administrators need to keep in mind that the Nurse's Office provides essential day to day services above and beyond the need for a "Special Covid-19 Area". Ventilation in these areas needs to be scrutinized and reviewed for proper flow and isolation.

Converting a Nurses Area into a Special Covid-19 Area compliant with ASHRAE 170 – Ventilation of Healthcare Facilities standards will present several obstacles. The Chart below is similar to the one constructed for the General Areas, however, achieving the first level of evaluation is highly unlikely given that the Nurses Area and School was not originally designed to be used as a Special Area under ASHRAE 170.

Ventilation – Special Spaces – Isolation Mode

Modify Existing Spaces to Meet ASHRAE 170 & Guidance – Isolation Mode

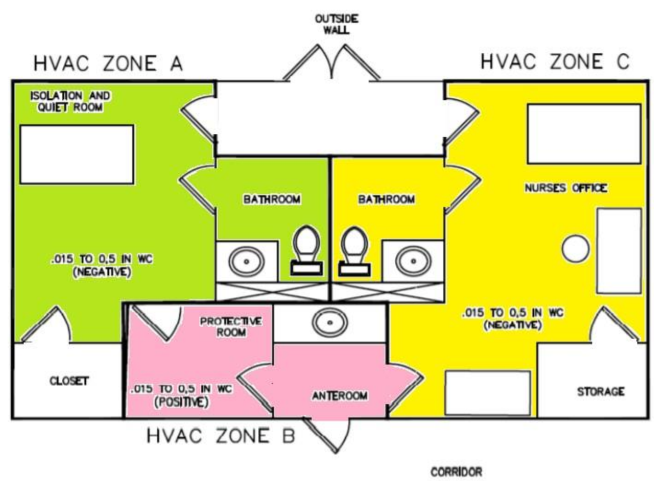
- It is highly unlikely that K-12 Nurses Area / Health Office have been constructed with the ability to meet the requirements of ASHRAE 170 - Isolation Mode, without modifications.
- 3 distinct spaces each with dedicated ventilation is required. #1 Isolation Room (negative pressure), #2 Ante Room / protective room (positive pressure), and #3 Nurses Room (negative pressure)
- Isolation mode ventilation requirements design for 10 ACH operate at 6 ACH.
- 100% OA required
- 2 Filtration banks Merv 7 and HEPA
- System must run 2 hours before and 2 hours after occupancy

Add Temporary Facilities (trailer) to Meet ASHRAE 170 & Guidance – Isolation Mode

- Requirements are the same as above.

When Making Changes to the Existing HVAC System

- Design and program system and controls to work on 2 modes – Normal and Isolation Mode



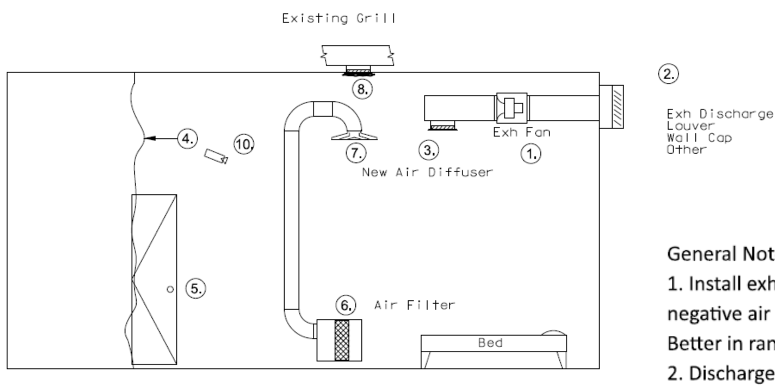
Note: Systems A, B, and C are the <u>Dedicated</u> "Isolation Mode "systems, each system is individually operated and controlled. The Supplementary HVAC systems for "Normal mode" are not shown.

There is some contradiction in recommendations for operating a special space, the Standard sets the ventilation rate at 12 <u>A</u>ir <u>C</u>hanges per <u>H</u>our, (ACH) the guidance document sets the design at 10 ACH and operation at 6 ACH. The standard further describes an ante room for dressing and gowning prior to entering the room. The AII room is also required to be air balanced negatively, by exhaust, with respect to adjoining room. The exhaust from AII rooms is to be expelled to the outside and not recirculated.

Separate from the ASHRAE 170 standards, ASHRAE has recently reaffirmed and re-released a 'Position Document on Airborne Infectious Diseases'. In the document, ASHRAE reaffirms the basic principles in controlling the spread of infectious diseases, namely:

- Filtration, providing clean air to the environment,
- Dilution with the introduction of increased airflow and,
- Containment through exhaust and airflow cleaning air within the room.

Dennis-Yarmouth Schools would not be housing potentially infected individuals for long periods of time and therefor designing and building of an ASHRAE 170 compliant facility for the opening of schools is not practical. For the use and purpose of Dennis-Yarmouth Schools, it is recommended that a separate, temporary, isolation room or rooms be created to isolate students exhibiting symptoms during the school day until a parent or guardian can take them home. Below is a schematic of how this would be accomplished. The goal is to place a potentially infected individual in a safe location "isolated" from the rest of the building occupants. Using remote monitoring the individual can be watched until such a time they can be discharged from the building.



General Notes:

1. Install exhaust fan from isolation room. Fan shall be sized to provide negative air flow into isolation room from adjoining spaces. Min. 150 CFM Better in range of 250-200 CFM.
2. Discharge air to be located 10 ft. away from building openings and above grade.
3. Locate generally over seating or bed area.
4. (optional) Temporary air curtain to create ante room for gowning and PPE. Access to hand wash sink recommended.
5. (optional) Door from ante room to isolation area
6. Portable HEPA fan filter negative air machine is required if existing HVAC ventilation systems cannot provide sufficient air to provide 10 ACH e.g. 250 SF room need about 330 CFM
7. Provide air diffuser or register to minimize air turbulence and currents within isolation space. Neck velocity shall be 500 -750 fpm range, throw values shall be near 10 ft. max.
8. Seal all registers that return or recirculate air back to air handlers or other recirculating equipment.
9. Verify air flow is moving inward from adjacent spaces into the isolation room.
10. Monitoring

3. Building Narratives & Findings

In the following section we have provided a narrative of our findings in summary form. Greater level of detail and measurements taken can be found in Appendix 3 – School / Room Data Collection Log of this document.

Baker Elementary School
The Baker Elementary School is a two story brick masonry building with approximately 60,000 sq.ft. of classroom, office, nurse, cafeteria, gym, library, and kitchen space.

General Areas:
Floor mounted and ceiling hung Unit Ventilators (UV) serve the classroom spaces in the center and east wings as well as the cafeteria. The UVs have MERV 8 filters and operate to maintain the space temperature set point by modulating the steam valve and face/bypass damper. The mixed air damper opens to a predetermined minimum outside air position during the occupied mode.

The classroom and library spaces in the west wing are served by two Energy Recovery Ventilator Units (ERV). The ERVs have plate and frame heat exchangers and provide ventilation. There are duct mounted steam coils that preheat the supply air. Split system heat pump units in each of the spaces provide additional heating and cooling.

The administrative office area in the center wing does not have any mechanical ventilation. Each space is served by fin tube radiation heat. The area does have operable windows that may be used for natural ventilation.

Two Heating & Ventilating (H&V) Units serve the gym. One of the units was operational while the other was not. The H&V Units have manual hand dampers that modulate the amount of outside air brought in through the unit. The outside air damper position was observed at 10% open.

The school exhaust system is part natural draft ventilation and part mechanical rooftop exhaust fans. A central natural gas fired steam plant serves the HVAC heating needs of the building. The HVAC equipment throughout the building is from several vintages. Most of the Unit Ventilators are 50+ years old and having exceeded its useful life. The gym H&V unit is 4 years old, and the ERV units are almost new. All the equipment in the school is pneumatically controlled with local thermostats in each of the spaces.

Several ventilation related issues were observed during the building assessment. These issues and their suggested solutions have been summarized below. For a complete detailed list of all issues, please see the Assessment Form in Appendix 3.

- Low airflow was measured from ERV-1. Filters and heat exchanger did not appear to be excessively blocked. Suggested that the system be rebalanced.
- Several Unit Ventilators are not meeting the recommended 150% of design ventilation as determined by ASHRAE 62.1 – 2015. It is suggested that the units' minimum outside air damper position be adjusted to meet the recommended 150% value. A 40% outside air position should be sufficient for most units. If the unit is not capable of meeting the recommended ventilation rate, standalone HEPA air filtration should be used to make up the remaining ventilation needed.
- Many of the Unit Ventilators have low supply airflows. Verify that all fans speeds are on the High setting. They are also older units which have accumulated dirt and debris over their life. These units could be cleaned and made sure that the filters are new to reduce airflow restriction.
- Several exhaust fans were found not operating. This equipment should be repaired back to full operation.
- The Administrative Offices do not have any source of mechanical ventilation. These spaces should not be occupied by more than one person at any time unless natural ventilation is utilized.
- Split System units were observed throughout the building. These units should not be used as they will keep the virus airborne without providing any positive dilution or filtration.

- One of the Cafeteria Unit Ventilators as well as the Kitchen Unit Ventilator are not operational. This equipment should be repaired back to full operation.
- One of the gym H&V Units is not operational and should be repaired back to full operation. Additionally, the lack of controlled duct dampers allows cold air to enter the unit during unoccupied hours. This could cause potential freezing issues and is also not energy efficient. It is suggested that control actuators are installed on the mixed air dampers.
- Some exhaust grills were observed to be covered with sheet metal. These grills should be uncovered and the equipment serving it returned to operation.

Special Areas:

The Nurse's area consists of an entry vestibule, exam room, and rest room. Each space is separated by doors, however only the entry vestibule is connected to the hallway. No mechanical ventilation is present in these spaces, but there are operable windows in the exam room. In the event that an occupant who is exhibiting COVID symptoms is brought to this area, it does not appear that the virus will be properly contained and prevented from spreading to other parts of the building due to the following:

- The Nurse's space does not have any mechanical ventilation to dilute the space with fresh air.
- There is no dedicated exhaust serving the COVID isolation room. Without this, contaminated air could migrate to other healthy portions of the building.

It is suggested that the special area recommendations as stated in Section 2 be followed to mitigate the spread of the virus from the special areas to other parts of the building. Further design considerations will need to be made to ensure proper implementation of these recommendations for this building.

It is also suggested that the COVID Isolation area be separate from the day to day Nurse operations to reduce risk of exposure. It appears that the single room serves both purposes currently.

Figure 1: ERV-2 heat exchanger

Wixon Innovation School
The Wixon Innovation School is a single story brick masonry building with approximately 130,000 sq.ft. of classroom, office, nurse, cafeteria, gym, library, auditorium, and kitchen space.

General Areas:
Floor and ceiling mounted Unit Ventilators (UV) serve the classroom spaces as well as the cafeteria, kitchen, and library. The UVs have MERV 8 filters and operate to maintain the space temperature set point by modulating the hot water valve and face/bypass damper. The mixed air damper opens to a predetermined minimum outside air position during the occupied mode.

The administrative office area does not have any mechanical ventilation. Each space is served by fin tube radiation heat. The area does have operable windows that may be used for natural ventilation.

Two Heating & Ventilating (H&V) Units serve the gym on the first floor. Two Ceiling Mounted Unit Ventilators (UV) serves the gym on the lower level.

The classrooms are served by a combination of floor mounted and rooftop mounted exhaust fans. A central natural gas fired hot water plant serves the HVAC heating needs of the building. The HVAC equipment throughout the building is from several vintages. Most of the Unit Ventilators are 50+ years old and having exceeded its useful life. The gym H&V unit appears to be approximately 15 years old. All the equipment in the school is pneumatically controlled with local thermostats in each of the spaces.

Several ventilation related issues were observed during the building assessment. These issues and their suggested solutions have been summarized below. For a complete detailed list of all issues, please see the Assessment Form in Appendix 3.

- Several Unit Ventilators are not meeting the recommended 150% of design ventilation as determined by ASHRAE 62.1 – 2015. It is suggested that the units' minimum outside air damper position be adjusted to meet the recommended 150% value. A 40% outside air position should be sufficient for most units. If the unit is not capable of meeting the recommended ventilation rate, standalone HEPA air filtration should be used to make up the remaining ventilation needed.
- A few Unit Ventilators have low supply airflows. Verify that all fans speeds are on the High setting. They are also older units which have accumulated dirt and debris over their life. These units could be cleaned and made sure that the filters are new to reduce airflow restriction.
- Several exhaust fans were found not operating. This equipment should be repaired back to full operation.
- The Administrative Offices do not have any source of mechanical ventilation. These spaces should not be occupied by more than one person at any time unless natural ventilation is utilized.
- Split System units were observed throughout the building. These units should not be used as they will keep the virus airborne without providing any positive dilution or filtration.
- Three of the five Cafeteria Unit Ventilators and both Kitchen Unit Ventilators are not operational. This equipment should be repaired back to full operation.
- The spaces on each side of the auditorium stage, room 222 & 223, are being used as classrooms. Neither of these spaces have any means of mechanical ventilation or natural ventilation. It is suggested that these rooms are not occupied by more than one person at anytime until they can be upgraded with mechanical ventilation.
- The hot water system is not equipped with glycol freeze protection. The school should consider adding this safety feature to protect against the increased ventilation requirements.

<u>Special Areas:</u>
There is a Nurse’s area, room 264, which handles the day to day normal operations. This space consists of a single exam room and two rest rooms. This room is served by a Unit Ventilator and rooftop exhaust, it also has operable windows for natural ventilation. No issues were observed in this space for the purposes it serves.

There is a second Nurse’s space which is used as a COVID isolation area. This space consists of an entry vestibule, Nurse’s Office, rest room, and isolation room. Each space is separated by doors and only the entry vestibule is connected to the hallway. There is a unit ventilator and rooftop exhaust fan that serves the space, however, neither was observed operational. There are operable windows in the office room. In the event that an occupant who is exhibiting COVID symptoms is brought to this area, it does not appear that the virus will be properly contained and prevented from spreading to other parts of the building due to the following:

- The mechanical ventilation is not operational and will not dilute the space with fresh air.
- The exhaust in this space is not operational. Without this, contaminated air could migrate to other healthy portions of the building.

It is suggested that the special area recommendations as stated in Section 2 be followed to mitigate the spread of the virus from the special areas to other parts of the building. Further design considerations will need to be made to ensure proper implementation of these recommendations for this building.

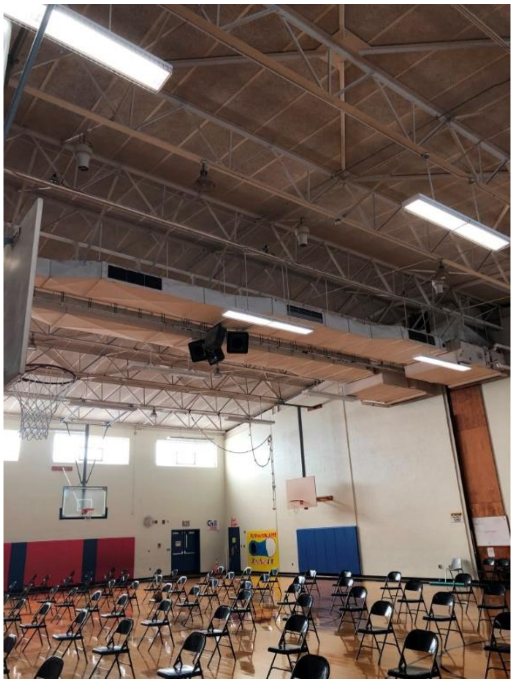


Figure 2: First Floor Gym Unit

Station Avenue Elementary School
The Station Avenue Elementary School is a single story brick masonry building with approximately 60,000 sq.ft. of classroom, office, nurse, cafeterorium, gym, library, and kitchen space.

General Areas:
Floor mounted and ceiling hung Unit Ventilators (UV) serve the classroom, principal's office, and library spaces. The UVs have MERV 8 filters and operate to maintain the space temperature set point by modulating the hot water and face/bypass damper. The mixed air damper opens to a predetermined minimum outside air position during the occupied mode.

The reception area as well as, office 219, and 220 do not have any mechanical ventilation. The space is served by fin tube radiation heat. The area does have operable windows that may be used for natural ventilation.

Two Heating & Ventilating (H&V) Units serve the gym. Another H&V Unit serves the cafeteria which is currently being used as a classroom.

The classrooms are served by rooftop mounted exhaust fans. A central natural gas fired hot water plant serves the HVAC heating needs of the building. The HVAC equipment throughout the building is in good condition and is of newer vintage. All the equipment in the school is pneumatically controlled with local thermostats in each of the spaces.

Several ventilation related issues were observed during the building assessment. These issues and their suggested solutions have been summarized below. For a complete detailed list of all issues, please see the Assessment Form in Appendix 3.

- Several Unit Ventilators are not meeting the recommended 150% of design ventilation as determined by ASHRAE 62.1 – 2015. It is suggested that the units' minimum outside air damper position be adjusted to meet the recommended 150% value. A 40% outside air position should be sufficient for most units. If the unit is not capable of meeting the recommended ventilation rate, standalone HEPA air filtration should be used to make up the remaining ventilation needed.
- Some Unit Ventilators have low supply airflows. Verify that all fans speeds are on the High setting. These units could be cleaned and made sure that the filters are new to reduce airflow restriction.
- Several exhaust fans were found not operating. This equipment should be repaired back to full operation.
- The reception and offices 219 & 220 do not have any source of mechanical ventilation. These spaces should not be occupied by more than one person at any time unless natural ventilation is utilized.
- Split System units were observed throughout the building. These units should not be used as they will keep the virus airborne without providing any positive dilution or filtration.
- Classroom 208 Unit Ventilator and the Cafeteria H&V Unit are not operational. This equipment should be repaired back to full operation.
- The hot water system is not equipped with glycol freeze protection. The school should consider adding this safety feature to protect against the increased ventilation requirements.

Special Areas:
The Nurse's area consists of an entry vestibule, day to day operations room, Nurse Office, COVID Isolation Room, and a rest room. Each space is separated by doors, however only the entry vestibule and day to day operations rooms are connected to the hallway. Facilities staff informed ENE Systems that a ceiling hung unit ventilator used to serve these spaces but has been abandoned in place some years back and replaced with a split system unit. The ceiling hung unit also used to serve conference room 321. There are operable windows in the exterior facing Nurse office and COVID Isolation Room. In the event that an occupant who is exhibiting COVID symptoms is brought to this area, it does not appear that the virus will be properly contained and prevented from spreading to other parts of the building due to the following:

- The Nurse's space does not have any mechanical ventilation to dilute the space with fresh air.
- There is no dedicated exhaust serving the COVID isolation room. Without this, contaminated air could migrate to other healthy portions of the building.

It is suggested that the special area recommendations as stated in Section 2 be followed to mitigate the spread of the virus from the special areas to other parts of the building. Further design considerations will need to be made to ensure proper implementation of these recommendations for this building.

Office Locations: 480 Neponset Street, Canton, MA – 19D Star Drive, Merrimack, NH – 17 Virginia Avenue Providence, RI

Appendix 1 – Terms & Definitions

- ACH – Air changes per Hour
- AII – Airborne Isolation Infection Room
- Ante Room - defined as a small room between areas of contamination and treatment areas.
- CFM – Cubic Feet Per Minute – measure of air flow
- OA – Outside Air
- DAT – Discharge Air Temperature
- MAT - Mixed Air Temperature
- DOAS – Dedicated Outside Air System
- UV – Unit Ventilator
- EF – Exhaust Fan
- VFD – Variable Frequency Drive – controls speed of motors
- ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality
- AHSRAE 170 – Ventilation for Healthcare Facilities
- ICC/IMC – International Commercial Code / International Mechanical Code 2009(NH), 2015(MA/RI)
- NAFA – National Air Filtration Association

Appendix 2 – ASHRAE Position Document on Airborne Infectious Diseases

ASHRAE Position Document on Airborne Infectious Diseases

Approved by ASHRAE Board of Directors
January 19, 2014

Reaffirmed by Technology Council
February 5, 2020

Expires August 5, 2020

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COMMITTEE ROSTER

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Note: ASHRAE's Technology Council and the cognizant committee recommend revision, reaffirmation, or withdrawal every 30 months.

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.

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ABSTRACT

Infectious diseases spread by several different routes. Tuberculosis and in some cases influenza, the common cold, and other diseases spread by the airborne route. The spread can be accelerated or controlled by heating, ventilating, and air-conditioning (HVAC) systems, for which ASHRAE is the global leader and foremost source of technical and educational information.

ASHRAE will continue to support research that advances the state of knowledge in the specific techniques that control airborne infectious disease transmission through HVAC systems, including ventilation rates, airflow regimes, filtration, and ultraviolet germicidal irradiation (UVGI).

ASHRAE's position is that facilities of all types should follow, as a minimum, the latest practice standards and guidelines. ASHRAE's 62.X Standards cover ventilation in many facility types, and Standard 170 covers ventilation in health-care facilities. New and existing health-care intake and waiting areas, crowded shelters, and similar facilities should go beyond the minimum requirements of these documents, using techniques covered in ASHRAE's *Indoor Air Quality Guide* (2009) to be even better prepared to control airborne infectious disease (including a future pandemic caused by a new infectious agent).

EXECUTIVE SUMMARY

This position document (PD) has been written to provide the membership of ASHRAE and other interested persons with information on the following:

- the health consequences and modes of transmission of infectious disease
- the implications for the design, installation, and operation of heating, ventilating, and air-conditioning (HVAC) systems
- the means to support facility management and planning for everyday operation and for emergencies

There are various methods of infectious disease transmission, including contact (both direct and indirect), transmission by large droplets, and inhalation of airborne particles containing infectious microorganisms. The practice of the HVAC professional in reducing disease transmission is focused primarily on those diseases transmitted by airborne particles.

1. THE ISSUE

The potential for airborne transmission of disease is widely recognized, although there remains uncertainty concerning which diseases are spread primarily via which route, whether it be airborne, short range droplets, direct or indirect contact, or multimodal (a combination of mechanisms).

Ventilation and airflow are effective for controlling transmission of only certain diseases. Several ventilation and airflow strategies are effective and available for implementation in buildings.

Although this PD is primarily applicable to diseases that spread from person to person, the principles also apply to infection from environmental reservoirs such as building water systems with *Legionella* spp. and organic matter with spores from mold (to the extent that the microorganisms spread by the airborne route).[1] The first step in control of such a disease is to eliminate the source before it becomes airborne.

2. BACKGROUND

2.1 Introduction to Infectious Disease Transmission

This position document covers the spread of infectious disease from an infected individual to a susceptible person, known as *cross transmission* or *person-to-person transmission*, by small airborne particles (an aerosol) that contain microorganisms.

This PD does not cover direct or indirect contact routes of exposure. Direct contact means any surface contact such as touching, kissing, sexual contact, contact with oral secretions or skin lesions, or additional routes such as blood transfusions or intravenous injections. Indirect contact involves contact with an intermediate inanimate surface (fomite), such as a doorknob or bedrail that is contaminated.

Exposure through the air occurs through (1) droplets, which are released and fall to surfaces about 1 m (3 ft) from the infected and (2) small particles, which stay airborne for hours at a time and can be transported long distances. The aerobiology of transmission of droplets and small particles produced by a patient with acute infection is illustrated in Figure 1.

Because large droplets are heavy and settle under the influence of gravity quickly, general dilution, pressure differentials, and exhaust ventilation do not significantly influence droplet concentrations, velocity, or direction, unless they reduce diameter by evaporation, thus becoming an aerosol. The term *droplet nuclei* has been used to describe desiccation of large droplets into small airborne particles (Siegel et al. 2007).

Of the modes of transmission, this PD's scope is limited to aerosols, which can travel longer distances through the airborne route, including by HVAC systems. The terms *airborne*, *aerosol*, and *droplet nuclei* are used throughout this PD to refer to this route. HVAC systems are not known to entrain the larger particles.

The size demarcation between droplets and small particles has been described as having a mass median aerodynamic diameter (MMAD) of 2.5 to10 µm (Shaman and Kohn 2009; Duguid 1946; Mandell 2010). Even particles with diameters of 30 µm or greater can remain suspended in the air (Cole and Cook 1998). Work by Xie and colleagues (2007) indicates that large droplets are those of diameter between 50 and 100 µm at the original time of release. Tang and others (2006) proposed a scheme of large-droplet diameter ≥60 µm,

[1] For ASHRAE's position concerning *Legionella*, see ASHRAE (2012a). Readers are referred to other resources that address mitigation of transmission of this waterborne pathogen (ASHRAE 2000; CDC 2003; the forthcoming ASHRAE Standard 188; OSHA 1999; SA Health 2013, and WHO 2007). For ASHRAE's position concerning mold and moisture, see ASHRAE (2013d).

small droplet diameter < 60 μm, and droplet nuclei with a MMAD of <10 μm. The exact size demarcation is less important than knowing that large droplets and small particles behave differently and that the latter can remain airborne.

Small particles that can become airborne are typically generated by coughing, sneezing, shouting, and to a lesser extent by singing and talking. Even breathing may generate such particles in sick and highly infectious individuals (Bischoff 2013). Particle size distributions of coughed materials are thought to encompass a broad range of diameters, from very small to large droplets, depending on differences in patients and diseases (Riley and Nardell 1989).

Fennelly et al. (2004) measured cough aerosol emanating directly from tuberculosis patients. The patients generated infectious aerosol that contained from three to four colony-forming units (CFU, a direct measure, using culturing techniques, of the number of viable, growing, and infectious organisms) to a maximum of 633 CFU. The size distributions that were measured in this study suggest that most of the viable particles in the cough-generated aerosols were immediately respirable, ranging from 0.65 to 3.3 μm. Wainwright et al. (2009) also measured cough aerosols from cystic fibrosis patients and documented that 70% of viable cough aerosols containing *Pseudomonas aeruginosa* and other Gram-negative bacteria were of particles ≤ 3.3 μm. Positive room air samples were associated with high total counts in cough aerosols.

There are not, however, enough data to fully describe or predict cough particle size distributions[2] for many diseases, and research is needed to better characterize them (Xie et al. 2009).

In the 1950s, the relationship among particle size, airborne suspension, and transmission implications began to become clear. The different routes require different control strategies, which have evolved over many years of infectious disease practice, and there are now standards of practice for infectious disease and hospital epidemiology. See the Professional Practice documents available from the Association for Professionals in Infection Control and Epidemiology at www.apic.org.

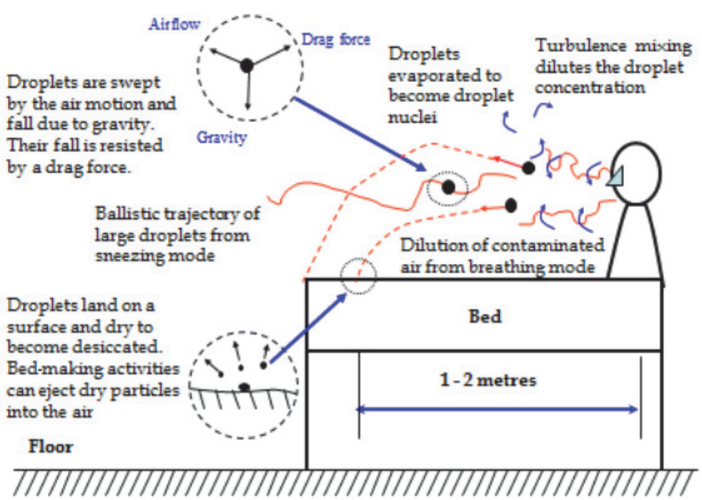

Figure 1 Droplet suspension: illustration of the aerobiology of droplets and small airborne particles produced by an infected patient.

[2] Cough particle size distributions are likely to vary based on the infected person's viscosity of secretions, anatomical structures in the oropharynx (roughly meaning throat) and airways, and disease characteristics.

Many diseases have been found to have higher transmission rates when susceptible individuals approach within close proximity, about 1 to 2 m (3 to 7 ft).[3] Over this short range, the susceptible person has a substantially greater exposure from the infected individual to droplets of varying size, both inspirable large droplets and airborne particles (e.g., see Figure 1). Nicas and Jones (2009) have argued that close contact permits droplet spray exposure and maximizes inhalation exposure to small particles and inspirable droplets. Thus, particles/droplets of varying sizes may contribute to transmission at close proximity (Li 2011).

To prevent this type of short-range exposure, whether droplet or airborne, maintaining a 2 m (7 ft) distance between infected and susceptible is considered protective, and methods such as ventilation dilution are not effective.

2.2 Mathematical Model of Airborne Infection

Riley and Nardell (1989) present a standard model of airborne infection usually referred to as the *Wells-Riley equation*, given below as Equation 1. Like all mathematical models, it has its limitations, yet it is useful for understanding the relationship among the variables such as the number of new infections (C), number of susceptibles (S), number of infectors (I), number of doses of airborne infection (q) added to the air per unit time by a case in the infectious stage, pulmonary ventilation per susceptible (p) in volume per unit time, exposure time (t), and volume flow rate of fresh or disinfected air into which the quanta are distributed (Q).

$$C = S(1 - e^{-Iqpt/Q}) \tag{1}$$

The exponent represents the degree of exposure to infection and $1 - e^{-Iqpt/Q}$ is the probability of a single susceptible being infected. Note that this model does not account for varying susceptibility among noninfected individuals. For this and other reasons, exposure does not necessarily lead to infection.[4] The parameter q is derived from the term *quantum*, which Wells (1995) used to indicate an infectious dose, whether it contains a single organism or several organisms. The ability to estimate q is difficult at best and has been reported in the literature to be 1.25 to 249 quanta per hour (qph) in tuberculosis patients (Riley et al. 1962; Catanzaro 1982) and 5480 qph for measles (Riley et al. 1978).

Because of the uncertainty in knowing q, Equation 1 is most useful for understanding the general relationships among the variables, for instance, the impact of increasing the volume of fresh or disinfected air on airborne infection. Increasing Q decreases exposure by diluting air containing infectious particles with infectious-particle-free air. Q can also be impacted through the use of other engineering control technologies, including filtration and UVGI, as discussed in Section 3.2. Therefore, a more complete representation of Q should include the total removal rate by ventilation, filtration, deposition, agglomeration, natural deactivation, and other forms of engineered deactivation.

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[3] Infectious pneumonias, like pneumococcal disease (Hoge et al. 1994) or plague (CDC 2001) are thought to be transmitted in this way.

[4] This applies differently to various microorganisms, whether they be fungal, bacterial, or viral. After exposure, the microorganism must reach the target in the body (e.g., lung or mucosa) to cause infection. Some infective particles must deposit on mucosa to result in infection, and if they instead deposit on the skin, infection may not result. Another important element that influences a person's risk of infection is his or her underlying immunity against select microorganisms and immune status in general. For example, individuals with prior *M. Tuberculosis* infection who have developed immunity are able to ward off the infection and a person who had chicken pox as a child or received chicken pox vaccine is not susceptible even if living in the same household as an individual with acute chicken pox. On the other hand, individuals infected with human immunodeficiency virus (HIV) are more susceptible to becoming infected, for instance, with tuberculosis.

2.3 For Which Diseases is the Airborne Transmission Route Important?

Roy and Milton (2004) describe a classification scheme of aerosol transmission of diseases as obligate, preferential, or opportunistic[5] on the basis of the agent's capacity to be transmitted and to induce disease. Under this classification scheme, tuberculosis may be the only communicable disease with obligate airborne transmission—an infection that is initiated only through aerosols. For *Mycobacterium tuberculosis*, the aerodynamic diameters of the airborne particles are approximately 1 to 5 µm.

Agents with preferential airborne transmission can naturally initiate infection through multiple routes but are predominantly transmitted by aerosols. These include measles and chicken pox.

There are probably many diseases with opportunistic airborne transmission—infections that naturally cause disease through other routes such as the gastrointestinal tract but that can also use fine-particle aerosols as an efficient means of propagating in favorable environments. The relative importance of the transmission modes for many of these diseases remains a subject of uncertainty (Shaman and Kohn 2009; Roy and Milton 2004; Li 2011).

The common cold (rhinoviruses) and influenza can both be transmitted by direct contact or fomites; there is also evidence of influenza and rhinovirus transmission via large droplets and the airborne route (D'Alesssio et al. 1984; Wong et al. 2010; Bischoff et al. 2013).

Work by Dick and colleagues (1967, 1987) suggests that the common cold may be transmitted through the airborne droplet nuclei route. Experimental studies (Dick et al. 1987) document the possibility of transmission beyond 1 m (3 ft) under controlled conditions in experimental chambers and strongly suggest airborne transmission as at least one component of rhinoviral infection. A recent field study (Myatt et al. 2004) supports this result and documents its likely importance in a field investigation.

Other literature acknowledges the potential importance of the airborne routes while suggesting that droplet transmission is far more important, at least for common viral diseases such as the common cold (Gwaltney and Hendley 1978).

Control of seasonal influenza has for decades relied on large-droplet precautions even though there is evidence suggesting a far greater importance for airborne transmission by small particles. For instance, a 1959 study of influenza prevention in a Veterans Administration nursing home identified an 80% reduction in influenza in staff and patients through the use of upper-room ultraviolet germicidal irradiation (UVGI) (McLean 1961). This suggests that air currents to the higher-room areas where the UVGI was present carried the airborne infectious particles, and they were inactivated. The inactivated (noninfectious) particles were therefore unable to infect staff and patients in control areas with UVGI, as compared to areas without UVGI.

Influenza transmission occurred from one index case to 72% of the 54 passengers aboard an airliner on the ground in Alaska while the ventilation system was turned off (Moser et al. 1979). This outbreak was widely thought to represent a second piece of evidence for airborne transmission, and it was also thought that the high attack rate was due in part to the ventilation system not being in operation (Moser 1979). A review by Tellier (2006) acknowledges the importance of these papers and suggests including consideration of airborne transmission in pandemic influenza planning. However, one systematic review by Brankston et al. (2007) concluded that the airborne transmission route was not important in the same outbreak.

[5] This use of the word *opportunistic* differs from the medical term of art, *opportunistic infection*, which refers to an infection caused by a microorganism that normally does not cause disease but becomes pathogenic when the body's immune system is impaired and unable to fight off infection.

A 1986 outbreak from the H1N1 influenza virus among U.S. Navy personnel was attributed to their having flown on the same airplanes. Many of the infected susceptibles were displaced considerably more than 2 m (7 ft) from the infected individuals (Klontz et al. 1989). This suggests the airborne route of transmission.

A 2009 outbreak of influenza A pandemic (H1N1) developed from a single index case patient in nine tour group members (30%) who had talked with the index case patient and in one airline passenger (not a tour group member) who had sat within two rows of her. None of the 14 tour group members who had not talked with the index case patient became ill. The authors therefore concluded that this outbreak was caused by droplet transmission and that airborne transmission was not a factor (Han et al. 2009).

Chu et al. (2005) documented that airborne transmission of severe acute respiratory syndrome (SARS, a severe form of pneumonia caused by a member of the coronavirus family of viruses—the same family that can cause the common cold) could occur. In one dramatic outbreak of SARS in the Amoy Gardens high-rise apartment, airborne transmission through droplet nuclei seemed to represent the primary mode of disease spread. This was likely due to a dried-out floor drain and airborne dissemination by the toilet exhaust fan and winds (Yu et al. 2004; Li et al. 2005a, 2005b). The observed pattern of disease spread from one building to another, and particularly on the upwind side of one building, could not be explained satisfactorily other than by the airborne route.

A study of Chinese student dormitories provides support for the theory of the airborne spread of the common cold (Sun et al. 2011). Ventilation rates were calculated from measured carbon-dioxide concentration in 238 dorm rooms in 13 buildings. A dose-response relationship was found between outdoor air flow rate per person in dorm rooms and the proportion of occupants with annual common cold infections ≥ 6 times. A mean ventilation rate of 5 L/(s·person) (10 cfm/[s·person]) in dorm buildings was associated with 5% of self-reported common cold ≥ 6 times, compared to 35% at 1 L/(s·person) (2 cfm /[s·person]).

A literature review by Wat (2004) tabulates the mode of transmission and seasonality of six respiratory viruses, indicating that rhinovirus, influenza, adenovirus, and possibly coronavirus are spread by the airborne route.

The reader of this document should keep an open mind about the relative importance of the various modes of transmission due to the uncertainty that remains (Shaman and Kohn 2009) as illustrated by the studies described above. Disease transmission is complex, and one-dimensional strategies are not suitable for universal application.

3. PRACTICAL IMPLICATIONS FOR BUILDING OWNERS, OPERATORS, AND ENGINEERS

Small particles may be transported through ventilation systems, as has been documented for tuberculosis, Q-fever, and measles (Li et al. 2007). Therefore, when outbreaks occur in the workplace, transmission through HVAC systems must be considered. As disease transmission by direct contact, fomite, and large-droplet routes is reduced by more efficient prevention strategies, the airborne route is likely to become relatively more important.

If influenza transmission occurs not only through direct contact or large droplets, as is the long-standing public health tradition, but also through the airborne route, as newer data suggest, HVAC systems may contribute far more both to transmission of disease and, potentially, to reduction of transmission risk.

There are practical limits to what HVAC systems can accomplish in preventing transmission of infections in large populations. In some cases, infections are transmitted in the absence of HVAC systems.

Owners, operators, and engineers are encouraged to collaborate with infection prevention specialists knowledgeable about transmission of infection in the community and the workplace and about strategies for prevention and risk mitigation.

3.1 Varying Approaches for Facility Type

Health-care facilities have criteria for ventilation design to mitigate airborne transmission of infectious disease (FGI 2010; ASHRAE 2008). Yet most infections are transmitted in ordinary occupancies in the community and not in industrial or health-care occupancies.

ASHRAE does not provide specific *requirements* for infectious disease control in schools, prisons, shelters, transportation, and other public facilities other than the general ventilation and air quality requirements of Standards 62.1 and 62.2 (ASHRAE 2013b, 2013c). However, the *guidance* in this PD does apply to these facilities.

In health-care facilities, many common interventions to prevent infections aim to reduce transmission by direct or indirect contact (for example, directly via the hands of health-care personnel). Interventions also aim to prevent airborne transmission (Aliabadi et al. 2011).

Because of the difficulties in separating out the relative importance of transmission modes, recent work in health-care facilities has focused on “infection control bundles” (i.e., use of multiple modalities simultaneously) (Apisarnthanarak et al. 2009, et al. 2010a, et al. 2010b; Cheng et al. 2010). For two prototype diseases, tuberculosis and influenza, this bundle includes administrative and environmental controls and personal protective equipment in health-care settings. Given the current state of knowledge, this represents a practical solution.

For studies and other publications with specific guidance on air quality and energy in biomedical laboratories, animal research facilities, and health-care facilities, see the National Institutes of Health (NIH) Office of Research Facilities’ website (http://orf.od.nih.gov/PoliciesAndGuidelines/Bioenvironmental).

A prerequisite to all of the strategies is a well-designed, installed, commissioned, and maintained HVAC system (Memarzadeh et al. 2010; NIOSH 2009a).

In considering going beyond requirements that include codes, standards, and practice guidelines, use guidance from published sources such as “Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Settings” (CDC 2005), *Guidelines for Design and Construction of Health Care Facilities* (FGI 2010), *Indoor Air Quality Guide: Best Practices for Design, Construction and Commissioning* (ASHRAE 2009), apic.org, and Table 1 in the Recommendations section, and discuss risk with the facility user. HVAC system designers can assist closely allied professionals such as architects and plumbing engineers to understand how sources of unplanned airflow can impact airborne infectious disease transmission. Examples include wastewater drains (especially if improperly trapped) and wall and door leakage (including the pumping action of swinging doors).

3.2 Ventilation and Air-Cleaning Strategies

Because small particles remain airborne for some period of time, the design and operation of HVAC systems that move air can affect disease transmission in several ways, such as by the following:

- supplying clean air to susceptible occupants
- containing contaminated air and/or exhausting it to the outdoors
- diluting the air in a space with cleaner air from outdoors and/or by filtering the air
- cleaning the air within the room

The following strategies are of interest: dilution ventilation, laminar and other in-room flow regimes, differential room pressurization, personalized ventilation, source capture ventilation, filtration (central or unitary), and UVGI (upper room, in-room, and in the airstream).

ANSI/ASHRAE/ASHE Standard 170-2008, *Ventilation of Health-Care Facilities*, covers specific mandatory HVAC requirements including ventilation rates, filtration, and pressure relationships among rooms (ASHRAE 2008). The *Guidelines for Design and Construction of Health Care Facilities* (FGI 2010) include the Standard 170 requirements and describe other criteria that can guide designers of these facilities.

Ventilation represents a primary infectious disease control strategy through dilution of room air around a source and removal of infectious agents (CDC 2005). Directed supply and/or exhaust ventilation, such as nonaspirating diffusers for unidirectional low-velocity airflow, is important in several settings, including operating rooms (FGI 2010; ASHRAE 2008).

However, it remains unclear by how much infectious particle loads must be reduced to achieve a measurable reduction in disease transmissions and whether the efficiencies warrant the cost of using these controls.

Energy-conserving strategies that reduce annualized ventilation rates, such as demand-controlled ventilation, should be used with caution, especially during mild outdoor conditions when the additional ventilation has low cost. Greater use of air economizers has a positive impact both on energy conservation and annualized dilution ventilation.

Natural ventilation, such as that provided by user-operable windows, is not covered as a method of infection control by most ventilation standards and guidelines. There are very few studies on natural ventilation for infection control in hospitals. One guideline that does address it recommends that natural ventilation systems should achieve specific ventilation rates that are significantly higher than the ventilation rates required in practice guidelines for mechanical systems (WHO 2009).

Room pressure differentials are important for controlling airflow between areas in a building (Siegel et al. 2007; CDC 2005). For example, airborne infection isolation rooms (AIIRs) are kept at negative pressure with respect to the surrounding areas to keep potential infectious agents within the rooms. Some designs for AIIRs incorporate supplemental dilution or exhaust/capture ventilation (CDC 2005). Interestingly, criteria for AIIRs differ substantially between cultures and countries in several ways, including air supply into anterooms, exhaust from space, and required ventilation air (Subhash et al. 2013; Fusco et al. 2012). This PD takes no position on whether anterooms should be required in practice guidelines.

Hospital rooms with immune-compromised individuals are kept at positive pressure in protective environments (PEs) to keep potential infectious agents (e.g., *Aspergillus* sp. or other filamentous fungi) out of the rooms (Siegel et al. 2007; FGI 2010; ASHRAE 2008).

Personalized ventilation systems that supply 100% outdoor air, highly filtered, or UV disinfected air directly to the occupant's breathing zone (Cermak et al. 2006; Sekhar et al. 2005) may be protective as shown by CFD analysis (Yang et al. 2013). However, there are no known field studies that justify the efficacy. Personalized ventilation may be effective against aerosols that travel both long distances as well as short-range routes (Li 2011).

The addition of highly efficient particle filtration to central ventilation systems is likely to reduce the airborne load of infectious particles (Azimi and Stephens 2013).[6] This control strategy can reduce the transport of infectious agents within individual areas and from one area to another when these areas share the same central ventilation system (e.g., from patient rooms in hospitals or lobbies in public access buildings to other occupied spaces).

Local, efficient filtration units (either ceiling mounted or portable, floor-standing) reduce local airborne loads and may serve purposes in specific areas such as health-care facilities or high-traffic public occupancies (Miller-Leiden et al. 1996; Kujundzic et al. 2006).

There are two UVGI strategies for general application: (1) installation into air handlers and/or ventilating ducts and (2) irradiation of the upper air zones of occupied spaces with shielding of the lower occupied spaces because UV is harmful to room occupants (Reed 2010). Two strategies used in some but not all health-care occupancies are in-room irradiation of unoccupied spaces and of occupied spaces (e.g., operating suites) when personnel have appropriate personal protective equipment (PPE) (NIOSH 2009b).

All UVGI depends on inactivation of viable agents, both in the air and on surfaces, depending on the strategy. ASHRAE (2009) describes effective application of the first two UVGI strategies. For efficacy of in-room irradiation. see, for instance, “Decontamination of Targeted Pathogens from Patient Rooms Using an Automated Ultraviolet-C-Emitting Device” (Anderson et al. 2013).

In both duct-mounted and unoccupied in-room UVGI, the amount of radiation applied can be much higher compared to what can be used for upper-zone UVGI, resulting in higher aerosol exposure and quicker inactivation. Duct-mounted UVGI can be compared to filtration in the central ventilation system, because it inactivates the potentially infectious organisms while filtration removes them. UVGI does not impose a pressure drop burden on the ventilation system.

There is research that shows UVGI in both the upper-room and in-duct configurations can inactivate some disease-transmitting organisms (Riley et al. 1962; Ko et al. 2002; CDC 2005; Kujundzic et al. 2007; VanOsdell and Foarde 2002; Xu et al. 2003, et al. 2005), that it can affect disease transmission rates (McLean 1961), and that it can be safely deployed (Nardell et al. 2008).

Upper-zone UVGI, when effectively applied (ASHRAE 2009; NIOSH 2009a; Miller et al. 2013; Xu et al. 2013), inactivates infectious agents locally and can be considered in public access and high-traffic areas such as cafeterias, waiting rooms, and other public spaces. The fixtures are typically mounted at least 2.1 m (7 ft) above the floor, allowing at least an additional 0.3 m (1 ft) of space above the fixture for decontamination to occur. It is typically recommended when ventilation rates are low.

At air change rates much greater than 6 ach (air changes per hour), there is evidence that upper-room UVGI is less effective relative to particle removal by ventilation. This is thought to be because the particles have less residence exposure time to UV.

In-room UVGI may be performed in patient rooms between successive occupants using elevated levels of irradiation applied in the unoccupied room for a specified length of time. This is primarily a surface disinfectant strategy, though it also disinfects the air that is in the room at the time of irradiation (Anderson et al. 2013; Mahida et al. 2013). Because the UV is turned off before the next patient arrives, it has no continuing effect on the air.

[6] Filter efficiency varies with particle size, so the type of filtration required in order to be effective varies with the type of organism and the aerosol that carries it. ASHRAE Standard 52.2 (ASHRAE 2012b) describes a minimum efficiency reporting value (MERV) for filter efficiency at various particle sizes, and HEPA filtration may not be necessary. Specific personnel safety procedures may be required when changing filters, depending on the types of organisms and other contaminants that have been collected on the used media.

A strategy of continuous irradiation of the air during surgery has been used, though this is not currently standard practice. When using this strategy, protection of operating room personnel from the UV radiation is advised.

Note that no controlled intervention studies showing the clinical efficacy of all of the above strategies have been conducted, *including dilution ventilation and pressure differential that are required under current practice standards and guidelines*.

If studies can be conducted, they should specifically include occupancies such as jails, homeless shelters, and health-care facilities. Compared to other facilities, these have a higher risk for both infected and susceptible individuals, which results in higher rates of disease transmission, making the impact more measurable and significant. Such research may lead to other recommended changes in HVAC system design. More research is also needed to document intrinsic (specific to microorganism) airborne virus and bacteria inactivation rates. See Table 1 for a summary of occupancy categories in which various strategies may be considered and priorities of research needs.

3.3 Temperature and Humidity

Many HVAC systems can control indoor humidity and temperature, which can in turn influence transmissibility of infectious agents. Although the weight of evidence at this time suggests that controlling relative humidity (RH) can reduce transmission of certain airborne infectious organisms, including some strains of influenza, this PD refrains from making a universal recommendation.

According to Memarzadeh (2011), in a review of 120 papers conducted on the effect of humidity and temperature on the transmission of infectious viruses, numerous researchers suggest that three mechanisms could potentially explain the observed influence of RH on transmission. One possible mechanism is slower evaporation from large droplets influenced by higher humidity that a lower humidity would more rapidly change them into droplet nuclei. Nicas and colleagues (2005) show by modeling that emitted droplets will evaporate to 50% of their initial diameter and that if the initial diameter is <20 μm this process will happen before the droplets fall to a surface. For larger diameters and higher humidity this does not happen quickly enough to change large droplets into droplet nuclei before they fall. Wang et al. (2005) found that people inhaled fewer droplets at a higher RH.

The second possible mechanism is that RH may act at the level of the host. Breathing dry air could cause desiccation of the nasal mucosa, which would in turn render the host more susceptible to respiratory virus infections. The third possible mechanism is that RH may act at the level of the virus particle to affect its virulence.

Yang and Marr (2012b) discuss in a minireview the complexities of the relationship between aerosolized viruses and RH, including multiple hypotheses such as water activity, surface inactivation, and salt toxicity, that may account for the association between humidity and viability of viruses in aerosols. They also propose their own hypothesis that changes in pH (induced by evaporation) within the aerosol compromise the infectivity. They conclude that the precise mechanisms underlying the relationship remain largely unverified; there are still large gaps in the literature, and a complete understanding will require more in-depth studies with collaboration across disciplines.

Memarzadeh (2011) further concludes that there is insufficient evidence to say that maintaining an enclosed environment at a certain temperature and at a certain RH, is likely to reduce the airborne survival and therefore transmission of influenza virus when compared with a similar environment that does not adhere to such tight control of indoor temperature and RH.

A sample of the findings of numerous individual studies follows.

Schaffer et al. (1976) revealed that viral transmission at low (<40%) and high (>80%) relative humidity was much higher than at medium relative humidity (about 50%).

Lowen et al. (2007) and Shaman and Kohn (2009) conclude that low humidity and low temperature strongly increase influenza transmission between guinea pigs and hypothesize this is caused by rapid formation of droplet nuclei and increased survival of the infectious agent. Lowen suggests that humidification of indoor air (particularly in places, such as nursing homes and emergency rooms, where transmission to those at high risk for complications is likely) may help decrease the spread and the toll of influenza during influenza season.

Yang et al. (2012a) studied the relationship between influenza A virus (IAV) viability over a large range of RH in several media, including human mucus. They found the relationship between viability and RH depends on droplet composition: viability decreased in saline solutions, did not change significantly in solutions supplemented with proteins, and increased dramatically in mucus. Thus, laboratory studies that do not use mucus may yield viability results that do not represent those of human-generated aerosols in the field. Their results also suggest that there exist three regimes of IAV viability defined by three different ranges of RH.

Noti et al. (2013) found that at low relative humidity (23%), influenza retains maximal infectivity (71% to 77%) and that inactivation (infectivity 16% to 22%) of the virus at higher relative humidity (43%) occurs rapidly (60 min) after coughing. This study used manikins and aerosolization in a nebulizer, using a cell culture medium.[7]

Another factor to consider before using higher indoor humidity to reduce airborne disease transmission is that it may interfere with the effectiveness of UVGI. Two studies with *S. marcescens* showed an increased survival in the presence of UV light at higher RH levels. This was suggested to be due to the protective effect of larger particle sizes, as evaporation would be less at these higher RH levels, thus indicating a protective effect of a thicker water coat against UV radiation (Tang 2009). Two other studies also show that UVGI is less effective at higher RH and suggest it is due to a change in DNA conformation (Peccia et al. 2001; Xu et al. 2005).

In addition to the above, there are comfort issues to be considered when selecting indoor temperature and humidity parameters for the operation of buildings. For instance, the optimum temperature to reduce the survival of airborne influenza virus may be above 30°C (86°F) at 50% rh (Tang 2009), which is not usually acceptable for human thermal comfort (ASHRAE 2013a). Furthermore, higher humidity increases the potential for mold and moisture problems (ASHRAE 2013b).

For all of the above reasons, this PD does not make a broad recommendation on indoor temperature and humidity for the purpose of controlling infectious disease. Practitioners may use the information above to make building design and operation decisions on a case-by-case basis.

3.4 Non-HVAC Strategies

Building owners and managers should understand that education and policies, such as allowing and encouraging employees to stay at home when ill, are more effective than any HVAC interventions. Administrative measures such as prompt identification of patients with

[7] Email correspondence with coauthor Linsley on November 22, 2013, explains that the medium used was complete Dulbecco's modified Eagle's medium (CDMEM), which consists of Dulbecco's modified Eagle's medium, 100 U/ml penicillin G, 100 µg/ml streptomycin, 2 mM L-glutamine, 0.2% bovine serum albumin, and 25 mM HEPES buffer.

influenza-like illness and use of source control (respiratory hygiene[8]) are also important, especially in health-care settings. In some cases, high-efficiency personal protective equipment (e.g., N95 respirators [CDC 2014]) may be considered.

Vaccination, a general public health measure, is efficient and effective for many diseases, in part because it does not rely on facility operation and maintenance. On the other hand, vaccination is sometimes unavailable or insufficiently effective. For example, despite an average effectiveness of 60% to 70% for influenza (Osterholm et al. 2012), effectiveness can decline to as low as 10% in "bad match" years (Belongia et al. 2009). In such a case, HVAC interventions may be more important, even though they are less well understood. For example, recent modeling (Gao et al. 2012) suggests that dilution ventilation can support pandemic management as an essential complement to social distancing and can reduce the necessity of school closures.

For current information on these nonventilation strategies, readers should consult websites maintained by public health and safety authorities, such as the Centers for Disease Control and Prevention (CDC), Department of Homeland Security (DHS), flu.gov, the official influenza website of the U.S. Department of Health and Human Services (USDHHS), and the World Health Organization (WHO) (in particular, www.who.int/influenza/preparedness/en/, WHO 2014).

3.5 Emergency Planning

Four worldwide (pandemic) outbreaks of influenza occurred in the twentieth century: 1918, 1957, 1968, and 2009 (BOMA 2012). Not classified as true pandemics are three notable epidemics: a pseudopandemic in 1947 with low death rates, an epidemic in 1977 that was a pandemic in children, and an abortive epidemic of swine influenza in 1976 that was feared to have pandemic potential. The most recent H1N1 pandemic in 2009 resulted in thousands of deaths worldwide but was nowhere near the death toll of the 1918 Spanish flu, which was the most serious pandemic in recent history and was responsible for the deaths of an estimated more than 50 million people. There have been about three influenza pandemics in each century for the last 300 years. If a new outbreak occurs and is caused by a microorganism that spreads by the airborne route, fast action affecting building operations will be needed.

Some biological agents that may be used in terrorist attacks are addressed elsewhere (USDHHS 2002, 2003).

Engineers can support emergency planning by understanding the design, operations, and maintenance adequacy of buildings for which they are responsible and helping emergency planners mitigate vulnerabilities or develop interventions. For instance, there may be means to increase dilution ventilation, increase relative humidity, or quickly apply upper-room UVGI in an emergency room, transportation waiting area, shelter, jail, and crowded entries to buildings in an emergency, provided that this does not create either (1) flow of air to less contaminated areas or (2) conditions of extreme discomfort. In other situations, curtailing ventilation or creating pressure differentials may be the appropriate strategy. Actions should be thoughtfully undertaken in collaboration with infection control professionals and based on knowledge of the system and its operation and the nature and source of the threat.

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[8] Respiratory hygiene includes behavior such as coughing into and disposing of facial tissue or putting masks on ill individuals to prevent dissemination of particles (CDC 2001; Siegel et al. 2007).

At the building level, engineers may provide support by (1) identifying vulnerabilities with air intake, wind direction, shielding, etc.; (2) identifying building systems and safe zones in the general building environment; (3) identifying approaches to interrupting air supply to designated “shelter-in-place” locations in general building environments; and 4) identifying cohorting possibilities for pandemic situations so that whole areas of a hospital may be placed under isolation and negative pressure. For guidance, see “Airborne Infectious Disease Management Manual: Methods for Temporary Negative Pressure Isolation” (MDH 2013).

Building operators and engineers should have information about how to contact public health authorities and other emergency planning support (BOMA 2012).

4. RECOMMENDATIONS

Some infectious diseases are transmitted through inhalation of airborne infectious particles, which can be disseminated through buildings by pathways that include ventilation systems. Airborne infectious disease transmission can be reduced using dilution ventilation; directional ventilation; in-room airflow regimes; room pressure differentials; personalized ventilation;[9] and source capture ventilation, filtration, and UVGI.

Engineers play a key role in reducing disease transmission that occurs in buildings. Goal 11 of the ASHRAE Research Strategic Plan for 2010–2015, “Understand Influences of HVAC&R on Airborne Pathogen Transmission in Public Spaces and Develop Effective Control Strategies,” recognizes the key role that ASHRAE plays (ASHRAE 2010).

Societal disruption from epidemics and the unexpected transmission of disease in workplaces, public access facilities, and transportation warrants further research on the effectiveness of engineering controls.

ASHRAE recommends the following:

- All facility designs should follow the latest practice standards, including but not limited to ASHRAE Standard 55 for thermal conditions (ASHRAE 2013a); ventilation Standards 62.1 (ASHRAE 2013b), 62.2 (ASHRAE 2013c), and 170 (ASHRAE 2008; and FGI *Guidelines for Design and Construction of Health Care Facilities* (FGI 2010).
- Commissioning, maintenance, and proper operation of buildings, and, in particular, systems intended to control airborne infectious disease, are necessary for buildings and systems to be effective.
- Building designers, owners, and operators should give high priority to enhancing well-designed, installed, commissioned, and maintained HVAC systems with supplemental filtration, UVGI, and, in some cases, to additional or more effective ventilation to the breathing zone. Filtration and UVGI can be applied in new buildings at moderate additional cost and can be applied quickly in existing building systems to decrease the severity of acute disease outbreaks. *Indoor Air Quality Guide* (ASHRAE 2009) contains information about the benefits of and techniques for accomplishing these enhancements.
- New health-care facilities, including key points of entry such as emergency, admission, and waiting rooms; crowded shelters; and similar facilities should incorporate the infrastructure to quickly respond to a pandemic. Such infrastructure might include, for

[9] For the purpose of this PD, personalized ventilation is a mechanical ventilation strategy of supplying air directly to the occupant’s breathing zone without mixing it with contaminated room air.

example, HVAC systems that separate high-risk areas; physical space and HVAC system capacity to upgrade filtration; the ability to increase ventilation even as high as 100% outdoor air; the ability to humidify air; and receptacles at the upper room and ceiling heights of at least 2.4 m (8 ft) to enable effective upper-room UVGI. Once the building is in operation, rapid availability of filter elements and upper-room UV fixtures should be arranged for rapid deployment in an emergency.

- Infection control strategies should always include a bundle of multiple interventions and strategies (not just ventilation).
- Multidisciplinary teams of engineers, building operators, scientists, infection prevention specialists, and epidemiologists should collaborate to identify and implement interventions aimed at mitigation of risk from airborne infectious disease and understand the uncertainty of the effectiveness of current practice recommendations.
- Building operators and engineers have a role to play in planning (BOMA 2012) for infectious disease transmission emergencies.
- Committees that write and maintain practice standards and guidelines for critical environments such as health-care facilities and crowded shelters should consider recent research and understanding of infectious disease control and consider adding or strengthening requirements for the following:
  - Improved particle filtration for central air handlers
  - Upper-room and possibly other UVGI interventions or at least the ceiling heights and electrical infrastructure to quickly deploy them
  - The ability to quickly and temporarily increase the outdoor air ventilation rate in the event of an infectious disease outbreak
  - Avoiding unintended adverse consequences in infectious disease transmission resulting from lower ventilation levels motivated solely by reduced energy consumption
- Airborne infectious disease researchers should receive input on study design, methodology, and execution from many discipline experts (including engineers, infection prevention specialists, health-care epidemiologists, public health officials, and others) to provide a better picture of the interplay between building systems and disease transmission.
- Controlled intervention studies should be conducted to quantify increases or decreases in disease propagation resulting from various ventilation rates.
- Controlled intervention studies should be conducted to quantify the relative airborne infection control performance and cost-effectiveness of specific engineering controls individually and in combination in field applications. Table 1 summarizes the research priority and applicable occupancy categories for each strategy. Studies should include occupancies at high-risk (such as jails, homeless shelters, schools, nursing homes, and health-care facilities).
- Research should quantify rates of airborne removal by filtration and inactivation by UVGI strategies specific to individual microorganisms and should field validate in real facilities the effectiveness of these interventions in preventing transmission.
- Research should be conducted to better characterize the particle size distributions of coughed materials, which are thought to encompass a broad range of diameters.

Table 1 Airborne Infectious Disease Engineering Control Strategies: Occupancy Interventions and Their Priority for Application and Research

Strategy	Occupancy Categories Applicable for Consideration*	Application Priority	Research Priority
Dilution ventilation	All	High	Medium
Temperature and humidity	All except 7 and 11	Medium	High
Personalized ventilation	1, 4, 6, 9, 10, 14	Medium	High
Local exhaust	1, 2, 8, 14	Medium	Medium
Central system filtration	All	High	High
Local air filtration	1, 4, 6, 7, 8 10	Medium	High
Upper-room UVGI	1, 2, 3, 5, 6, 8, 9, 14	High	Highest
Duct and air-handler UVGI	1, 2, 3, 4, 5, 6, 8, 9, 14	Medium	Highest
In-room flow regimes	1, 6, 8, 9, 10, 14	High	High
Differential pressurization	1, 2, 7, 8 11, 14	High	High

Note: In practical application, a combination of the individual interventions will be more effective than any single one in isolation.
*Occupancy Categories:

1. Health care (residential and outpatient)
2. Correctional facilities
3. Educational < age 8
4. Educational > age 8
5. Food and beverage
6. Internet café/game rooms
7. Hotel, motel, dormitory
8. Residential shelters
9. Public assembly and waiting
10. Transportation conveyances
11. Residential multifamily
12. Retail
13. Sports
14. Laboratories where infectious diseases vectors are handled

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Appendix 3 – School / Room Data Collection Log

Date: 12/08/20

School Building	Total Spaces	Spaces with Operable Window for Natural Ventilation	Number of Spaces Assessed	# of Spaces That Currently Meet ASHRAE 62.1 Std	# of Spaces That Currently Meet COVID Guidance 150% of ASHRAE 62.1 Std	# of HEPA Filter Units Required	Total # of Spaces That Currently Meet Guidance or Will Meet Guidance After HEPA Filter is Installed.	# of Spaces That Are Unable to Meet Guidance With a HEPA Filter Installed	# of Spaces That Would Benefit From HVAC Equipment Repairs and/or Modifications	Does the School Have a Glycol Freeze Protection System?	Building Automation System Type
Baker	45	42	30	14	9	21	29	1	16	Steam - N/A	DDC - Pneumatic Hybrid
Wixon	59	53	54	32	21	39	53	1	25	Hydronic - No	DDC - Pneumatic Hybrid
Station Ave	36	33	35	15	9	30	34	1	22	Hydronic - No	DDC - Pneumatic Hybrid
Total Number	140	128	119	61	39	90	116	3	63		
Total Percent	100%	91%	85%	51%	33%		97%	3%	53%		

Notes:

1. If space does not meet COVID Guidelines, no more than one person should occupy the space at any time or it shall be supplemented with natural ventilation via operable window.
2. Results based on reduced hybrid space occupancy as determined by the school district. Results not valid for normal full space occupancy.
3. All offices have been treated as passing COVID Guidelines under the assumption that each will be occupied by only 1 person at any time.
4. The total number of HEPA filter units needed may decrease if repairs and/or modifications described in assessment form are performed.

Date: 11/13/20	ROOM #	Date Tested	Room Occupancy Type	SERVED BY UNIT	ROOM (SQ. FT.)	CEILING HEIGHT (FT.)	OUTSIDE AIR CFM	SUPPLY CFM	EXHAUST CFM	RETURN CFM	ASHRAE 62.1 Suggested Occupancy	Hybrid Occupancy	ASHRAE 62.1 Ventilation Std	150% of ASHRAE 62.1 Ventilation Std	Ventilation Air Changes Per Hour	Total Air Changes Per Hour	Does This Space Have Operable Windows?	Does This Space Meet ASHRAE Ventilation Standard	Does This Space Meet 150% of ASHRAE Ventilation Standard	Does This Space Require Supplemental HEPA Filtration	Ventilation Air With Supplemental HEPA Filter	Could This Space Benefit from HVAC Equipment Repairs and/or Modifcations?	Will This Space Meet COVID Guidelines	ENE Assessment Notes:	Service Notes
Baker School Assessed On 11/03/2020																									
Baker	Art Room	11/4/2020	Classroom 9+	ERV-2	850	7.5	427		336		30	12	222	333	4.0	4.0	5	YES	YES	-	427	-	YES	(5) 2x3 Windows hinged opening. Served by ERV-2, no heating. Mitsubishi split system provides heating and cooling.	
Baker	Music	11/4/2020	Classroom 9+	ERV-2	790	7.5	497		450		28	12	215	322	5.0	5.0	3	YES	YES	-	497	-	YES	(3) 2x3 Windows hinged opening. Served by ERV-2, no heating. Mitsubishi split system provides heating and cooling.	
Baker	Comp Lab	11/4/2020	Classroom 9+	ERV-1	560	7.5	266		265		20	10	167	251	3.8	3.8	0	YES	YES	-	266	-	YES	No windows. Served by ERV-1. Open to library	
Baker	Library	11/4/2020	Classroom 9+	ERV-1	850	7.5	207				30	11	212	318	1.9	1.9	5	NO	NO	1	407	YES	YES	(5) 2x3 Windows hinged opening. Served by ERV-2, no heating. Mitsubishi split system provides heating and cooling. Can try to rebalance system to get more airflow out of diffuser.	
Baker	Media	11/4/2020	Classroom 9+	ERV-1	450	7.5	150		84		16	5	104	156	2.7	2.7	0	YES	NO	1	350	YES	YES	No windows. Served by ERV-1. Open to library. Can try to rebalance system to get more airflow out of diffuser.	
Baker	Conf Rm	11/4/2020	Office	ERV-1	175	7.5	35				1	1	16	23	1.6	1.6	0	YES	YES	-	35	-	YES		
Baker	Foreign Language	11/4/2020	Office	ERV-2	300	7.5	101				2	2	28	42	2.7	2.7	2	YES	YES	-	101	-	YES		
Baker	127	11/4/2020	Classroom 9+	UV	670	9	39				24	10	180	271	0.4		9	NO	NO	2	439	YES	YES	Unable to measure supply airflow. Fully operable window 2x3. Exhaust is blocked off. Adjust OA damper position to aproximately 40%.	
Baker	128	11/4/2020	Classroom 9+	UV	700	9	35				25	10	184	276	0.3		9	NO	NO	2	435	YES	YES	Unable to measure supply airflow. Fully operable window 2x3. Adjust OA damper position to aproximately 40%.	
Baker	Gym	11/4/2020	Classroom 9+	(2) H&V	5500	18					193	0	660	990			6	-	-	N/A	N/A	-	-	Served by 2 H&V units with manual dampers. 1 was not operating, the second was operating but hand damper was set to 10% OA. Being used as storage. Air measurements not accessible.	Adjusted damper and locked at 50% oa. 11/19/2020 MS
Baker	108	11/4/2020	Classroom 9+	UV	600	9	303	798			21	10	172	258	3.4	8.9	6	YES	YES	-	303	-	YES	(6) 2x3 windows.	
Baker	110	11/4/2020	Classroom 9+	UV	600	9		695			21	10	172	258		7.7	6	-	-	N/A	N/A	-	-	OA not accessible to measure.	
Baker	109	11/4/2020	Classroom 9+	UV	600	9		749			21	10	172	258		8.3	6	-	-	N/A	N/A	-	-	OA not accessible to measure. (6) 2x3 windows.	
Baker	107	11/4/2020	Classroom 9+	UV	600	9	186	731			21	10	172	258	2.1	8.1	6	YES	NO	1	386	YES	YES	Adjust OA damper position to aproximately 40%.	
Baker	Main Office	11/4/2020	Office	None	430	8	0	0			3	1	31	46	0.0	0.0	4	NO	NO	-	0	-	YES	No mechanical ventilation present.	
Baker	Principal	11/4/2020	Office	None	200	8	0	0			1	1	17	26	0.0	0.0	2	NO	NO	-	0	-	YES	No mechanical ventilation present	
Baker	AP	11/4/2020	Office	None	200	8	0	0			1	1	17	26	0.0	0.0	1	NO	NO	-	0	-	YES	No mechanical ventilation present	
Baker	SW	11/4/2020	Office	None	100	8	0	0			1	1	11	17	0.0	0.0	2	NO	NO	-	0	-	YES	No mechanical ventilation present	
Baker	106	11/4/2020	Classroom 9+	UV	850	12	27	387		181	30	10	202	303	0.2	2.3	6	NO	NO	2	427	YES	YES	Fan speed was on medium @ 359 cfm. Changed to high speed. 1960s model unit. Can try to clean unit to increase supply airflow. Adjust OA damper position to aproximately 40%.	
Baker	105	11/4/2020	Classroom 9+	UV	850	12	142	460		185	30	10	202	303	0.8	2.7	6	NO	NO	1	342	YES	YES	(6) 2x3 windows. 1960s model unit. Can try to clean unit to increase supply airflow. Adjust OA damper position to aproximately 40%.	
Baker	104	11/4/2020	Classroom 9+	UV	850	12	205	433		197	30	10	202	303	1.2	2.5	6	YES	NO	1	405	YES	YES	(6) 2x3 windows. 1960s model unit. Can try to clean unit to increase supply airflow.	
Baker	Nurse	11/4/2020	Nurse	None	450	12	0	0		0	NA	2	NA	NA	0.0	0.0	5	NO	NO	N/A	N/A	-	NO	No mechanical ventilation present. 5 operable windows. Entry , Nurse, RR.	
Baker	103	11/4/2020	Classroom 9+	UV	850	12	224	495			30	10	202	303	1.3	2.9	6	YES	NO	1	424	YES	YES	1960s model unit. Can try to clean unit to increase supply airflow.	
Baker	102	11/4/2020	Classroom 9+	UV	850	12	196	461		211	30	10	202	303	1.2	2.7	6	NO	NO	1	396	YES	YES	1960s model unit. Can try to clean unit to increase supply airflow.	
Baker	112	11/4/2020	Classroom 5-8	UV	780	9.5	467	583			20	10	194	290	3.8	4.7	4	YES	YES	-	467	-	YES		
Baker	101	11/4/2020	Classroom 5-8	UV	850	12	165	380			22	10	202	303	1.0	2.2	6	NO	NO	1	365	YES	YES	Fan will not work on high speed. 1960s model unit. Can try to clean unit to increase supply airflow.	Oiled all bearings and tested in all 3 speeds. 11/25/2020 MS
Baker	111	11/4/2020	Classroom 5-8	UV	700	9.5		547			18	10	184	276		4.9	6	-	-	N/A	N/A	-	-	OA not accessible.	
Baker	113	11/4/2020	Classroom 5-8	UV	700	9.5		526			18	10	184	276		4.7	6	-	-	N/A	N/A	-	-	OA not accessible.	
Baker	114	11/4/2020	Classroom 5-8	UV	700	9.5		595			18	10	184	276		5.4	6	-	-	N/A	N/A	-	-	OA not accessible.	
Baker	115	11/4/2020	Classroom 5-8	UV	700	9.5		646			18	10	184	276		5.8	6	-	-	N/A	N/A	-	-	OA not accessible.	
Baker	116	11/4/2020	Classroom 5-8	UV	700	9.5	72	570			18	10	184	276	0.6	5.1	6	NO	NO	2	472	YES	YES	1960s model unit. Can try to clean unit to increase supply airflow. Adjust OA damper position to aproximately 40%.	
Baker	117	11/4/2020	Classroom 5-8	UV	700	9.5		493			18	10	184	276		4.4	6	-	-	N/A	N/A	-	-	OA not accessible	
Baker	Teachers Rm	11/4/2020	Conf/Meeting	UV	540	9.5		501			27	5	57	86		5.9	4	-	-	N/A	N/A	-	-	OA not accessible	
Baker	118	11/4/2020	Classroom 5-8	UV	700	9.5		546			18	10	184	276		4.9	6	-	-	N/A	N/A	-	-	OA not accessible	

Date: 11/13/20	ROOM #	Date Tested	Room Occupancy Type	SERVED BY UNIT	ROOM (SQ. FT.)	CEILING HEIGHT (FT.)	OUTSIDE AIR CFM	SUPPLY CFM	EXHAUST CFM	RETURN CFM	ASHRAE 62.1 Suggested Occupancy	Hybrid Occupancy	ASHRAE 62.1 Ventilation Std	150% of ASHRAE 62.1 Ventilation Std	Ventilation Air Changes Per Hour	Total Air Changes Per Hour	Does This Space Have Operable Windows?	Does This Space Meet ASHRAE Ventilation Standard	Does This Space Meet 150% of ASHRAE Ventilation Standard	Does This Space Require Supplemental HEPA Filtration	Ventilation Air With Supplemental HEPA Filter	Could This Space Benefit from HVAC Equipment Repairs and/or Modifcations?	Will This Space Meet COVID Guidelines	ENE Assessment Notes:	Service Notes
Baker	Cafeteria	11/4/2020	Conf/Meeting	(3) UV	3300	9.5	612	1801			165	50	448	672	1.2	3.4	10	YES	NO	1	812	YES	YES	One of the Uvs is not operating and needs to be repaired.	Changed blower motor and bearing. Confirmed operation. 11/25/2020 MS
Baker	Kitchen	11/4/2020	Kitchen	UV	1000	9.5	0	0			20	3	143	214	0.0	0.0	10	NO	NO	2	400	YES	YES	UV not operating	Unit was shut off. Turned back on and tested operation. Oiled all bearings. 11/25/2020 MS
Baker	132	11/4/2020	Classroom 5-8	UV	1200	9.5	438	660			30	10	244	366	2.3	3.5	6	YES	YES	-	438	-	YES		
Baker	130	11/4/2020	Classroom 5-8	UV	950	9.5	381	586			24	10	214	321	2.5	3.9	6	YES	YES	-	381	-	YES		
Baker	131	11/4/2020	Classroom 5-8	UV	1070	9.5	106	575			27	10	228	343	0.6	3.4	6	NO	NO	2	506	YES	YES	Adjust OA damper position to aproximately 40%.	
Baker	204/206	11/4/2020	Classroom 5-8	(2) UV	950	9		1532			24	10	214	321		10.8	6	-	-	N/A	N/A	-	-	OA not accessible	
Baker	205	11/4/2020	Classroom 5-8	UV	620	9		727			16	5	124	187		7.8	4	-	-	N/A	N/A	-	-	OA not accessible	
Baker	203	11/4/2020	Classroom 5-8	UV	620	9		719			16	5	124	187		7.7	4	-	-	N/A	N/A	-	-	OA not accessible	
Baker	201	11/4/2020	Classroom 5-8	UV	620	9		733			16	5	124	187		7.9	6	-	-	N/A	N/A	-	-	OA not accessible	
Baker	200	11/4/2020	Office	None	200	12	0	0			1	1	17	26	0.0	0.0	1	NO	NO	-	0	YES	YES	No mechanical ventilation	
Baker	202	11/4/2020	Classroom 5-8	UV	600	9		718			15	5	122	183		8.0	6	-	-	N/A	N/A	-	-	OA not accessible. General School Notes - All Uvs have pneumatic controls. EF-4, 1, 5A not operating. Steam boiler system.	EF 1 was off at breaker, turned back on and checked. EF4 is a bathroom ex that only comes on when light is turned on. EF 5a was running 11/19/2020 MS
Wixon School Assessed On 11/05/2020																									
Wixon	Gym 1	11/4/2020	Classroom 9+	HV-1&2	6340	27			Yes		222	50	1261	1891			8	-	-	N/A	N/A	-	-	General School Notes - Hot water boilers, no glycol. Gym unit not accessible to measure	All classroom exhausters are bypassed to run 24/7 per Sandy. 12/7/2020 MS
Wixon	267	11/4/2020	Classroom 9+	UV	850	9.5	172	695	0	198	30	10	202	303	1.3	5.2	2	NO	NO	1	372	YES	YES	1x3 windows hinged. UV exhaust, not operating. Adjust OA damper position to aproximately 40%. EF not working.	All classroom exhausters are bypassed to run 24/7 per Sandy. 12/7/2020 MS
Wixon	266	11/4/2020	Classroom 9+	UV	850	9.5	249	706	0		30	10	202	303	1.9	5.2	2	YES	NO	1	449	YES	YES	Adjust OA damper position to aproximately 40%. EF not working.	All classroom exhausters are bypassed to run 24/7 per Sandy. 12/7/2020 MS
Wixon	206	11/4/2020	Classroom 9+	UV	850	9.5	352	620	0	268	30	10	202	303	2.6	4.6	3	YES	YES	-	352	-	YES		
Wixon	Nurse 1	11/4/2020	Nurse	UV	680	9.5	131	415	1053		2	2	NA	NA	1.2	3.9	2	N/A	N/A	N/A	N/A	-	YES	Single room with a unit vent and ceiling exhaust. Day to day nurse operations.	
Wixon	263	11/4/2020	Classroom 9+	UV	1200	9.5	413	895	0		42	12	264	396	2.2	4.7	2	YES	YES	-	413	-	YES	EF not working.	Changed ex fan for this area 12/2/2020 MS
Wixon	210	11/4/2020	Classroom 9+	UV	850	9.5	272	724	102		30	12	222	333	2.0	5.4	2	YES	NO	1	472	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	212	11/4/2020	Office	EF	300	9.5	0	0	0		2		18	27	0.0	0.0	2	NO	NO	-	0	-	YES	EF not operating. No mechanical ventilation present.	Ef only runs when light is turned on at toggle switch on wall 11/25/2020
Wixon	275	11/4/2020	Classroom 9+	UV	850	9.5	430	767	172		30	10	202	303	3.2	5.7	1	YES	YES	-	430	-	YES		
Wixon	274	11/4/2020	Classroom 9+	UV	850	9.5	411	892	NA		30	10	202	303	3.1	6.6	1	YES	YES	-	411	-	YES		
Wixon	273	11/4/2020	Conf/Meeting	UV	850	9.5	120	860			43	5	76	114	0.9	6.4	1	YES	YES	-	120	-	YES		
Wixon	279	11/4/2020	Classroom 9+	UV	1300	9.5	308	738	0		46	12	276	414	1.5	3.6	3	YES	NO	1	508	YES	YES	EF not working.	All classroom exhausters are bypassed to run 24/7 per Sandy. 12/7/2020 MS
Wixon	278	11/4/2020	Conf/Meeting	UV	1400	9.5	545	843	0		70	5	109	164	2.5	3.8	3	YES	YES	-	545	-	YES	EF not working	All classroom exhausters are bypassed to run 24/7 per Sandy. 12/7/2020 MS
Wixon	COVID ISO Room	11/4/2020	Nurse	UV	500	9.5	0	0	0		2	2	N/A	N/A	0.0	0.0	1	NO	NO	N/A	N/A	YES	NO	UV not operating, EF not operating.	Unit was off on freeze. Adj to 35* & reset. Tested unit is ok at this time 11/25/2020 MS. Changed ef for this area 12/2/2020 MS
Wixon	Main Offices	11/4/2020	Office	None	1000	9.5	0	0	0		5	5	85	128	0.0	0.0	1	NO	NO	-	0	-	YES	No mechanical ventilation. Operable window in each office.	
Wixon	Guidance Offices	11/4/2020	Office	None	1000	9.5	0	0	0		5	5	85	128	0.0	0.0	1	NO	NO	-	0	-	YES	No mechanical ventilation. Operable window in each office.	
Wixon	208	11/4/2020	Classroom 9+	UV	850	9.5	441	771	65		30	12	222	333	3.3	5.7	3	YES	YES	-	441	-	YES		
Wixon	209	11/4/2020	Classroom 9+	UV	850	9.5	489	733	73		30	12	222	333	3.6	5.4	3	YES	YES	-	489	-	YES	OA not accessible	
Wixon	261	11/4/2020	Classroom 9+	UV	1200	9.5	159	951	33		42	12	264	396	0.8	5.0	2	NO	NO	2	559	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	205	11/4/2020	Classroom 9+	UV	850	9.5		672	0		30	12	222	333		5.0	3	-	-	N/A	N/A	YES	-	EF off. Outside air not accessible. Failed face/bypass damper.	Changed diaphragm for F&B damper 11/25/2020 MS All classroom ex is bypassed to run 24/7 per Sandy. 12/7/2020 MS
Wixon	204	11/4/2020	Classroom 9+	UV	850	9.5	536	843	0		30	12	222	333	4.0	6.3	3	YES	YES	-	536	-	YES	EF off	All classroom exhausters are bypassed to run 24/7 per Sandy. 12/7/2020 MS
Wixon	203	11/4/2020	Classroom 9+	UV	1200	9.5	329	856	0		42	12	264	396	1.7	4.5	4	YES	NO	1	529	YES	YES	EF off. Adjust OA damper position to aproximately 40%.	All classroom exhausters are bypassed to run 24/7 per Sandy. 12/7/2020 MS
Wixon	201/202	11/4/2020	Classroom 9+	UV	850	9.5		791	0		30	12	222	333		5.9	4	-	-	N/A	N/A	-	-	EF off. OA not accessible.	All classroom exhausters are bypassed to run 24/7 per Sandy. 12/7/2020 MS
Wixon	314	11/4/2020	Office	UV	335	9.5	88	287	0		2	2	30	45	1.7	5.4	2	YES	YES	-	88	-	YES	EF off	Changed belts and tested fan. Unit is now working. 11/30/2020 MS
Wixon	315	11/4/2020	Classroom 9+	UV	850	9.5	400	733			30	12	222	333	3.0	5.4	2	YES	YES	-	400	-	YES		
Wixon	316	11/4/2020	Classroom 9+	UV	850	9.5	452	828			30	12	222	333	3.4	6.2	2	YES	YES	-	452	-	YES		
Wixon	317	11/4/2020	Classroom 9+	UV	850	9.5	374	694			30	12	222	333	2.8	5.2	2	YES	YES	-	374	-	YES		
Wixon	318	11/4/2020	Classroom 9+	UV	850	9.5	232	697			30	12	222	333	1.7	5.2	2	YES	NO	1	432	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	320	11/4/2020	Classroom 9+	UV	850	9.5	436	784			30	12	222	333	3.2	5.8	2	YES	YES	-	436	-	YES		
Wixon	321	11/4/2020	Classroom 9+	UV	850	9.5	466	816			30	12	222	333	3.5	6.1	2	YES	YES	-	466	-	YES		

Date: 11/13/20	ROOM #	Date Tested	Room Occupancy Type	SERVED BY UNIT	ROOM (SQ. FT.)	CEILING HEIGHT (FT.)	OUTSIDE AIR CFM	SUPPLY CFM	EXHAUST CFM	RETURN CFM	ASHRAE 62.1 Suggested Occupancy	Hybrid Occupancy	ASHRAE 62.1 Ventilation Std	150% of ASHRAE 62.1 Ventilation Std	Ventilation Air Changes Per Hour	Total Air Changes Per Hour	Does This Space Have Operable Windows?	Does This Space Meet ASHRAE Ventilation Standard	Does This Space Meet 150% of ASHRAE Ventilation Standard	Does This Space Require Supplemental HEPA Filtration	Ventilation Air With Supplemental HEPA Filter	Could This Space Benefit from HVAC Equipment Repairs and/or Modifcations?	Will This Space Meet COVID Guidelines	ENE Assessment Notes:	Service Notes
Wixon	277	11/4/2020	Classroom 9+	(2) UV	850	9.5	402	691			30	12	222	333	3.0	5.1	4	YES	YES	-	402	YES	YES	2nd UV is not operating and needs to be repaired.	Second univent is heat only with no fresh air make up. 11/25/2020 MS
Wixon	277A	11/4/2020	Classroom 9+	FCU	300	9.5	0	0			11	5	86	129	0.0	0.0	1	NO	NO	1	200	-	YES	No outside air capabilities.	
Wixon	276	11/4/2020	Classroom 9+	UV	630	9.5	268	618			23	12	196	293	2.7	6.2	3	YES	NO	1	468	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	Cafeteria	11/4/2020	Multi Use	(5) UV	4300	13	392	1955			430	50	633	950	0.4	2.1	16	NO	NO	3	992	YES	YES	3 of the 5 Uvs not running.	2 units were off at switches. Turned back on 11/25/2020 MS Changed freeze stat on 1 unit 12/7/2020 MS all units are on
Wixon	Kitchen	11/4/2020	Kitchen	(2) UV	2000	11	0	0			40	5	278	416	0.0	0.0	0	NO	NO	3	600	YES	YES	Both Uvs not working	Both units were off at switches. Turned back on, oiled bearing and changed 1 diaphragm for F&B damper. 11/25/2020
Wixon	223	11/4/2020	Classroom 9+	FCU	600	25	0	0			21	12	192	288	0.0	0.0	0	NO	NO	2	400	-	YES	No outside air capabilities. Possibility to ventilate space from the auditorium unit that is in that space.	
Wixon	Auditorium	11/4/2020	Multi Use	H&V	5900	25					590	50	729	1094			0	-	-	N/A	N/A	-	-	H&V unit running but not accessible to measure	
Wixon	222	11/4/2020	Classroom 9+	FCU	600	25	0	0			21	12	192	288	0.0	0.0	0	NO	NO	2	400	-	YES	No outside air capabilities.	
Wixon	146	11/4/2020	Classroom 9+	UV	800	9	175	812			28	12	216	324	1.5	6.8	2	NO	NO	1	375	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	144	11/4/2020	Classroom 9+	UV	800	9	398	802	0		28	12	216	324	3.3	6.7	2	YES	YES	-	398	-	YES	EF not on	Changed belts and tested fan. Unit is now working. 11/30/2020 MS
Wixon	143	11/4/2020	Classroom 9+	UV	800	9	110	965			28	12	216	324	0.9	8.0	2	NO	NO	2	510	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	142	11/4/2020	Classroom 9+	UV	800	9	323	670			28	12	216	324	2.7	5.6	2	YES	NO	1	523	YES	YES	Clean unit. Adjust OA damper position to aproximately 40%.	
Wixon	Gym 2	11/4/2020	Classroom 9+	(2) UV	3000	28					105	0	360	540			0	-	-	N/A	N/A	-	-	Not accessible to measure. Being used as storage	
Wixon	140	11/4/2020	Classroom 9+	(2) UV	800	9	370	1008			28	12	216	324	3.1	8.4	2	YES	YES	-	370	-	YES		
Wixon	102	11/4/2020	Classroom 9+	UV	800	9	96	624			28	12	216	324	0.8	5.2	3	NO	NO	2	496	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	103	11/4/2020	Classroom 9+	UV	800	9	119	710			28	12	216	324	1.0	5.9	3	NO	NO	2	519	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	104	11/4/2020	Classroom 9+	UV	800	9	250	602			28	12	216	324	2.1	5.0	3	YES	NO	1	450	YES	YES	Clean unit. Adjust OA damper position to aproximately 40%.	
Wixon	105	11/4/2020	Classroom 9+	UV	800	9	150	691			28	12	216	324	1.3	5.8	3	NO	NO	1	350	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	106	11/4/2020	Classroom 9+	UV	800	9	203	690			28	12	216	324	1.7	5.8	3	NO	NO	1	403	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	107	11/4/2020	Classroom 9+	UV	800	9	404	809			28	12	216	324	3.4	6.7	3	YES	YES	-	404	-	YES		
Wixon	108	11/4/2020	Classroom 9+	UV	800	9	234	475			28	12	216	324	2.0	4.0	3	YES	NO	1	434	YES	YES	Clean unit to increase supply airflow.	
Wixon	109	11/4/2020	Classroom 9+	UV	800	9	272				28	12	216	324	2.3		3	YES	NO	1	472	YES	YES	Not accessible to measure supply air. Classroom items on top. Adjust OA damper position to aproximately 40%.	
Wixon	110	11/4/2020	Classroom 9+	UV	800	9	297	812			28	12	216	324	2.5	6.8	3	YES	NO	1	497	YES	YES	Adjust OA damper position to aproximately 40%.	
Wixon	111	11/4/2020	Office	None	200	9	0	0			1	1	17	26	0.0	0.0	1	NO	NO	-	0	-	YES	No mechanical ventilation present	
Wixon	115	11/4/2020	Classroom 9+	UV	800	9	441	887			28	12	216	324	3.7	7.4	3	YES	YES	-	441	-	YES		
Wixon	116	11/4/2020	Office	None	200	9	0	0			1	1	17	26	0.0	0.0	1	NO	NO	-	0	-	YES	No mechanical ventilation present	
Wixon	118	11/4/2020	Classroom 9+	UV	600	9	0	0			21	12	192	288	0.0	0.0	3	NO	NO	2	400	-	YES	No mechanical ventilation present	
Wixon	117	11/4/2020	Classroom 9+	UV	950	9	596	840		244	34	12	234	351	4.2	5.9	0	YES	YES	-	596	-	YES		
Wixon	Library	11/4/2020	Classroom 9+	(2) UV	2000	10	357	1574		1217	70	35	590	885	1.1	4.7	6	NO	NO	3	957	YES	YES	Adjust OA damper position to aproximately 40%.	
Station Ave School Assessed On 11/05/2020																									
Station Ave	310	11/5/2020	Conf/Meeting	Ceiling UV	900	9	732	1495	351	763	45	10	104	156	5.4	11.1	0	YES	YES	-	732	-	YES	HW no glycol. Pnuematics. EF-8, EFs above gym, 2 Efs above nurse office not operating.	EF 8 off @ starter switch. Turned back on. EF for nurse off because it was distracting to guidance office. 2 gym fans were off @ starter. Reset and checked ops. 11/25/2020 ms
Station Ave	311	11/5/2020	Classroom 9+	Ceiling UV	2100	9	962	1824	377	862	74	20	452	678	3.1	5.8	9	YES	YES	-	962	-	YES	Ceiling UV serves library spaces.	
Station Ave	312	11/5/2020	Office	Ceiling UV	150	9	57	114			1	2	19	29	2.5	5.1	1	YES	YES	-	57	-	YES		
Station Ave	321	11/5/2020	Office	Ceiling UV	150	9	0	0			1	2	19	29	0.0	0.0	0	NO	NO	-	0	YES	YES	Ceiling UV unit not operating.	Fixed pneumatic leak, now running. 11/19/2020 MS
Station Ave	Nurse	11/5/2020	Nurse	Ceiling UV	500	9	0	0			2	2	N/A	N/A	0.0	0.0	4	NO	NO	N/A	N/A	YES	NO	Ceiling UV unit not operating.	Fixed pneumatic leak, now running. 11/19/2020 MS
Station Ave	112 Reception	11/5/2020	Office	None	200	9	0	0			1	1	17	26	0.0	0.0	1	NO	NO	-	0	-	YES	No mechanical ventilation present.	
Station Ave	113	11/5/2020	Office	None	150	9	0	0			1	1	14	21	0.0	0.0	1	NO	NO	-	0	-	YES	No mechanical ventilation present.	
Station Ave	Gym	11/5/2020	Classroom 9+	HV-1&3	7000	25					245	100	1840	2760			0	-	-	N/A	N/A	-	-	Not accessible to measure although observed operating	
Station Ave	306	11/5/2020	Classroom 5-8	UV	750	9	100	644			19	10	190	285	0.9	5.7	4	NO	NO	1	300	YES	YES	Adjust OA damper position to aproximately 40%.	
Station Ave	305	11/5/2020	Classroom 5-8	UV	750	9	80	695			19	10	190	285	0.7	6.2	4	NO	NO	2	480	YES	YES	Adjust OA damper position to aproximately 40%.	
Station Ave	304	11/5/2020	Classroom 5-8	UV	1000	9	302	970			25	12	240	360	2.0	6.5	4	YES	NO	1	502	YES	YES	Adjust OA damper position to aproximately 40%.	
Station Ave	303	11/5/2020	Classroom 5-8	UV	750	9	337	656			19	10	190	285	3.0	5.8	4	YES	YES	-	337	-	YES		
Station Ave	302	11/5/2020	Classroom 5-8	UV	750	9	236	756			19	10	190	285	2.1	6.7	4	YES	NO	1	436	YES	YES	Adjust OA damper position to aproximately 40%.	

Date: 11/13/20	ROOM #	Date Tested	Room Occupancy Type	SERVED BY UNIT	ROOM (SQ. FT.)	CEILING HEIGHT (FT.)	OUTSIDE AIR CFM	SUPPLY CFM	EXHAUST CFM	RETURN CFM	ASHRAE 62.1 Suggested Occupancy	Hybrid Occupancy	ASHRAE 62.1 Ventilation Std	150% of ASHRAE 62.1 Ventilation Std	Ventilation Air Changes Per Hour	Total Air Changes Per Hour	Does This Space Have Operable Windows?	Does This Space Meet ASHRAE Ventilation Standard	Does This Space Meet 150% of ASHRAE Ventilation Standard	Does This Space Require Supplemental HEPA Filtration	Ventilation Air With Supplemental HEPA Filter	Could This Space Benefit from HVAC Equipment Repairs and/or Modifcations?	Will This Space Meet COVID Guidelines	ENE Assessment Notes:	Service Notes
Station Ave	220	11/5/2020	Office	NONE	200	9	0	0			1	1	17	26	0.0	0.0	1	NO	NO	-	0	-	YES	No mechanical ventilation present.	
Station Ave	219	11/5/2020	Office	NONE	200	9	0	0			1	1	17	26	0.0	0.0	1	NO	NO	-	0	-	YES	No mechanical ventilation present.	
Station Ave	209	11/5/2020	Classroom 5-8	UV	750	9	290	708			19	10	190	285	2.6	6.3	4	YES	YES	-	290	-	YES		
Station Ave	201	11/5/2020	Classroom 5-8	UV	750	9	214	746			19	10	190	285	1.9	6.6	4	YES	NO	1	414	YES	YES	Adjust OA damper position to aproximately 40%.	
Station Ave	202	11/5/2020	Classroom 5-8	UV	900	9	192	652			23	10	208	312	1.4	4.8	4	NO	NO	1	392	YES	YES	Adjust OA damper position to aproximately 40%. Clean unit and or replace filter to get more supply airflow	
Station Ave	203	11/5/2020	Classroom 5-8	UV	900	9	410	744			23	10	208	312	3.0	5.5	4	YES	YES	-	410	-	YES		
Station Ave	204	11/5/2020	Classroom 5-8	UV	900	9	90	554			23	10	208	312	0.7	4.1	4	NO	NO	2	490	YES	YES	Adjust OA damper position to aproximately 40%. Clean unit and or replace filter to get more supply airflow	
Station Ave	205	11/5/2020	Classroom 5-8	UV	900	9	202	622			23	10	208	312	1.5	4.6	4	NO	NO	1	402	YES	YES	Adjust OA damper position to aproximately 40%. Clean unit and or replace filter to get more supply airflow	
Station Ave	206	11/5/2020	Classroom 5-8	UV	900	9	318	734			23	10	208	312	2.4	5.4	4	YES	YES	-	318	-	YES		
Station Ave	207	11/5/2020	Classroom 5-8	UV	900	9	223	659			23	10	208	312	1.7	4.9	4	YES	NO	1	423	YES	YES	Adjust OA damper position to aproximately 40%. Clean unit and or replace filter to get more supply airflow	
Station Ave	208	11/5/2020	Classroom 5-8	UV	900	9	0	0			23	10	208	312	0.0	0.0	4	NO	NO	2	400	YES	YES	Unit is not operational.	Changed motor and transformer, now operating. 11/19/2020
Station Ave	Cafeteria	11/5/2020	Classroom 5-8	HV-2	2350	14	0	0			59	25	532	798	0.0	0.0	6	NO	NO	4	800	YES	YES	Unit is not operational.	Unit was off @ switch due to noise during school com.mtg and was never turned back on by maint. Back on now 11/19/2020 MS
Station Ave	Office 334	11/5/2020	Office	UV	300	9	210	541			2	1	23	35	4.7	12.0	2	YES	YES	-	210	-	YES		
Station Ave	335 Office	11/5/2020	Office	UV	300	9	187	580			2	1	23	35	4.2	12.9	2	YES	YES	-	187	-	YES		
Station Ave	101	11/5/2020	Classroom 5-8	UV	900	9	182	583			23	13	238	357	1.3	4.3	3	NO	NO	1	382	YES	YES	Adjust OA damper position to aproximately 40%. Clean unit and or replace filter to get more supply airflow	
Station Ave	109	11/5/2020	Classroom 5-8	UV	1200	9	126	765			30	13	274	411	0.7	4.3	4	NO	NO	2	526	YES	YES	Adjust OA damper position to aproximately 40%.	
Station Ave	108	11/5/2020	Classroom 5-8	UV	1200	9	179	710			30	13	274	411	1.0	3.9	4	NO	NO	2	579	YES	YES	Adjust OA damper position to aproximately 40%.	
Station Ave	107	11/5/2020	Classroom 5-8	UV	900	9	143	693			23	13	238	357	1.1	5.1	4	NO	NO	2	543	YES	YES	Adjust OA damper position to aproximately 40%.	
Station Ave	106	11/5/2020	Classroom 5-8	UV	900	9	170	596			23	13	238	357	1.3	4.4	4	NO	NO	1	370	YES	YES	Adjust OA damper position to aproximately 40%. Clean unit and or replace filter to get more supply airflow	
Station Ave	105	11/5/2020	Classroom 5-8	UV	900	9	232	587			23	13	238	357	1.7	4.3	4	NO	NO	1	432	YES	YES	Adjust OA damper position to aproximately 40%. Clean unit and or replace filter to get more supply airflow	
Station Ave	104	11/5/2020	Classroom 5-8	UV	900	9	288	626			23	13	238	357	2.1	4.6	4	YES	NO	1	488	YES	YES	Clean unit and or replace filter to get more supply airflow	
Station Ave	103	11/5/2020	Classroom 5-8	UV	900	9	249	576			23	13	238	357	1.8	4.3	4	YES	NO	1	449	YES	YES	Clean unit and or replace filter to get more supply airflow	
Station Ave	102	11/5/2020	Classroom 5-8	UV	900	9	100	544			23	13	238	357	0.7	4.0	4	NO	NO	2	500	YES	YES	Adjust OA damper position to aproximately 40%. Clean unit and or replace filter to get more supply airflow	

Appendix 4 – ASHRAE Infectious Aerosols April 2020

ASHRAE Position Document on Infectious Aerosols

Approved by ASHRAE Board of Directors
April 14, 2020

Expires
April 14, 2023

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COMMITTEE ROSTERS

The ASHRAE Position Document on Infectious Aerosols was developed by the Society's Environmental Health Position Document Committee formed on April 24, 2017, with Erica Stewart as its chair.

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HISTORY OF REVISION/REAFFIRMATION/WITHDRAWAL DATES

The following summarizes this document's revision, reaffirmation, and withdrawal dates:

6/24/2009—BOD approves Position Document titled *Airborne Infectious Diseases*

1/25/2012—Technology Council approves reaffirmation of Position Document titled *Airborne Infectious Diseases*

1/19/2014—BOD approves revised Position Document titled *Airborne Infectious Diseases*

1/31/2017—Technology Council approves reaffirmation of Position Document titled *Airborne Infectious Diseases*

2/5/2020—Technology Council approves reaffirmation of Position Document titled *Airborne Infectious Diseases*

4/14/2020—BOD approves revised Position Document titled *Infectious Aerosols*

Note: ASHRAE's Technology Council and the cognizant committee recommend revision, reaffirmation, or withdrawal every 30 months.

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.

CONTENTS

ASHRAE Position Document on Infectious Aerosols

ABSTRACT

The pathogens that cause infectious diseases are spread from a primary host to secondary hosts via several different routes. Some diseases are known to spread by infectious aerosols; for other diseases, the route of transmission is uncertain. The risk of pathogen spread, and therefore the number of people exposed, can be affected both positively and negatively by the airflow patterns in a space and by heating, ventilating, and air-conditioning (HVAC) and local exhaust ventilation (LEV) systems. ASHRAE is the global leader and foremost source of technical and educational information on the design, installation, operation, and maintenance of these systems. Although the principles discussed in this position document apply primarily to buildings, they may also be applicable to other occupancies, such as planes, trains, and automobiles.

ASHRAE will continue to support research that advances the knowledge base of indoor air-management strategies aimed to reduce occupant exposure to infectious aerosols. Chief among these ventilation-related strategies are dilution, airflow patterns, pressurization, temperature and humidity distribution and control, filtration, and other strategies such as ultraviolet germicidal irradiation (UVGI). 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.

To better specify the levels of certainty behind ASHRAE's policy positions stated herein, we have chosen to adopt the Agency for Healthcare Research and Quality (AHRQ) rubric for expressing the scientific certainty behind our recommendations (Burns et al. 2011). These levels of certainty, as adapted for this position document, are as follows:

Evidence Level	Description
A	Strongly recommend; good evidence
B	Recommend; at least fair evidence
C	No recommendation for or against; balance of benefits and harms too close to justify a recommendation
D	Recommend against; fair evidence is ineffective or the harm outweighs the benefit
E	Evidence is insufficient to recommend for or against routinely; evidence is lacking or of poor quality; benefits and harms cannot be determined

ASHRAE's position is that 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 nonresidential 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.

EXECUTIVE SUMMARY

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.

Designers of mechanical systems should be aware that ventilation is not capable of addressing all aspects of infection control. HVAC systems,[1] however, do impact the distribution and bio-burden of infectious aerosols. Small aerosols may persist in the breathing zone, available for inhalation directly into the upper and lower respiratory tracts or for settling onto surfaces, where they can be indirectly transmitted by resuspension or fomite[2] contact.

Infectious aerosols can pose an exposure risk, regardless of whether a disease is classically defined as an "airborne infectious disease." This position document covers strategies through which HVAC systems modulate aerosol[3] distribution and can therefore increase or decrease exposure to infectious droplets,[4] droplet nuclei,[5] surfaces, and intermediary fomites[6] in a variety of environments.

This position document provides recommendations on the following:

- The design, installation, and operation of heating, ventilating, and air-conditioning (HVAC) systems, including air-cleaning, and local exhaust ventilation (LEV) systems, to decrease the risk of infection transmission.
- Non-HVAC control strategies to decrease disease risk.
- Strategies to support facilities management for both everyday operation and emergencies.

Infectious diseases can be controlled by interrupting the transmission routes used by a pathogen. HVAC professionals play an important role in protecting building occupants by interrupting the indoor dissemination of infectious aerosols with HVAC and LEV systems.

COVID-19 Statements

Separate from the approval of this position document, ASHRAE's Executive Committee and Epidemic Task Force approved the following statements specific to the ongoing response to the COVID-19 pandemic. The two statements are appended here due to the unique relationship between the statements and the protective design strategies discussed in this position document:

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

[1] Different HVAC systems are described in *ASHRAE Handbook—HVAC Systems and Equipment* (ASHRAE 2020).
[2] An object (such as a dish or a doorknob) that may be contaminated with infectious organisms and serve in their transmission.
[3] An aerosol is a system of liquid or solid particles uniformly distributed in a finely divided state through a gas, usually air. They are small and buoyant enough to behave much like a gas.
[4] In this document, *droplets* are understood to be large enough to fall to a surface in 3–7 ft (1–2 m) and thus not become aerosols.
[5] Droplet nuclei are formed from droplets that become less massive by evaporation and thus may become aerosols.
[6] Fomite transmission is a form of indirect contact that occurs through touching a contaminated inanimate object such as a doorknob, bed rail, television remote, or bathroom surface.

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.

1. THE ISSUE

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 disease varies by pathogen infectivity, reservoirs, routes, and secondary host susceptibility (Roy and Milton 2004; Shaman and Kohn 2009; Li 2011). 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 (a microbe that causes disease) is carried in an initial host or reservoir, gains access to a route of ongoing transmission, and with sufficient virulence 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.

Building science professionals must recognize the importance of facility operations and ventilation systems in interrupting disease transmission. Non-HVAC measures for breaking the chain of infection, such as effective surface cleaning, contact and isolation precautions mandated by employee and student policies, and vaccination regimens, are effective strategies that are beyond the scope of this document. Dilution and extraction ventilation, pressurization, airflow distribution and optimization, mechanical filtration, ultraviolet germicidal irradiation (UVGI), and humidity control are effective strategies for reducing the risk of dissemination of infectious aerosols in buildings and transportation environments.

Although this position document is primarily applicable to viral and bacterial diseases that can use the airborne route for transmission from person to person, the principles of containment may also apply to infection from building reservoirs such as water systems with *Legionella spp.* and organic matter containing spores from mold (to the extent that the microorganisms are spread by the air). The first step in control of such diseases is to eliminate the source before it becomes airborne.

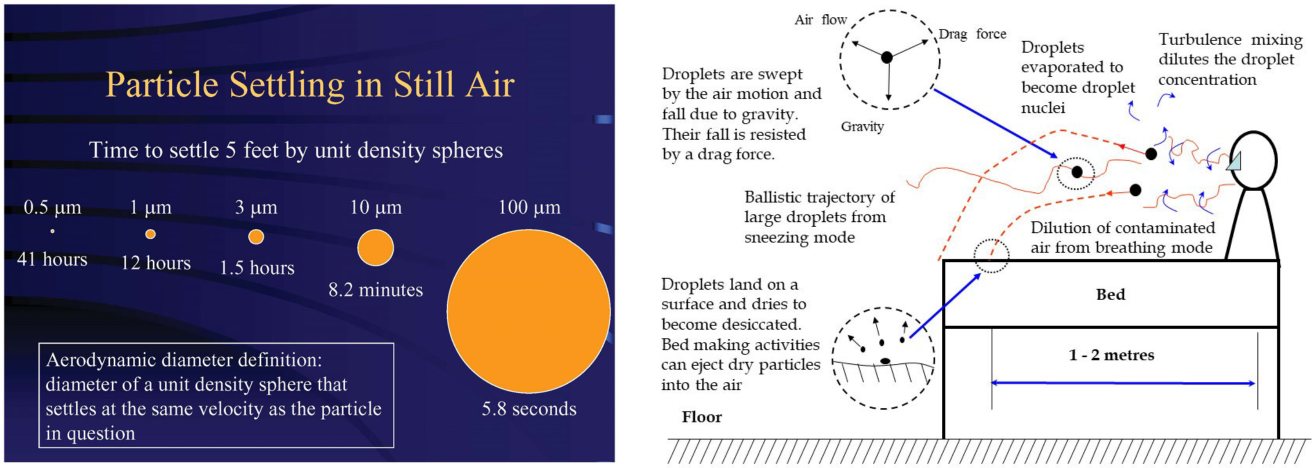
2. BACKGROUND

ASHRAE provides guidance and develop standards intended to mitigate the risk of infectious disease transmission in the built environment. Such documents provide engineering strategies for reducing the risk of disease transmission and therefore could be employed in a variety of other spaces, such as planes, trains, and automobiles.

This position document covers the dissemination of infectious aerosols and indirect transmission by resuspension but not direct-contact routes of transmission. *Direct contact* generally refers to bodily contact such as touching, kissing, sexual contact, contact with oral secretions or skin lesions and routes such as blood transfusions or intravenous injections.

2.1 Airborne Dissemination

Pathogen dissemination through the air occurs through droplets and aerosols typically generated by coughing, sneezing, shouting, breathing, toilet flushing, some medical procedures, singing, and talking (Bischoff et al. 2013; Yan et al. 2018). The majority of larger emitted droplets are drawn by gravity to land on surfaces within about 3–7 ft (1–2 m) from the source (see Figure 1). General dilution ventilation and pressure differentials do not significantly influ-



(a) (b)

Figure 1 (a) Comparative settling times by particle diameter for particles settling in still air (Baron n.d.) and (b) theoretical aerobiology of transmission of droplets and small airborne particles produced by an infected patient with an acute infection (courtesy Yuguo Li).

ence short-range transmission. Conversely, dissemination of smaller infectious aerosols, including droplet nuclei resulting from desiccation, can be affected by airflow patterns in a space in general and airflow patterns surrounding the source in particular. Of special interest are small aerosols (<10 µm), which can stay airborne and infectious for extended periods (several minutes, hours, or days) and thus can travel longer distances and infect secondary hosts who had no contact with the primary host.

Many diseases are known to have high transmission rates via larger droplets when susceptible individuals are within close proximity, about 3–7 ft (1–2 m) (Nicas 2009; Li 2011). Depending on environmental factors, these large (100 µm diameter) droplets may shrink by evaporation before they settle, thus becoming an aerosol (approximately <10 µm). The term *droplet nuclei* has been used to describe such desiccation of droplets into aerosols (Siegel et al. 2007). 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.

3. PRACTICAL IMPLICATIONS FOR BUILDING OWNERS, OPERATORS, AND ENGINEERS

Even the most robust HVAC system cannot control all airflows and completely prevent dissemination of an infectious aerosol or disease transmission by droplets or aerosols. An HVAC system's impact will depend on source location, 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. Thus, strategies for prevention and risk mitigation require collaboration among designers, owners, operators, industrial hygienists, and infection prevention specialists.

3.1 Varying Approaches for Facility Type

Healthcare facilities have criteria for ventilation design to mitigate airborne transmission of infectious diseases (ASHRAE 2013, 2017a, 2019a; FGI 2010); however, infections are also transmitted in ordinary occupancies in the community and not only in industrial or healthcare occupancies. 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.

In healthcare facilities, most infection control interventions are geared at reducing direct or indirect contact transmission of pathogens. These interventions for limiting airborne transmission (Aliabadi et al. 2011) emphasize personnel education and surveillance of behaviors such as hand hygiene and compliance with checklist protocols and have largely been restricted to a relatively small list of diseases from pathogens that spread only through the air. Now that microbiologists understand that many pathogens can travel through both contact and airborne routes, the role of indoor air management has become critical to successful prevention efforts. In view of the broader understanding of flexible pathogen transmission modes, healthcare facilities now use multiple modalities simultaneously (measures that are referred to as *infection control bundles*) (Apisarnthanarak et al. 2009, 2010a, 2010b; Cheng et al. 2010). For example, in the cases of two diseases that clearly utilize airborne transmission, tuberculosis and measles, bundling includes administrative regulations, environmental controls, and personal protective equipment protocols in healthcare settings. This more comprehensive approach is needed to control pathogens, which can use both contact and airborne transmission pathways. Similar strategies may be appropriate for non-healthcare spaces, such as public transit and airplanes, schools, shelters, and prisons, that may also be subject to close contact of occupants.

Many buildings are fully or partially naturally ventilated. They may use operable windows and rely on intentional and unintentional openings in the building envelope. These strategies create different risks and benefits. Obviously, the airflow in these buildings is variable and unpredictable, as are the resulting air distribution patterns, so the ability to actively manage risk in such buildings is much reduced. However, naturally ventilated buildings can go beyond random opening of windows and be engineered intentionally to achieve ventilation strategies and thereby reduce risk from infectious aerosols. 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. The World Health Organization has published guidelines for naturally ventilated buildings that should be consulted in such projects (Atkinson et al. 2009).

3.2 Ventilation and Air-Cleaning Strategies

The design and operation of HVAC systems can affect infectious aerosol transport, but they are only one part of an infection control bundle. The following HVAC strategies have the potential to reduce the risks of infectious aerosol dissemination: air distribution patterns, differential room pressurization, personalized ventilation, source capture ventilation, filtration (central or local), and controlling temperature and relative humidity. While UVGI is well researched and validated, many new technologies are not (ASHRAE 2018). (Evidence Level B)

Ventilation with effective airflow patterns (Pantelic and Tham 2013) is a primary infectious disease control strategy through dilution of room air around a source and removal of infectious agents (CDC 2005). However, it remains unclear by how much infectious particle loads must be reduced to achieve a measurable reduction in disease transmissions (infectious doses vary widely among different pathogens) and whether these reductions warrant the associated costs (Pantelic and Tham 2011; Pantelic and Tham 2012). (Evidence Level B)

Room pressure differentials and directional airflow are important for controlling airflow between zones in a building (CDC 2005; Siegel et al. 2007) (Evidence Level B). Some designs for airborne infection isolation rooms (AIIRs) incorporate supplemental dilution or exhaust/ capture ventilation (CDC 2005). Interestingly, criteria for AIIRs differ substantially between regions and countries in several ways, including air supply into anterooms, exhaust from space, and required amounts of ventilation air (Fusco et al. 2012; Subhash et al. 2013). A recent ASHRAE Research Project found convincing evidence that a properly configured and operated anteroom is an effective means to maintain pressure differentials and create containment in hospital rooms (Siegel et al. 2007; Mousavi et al. 2019). Where a significant risk of transmission of aerosols has been identified by infection control risk assessments, design of AIIRs should include anterooms. (Evidence Level A)

The use of highly efficient particle filtration in centralized HVAC systems reduces the airborne load of infectious particles (Azimi and Stephens 2013). This strategy reduces the transport of infectious agents from one area to another when these areas share the same central HVAC system through supply of recirculated air. When appropriately selected and deployed, single-space high-efficiency filtration units (either ceiling mounted or portable) can be highly effective in reducing/lowering concentrations of infectious aerosols in a single space. They also achieve directional airflow source control that provides exposure protection at the patient bedside (Miller-Leiden et al. 1996; Mead and Johnson 2004; Kujundzic et al. 2006; Mead et al. 2012; Dungi et al. 2015). Filtration will not eliminate all risk of transmission of airborne particulates because many other factors besides infectious aerosol concentration contribute to disease transmission. (Evidence Level A)

The entire ultraviolet (UV) spectrum can kill or inactivate microorganisms, but UV-C energy (in the wavelengths from 200 to 280 nm) provides the most germicidal effect, with 265 nm being the optimum wavelength. The majority of modern UVGI lamps create UV-C energy at a near-optimum 254 nm wavelength. UVGI inactivates microorganisms by damaging the structure of nucleic acids and proteins with the effectiveness dependent upon the UV dose and the susceptibility of the microorganism. The safety of UV-C is well known. It does not penetrate deeply into human tissue, but it can penetrate the very outer surfaces of the eyes and skin, with the eyes being most susceptible to damage. Therefore, shielding is needed to prevent direct exposure to the eyes. While *ASHRAE Position Document on Filtration and Air Cleaning* (2018) does not make a recommendation for or against the use of UV energy in air systems for minimizing the risks from infectious aerosols, Centers for Disease Control and Prevention (CDC) has approved UVGI as an adjunct to filtration for reduction of tuberculosis risk and has published a guideline on its application (CDC 2005, 2009).[7] (Evidence Level A)

Personalized ventilation systems that provide local exhaust source control and/or supply 100% outdoor, highly filtered, or UV-disinfected air directly to the occupant's breathing zone (Cermak et al. 2006; Bolashikov et al., 2009; Pantelic et al. 2009, 2015; Licina et al. 2015a, 2015b) may offer protection against exposure to contaminated air. Personalized ventilation may be effective against aerosols that travel both long distances as well as short ranges (Li 2011).

[7] In addition to UVGI, optical radiation in longer wavelengths as high as 405 nm is an emerging disinfection technology that may also have useful germicidal effectiveness.

Personalized ventilation systems, when coupled with localized or personalized exhaust devices, further enhance the overall ability to mitigate exposure in breathing zones, as seen from both experimental and computational fluid dynamics (CFD) studies in healthcare settings (Yang et al. 2013, 2014, 2015a, 2015b; Bolashikov et al. 2015; Bivolarova et al. 2016). However, there are no known epidemiological studies that demonstrate a reduction in infectious disease transmission. (Evidence Level B)

Advanced techniques such as computational fluid dynamics (CFD) analysis, if performed properly with adequate expertise, can predict airflow patterns and probable flow paths of airborne contaminants in a space. Such analyses can be employed as a guiding tool during the early stages of a design cycle (Khankari 2016, 2018a, 2018b, 2018c).

3.3 Temperature and Humidity

HVAC systems are typically designed to control temperature and humidity, which can in turn influence transmissibility of infectious agents. Although HVAC systems can be designed to control relative humidity (RH), there are practical challenges and potential negative effects of maintaining certain RH set points in all climate zones. However, while the weight of evidence at this time (Derby et al. 2016), including recent evidence using metagenomic analysis (Taylor and Tasi 2018), suggests that controlling RH reduces transmission of certain airborne infectious organisms, including some strains of influenza, this position document encourages designers to give careful consideration to temperature and RH.

In addition, immunobiologists have correlated mid-range humidity levels with improved mammalian immunity against respiratory infections (Taylor and Tasi 2018). Mousavi et al. (2019) report that the scientific literature generally reflects the most unfavorable survival for microorganisms when the RH is between 40% and 60% (Evidence Level B). Introduction of water vapor to the indoor environment to achieve the mid-range humidity levels associated with decreased infections requires proper selection, operation, and maintenance of humidification equipment. Cold winter climates require proper building insulation to prevent thermal bridges that can lead to condensation and mold growth (ASHRAE 2009). Other recent studies (Taylor and Tasi 2018) identified RH as a significant driver of patient infections. These studies showed that RH below 40% is associated with three factors that increase infections. First, as discussed previously, infectious aerosols emitted from a primary host shrink rapidly to become droplet nuclei, and these dormant yet infectious pathogens remain suspended in the air and are capable of traveling great distances. When they encounter a hydrated secondary host, they rehydrate and are able to propagate the infection. Second, many viruses and bacteria are anhydrous resistant (Goffau et al. 2009; Stone et al. 2016) and actually have increased viability in low-RH conditions. And finally, immunobiologists have now clarified the mechanisms through which ambient RH below 40% impairs mucus membrane barriers and other steps in immune system protection (Kudo et al. 2019). (Evidence Level B)

This position document 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.

3.4 Emerging Pathogens and Emergency Preparedness

Disease outbreaks (i.e., epidemics and pandemics) are increasing in frequency and reach. Pandemics of the past have had devastating effects on affected populations. Novel microorganisms that can be disseminated by infectious aerosols necessitate good design, construction, commissioning, maintenance, advanced planning, and emergency drills to facilitate fast action to mitigate exposure. In many countries, common strategies include naturally ventilated buildings and isolation. Control banding is a risk management strategy that should be considered for applying the hierarchy of controls to emerging pathogens, based on the likelihood and duration of exposure and the infectivity and virulence of the pathogen (Sietsema 2019) (Evidence Level B). Biological agents that may be used in terrorist attacks are addressed elsewhere (USDHHS 2002, 2003).

4. CONCLUSIONS AND RECOMMENDATIONS

Infectious aerosols can be disseminated through buildings by pathways that include air distribution systems and interzone airflows. Various strategies have been found to be effective at controlling transmission, including optimized airflow patterns, directional airflow, zone pressurization, dilution ventilation, in-room air-cleaning systems, general exhaust ventilation, personalized ventilation, local exhaust ventilation at the source, central system filtration, UVGI, and controlling indoor temperature and relative humidity. Design engineers can make an essential contribution to reducing infectious aerosol transmission through the application of these strategies. Research on the role of airborne dissemination and resuspension from surfaces in pathogen transmission is rapidly evolving. Managing indoor air to control distribution of infectious aerosols is an effective intervention which adds another strategy to medical treatments and behavioral interventions in disease prevention.

4.1 ASHRAE's Positions

- HVAC design teams for facilities of all types should follow, as a minimum, the latest published standards and guidelines and good engineering practice. 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.
- 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 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.
- Based on risk assessments, buildings and transportation vehicles should 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. (Evidence Level A)
- Where a significant risk of transmission of aerosols has been identified by infection control risk assessments, design of AIIRs should include anterooms. (Evidence Level A)

- Based on risk assessments, the use of specific HVAC strategies supported by the evidence-based literature should be considered, including the following:
  - Enhanced filtration (higher minimum efficiency reporting value [MERV] filters over code minimums in occupant-dense and/or higher-risk spaces) (Evidence Level A)
  - Upper-room UVGI (with possible in-room fans) as a supplement to supply airflow (Evidence Level A)
  - Local exhaust ventilation for source control (Evidence Level A)
  - Personalized ventilation systems for certain high-risk tasks (Evidence Level B)
  - Portable, free-standing high-efficiency particulate air (HEPA) filters (Evidence Level B)
  - Temperature and humidity control (Evidence Level B)
- Healthcare buildings[8] should consider design and operation to do the following:
  - Capture expiratory aerosols with headwall exhaust, tent or snorkel with exhaust, floor-to-ceiling partitions with door supply and patient exhaust, local air HEPA-grade filtration.
  - Exhaust toilets and bed pans (a must).
  - Maintain temperature and humidity as applicable to the infectious aerosol of concern.
  - Deliver clean air to caregivers.
  - Maintain negatively pressurized intensive care units (ICUs) where infectious aerosols may be present.
  - Maintain rooms with infectious aerosol concerns at negative pressure.
  - Provide 100% exhaust of patient rooms.
  - Use UVGI.
  - Increase the outdoor air change rate (e.g., increase patient rooms from 2 to 6 ach).
  - Establish HVAC contributions to a patient room turnover plan before reoccupancy.
- Non-healthcare buildings should have a plan for an emergency response. The following modifications to building HVAC system operation should be considered:
  - 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.
- Design and build inherent capabilities to respond to emerging threats and plan and practice for them. (Evidence Level B)

[8] It is assumed that healthcare facilities already have emergency response plans.

4.2 ASHRAE's Commitments

- Address research gaps with future research projects, including those on the following topics:
  - Investigating and developing source generation variables for use in an updated ventilation rate procedure
  - Understanding the impacts of air change rates in operating rooms on patient outcomes
  - Determining the effectiveness of location of supply, return, and exhaust registers in patient rooms
  - Conducting controlled interventional studies to quantify the relative airborne infection control performance and cost-effectiveness of specific engineering strategies, individually and in combination, in field applications of high-risk occupancies
  - Evaluating and comparing options to create surge airborne isolation space and temporary negative pressure isolation space and the impacts on overall building operation
  - Understanding the appropriate application of humidity and temperature control strategies across climate zones on infectious aerosol transmission
  - Investigating how control banding techniques can be applied to manage the risk of infectious aerosol dissemination
- Partner with infection prevention, infectious disease, and occupational health experts and building owners to evaluate emerging control strategies and provide evidence-based recommendations.
- Educate stakeholders and disseminate best practices.
- Create a database to track and share knowledge on effective, protective engineering design strategies.
- Update standards and guidelines to reflect protective evidence-based strategies.

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Appendix 5 – ASHRAE Reopening Schools & Universities

ASHRAE EPIDEMIC TASK FORCE

SCHOOLS & UNIVERSITIES | Updated 7-17-2020

Introduction

Protecting the health, safety and welfare of the world's students from the spread of SARS-Cov-2 (the virus that causes COVID-19 disease) is essential to protecting the health, safety and welfare of the entire population.

ASHRAE's position is that "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 [HVAC] systems, can reduce airborne exposures."

There is broad variation of complexity, flexibility, and age in HVAC equipment, systems, controls and Building Automation Systems (BAS) in educational facilities.

This guidance has been formulated to help designers retrofit and plan for the improvement of indoor air quality and to slow the transmission of viruses via the HVAC systems. The underlying effort of the designer should be to increase outside air to the spaces and treat return air. The designer should also be concerned with mechanical filtration of the supply air and maintaining indoor comfort as defined by the design temperature and relative humidity.

This guidance should be applied to each unique climate zone, unique school building and HVAC system. All retrofits and modifications must not contradict ASHRAE 62.1 guidelines and must continue to or exceed the standards and codes adopted by local jurisdictions. The designer needs to work closely with the local school system to work in conjunction with new operational protocols and school operations.

The following is meant to provide practical information and checklists to school district and university campus environmental health managers, facility managers, administrators, technicians, and service providers to prepare educational buildings to resume occupancy. This information describes how the HVAC systems should be operating to help minimize the chance of spreading SARS-Cov-2 and how to practically check/verify that operation.

Determining Building Readiness and Operations for Existing Facilities to Reoccupy After Shut-Down due to Pandemic

These recommendations and strategies are organized in order from simple first steps, more involved next steps and then more long-term improvements

1. Create a District or Campus Health and Safety Committee that includes all stakeholders (environmental health and safety, administration, education staff, operations staff, local healthcare providers, etc.)

2. Develop policies for staff and contractor PPE requirements for completing work at facilities that follow local authority, CDC, and OSHA guidelines for the proper use of Personal Protective Equipment (PPE).

3. Where semi-annual / annual scheduled maintenance on the equipment can be performed safely, do not defer this maintenance cycle.

4. Where worker safety could be at risk, defer semi-annual/ annual maintenance on the equipment up to 60 days until worker safety can be accomplished.

5. During the summer period before occupancy perform Checklist No. 1 Summer Checklist for Fall Start of Classes.

6. Operate all HVAC in occupied mode for a minimum of one week prior to occupancy.

7. During the week prior to occupancy perform Checklist No. 2 Startup Checklist for HVAC Systems Prior to Occupancy.

Checklist No. 1:
Summer Checklist for Fall Start of Classes

- ❑ Review design guidance for potential system modifications to comply with this guidance.
- ❑ Review air distribution conditions of existing spaces (look for covered diffusers, blocked return grilles, overly closed supply diffusers/registers and return/exhaust grilles creating short cycling, possible measurements of airflows by commissioning or balancing professionals, possible review of overall system configuration by design professional, etc.)
- ❑ Review existing Indoor Air Quality issues, if any, records of documents and investigate current status of complaint and address any deficiencies identified, if possible.
- ❑ General inspection of spaces to identify any potential concerns for water leaks or mold growth that could negatively impact occupant health.
- ❑ Check all lavatories and sinks for correct operation and ensure soap dispensers are functional and adequate supply of soap is available to allow for proper handwashing.
- ❑ Coordinate with local utilities to identify when buildings will be restarted, identify when systems will be operated (if different than prior operations) and identify that demands may increase (primarily electric but gas may apply as well for some facilities).
- ❑ Consider completing preventative and deferred maintenance projects not directly related to pandemic, but potentially improving facility IEQ:
  - ❑ Clean/disinfect building surfaces, focusing on high touch surfaces – secure spaces from access once cleaning is complete.
  - ❑ Consider asbestos abatement work if applicable.
  - ❑ Consider lead paint abatement work if applicable.
  - ❑ Consider access improvements, including repairs to walkways and ramps, ADA upgrades, handrail repairs, etc.
  - ❑ Consider grounds work including improvement of water drainage away from buildings, planting of native plants or trees to help control water penetration into ground and shading of facilities to reduce cooling load.
- ❑ Review control sequences to verify systems are operating according to this guidance to maintain required ventilation, temperature and humidity conditions to occupied areas.

Checklist No. 2:

Startup Checklist for HVAC Systems Prior to Occupancy

- ❑ Maintain proper indoor air temperature and humidity to maintain human comfort, reduce potential for spread of airborne pathogens and limit potential for mold growth in building structure and finishes (refer to ASHRAE Standard 55, recommended temperature ranges of 68-78 degrees F dry bulb depending on operating condition and other factors, recommend limiting maximum RH to 60%). Consider consulting with a local professional engineer to determine appropriate minimum RH levels based on local climate conditions, type of construction and age of the building under consideration. Recommend minimum RH of 40% if appropriate for building. Consider the addition of humidification equipment only when reviewed by a design professional to verify minimum RH set points will not adversely impact building or occupants by contributing to condensation and possible biological growth in building envelope.
- ❑ Trend and monitor temperature and humidity levels in each space to the extent possible and within the capability of BAS, portable data loggers and handheld instruments.
- ❑ Verify proper separation between outdoor air intakes and exhaust discharge outlets to prevent/limit re-entrainment of potentially contaminated exhaust air (generally minimum of 10-foot separation - comply with local code requirements).
- ❑ Consider having airflows and building pressurization measured/balanced by a qualified Testing, Adjusting and Balancing (TAB) service provider.
- ❑ Consider having airflows and system capacities reviewed by design professionals to determine if additional ventilation can be provided without adversely impacting equipment performance and building Indoor Environmental Quality (IEQ).
- ❑ Measure building pressure relative to the outdoors. Adjust building air flows to prevent negative pressure differential.
- ❑ Verify coil velocities and coil and unit discharge air temperatures required to maintain desired indoor conditions and to avoid moisture carry over from cooling coils.
- ❑ Review outdoor airflow rates compared to the most current version of ASHRAE Standard 62.1 or current state-adopted code requirements.

Checklist No. 2 Continued:

Startup Checklist for HVAC Systems Prior to Occupancy

- **Filtration in all mechanical equipment:**
  - ❑ Verify filters are installed correctly.
  - ❑ Develop standards for frequency of filter replacement and type of filters to be utilized.
  - ❑ Select filtration levels (MERV ratings) that are maximized for equipment capabilities, use MERV 13 if equipment allows, while assuring the pressure drop is less than the fans capability. See Filtration Upgrades.

❑ **If Demand-Controlled Ventilation (DCV) systems using Carbon Dioxide (CO_2) sensors are installed, operate systems to maintain maximum CO_2 concentrations of 800-1,000 Parts Per Million (ppm) in occupied spaces:**
  - ❑ Trend and monitor levels continuously if controls system is capable of doing so (use portable data loggers and handheld instruments and document readings where needed to demonstrate compliance with District or Campus requirements).
  - ❑ Consider adjusting to maximize outdoor air or disabling operation of DCV if it will not adversely impact operation of overall system (Temporary recommendation while operating under infectious disease crisis).

❑ **Perform initial air flush of all spaces prior to occupants re-entering building:**
  - ❑ Mechanical systems should operate in occupied mode for minimum period of one week prior to students returning (may be completed at same time as teachers start returning to building) while assuring the outside air dampers are open.

❑ **Domestic water systems shall be prepared for use:**
  - ❑ Systems should be flushed to remove potential contaminants from stagnant equipment, piping, fixtures, etc.
  - ❑ Domestic cold-water systems should be flushed with all fixtures on a branch of piping opened simultaneously for a minimum period of five minutes – preferred approach is to have all building fixtures open at same time if possible – if not, care should be taken to ensure flow rate is adequate to flush piping mains and branch lines.
  - ❑ Domestic hot water systems should be flushed with all fixtures on a branch of piping opened simultaneously for a minimum period of 15 minutes – preferred approach is to have all building fixtures open at same time if possible – if not, care should be taken to ensure flow rate is adequate to flush piping mains and branch lines.
  - ❑ Reference Standard 188 and Guideline 12 (available read-only on website)

Equipment and System Specific Checks and Verifications During the Academic Year

Cleaning and Air Flush: Daily

- ❑ Daily flush prior to occupancy: Mechanical Systems should be operated in occupied mode (including normal or peak outside air rate introduced to each space) for minimum period of 2 hours prior to occupants re-entering building.

- ❑ Cleaning:
  - ❑ All areas that have been occupied after previous cleaning efforts should be re-cleaned.
  - ❑ All restrooms should be thoroughly cleaned.
  - ❑ All food preparation areas should be thoroughly cleaned.
  - ❑ Any spaces not previously cleaned should have all accessible surfaces properly cleaned.

Boilers: Monthly

- ❑ For systems with Steam Boilers, develop a schedule that provides minimum supervision on-site.

- ❑ Perform chemical testing of system water. Verify water treatment target levels are being maintained.

- ❑ For systems using fuel oil:
  - ❑ Check fuel pump for proper operation.
  - ❑ Inspect fuel filter; clean and verify proper operation.

- ❑ For systems using natural gas:
  - ❑ Check gas pressure, gas valve operation, and combustion fan operation.
  - ❑ Check for evidence of leakage of fuel supply, heat transfer fluid, and flue gas.

- ❑ Verify proper operation of safety devices per manufacturer's recommendations.

Equipment and System Specific Checks and Verifications During the Academic Year Continued

Chilled Water, Hot Water and Condenser Water Systems: Monthly

- ❑ Perform chemical testing of system water. Verify water treatment target levels are being maintained.
- ❑ Check the control system and devices for evidence of improper operation.
- ❑ Verify control valves operate properly.
- ❑ Check variable-frequency drives for proper operation.

Air Cooled Chillers: Monthly

- ❑ Check the refrigerant system for evidence of leaks.
- ❑ Check and clean fan blades and fan housing.
- ❑ Check coil fins and check for damage.
- ❑ Check for proper evaporator fluid flow and for fluid leaks.

Water Cooled Chillers: Monthly

- ❑ Check the refrigerant system for evidence of leaks.
- ❑ Check for proper evaporator and condenser fluid flow and for fluid leaks.
- ❑ Check compressor oil level and/or pressure on refrigerant systems having oil level and/or pressure measurement means.

Equipment and System Specific Checks and Verifications During the Academic Year Continued

Cooling Towers and Evaporative-Cooled Devices Monthly

- ❑ Perform chemical testing of system water. Verify water treatment target levels are being maintained.
- ❑ Check chemical injector device for proper operation.
- ❑ Check conductivity and other sensors for proper readings.
- ❑ Check the water system ultraviolet lamp, replace bulbs as needed (if applicable).
- ❑ Check the control system and devices for evidence of improper operation.
- ❑ Check variable frequency drive for proper operation.
- ❑ Check for proper condenser water flow and for leaks.
- ❑ Check for proper damper operation.
- ❑ Inspect pumps and associated electrical components for leaks and normal operation.
- ❑ Verify control valves operate properly.

Steam Distribution Systems: Monthly

- ❑ Perform chemical testing of system condensate and feed water.
- ❑ Check piping for leaks.
- ❑ Check steam traps and condensate return units for proper operation.
- ❑ Check safety devices per manufacturer’s recommendations.
- ❑ Verify control valves operate properly.

Equipment and System Specific Checks and Verifications During the Academic Year Continued

HVAC Water Distribution Systems: Monthly

- ❑ Perform chemical testing of system water. Verify water treatment target levels are being maintained.
- ❑ Check for proper fluid flow and for fluid leaks. If necessary, vent air from system high points and
- ❑ verify backflow preventers and pressure regulating valves on makeup water lines are functioning properly.
- ❑ Check expansion tanks and bladder type compression tanks have not become waterlogged.
- ❑ Verify control valves operate properly.

Pumps: Annually

- ❑ Inspect pumps and associated electrical components for proper operation.
- ❑ Check variable-frequency drive for proper operation.
- ❑ Check the control system and devices for evidence of improper operation.

Equipment and System Specific Checks and Verifications During the Academic Year Continued

Air Handling Units: Monthly

- ❑ Check for particulate accumulation on filters, replace filter as needed.
- ❑ Check ultraviolet lamp, replace bulbs as needed (if applicable).
- ❑ Check P-trap on drain pan.
- ❑ Check the control system and devices for evidence of improper operation.
- ❑ Check variable-frequency drive for proper operation.
- ❑ Check drain pans for cleanliness and proper slope.
- ❑ Verify control dampers operate properly.
- ❑ Confirm AHU is bringing in outdoor air and removing exhaust air as intended.
- ❑ Verify filters are installed correctly.
- ❑ Follow filter replacement policy.
- ❑ Review condition of cooling coils in air handling equipment – if issues with condensate drainage are identified or biological growth is identified, corrective action should be taken to clean or repair.

Equipment and System Specific Checks and Verifications During the Academic Year Continued

Roof Top Units: Monthly

- ❑ Check for particulate accumulation on outside air intake screens and filters. Replace filter as needed.
- ❑ Check ultraviolet lamp, replace bulbs as needed (if applicable).
- ❑ Check P-trap.
- ❑ Check drain pans for cleanliness and proper slope.
- ❑ Check the control system and devices for evidence of improper operation.
- ❑ Check variable frequency drive for proper operation.
- ❑ Check refrigerant system for leaks.
- ❑ Check for evidence of leaks on gas heat section heat-exchanger surfaces.
- ❑ For fans with belt drives, inspect belts and adjust as necessary.
- ❑ Verify control dampers operate properly.

Equipment and System Specific Checks and Verifications During the Academic Year Continued

Unitary and Single Zone Equipment (For example: Wall Hung Units, Unit Ventilators, Mini-Splits, Packaged Terminal Air Conditioners, Water-Source Heat Pumps, Fan Coil Units)**:**

Monthly

- ❑ Check for particulate accumulation on filters, replace filter as needed.
- ❑ Check P-trap.
- ❑ Check drain pans for cleanliness and proper slope.
- ❑ Check the control system and devices for evidence of improper operation.
- ❑ Verify control dampers operate properly.

New/Modified Facility Design Recommendations

Introduction

This guidance has been formulated to help designers retrofit and plan for the improvement of indoor air quality and to slow the transmission of viruses via the HVAC systems. The underlying effort of the designer should be to increase outside air to the spaces, treat return air and or supply air to spaces via mechanical filtration and maintain indoor comfort as defined by the design temperature and relative humidity.

This guidance should be applied to each unique climate zone, unique school building and HVAC system. All retrofits and modifications must not contradict ASHRAE 62.1 guidelines and must continue to meet or exceed applicable codes and standards. The designer needs to work closely with the local school system to work in conjunctions with new operational protocols and school operations.

Nurse office suite design should follow health care facilities design practices as described in standards such as ASHRAE Standard 170 and other applicable guidelines and design information.

Designer Guidelines – General School

Temperature and Humidity Design Criteria

1. **Winter classroom design guidelines 72 F/40- 50% RH**
   - 40- 50% RH in winter is primary guidance via humidifiers/active humidification (central or local, depending on the classroom/space system). The humidity minimum, humidifier, and sensor location should be made after consultation with your ASHRAE professional regarding the envelope design due to the potential for condensation within the building envelope.
2. **Summer classroom design guidelines 75 F/50%-60% RH**

   Designing to 50% RH in summer is primary guidance, depending on the classroom system.

Ventilation Design Criteria/Guideline

- Follow current ASHRAE 62 standard or local ventilation standards for minimum outside air requirements.
- For remodeling an existing AHU, increase outside air to maximum allowable per Air Handling Unit (AHU) without compromising indoor thermal comfort for learning environment (due to severe thermal outdoor air conditions) or space IAQ due to poor outdoor ambient conditions (pollution).
- For Dedicated Outdoor Air Systems (DOAS) that are being replaced, size unit capacity for at least 150% of code minimum flow.
- During the Pandemic, disable any Demand Control Ventilation (DCV) and introduce the maximum possible OA flow 24/7 until further notice (including DOAS).
- Apply and utilize outdoor air quality sensors or reliable web-based data for outdoor pollution information as part of the new ventilation operation.

Designer Guidelines – General School Continued

Filtration Design Criteria/ Guideline

1. **Follow 2019 ASHRAE- Applications Handbook, chapter 8, table 7 for minimum Filtration Efficiency**
    - Apply the highest Minimum Efficiency Reporting Value (MERV) applicable for the HVAC units (local, central and DOAS). HEPA or MERV 13 is recommended minimum if equipment can accommodate pressure drop and MERV 14 is preferred.
2. **Introduce portable, all electric HEPA/UV Machines in each classroom**
    - Guideline minimum of 2 Air rotations/hour
    - Ensure flow patterns maximize mixing of air in classrooms

Operation and Scheduling Guideline for Existing AHUs during the Pandemic

1. **Cooling and Heating equipment- Change the start of operation hours (e.g. change 6 am start to 4 am) and run DOAS**
    - Cooling and Heating systems (Local, central)- Goal is to create a thermal lag and minimize HVAC operations when occupied
    - DOAS Systems - Run DOAS units two hours before and after occupancy.
2. **Exhaust fans- Turn on when DOAS is running**
    - Only applies to school days not weekend operations
    - Goal is to flush the building with OA and positively pressurize the building
3. **Dedicated Outdoor Air Systems (DOAS) – Create "Minimum Transmission Sequence of Operation"**
    - DOAS Systems - Run DOAS units two hours before and after occupancy as part of new DOAS sequence of Operation
    - For DOAS units equipped with active, thermally operated desiccant dehumidifier, consult the manufacturer for safe operation.
    - For new installations, designer should designate a "Purge/Flush" mode for operations to minimize the virus transmission via HVAC systems.
4. **Energy Recovery Systems**
    - Many air handling system types (central air handling units, DOAS units, terminal systems, etc.) include Energy Recovery Ventilation (ERV) systems (these can include energy recovery wheels, plate-type heat exchangers, heat pipes, run around loops, etc.)
    - Some types or configurations for energy recovery systems allow for exhaust air transfer from the exhaust airstream to the supply airstream, while others do not – depending on system configuration this may be cause for concern
    - A document focused on operational considerations for energy recovery systems for many system types and configurations is available here.

Designer Guidelines – General School Continued

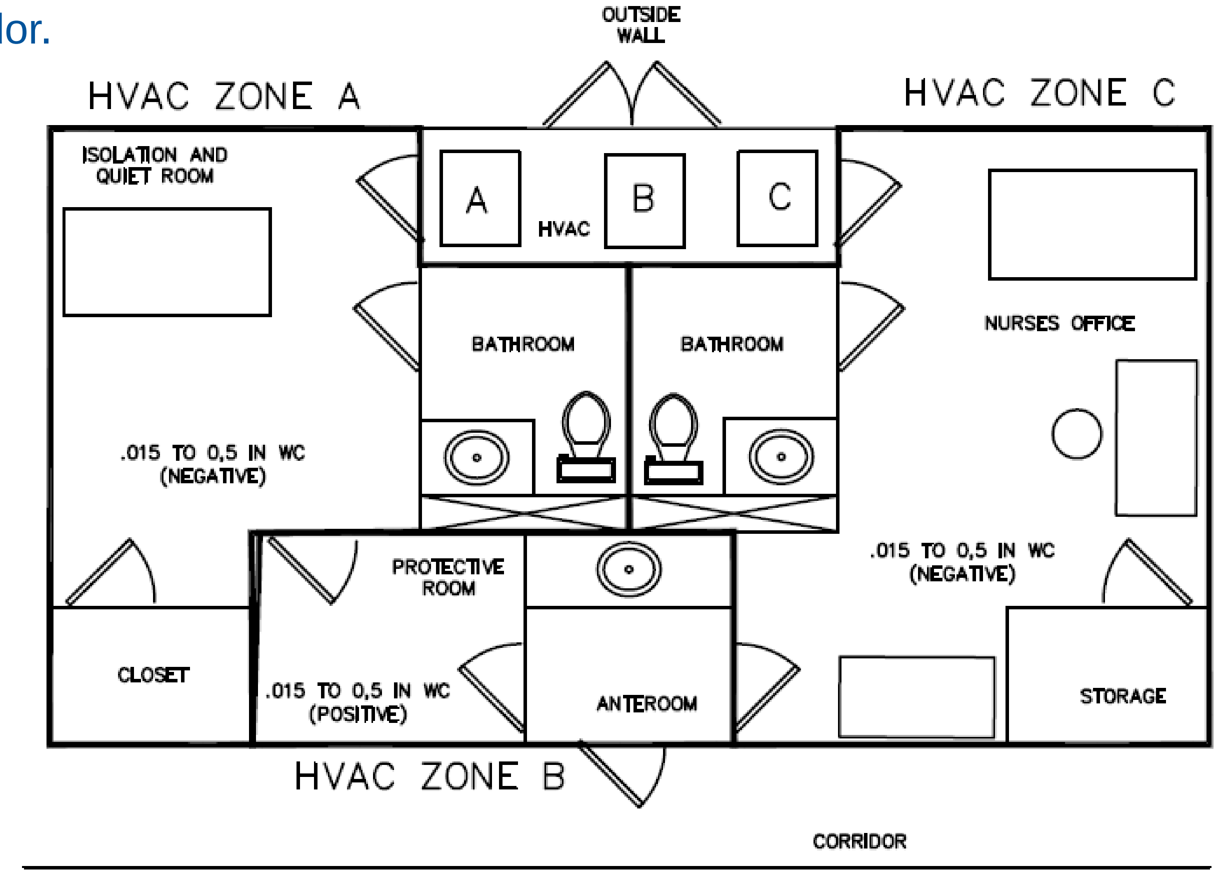
4. **AHU's (SZ and VAV) and Packaged Rooftop units (PSZ, PVAV)**
   - During the Pandemic, increase Filtration to that recommended in the Filtration Upgrade section below.
   - For existing units, an increase in filtration efficiency may reduce airflow capacity. Compensate for loss of capacity in winter with portable plug in elec. Heaters or higher discharge temps.
   - Compensate for loss of capacity in summer with lower discharge temps off of AHU – recommend 52 F (this is mainly for VAV units where supply air temperature is controlled and due to additional pressure drop associated with higher efficiency filters).
   - Check and fix economizer dampers and controls and maximize the economizer operation when possible (favorable outdoor conditions and outdoor air pollution).
   - Check, fix and modify control sequences in VAV systems to avoid outdoor air flow /minimum OA air flow shortage.
   - In VAV systems maximize the total supply air flow in each VAV terminal when the system is in full economizer mode.
   - Minimize the unit air recirculation to minimize zones cross contamination thru the return air system.
   - Install UV/C lights, ionization in AHU's – UV min 1500 microwatts/cm^2 when possible. UV/C lights a destructive to filter media. Ensure no UV lights shall shine on filters.
   - Install Humidifiers in AHUs and Packaged rooftop units if possible.
   - Install duct mounted humidifiers at classrooms as an alternate.

5. **Local HVAC units (Fan Coils, WSHP, GSHP, Mini Split, VRF, Unit Ventilators, Radiators/baseboards)**
   - Increase Filtration to the maximum MERV suggested by the manufacturer.
   - Compensate for loss of capacity in winter with portable plug in electric heaters or higher discharge temps.
   - Hydronic /Electric radiators / baseboard can remain operational.
   - Check unit ventilators for proper amounts of OA and operation.
   - Install Portable humidifiers in each classroom for local humidity control.

6. **Space Air Flow**
   - Ensure airflow patterns in classrooms are adjusted to minimize occupant exposure to particles.
   - Recommended guidance is to provide lowest possible particulate concentration anywhere in the space.

Nurses Office – General Requirements

- Treat as Isolation rooms – 1 bed per building – follow ASHRAE 170 and 2019 ASHRAE Handbook Chapter 9.
- If retrofits are not possible recommend temporary nurse's station trailers.
- Dedicated bathrooms.
- The nurse station will include Anteroom/Protective Equipment Room.
- Normal non-isolation nursing office.
- Provisions for Biohazard waste.
- Two (2) modes of operation, (1) "Isolation Mode and (2) "Normal Mode"
- For "Isolation mode" design Dedicated HVAC system.
- For the "Normal Mode" the HVAC system can be (supplementary) standard HVAC system (VRF +DOAS, Fan coils, WSHP/GSHP, DOAS etc) with current design practices (ASHRAE 62.1, ASHRAE 90.1and local codes etc).
- The HVAC operation will be "Isolation mode" OR "Normal Mode".
- Follow CDC guidelines for supply air return air paths, do not mix isolation room air with any other spaces. Directly exhaust isolation rooms. Follow design guidelines for location of OA intakes and exhaust air from exhaust fans.
- Recommend locations of nurse's office HVAC on an exterior wall.
- Maintain pressure relationship for room, ante room and corridor.



Note: Systems A, B, and C are the Dedicated "Isolation Mode "systems, each system is individually operated and controlled. The Supplementary HVAC systems for "Normal mode" are not shown.

Nurses Office – General Requirements Continued

Temperature and Humidity Design Criteria- Isolation Mode

- Winter Nurse Station design guidelines 72 F/50-55% RH
- Summer Nurse Station design guidelines 72 F/50%-60% RH

Ventilation Design Criteria/Guideline- Isolation Mode

- 100 % OA system
- Design for a maximum of 10 Air Changes per Hour (ACH), can operate at 6 ACH

Filtration Design Criteria/ Guideline- Isolation Mode

- Follow ASHRAE 170, table 6.4 – Protective Environment (PE) room filter guidelines
    - Two filter banks, MERV 7 and HEPA (MERV 14 for existing HVAC that is unable to support HEPA)

Space Pressurization Design Criteria/ Guideline- Isolation Mode

- Follow ASHRAE 170, section 7.2 and other related sections for space pressure requirements
    - Isolation Room and Nurse office will be Negative Pressure (- 0.015” to – 0.5” W.C)
    - Protective Room will be Positive Pressure ((+ 0.015” to + 0.5” W.C)
    - Given the small size of the systems serving the Nurse Station in Isolation Mode, it is suggested considering Constant Volume, hard balanced air system.

Space Air Distribution/Diffusion Design Criteria/ Guideline- Isolation Mode

- Follow ASHRAE 170, Table 6.7.2 – PE Group E non-aspirating (for additional information refer to 2017 ASHRAE – Fundamentals, chapter 20).

Nurses Office – General Requirements Continued

General Design Parameters- Isolation Mode

- Follow ASHRAE 170, Table 7-1
  - Treat as PE anteroom and combination AII/PE.
  - ACH = 10.
  - Exhaust directly to outdoors
  - No air re-circulation
  - All should be under negative pressure.
  - PE rooms with respective to adjacent rooms should be under positive pressure.
- Follow ASHRAE 170, section 7.2.1.
  - Infection Control Risk Assessment (ICRA) is to be performed for new construction and renovations of nurse facilities.
  - Refer to guidance on ICRA for renovations and creating a CX plan and well as phasing the construction.
- Follow ASHRAE 170, Section 6.8.2 which refers to energy recovery.
  - No energy recovery for airborne infectious isolation rooms.
  - Refer to section 6.8.2 exception for cases where Energy Recovery can be applied.

Operation and Scheduling Guideline

- **Isolation Mode (Dedicated 100 % OA systems)**
  - Cooling, Heating, Humidification, Dehumidification, Ventilation – run 2 hours before and after occupancy
  - Exhaust fans – run when ventilation is on
- **Normal Mode (Supplementary HVAC systems)**
  - Cooling, Heating, Ventilation - per normal school schedule(occupied/unoccupied)
  - Exhaust fans - per normal school schedule (occupied/unoccupied), might be **OFF** during unoccupied hours

Filtration Upgrades

Introduction

The focus of this section is to provide instructions for educational facility managers to increase their filtration efficiency in existing air systems on a temporary basis during the pandemic. The presentation focuses on filtration basics for a facility manager, an information gathering phase, a data analytics and review phase and lastly a series of implementation and considerations an educational facility manager may address. Refer to the section on Filtration/Disinfection under the COVID-19.

This guidance has been formulated to help designers and facility managers to retrofit and plan for the improvement of indoor air quality and to slow the transmission of virus via the HVAC systems. The underlying effort of the designer should be to increase outside air to the spaces, treat return air and or supply air to spaces via mechanical filtration or treating the air and maintain indoor comfort as defined by temperature and relative humidity.

The guidance should be applied to each unique climate zone, unique school building and HVAC system. All retrofits and modifications must not contradict ASHRAE 62.1 guidelines and must continue to meet code. The designer needs to work closely with the local school system to work in conjunctions with new operational protocols and school operations.

Filtration Basics

Key Terminology for Filtration

- **Arrestance** – A measure of the ability of an air filtration device to remove synthetic dust from the air. The arrestance describes how well an air filter removes larger particles - such as dirt, lint, hair and dust.

- **Atmospheric Dust Spot Efficiency** - The ability of a filter to remove atmospheric dust from the air and designated as a percentage.

- **MERV Rating** - Minimum Efficiency Reporting Values, or MERVs, report a filter's ability to capture particles between 0.3 and 10 microns (µm).
- Particle Size Range – This is the composite particle size efficiency percentage within a range of particle size. The three ranges used in Std 52.2 are E1 - (0.3-1.0 µm), E2 - (1.0-3.0 µm), and E3 – (3.0-10.0 µm).

Mechanical Air Filters

- Consist of media with porous structures of fibers or stretched membrane material to remove particles from airstreams. Filters range in size but the typical depths of filters are 1”, 2”, 4” and 12-15”.
- Some filters have a static electrical charge applied to the media to increase particle removal.
- The fraction of particles removed from air passing through a filter is termed “filter efficiency” and is provided by the Minimum Efficiency Reporting Value (MERV) under standard conditions.
  - MERV ranges from 1 to 16; higher MERV = higher efficiency
  - MERV ≥13 (or ISO equivalent) are efficient at capturing airborne viruses
- Generally, particles with an aerodynamic diameter around 0.3 µm are most penetrating; efficiency increases above and below this particle size.
- Overall effectiveness of reducing particle concentrations depends on several factors:
  - Filter efficiency
  - Airflow rate through the filter
  - Size of the particles
  - Location of the filter in the HVAC system or room air cleaner

Filtration Basics Continued

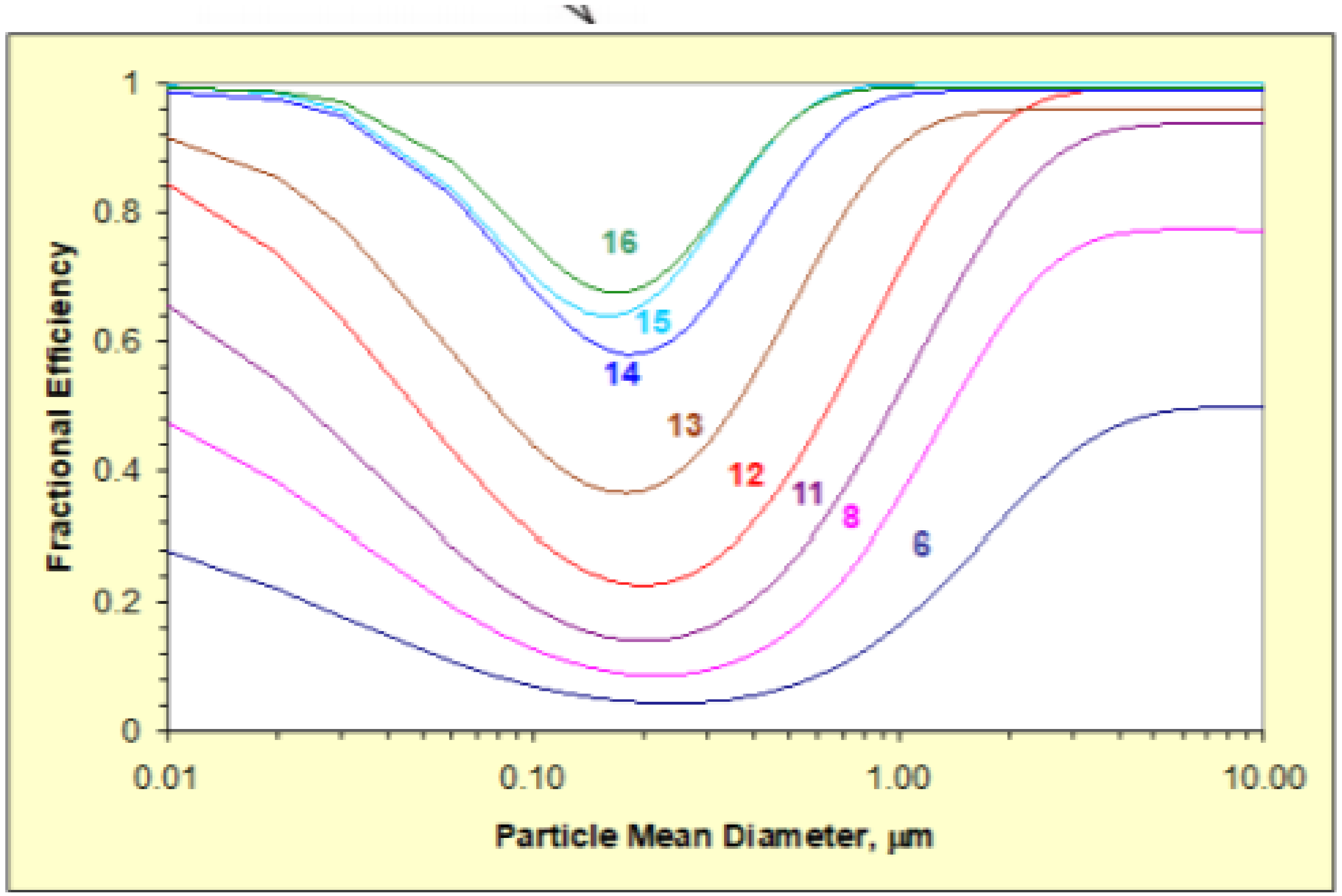
ASHRAE Standard 52.2-2017 -- Minimum Efficiency Reporting Value (MERV)

Table 12-1 Minimum Efficiency Reporting Value (MERV) Parameters

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency, % in Size Range, µm			
	Range 1 0.30 to 1.0	Range 2 1.0 to 3.0	Range 3 3.0 to 10.0	Average Arrestance, %
1	N/A	N/A	$E_3 < 20$	$A_{avg} < 65$
2	N/A	N/A	$E_3 < 20$	$65 \le A_{avg}$
3	N/A	N/A	$E_3 < 20$	$70 \le A_{avg}$
4	N/A	N/A	$E_3 < 20$	$75 \le A_{avg}$
5	N/A	N/A	$20 \le E_3$	N/A
6	N/A	N/A	$35 \le E_3$	N/A
7	N/A	N/A	$50 \le E_3$	N/A
8	N/A	$20 \le E_2$	$70 \le E_3$	N/A
9	N/A	$35 \le E_2$	$75 \le E_3$	N/A
10	N/A	$50 \le E_2$	$80 \le E_3$	N/A
11	$20 \le E_1$	$65 \le E_2$	$85 \le E_3$	N/A
12	$35 \le E_1$	$80 \le E_2$	$90 \le E_3$	N/A
13	$50 \le E_1$	$85 \le E_2$	$90 \le E_3$	N/A
14	$75 \le E_1$	$90 \le E_2$	$95 \le E_3$	N/A
15	$85 \le E_1$	$90 \le E_2$	$95 \le E_3$	N/A
16	$95 \le E_1$	$95 \le E_2$	$95 \le E_3$	N/A

Filtration Target Level

Target Level for Filtration for Schools is MERV 13 or higher.
This minimum target will on average remove a minimum of 75% of particle size of 0.3-1.0 µm.



Information Gathering Stage

Data Collection Stage – Can be done by any staff

- Determine if the Building was LEED or CHPS Certified.
- Determine the current size, depth and quantity of filters in equipment. Make a list by piece of equipment.
- Determine if there are one or two filter banks.
- Document MERV rating of existing filters installed. May need to review previous filter orders.
- Determine the area of filter banks. This can also be determined by quantity of filters broken down by size of filter.
- Collect Original Design Drawings if available.
- Gather equipment shop drawings or Operation and Maintenance Manuals.
- Record the Model or Serial number of the air handling equipment.
- Determine the type of motor that is used in the equipment.
- Determine if the equipment served from a Variable Frequency Drive.

Record all Data Collected

Data Analysis & Review

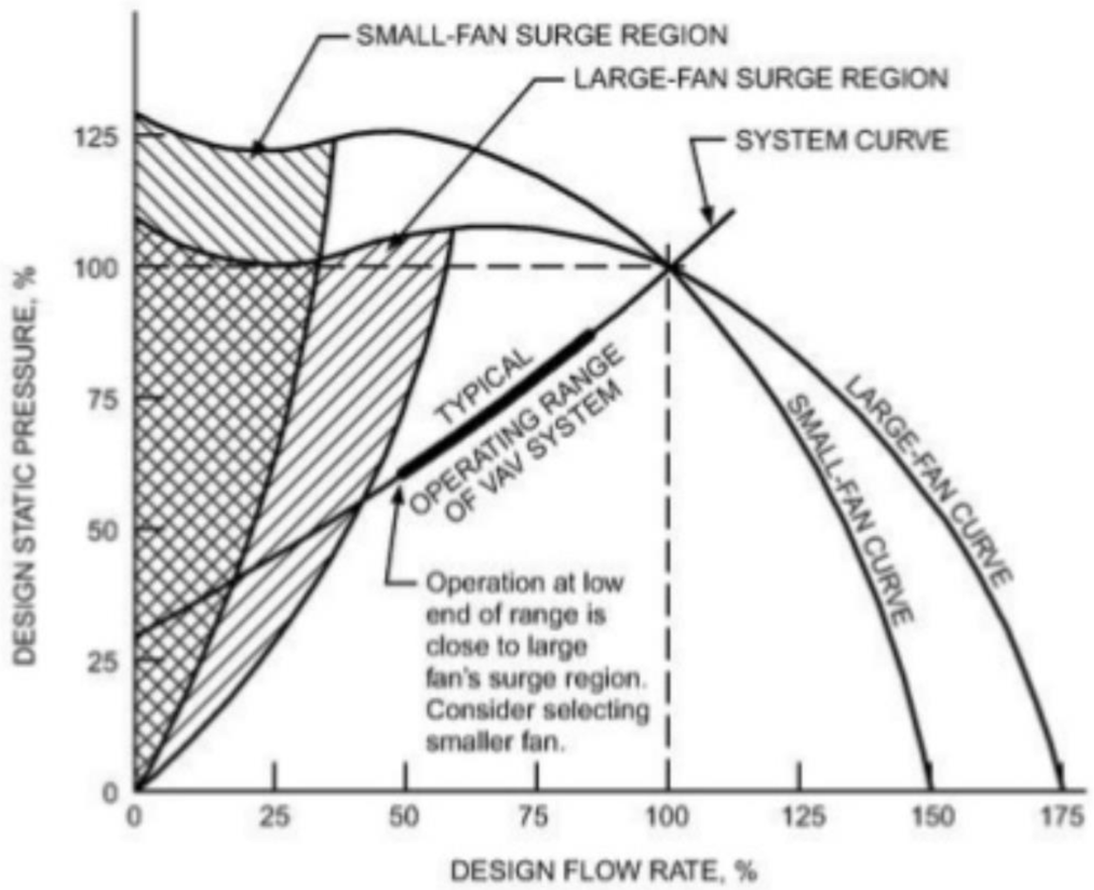
The following are steps for Data Analysis:

- If the project is a LEED or CHPS project then the filters should already be designed for MERV 13. If MERV 13 is not in place, change filters to MERV 13.
- If the existing filters and filter bank are 2" or thicker install a MERV 13 Filter. Determine if a 1" rack can be refitted with a larger rack.
- If filter racks can accept a minimum MERV 13 filter but were not part of the original design, the following analysis can be completed by internal staff or a consulting engineer:
    - Provide Information previously gathered in the Gathering Stage to individual completing additional analysis.
    - Calculate the velocity of the existing filter bank to determine existing filter pressure drop when clean.
    - Typical Velocity is between 300-500 fpm.
    - Determine the initial and final pressure drop for the filters in the original system design.
    - Calculate the increase in filter pressure drop after installing the new MERV 13 filters. Remember the final pressure drop of any filter is an operational choice.
    - Review the original design and equipment shop drawings to determine available External Static Pressure for equipment.
    - Determine the effect of additional external static pressure on the fan.

Data Analysis & Review Continued

Motors and Fan Curves

- Determine if the fan speed can be increased to compensate for the additional pressure drop while maintaining the required airflow.
- Determine if the speed increase exceeds the fan maximum tip speed.
- Determine if the speed increase exceeds the maximum motor power.
- Fan airflow is reduced with increase in filter restriction. This may lead to DX low suction pressures which causes faults in cooling or DX high pressure trips in heating with HP's. Electric heat elements must have sufficient airflow to operate.
- A constant cfm ECM fan will be noisier with restriction. Could increase noise in space and have a negative impact to the acoustics of the space.
- Be aware of fan surge under increased static pressure and low flow rate.



Data Analysis & Review Continued

Fan laws are relatively straightforward:

Q = FLOW
P = PRESSURE
PWR = HORSEPOWER
RPM = FAN SPEED

$$Q_2 = Q_1 \frac{RPM_2}{RPM_1} \qquad P_2 = P_1 \left(\frac{RPM_2}{RPM_1} \right)^2 \qquad PWR_2 = PWR_1 \left(\frac{RPM_2}{RPM_1} \right)^3$$

Fan performance

Minimum CFM

Table 8: Standard PSC static motor

Unit Size	Speed	Factory Wired	Nominal cfm	External Static Pressure (in. w.c.)													
				0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
007	High	Yes	300	410	400	390	380	360	350	330	320	310	290	270	250		
009	High	Yes	300	410	400	390	380	360	350	330	320	310	290	270	250		

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Implementation & Considerations

What are the next steps?

- If MERV 13 filters are installed in the existing equipment then order additional filters for future filter changes.
- Filter Rack Maintenance and Replacement:
  - If filter rack is damaged then repair rack,
  - Ensure filter rack is sealed to prevent bypass of unfiltered air,
  - Review seal installation procedures with maintenance and operations staff,
  - Replace and Upgrade Rack if possible, to accept a filter with a higher MERV rating.
- Consider changing out motor to increase static pressure available, but this may require significant electrical modifications.
- Adjust the Variable Frequency Drives to address increase in static pressure for filters.

Implementation & Considerations Continued

If MERV 13 Filters cannot be installed consider the following:

- Increase the filtration in the unit to the maximum available
- Provide a recirculation fan filtration unit and duct into the return of units
- Provide a HEPA filtration unit which re-circulates air within the space
- Consider Air Ionization system or static charge on filters
- Consider UV treatment but review location to avoid impacts of liners and other internal components
- Refer to ASHRAE Filtration and Disinfection system section for additional information
- Consider alternate filter locations in return duct or grille but consider static pressure drop implications and relationship with outside air dampers

Additional Considerations:

- Install a pressure gauge on units to assist in determining filter change frequency
- Document motor amperages before and after filter changes, alarm points in BAS may need to be updated
- Filter change frequency may increase due to seasonal and atmospheric considerations at different sites (such as Pollen Season)
- There will be an increase in fan energy used to overcome additional pressure drop from filters
- With an increase pressure drop for filtration there will be less airflow to heat and cool the spaces during peak design days
- Additional supplementary heaters or cooling devices may be required

Implementation & Considerations Continued

HVAC System Maintenance and Filter Replacement during the COVID-19 Pandemic:

- For HVAC systems suspected to be contaminated with SARS-CoV-2, it is not necessary to suspend HVAC system maintenance, including filter changes but additional safety precautions are warranted
- The risks associated with handling filters contaminated with coronaviruses in ventilation systems under field-use conditions have not been evaluated
- Workers performing maintenance and/or replacing filters on any ventilation system with the potential for viral contamination should wear appropriate personal protective equipment (PPE)
- When feasible, filters can be disinfected with a 10% bleach solution or another appropriate disinfectant, approved for use against SARS-CoV-2, before removal. Filters (disinfected or not) can be bagged and disposed of in regular trash, or applicable local health and safety standards
- When maintenance tasks are completed, maintenance personnel should immediately wash their hands with soap and water or use an alcohol-based hand sanitizer.

Operation of Occupied Facilities

1. Measure/Trend all information possible, including temperature (dry bulb), relative humidity, carbon dioxide concentration, zone population, etc. - may be done with central Building Automation System (BAS) if available - mobile/handheld devices may be used if central monitoring not available.
2. Follow up on temperature control, humidity control or elevated carbon dioxide concentration issues observed to address cause(s).
3. Document any unusual observations other than those that can be recorded by control systems.
4. Share pertinent information between all appropriate groups: Maintenance, Energy, Environmental Health & Safety, Building Managers, Administration, etc.
5. Create reporting methodology for tracking and reporting of critical infections. Develop policies for use of drinking fountains/water coolers.
6. Develop policies for lockers or storage spaces.
7. Develop maintenance policies for new/added equipment such as local air cleaners, humidifiers, additional filtration in mechanical equipment, etc.

Controlling Infection Outbreaks in School Facilities

1. Identify symptoms in Student.
2. Provide PPE and remove suspect individual – relocate to nursing or isolation space.
3. **a.** A K-12 Facility should develop a policy to isolate the student near the nurse's office in a room described in this guidance, inform parents and release symptomatic student according to that policy.
   b. Higher education facilities should isolate that student at the Student Health Facility in a room described in this guidance until that student can either safely travel home or be transported to a medical facility, if necessary.
4. Notify appropriate individuals (either parents or students) about possible contact.
5. Develop protocol to handle quarantine of other individuals who may have been exposed, wash/sanitize belongings and impacted spaces, look at potential for spread to adjacent spaces or other building areas through mechanical systems or other means.
6. Develop protocol to handle air cleaning for space prior to re-occupying (ozone, local HEPA filtration, combination unit with filtration and UV, similar technologies).
7. Report/track incident through defined policies.

Higher Education Facilities

Student Health Facilities

Screen patients entering clinic in waiting area

- ❑ Establish physical barrier in waiting room for screening
- ❑ Require face mask and hand sanitation from a sanitizer dispenser
- ❑ Increase ventilation rate six ACH clean air
- ❑ Create at least one isolation exam room in waiting area (can be temporary)
- ❑ Add non-woven fabrics for seating
- ❑ Use laminate or solid surface casework to improve cleaning
- ❑ Remove carpet for flooring

Student Health Facilities

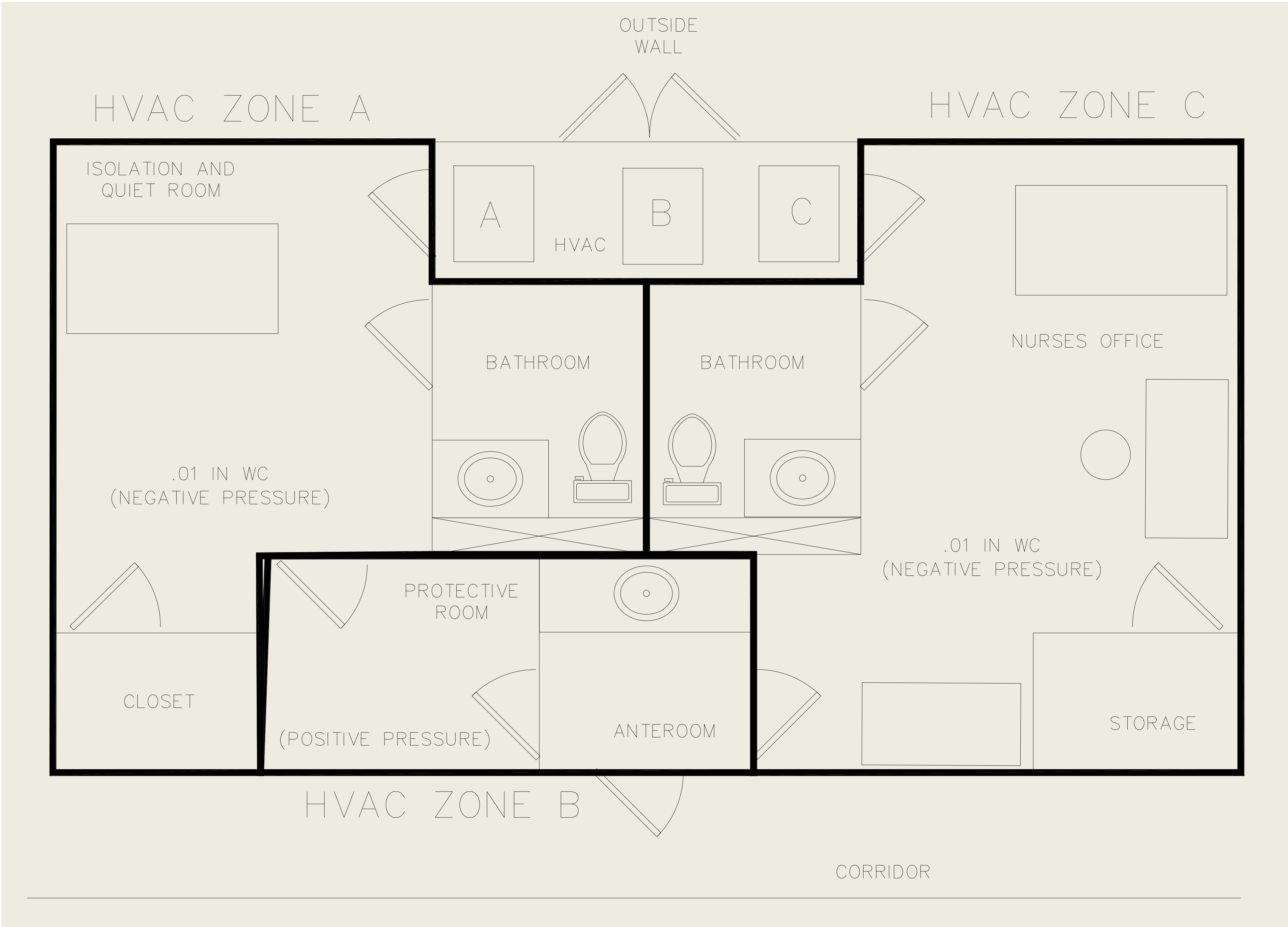
Temporary Isolation Rooms during Pandemic in addition to waiting room

- Isolation rooms – Follow ANSI/ASHRAE/ASHE Standard 170
  - Negative Pressure to 0.01 inches of water
  - Twelve air changes (HEPA recirculation allowed)
  - All air exhausted to outdoors (exhaust grill above exam table)
- Provide minimum two isolation rooms (conduct risk assessment)
- Dedicated HVAC capable of 100% OA
- Anteroom/Protective Equipment Room
- Normal non-isolation nurses office can become iso-room
- Include Biohazard waste storage in anteroom and iso-room for PPE

Student Health Facilities

Temporary Isolation Rooms during Pandemic in addition to waiting room: Design Concepts

See layout suggestion here, can be modified as needed



Laboratories (NFPA 45 type lab)

Before Student Occupation during Pandemic

- ❑ Verify space has one-pass air or maximum OA capable for lab operating requirements
- ❑ Screen occupants upon entry
- ❑ Require face mask and hand sanitation
- ❑ Modify workstations to comply with social distancing
- ❑ Install hand sanitizer dispenser in entryway
- ❑ Verify all fume hoods and bio-safety cabinets are up-to-date on certification
- ❑ Conduct smoke tests in all spaces to verify airflow patterns

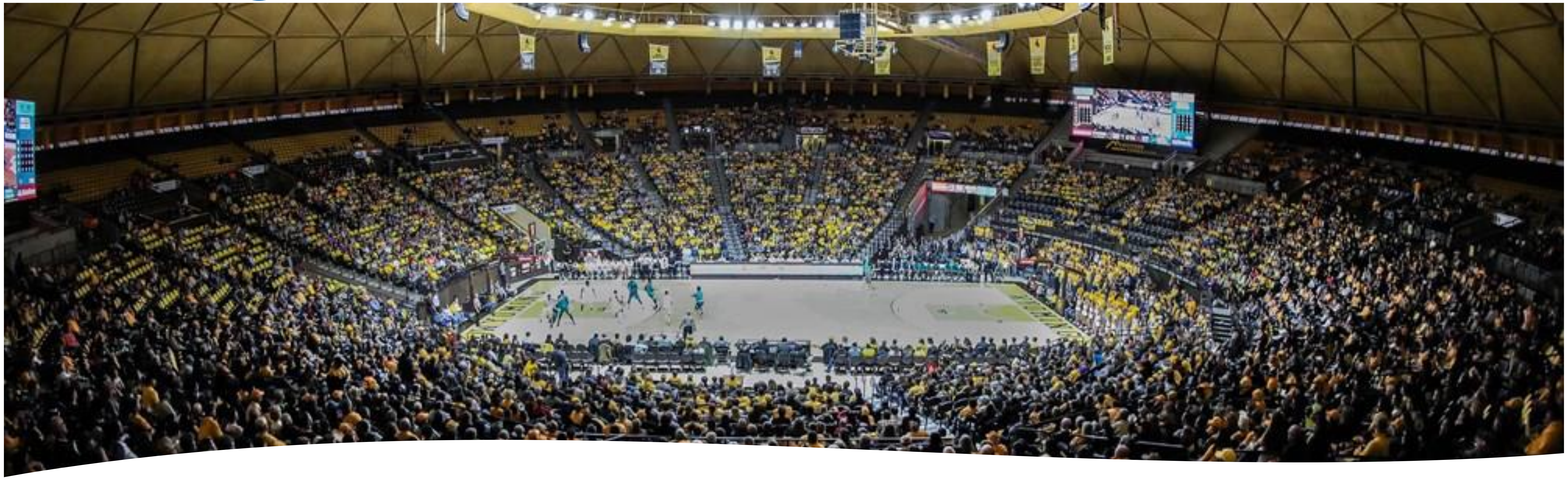
Athletics Facilities

- Move activities outdoors if possible
- Limit occupancy to maintain social distancing guidelines and avoid unnecessary occupants
  - Increase outdoor air ventilation rates
  - Increase rates as high as possible
- Maintain minimal comfort conditions
- Avoid use of locker rooms but if necessary Increase airflow in locker rooms and keep negative
- Verify all locker room exhaust flows exceed [ANSI/ASHRAE Standard 62.1]

Residence Halls

- Consider reducing occupancy in rooms, suites and common areas
- Consider HEPA/UVC portables
- Install hand sanitizer dispenser in common areas
- Use non-woven fabrics for seating
- Use laminate or solid surface casework
- Cover or remove carpet for flooring
- Verify exhaust air flow in all restrooms and laundries
  - Minimum 1.0 cfm/sf
- Verify all outdoor air flows are well distributed (> 0.16 cfm/sf)
- Replace filters with MERV 13 or higher where ever possible
- Refer to [the Filtration and Disinfection Guidance]
- This guidance assumes no COVID-19 cases are housed

Large Assemblies, Lecture, Theater



- ❑ Limit occupancy to maintain social distancing guidelines
- ❑ Increase outdoor air ventilation rates
- ❑ Replace all filters with MERV 13 or higher
- ❑ Verify exhaust airflows in all toilets and locker rooms
  - ❑Minimum 1.0 cfm/sf
- ❑ Verify exhaust airflows from all concession stands
  - ❑Minimum 0.7 cfm/sf
- ❑ Provide additional outdoor air and/or HEPA filter units in rehearsal rooms and green rooms
- ❑ Disable demand control ventilation control

Appendix 6 – MA Fall Reopening Guide K-12 7/22/20

Fall Reopening Facilities and Operations Guidance

July 22, 2020

Table of Contents

Introduction

As a supplement to *DESE's Initial Fall School Reopening Guidance*, we are providing districts and schools with this guidance on **facilities and operations** for reopening this fall.

As stated in our *Initial Fall Reopening Guidance*, our goal is to promote the **safe** in-person return of as many students as possible in a school setting. For students and staff to return to school, schools and districts will need to prepare their facilities and adapt operating procedures to adhere to medically-advised health and safety requirements. Additionally, districts should follow federal, state, and local safety requirements applicable to school buildings.

As we continually review the medical and science literature, various reports and articles, and information from the Centers for Disease Control (CDC), World Health Organization (WHO), and other countries and states, ***it is clear that it is not a single action, but the combination of actions that minimize risk, mitigate the virus's transmission, and help create safe environments.***

This Facilities and Operations Guidance provides additional details and considerations for school facilities and grounds, as well as operational protocols based on the most recent information we have about COVID-19 and related mitigation practices. As the knowledge and research related to COVID-19 continues to evolve, this Facilities and Operations Guidance will be updated as appropriate.

This guidance begins with a summary of the critical health and safety requirements, followed by communications guidance. It then provides information in three main sections, followed by examples of classroom, lab, and other space planning diagrams. The three sections are:

1. Preparing spaces,
2. Making systems and other space-use modifications, and
3. Developing operational protocols

Support for schools and districts

To support districts and schools in implementing this Facilities and Operations Guidance, DESE is providing the following assistance:

Financial resources:

To date, the following federal grants have been available to cities and towns for educational expenses related to COVID-19:

- $193.8 million from the Elementary and Secondary School Emergency Relief (ESSER) Fund to districts, largely based on the Title I formula.
- A portion of the $502 million from the Coronavirus Relief Fund (CvRF) already allocated to cities and towns

In addition to the above funds, the Commonwealth is making available:

- **$202 million from the CvRF to support school reopening.** Of the $202 million, $182 million will be formula grants ($225 per pupil), and $20 million will be available at the Commissioner's discretion for distribution to districts with unmet needs.
- **$25 million available for remote learning technology grants** to match local amounts that districts plan to spend by the beginning of the school year.

While school and district budgets remain uncertain, these additional resources will help schools and districts provide a healthy and safe environment for in-person learning in the fall.

Technical assistance, including with ventilation/HVAC systems:

For help with general questions about the information in this Facilities and Operations Guidance, please contact:

- **Russell Johnston**: Senior Associate Commissioner, Russell.Johnston@mass.gov, 781-605-4958
- **Erin McMahon:** Fall Reopening Implementation Lead, Erin.K.Mcmahon@mass.gov, 781-873-9023

For help with questions about ventilation and HVAC systems, please contact: **Matt Deninger**, Acting Chief Strategy and Research Officer, at Matthew.J.Deninger@mass.gov or 781-338-3117.

Waivers for student learning time requirements:

For changes in scheduling related to the use of spaces, including staggered schedules and mealtime scheduling, schools and districts may require flexibilities with student learning time requirements in order to enable more students to return to school in-person. If so, districts should contact Russell Johnston (russell.johnston@mass.gov) or Erin McMahon (erin.k.mcmahon@mass.gov) to request a waiver from student learning time requirements. More information on waiver requests will be forthcoming.

Critical health and safety requirements for facilities

Developed in consultation with pediatricians, infectious disease physicians, other medical advisers, and the COVID-19 Command Center's Medical Advisory Board, and including a review of CDC and WHO guidance, the health and safety standards and requirements below will enable students and staff to safely return to school this fall. These requirements will need to be supported by adjustments to how school facilities are used and how they operate. More details on implementation practices and considerations follow in this document.

- **Masks:** Masks are one of the most important tools to prevent transmission of the virus. From a facilities and operations perspective, it is important to consider how to best support adherence to masking, including putting up signs with reminders to wear masks and how to remove them safely, having a supply of masks for staff and students who may need them, safely disposing of soiled or unusable masks, and identifying spaces that are appropriate for mask breaks. ***Masks covering the nose and mouth*** are to be worn by students (required for grade 2 students and up and strongly encouraged for kindergarten and grade 1), staff, visitors, and vendors. Exceptions for meals, mask breaks, and medical exemptions are permitted.

- **Handwashing and hand sanitizing:** Enabling good hand hygiene practices is another key tool to mitigate transmission of the virus. From a facilities and operations perspective, enabling good hand hygiene practices spans from student and staff arrival at school until their departure. This includes providing handwashing or sanitizing stations (touchless if feasible) in commonly used areas (e.g., entries and exits, classrooms, bathrooms, eating areas, stairwell exits, etc.), ensuring sufficient supplies to accommodate frequent hand washing, and having hand sanitizer readily accessible.

- **Physical distancing:** Physical distancing is a critical component in mitigating the transmission of the virus. Schools should aim for a physical distance of 6 feet when feasible; 3 feet is the minimum distance allowed. During meals, mask breaks, and other times when masks are not worn, 6 feet is the minimum distance allowed. From a facilities and operations perspective, it is important to understand how these minimum requirements will affect space layouts and movement protocols.

- **Creating cohorts wherever possible:** Directly related to physical distancing is the idea of creating cohorts (e.g. self-contained groups) of students wherever possible and limiting the cohort from interaction with others. Examples of cohorts could include an elementary school class, students on a bus, or groups of older students with similar schedules. By grouping students and staff into cohorts, interaction will be limited. This means that if there is a positive COVID-19 case in the school, fewer individuals will have interacted with that person. Cohorts should be used to the extent feasible for classes, transportation, mask breaks, meals, recess, and extra-curriculars. **To assist with establishing cohorts, all students should have assigned seating** in each class and to the extent feasible for meals and other activities. Washable mats could be used for early elementary and preschool students to define individual spaces for children.

- **School cleaning and disinfecting:** From a facilities perspective, schools should update cleaning and disinfecting protocols, obtain additional supplies, and train staff appropriately. Cleaning and disinfecting should occur at least daily for shared spaces and furniture. For high-touch surfaces (e.g., door handles, light switches, handrails), cleaning and disinfecting should occur multiple times per day between uses.

- **Ventilation:** Schools should work to increase outdoor air ventilation instead of using recirculated air and increase air filtration as much as possible for the ventilation and filtration system.

- **Movement protocols within facilities:** Develop clear movement protocols to avoid crowding, maintain cohorts, and minimize unnecessary person-to-person interactions. These protocols should include a plan for arrival and dismissal times, transitions between classes, and bathroom breaks, as well as outlining one-way movement pathways for hallways and cafeterias.

Communicating facilities-related changes

Schools should develop a comprehensive approach to communications with educators, staff, students, families, and other community members.

While strong communication is always important, the ever-changing circumstances related to COVID-19 make an effective, multi-faceted communication plan essential to districts. We have highlighted some initial communication topics below for facilities, but each district should identify additional topics as needed:

- **Summary of major facility changes** (e.g., installation of additional handwashing and hand sanitizing stations, installation of barriers, configuration of classroom desks) to promote a healthy and safe return to school
- **Guidance for health and safety protocols** expected from students and staff (e.g., frequent handwashing, maintaining physical distance, following one-way directions in hallways, limiting use of bathrooms during high-traffic periods etc.). Create and use visual cues and posters to communicate, especially with younger students.
- **Food services and distribution** changes to emphasize individually packaged foods and use of disposable cups or water bottles, as well as changes in remote meal offerings from spring and summer programs
- **Visitor protocols** for parents and guardians
- **Arrival and dismissal protocols** related to pick-up and drop-off
- **Medical waiting room procedures** in case a student experiences COVID-19 symptoms

Informing students, families, and staff to ensure alignment and adherence to guidance

Districts should develop a series of information sessions for staff, students, and families to share information on new school protocols and roles and responsibilities and to answer questions. . To help with the development of this information, DESE will provide reference materials and examples as we are able, including some best practice examples. Below, we have highlighted some initial topics that should be shared:

- All health and safety protocols (e.g., wearing masks, hand hygiene, shared items, transitions, medical waiting room)
- Proper use of masks and other PPE
- Facility operations changes, including hallway movement, locker use
- Proper cleaning and disinfecting procedures
- Food services and distribution procedures
- Arrival and dismissal procedures

Facilities and operations planning checklist

Each district and school should develop a facilities and operations plan to ensure effective implementation of health and safety guidance. This plan should include the following key areas:

- ☐ **Prepare spaces in the facilities:** Develop plans to prepare the following spaces prior to the start of the school year.
  - ☐ Student learning spaces
  - ☐ Staff office set-up
  - ☐ Mask break spaces
  - ☐ Student eating areas
  - ☐ Medical waiting room
  - ☐ Entry and exit points
  - ☐ Storage and disposal of unnecessary furniture or other items
- ☐ **Make modifications to facilities and building systems as feasible:** Develop plans to ensure set-up of additional fixtures and appropriate modifications to the existing physical infrastructure.
  - ☐ Handwashing and hand sanitizing stations
  - ☐ Ventilation and HVAC systems
  - ☐ Hallways
  - ☐ Bathrooms
  - ☐ Water fountains
  - ☐ Lockers
  - ☐ Signage throughout the building
- ☐ **Develop operational protocols:** Develop operations plans to align all staff, families, students, and visitors on expected healthy behaviors and precautions.
  - ☐ Cleaning and disinfecting
  - ☐ Food preparation and distribution
  - ☐ Movement in the facility
  - ☐ Arrival and dismissal of students
  - ☐ Sharing items
  - ☐ Visitor and volunteer engagement
  - ☐ Using the medical waiting room
- ☐ **Develop communication protocols**
- ☐ **Inform students, families, staff, and visitors to ensure alignment and adherence to guidance**

Preparing spaces

Learning spaces

We acknowledge that districts and schools face individual constraints and each school building presents unique features and layouts (i.e., furniture, storage, classroom size and shape). To inform this guidance, we conducted classroom visits and set up model classrooms to derive options for districts to consider. Further examples and details are in Appendix A.

- **Space inventory:** Create a list of all classrooms, large spaces (such as auditoriums or libraries), and additional spaces that could be used for student activities, including outdoor areas, certain corridors, etc.
- **Measure spaces:** Know the dimensions of each space. If available, obtain building plans to understand square footage. These plans might be available from your district offices or the architectural and engineering firms that worked on the building. If the dimensions are not available on the building plans or if those are difficult to work with, you may need to manually measure spaces. This will only have to be done once for those classrooms and spaces that are the same size and can help with assessing different space use variations.
- **Clear spaces:** Clear classrooms and other spaces in the school building (auditorium, library, etc.) of any non-essential items or furniture to maximize available space. Keep only what is truly essential in each room, as every additional item that remains could displace a student. As it is recommended to limit shared items or supplies between individuals, consider what items may no longer be used in the class and what items may now need to be available on an individual basis.
- **Outdoor spaces:** As feasible, consider the use of outdoor spaces for classes, breaks, meals, and other activities. Some jurisdictions have considered tents, platforms, and other not-permanent structures in spaces adjacent to buildings, such as courtyards, play areas and parking lots.
- **'Off campus' spaces:** Review community and municipal spaces with local stakeholders to determine if other buildings are available to provide additional classroom space.
- **Design to maximize space:** Map out each space to optimize for student learning, based on the sample diagrams and parametric tool in Appendix A. The medically-advised minimum distance allowed is 3 feet from seat edge to seat edge. Desks should face in the same direction. There is no maximum number for group size, so long as schools adhere to the physical distancing requirements. Six feet of physical distance is required when people are not wearing masks (e.g. eating or mask breaks). All students should have assigned seating in each class and, to the extent feasible, for eating, mask breaks, and other activities.
- **Reconfigure spaces:** Consider using temporary walls or dividers to break up large areas into smaller classrooms, separate cohorts for meals, or structure other activities. In elementary and preschool classrooms, the classroom and "stations" can be set up to create natural physical distancing. Some jurisdictions are considering installing temporary floor-to-ceiling walls to maximize cohorts in larger spaces. Be mindful that temporary barriers may not block sound as well as permanent walls.

- **Fire code and safety:** Throughout planning, schools and districts should be aware of their fire code and building safety guidelines as they work to maximize space within buildings. Ensure that desks are not blocking means of egress in the event of an emergency and that desks are adequately spaced from radiators or other heating or cooling elements. Avoid obstructing means of egress if you are storing items in hallways. If appropriate, consider propping open doors to improve air circulation and reduce the number of times people touch door handles.
- **Plexiglass barriers: There are pros and cons to the use of plexiglass barriers.** In general, we do not recommend setting up plexiglass barriers in regular classrooms, since they represent an additional high-risk surface to clean and disinfect. However, barrier use is permitted if classroom furniture cannot be replaced and if required physical distancing cannot be achieved without the use of barriers, such as in shared table or laboratory settings where there is limited capacity and desks are often heavy or immovable. *Additional considerations for barrier use in laboratory spaces can be found in Appendix B.*

Considerations for early childhood and younger elementary classrooms:

- Remove all soft and cloth-based materials, such as rugs, pillows, stuffed animals, and dress-up clothing. Children can bring their own stuffed animal, but it cannot be shared.
- In lieu of forcing young children to sit continuously at desks, consider making laminated mats with children's pictures. Washable mats, plastic trays, and other items which can be easily cleaned can be used to define space for each student.
- **Learning centers**: Instead of having different small groups of children (three to four, depending on space available) rotate among different learning spaces as they engage in different activities, consider having each small cohort remain in one location and have materials for the next "center" brought to them.
- **Marking spaces:** Consider marking spaces with footprints facing the correct direction the children's feet would be pointing to indicate one way in and one way out.

Staff office spaces

- **Reconfigure spaces**: Rearrange furniture to support physical distancing, with staff desks facing in the same direction when possible.
- **Staff break rooms**: Rearrange furniture to support physical distancing and consider adjusting staff schedules to limit the number of individuals in the room at one time.
- **Barrier use**: Consider setting up barriers (e.g., plexiglass shielding) in high traffic areas or areas where physical distancing between staff cannot be achieved. Design the cleaning schedule to ensure proper cleaning and disinfecting of barriers by custodial staff.[1]

Spaces for mask breaks

- **Purpose:** It is recommended that students have at least two mask breaks per day (e.g. mealtime and recess). If additional mask breaks are scheduled, identify what spaces (ideally outdoors) will be used.
- **Requirements:** Spaces for mask breaks must allow students to be at least 6 feet apart. Consider using tape or other markers to identify where students should be to maintain 6 feet of separation. Hand washing facilities or hand sanitizer must be available upon entering and leaving this space. Provide napkins or paper towels for masks to be set on (inside face up) when removed. Consider adding signage in mask break areas on how to properly put on and take off masks. As mask wearing is recommended for children younger than second grade, it is important to note that these students may need additional mask breaks during the day.

Medical waiting room

- **Purpose:** This is a separate space from the nurse's office or the regular space for providing medical care. It may be located near a nurse's or other health related office. The medical waiting room will be used when a student presenting COVID-19 symptoms needs to be separated. From a facilities perspective, every effort should be made to find a self-contained space, ideally near an exit/entrance and with a dedicated bathroom.
- **Staffing:** When occupied, the medical waiting room should always be monitored by appropriate staff.
- **Masks required**: Masks are always strictly required in this space, even for students in kindergarten and grade 1. The individual supervising this space must always maintain 6 feet of physical distance, remain masked, and wear a face shield or goggles. Be sure to have face shields or appropriate goggles available to staff. Personal protective equipment guidance recommends that nurses or other staff in this area be equipped with N-95 masks. If a student is unable to wear a mask, there should be no other students in this room.
- **Hand hygiene:** Hand washing facilities or hand sanitizer needs to be used when entering and leaving the space, as well as before and after eating.
- **Food/drink:** If any food or drink must be consumed before the student is picked up, the individual should be walked outside to consume food or drink if possible (because mask will have to be taken off for eating). If not possible to go outside, one student can consume food or drink at a time in the medical waiting room, but, again, only if all others remain at least 6 feet away.
- **Ventilation:** When possible, this space should have windows that open and exhaust directly into the outdoors. Depending upon the facility, other options should be explored to increase ventilation to this area and/or otherwise improve the air filtration.
- **Size:** This space should be large enough to accommodate several individuals at least 6 feet apart. All people in the COVID-19 waiting room must be as far apart as possible and no less than 6 feet apart, even when masked.

Entry and exit points

- **Arrival to school:**
  - Prioritize overall safety considerations, (e.g. child welfare, preventing intruders

and weapons) in planning school arrival/exit.
    - As practical, consider assigning multiple entry points or staggering arrival times to avoid crowding in entry areas.
    - Post appropriate signage and reminders about the health and safety requirements that everyone needs to follow. [2]
    - Ensure hand washing or sanitization is available upon entry, as well as appropriate disposal containers.
    - Ensure that all students, staff, and visitors, with noted exceptions for medical needs, are wearing masks covering their nose and mouth.
    - Ensure that additional masks are available at the entry as may be necessary.
    - Consider having staff monitor entry to ensure everyone properly disinfects their hands and is wearing masks.
    - While there are no screening procedures required at the point of entry, school staff should observe students throughout the day and refer students who may be symptomatic to the school healthcare point of contact.[3]
- **Limit contact with doors**: If allowed by school safety guidelines, consider keeping doors propped open during entry/exit times if constantly monitored. Consider installing touchless doors as feasible.
- **Dismissal from school:** Consider designating multiple exit points, staggering dismissal times, and monitoring handwashing or hand sanitization upon exit. Before students are dismissed, confirm they have gathered all personal belongings before leaving, especially those that require cleaning at home. *Additional details on pick-up and drop-off protocols can be found in the Transportation Guidance.*

Recess

- **Hand hygiene:** Hand washing facilities or hand sanitizer needs to be used upon entering and leaving recess space.
- **Cohorting:** Consider designating outdoor spaces to separate cohorts and support physical distancing while still providing recess opportunities.[4]
- **Cleaning and disinfecting:** When possible, clean and disinfect high-touch surfaces made of plastic or metal between cohort use.
- **Masking:** If students are outdoors and maintain a distance of at least 6 feet, consider using recess as an unmasked time. Otherwise, monitor for adherence to masking requirements and at least 3 feet of distancing.
- **Activities:** Playgrounds can be used with staff monitoring to ensure physical distancing and masking. Consider whether the number of staff at recess will need to be increased. Additional staff may be needed during high-risk times (the beginning and end of recess) and in high-risk locations (enclosed or small, hard-to-see places on fixed equipment, or anywhere with high child density).[5]

Storage and disposal

- **Storage of furniture and other items:** Given the critical need for space and in order to move furniture and non-essential items, districts may need to use storage pods or other spaces in the community. Districts could also consider renting storage space temporarily.

- **Storage for cleaning supplies:** Adequate storage space should be allocated for cleaning supplies and disinfectants, and it should be accessible only to staff. More information on storing cleaning supplies and disinfectants is available in this EPA resource.

2. Making systems and other space use modifications

Handwashing and hand sanitizing stations

Handwashing removes pathogens from the surface of the hands. While handwashing with soap and water is the best option, alcohol-based hand sanitizer (at least 60 percent ethanol or at least 70 percent isopropanol) may be utilized when handwashing is not available.[6] [7]

Provide handwashing or hand sanitizing stations in the following common areas and ensure there are enough supplies (soap and sanitizer) at all times to accommodate frequent hand washing and sanitizing:

- All entries and exits
- In bathrooms
- In classrooms
- In libraries and shared activity spaces
- Next to meal distribution and consumption areas
- Next to water fountains that require touch to operate
- Next to mask break areas (if additional mask break areas are identified)

Given the importance of maximizing handwashing and sanitization stations, it may be permissible to have students within 3 feet of distance for a brief period of time (20 seconds) during hand washing as long as masks are worn and students are not directly facing one another. This will permit all sinks in a bathroom to be used even if closer than 3 feet apart, for example.

Ventilation and HVAC systems

Appropriate mask usage remains the best defense against all forms of respiratory transmission. Schools can further mitigate airborne transmission by increasing outdoor air ventilation or filtering air that is recirculating within a room or building. From a facilities and operations perspective, it is important to determine the best approach for each school site given differences in ventilation capabilities.

While there have been many schools built over the past decade with similar building plans and operating systems, most schools have different ventilation and HVAC systems and capabilities. From a facilities perspective, this means it is important to understand the opportunities and challenges unique to your building.

- For buildings that have facility-wide HVAC systems, it is likely that you will also have a contact or contract with experts to help maximize ventilation and filtration.
- For other buildings, this guidance is meant to provide you with direction and to answer key questions.

- If you have specific questions about ventilation and HVAC, please contact Matt Deninger at Matthew.J.Deninger@mass.gov or 781-338-3117.

Prepare ventilation systems

- **Clean ventilation system:** Ensure the school ventilation system is properly cleaned.
- **Run HVAC systems**: Operate HVAC systems with outside air dampers open for a minimum period of one week prior to reopening schools.
- **Consider upgrading filters**: In buildings with mechanical ventilation systems, consider upgrading filters to increased efficiency ratings.[8] Schools that are not able to upgrade filters may explore alternative ways to improve ventilation (e.g., through open windows), if appropriate for their system.

Increase outdoor air ventilation

- **Adjust HVAC settings**: Some mechanical ventilation systems can forcibly bring outdoor air inside and then distribute that fresh air to different areas of the building. If possible with the site's HVAC system, adjust settings to increase the flow of outdoor air. If your system can do this, evaluate the impact of adjusting windows or doors manually, as they may negatively impact the system itself.
- **Open windows or doors (when appropriate and safe)**: For facilities without the above HVAC capability, evaluate the options to open windows and doors when safe to do so, as well as the feasibility of increasing outdoor air intake with fan boxes in windows.
- **Prevent or minimize air recirculation**: Facilities staff should evaluate how to eliminate or minimize air recirculation in their HVAC systems to the extent possible.[9]
- **Maintain ventilation for longer hours**: If possible, schools should leave ventilation systems running longer than normal. Ideally, ventilation systems would run continuously, but it is recommended they run at least two hours before and after school, as there may still be individuals in the building (students or staff).[10]

Indoor spaces without windows

- For any spaces without windows that may be used for student activities, special attention must be made to ensure that there are adequate HVAC capabilities for the space.
- Otherwise, indoor spaces without windows and adequate HVAC should not be used or only used as may be appropriate for storage or similar uses.

Hallways

- **Create standard routes:** Outline a plan for hallway use to minimize congestion. When possible, make hallways one-directional to prevent students from directly passing each other. This is especially important for small hallways. Ensure that stairwells are also properly marked and one-directional. Staff should reinforce these directions, adherence to physical distancing, and masking. Schools should test emergency evacuation protocols and carefully communicate any relevant changes.

- **Close off certain hallways:** Consider closing off hallways or areas that are too narrow for proper physical distancing and unable to be one-directional.
- **Stagger class transitions:** Develop a plan for transitions between classes to avoid crowding in hallways. Consider dismissing students grade-by-grade or according to other cohort models. Consider identifying facility monitors or class monitors to ensure students wear masks, maintain distance, and do not linger in the hallway.

Bathrooms

- **Hand dryers:** Consider replacing hand dryers with disposable towels, as hand dryers increase the flow of air particles in the bathroom.[11] [12] [13]
- **Touchless technology:** Place a trash can and paper towels by the bathroom door to allow students and staff to avoid touching door handles directly. If possible, consider installing touchless technology in the bathroom equipment (e.g. hand soap, paper towel dispensers, automatic doors).
- **Ventilation:** When feasible, open windows in bathrooms that do not pose a safety or privacy risk and if not against HVAC system standards.
- **Bathroom use:** Consider not allowing students to use the bathroom during transition times, and otherwise using a bathroom sign out system to reduce the number of students in bathrooms at one time. Ensure that students use their own writing instruments for the sign out log.

Lockers

- **Limit usage:** Consider suspending the use of lockers. If lockers are needed, stagger access times and monitor students for masking and physical distancing.
- **Shared lockers:** Sharing lockers is not recommended but is allowed if access can be staggered and there is a minimum of 3 feet separating the lockers used at one time.

Signage

Ensure clear and age-appropriate signage is posted in highly visible locations throughout school property, reminding students and staff to follow proper health and safety protocols. Example signage on how to wear masks and reminders to wash hands are provided by both the DPH and CDC. Signage should be translated into a language understood by each student. Signage should be posted in the following key areas (non-exhaustive):

- **By handwashing and hand sanitizing stations**: To remind individuals of the proper way to clean and sanitize hands
- **In bathrooms**: To remind individuals to properly clean and sanitize hands, utilize no-touch solutions as much as possible
- **By entry/exits**: To remind students to wear masks and maintain physical distance
- **By eating areas**: Use markers to map out entry/exit flow for students, to space out lines for students picking up their meals, and to identify distancing between students as they eat. Post signs to remind students to avoid sharing food, utensils, and drinks
- **By mask break areas**: To remind individuals to maintain 6 feet of physical distance and

to follow correct mask removal procedure

- **In classrooms**: To remind individuals of physical distancing, reduce sharing of items, and keep masks on
- **Around playgrounds**: To encourage physical distancing while outside and maintain cleaning and disinfecting of high-touch areas
- **In hallways**: Use well-marked lines on the floor to encourage physical distancing and indicate direction of travel, especially in small hallways. Include signage to encourage healthy behaviors (e.g., wearing of masks)
- **Next to frequently shared equipment:** Post signs to remind students and staff to wipe down frequently shared equipment (e.g., computers and keyboards) before and after use
- **Areas where queueing may occur**: Use well-marked lines on the floor to encourage physical distancing
- **By closed areas**: Mark off closed areas

3. Developing operational protocols

School cleaning and disinfecting

Although it is not the main way the virus spreads, it may be possible for an individual to get COVID-19 by touching an object that is contaminated and then touching their own mouth, nose or possibly eyes.[14] Ensure facilities are properly cleaned and disinfected each day following the guidelines below:

- **Frequency:** Cleaning and disinfecting should occur at least daily for shared spaces and furniture. For high-touch surfaces (e.g., door handles, light switches, water fountains, toilet seats) cleaning and disinfecting should occur three to four times per day and/or between uses.
    - **Desks:** Desks should be cleaned at least daily. For situations when cohorts of students move between classrooms or where meals are eaten at desks, cleaning of desks must take place between classes and before and after meals. Cleaning of desks can be done by students or custodial staff. Carefully choose disinfectant solutions that require a short dwell or drying time and are appropriate with food surfaces.
    - **Electronics**: Consider putting a flat, wipeable cover on electronics that are difficult to clean (e.g., keyboards). Follow manufacturer's instruction to determine the appropriate disinfectant solution and how to properly clean and disinfect. If there is no guidance, use alcohol-based wipes or sprays containing at least 60 percent ethanol or 70 percent isopropanol.[15] If shared, electronics must be cleaned between use by students or custodial staff.
    - **Outdoor play areas:** High-touch surfaces made of plastic or metal should be cleaned and disinfected at least daily or between use by custodial staff.
- **Responsibility:** Dedicated custodial staff should handle all disinfection requiring chemicals for facilities (e.g., classrooms, bathrooms, mask break areas) and high-touch

objects (e.g., door handles, light switches, water fountains). For other surfaces, determine cleaning responsibility on a case-by-case basis. For shared and high-touch items such as desks, cleaning responsibility may be shared by students, if the task is age appropriate and safe.

- **Disinfectant solutions**: To select the proper disinfectant, review the suggested list on the EPA website. Consider using an alcohol solution with at least 60 percent ethanol or 70 percent isopropanol, a diluted bleach solution (if prepared daily to ensure efficacy), or an EPA-approved disinfectant unless otherwise instructed by the manufacturer's instructions. When selecting a disinfectant solution, consider the dwell time, which surfaces are used as eating surfaces, and the potential risk of triggering asthma symptoms for sensitive individuals.
- **Mask disposal:** If a reusable mask breaks and needs to be thrown out or if a single-use mask needs to be disposed of, it should be placed into the nearest trash can by the individual who wore the mask. The individual should immediately put on a new mask after washing their hands.

Shared items

- **Limit sharing**: Sharing materials is discouraged, but when shared, they must be cleaned before being used by other students.[16]
    - To the extent possible, limit sharing of electronic devices, toys, games, learning aids, art material and other items that are difficult to clean or disinfect.[17] Limit the use of supplies and equipment to one group of children at a time, and clean and disinfect items between uses.
    - Library books may be checked out if students clean their hands before and after use and if students only select books from the shelves, instead of the return area.[18] Books and other paper-based materials are not considered a high risk for transmission and do not need additional cleaning procedures.[19]
    - Identify and develop new classroom protocols that reduce passing supplies or items between students.
- **Hand hygiene**: Frequent hand washing or sanitizing, including before and after using shared materials, is an important control strategy that should be reinforced when objects and materials will be shared.
- **Purchase additional items:** Consider what supplies might need to be available on an individual basis, and purchase additional items to minimize sharing (e.g., assigning each student their own art supplies), as feasible.
- **Storage**: Keep each student's belongings separated from others' and in individually labeled containers, cubbies, or areas. Similar to locker usage, make sure to stagger access to these areas to maintain physical distancing if used. Additional guidance on sharing protocols is forthcoming.

Food service operations

Eating areas for students: As students will be unmasked to eat, there is a strict requirement of 6 feet of physical distance between each student. Based on current CDC recommendations, it is preferable for students to eat in classroom spaces. This may not be feasible for all sites, given classroom sizes, room scheduling, and physical distancing requirements. Schools may need to explore alternative options for students to eat their meals. Our prioritized recommendation includes the following options.[20]

- **Eating in the classroom:** Based on CDC recommendations, it is preferable for students to eat in classroom spaces. Meals can be delivered to classrooms, or students can bring food back from the cafeteria to eat. Schools may consider having half of the class take an outdoor mask break or recess time while the other half eats and then switching these groups to enable 6 feet of distancing. Additional staff may be needed to supervise, as the students are in two separate spaces in this model. The desks and other surfaces that students are using for meals should be cleaned between groups. Cleaning includes using an approved EPA disinfectant on these surfaces and then appropriately disposing of the materials used to wipe down the surfaces. Custodial staff or students may perform this surface cleaning, if appropriate.
- **Eating in the cafeteria:** If a single large lunchroom is to be used for eating (and is not utilized for classroom space), clearly mark spaces where cohorts and students can sit. Students must maintain 6 feet of distance when unmasked unless plexiglass barriers are used to separate students. Ensure that students do not mingle with other cohorts. The tables and other surfaces that students are using for meals should be cleaned between groups. Cleaning includes using an approved EPA disinfectant and then appropriately disposing of the materials used to wipe down the surfaces. Custodial staff or students may perform this surface cleaning, if appropriate. *Please refer to Appendix C for further details and considerations on utilizing cafeteria space.*
- **Eating in alternative spaces:** Outdoor meal consumption can be an effective way to ensure physical distancing, weather permitting. Consider other available spaces as well that will not obstruct egress or create other fire code issues. For example, use of hallways for mealtime may be possible depending on hallway width. Half of the students could eat their lunch in the classroom, with strict 6 foot distancing in place. The other half could eat in the hallway on benches or chairs, with 6 feet of distance between each student. The benches and other surfaces that students are using for meals should be cleaned between groups. Cleaning includes using an approved EPA disinfectant and then appropriately disposing of the materials used to wipe down the surfaces. Custodial staff or students may perform this surface cleaning, if appropriate.

Food preparation and serving space and related protocols

- **Evaluate kitchen workstations:** Modify stations for physical distancing. If the kitchen is small, consider moving workstations into larger areas. Face workstations in the same direction or against the wall.
- **Stagger service staff**: For large food service staff, consider having the staff work in cohort-based schedules to reduce opportunities for transmission.
- **Ensure food continuity**: Consider methods for ensuring continuity of food service operations if food service staff become sick. This could include setting up coverage from other schools within the district or purchasing a supply of shelf-stable meals.
- **Receiving deliveries**: Work with kitchen staff and vendors to determine safer ways to

handle deliveries given COVID-19 considerations. Mark entrances where deliveries will be handled, and schedule deliveries in a way that reduces crowding. If the vendor plans to drop deliveries outside and reduce the number of visitors inside the building, consider investing in dollies or assisting kitchen staff with moving deliveries to avoid workplace injuries.

- **Ensure food safety training**: Ensure that food service staff and substitutes have food safety training. Review current food safety plans and revise as needed. Free web-based food safety resources include:
    - John Stalker Institute Food Allergy Resources
    - Breakfast in the Classroom operational and safety protocols
    - School Food Service Safety Precautions for School Nutrition Professionals
    - Massachusetts Food Safety and Education Safe Bag Lunches:
    - CDC Food and Coronavirus

Preparation and distribution

- **Health and safety requirements:** Adjust food preparation and service procedures to minimize shared items (i.e. serving utensils), maintain physical distance, and comply with health and safety regulations.[21] Detailed guidance on safe food preparation can be found in Massachusetts' Safety Standards and Checklist: Restaurants.
- **Individually packaged meals:** Adjust food offerings to provide individually packaged, to-go style lunches, instead of buffet style served directly to students. Consider developing non-contact pre-payment systems for schools when offering individually packaged meals, if feasible. Consider establishing incentives for prepayment of meals.
- **Schedule and distribution:** Establish a meal serving schedule and distribution process that limits interactions between classrooms and contamination of food items or meal distribution areas. For instance, schools may schedule classroom deliveries or set times for each classroom to pick up their meals from a central location. Meal distribution should limit high-touch surfaces and exclude buffet style serving. If meals are delivered to the classroom, consider how students can pre-order meals to ensure the correct number of meals are delivered to the class each day. Consider how to return meal service materials (i.e. carts, trays) to a central location each day.[22]
- **Special dietary accommodations:** Ensure new menus offer meal accommodations for special dietary needs. Ensure these meals are clearly marked and transported without risk for cross-contamination to alternative points of service. Communicate special dietary accommodations to staff distributing meals to ensure student safety and privacy.
- **Non-essential food distribution:** Consider closing non-essential food distribution, such as school stores or vending machines to limit eating or food preparation outside of set breakfast and lunch times. Discontinue the use of any self-service food or beverage distribution in the cafeteria.

Meal consumption

- **Masks**: Ensure proper removal and placement of masks before eating. Masks should be removed by handing the ties or back/ear areas of the mask once seated. Do not touch the outside or inside of the part covering the face. While eating, masks should be placed on a napkin, paper towel, or other container on the table, with the inside of the mask facing up. Masks should be put back on before leaving the seat. More information is available here.

- **Distancing:** Individuals must be at least 6 feet apart at all times when masks are removed.
- **Hand hygiene:** Individuals must properly wash or sanitize hands before and after eating.
- **Water fountain usage**: Schools must provide potable water to students during mealtimes. Touchless or motion activated fountains are preferred for reusable water bottles, but other fountains, water jugs, or coolers can be used with single-use cups if students wash hands or use hand sanitizer before and after fountain use. **Water fountains cannot be used for direct consumption.** High-touch surfaces on water fountains, jugs or coolers should be cleaned multiple times a day. Schools may also consider providing disposable water bottles during mealtimes.
- **Food allergies:** Stay informed of student needs, including food allergies or any needed feeding assistance to enable safe meal service and clean up.
- **Food waste removal:** Work with nutrition and facilities staff to determine protocols for waste management. Additional garbage cans may be needed to accommodate food waste, especially if classroom spaces are used for meals. Consider how normal cleaning procedures and schedules may be affected by new processes. Consider how students can support clean-up, such as cleaning their own eating area after the meal, if age appropriate and safe to do so.

Meals for remote learners: Schools must continue to offer meals to eligible students who are learning remotely from home. Begin planning how to operate lunch, breakfast, and/or snack programs (as applicable) for students who will not be attending in-person school five days a week. *Additional guidance will be provided by DESE's Office for Food and Nutrition Programs.*

- **Communication:** Communicate with families on how remote meal processes will be different from this past spring.
- **Delivery Methods:** Begin planning for drive-through, delivery, curb-side pick-up, or end of school day take-home meals (as appropriate) for students who are not attending in-person school five days a week. Meal distribution methods utilized this past spring, including parent pick-up, can be continued, including providing meals to cover multiple days.

Visitors and volunteers

- **Reduce outside visitors or volunteers**: No outside visitors and volunteers are recommended, except for contracted service providers for the purpose of special education, required support services, or program monitoring as authorized by the school or district. Assign a staff member to enforce this protocol.
- **Single entry/exit**: Designate a single entry and exit point for all visitors and volunteers to be visually screened and logged in. For visitors who need to enter, they should first gain approval, be briefed on school COVID-19 policies, and verify they do not have symptoms. Ensure that these individuals all are wearing masks covering their nose and mouth at all times and are aware of any other health and safety protocols for the school.

- **Track visitor log**: A log of all visitors must be kept and maintained for 30 days, with the date, contact phone number, arrival/departure times, and areas visited within the building for each visit.
- **Minimize parent/family visits** and require them to occur only in the school office and/or outside spaces, if appropriate.
    - Visitors necessary for drop off or pick up must wear masks.
    - Schools should encourage only one guardian to visit a building when possible and continue to utilize virtual communication options with families (e.g., for parent-teacher conferences). [23]
    - It is recommended that the same adult drop off and pick up the child each day if it necessary that they enter the building.
- **Restrict visitor time**: Schools can also consider restricting visitor access to limited times when classes are in session (i.e., at times when there will not be many people in the hallways). [24]

Appendix A: Maximizing school space

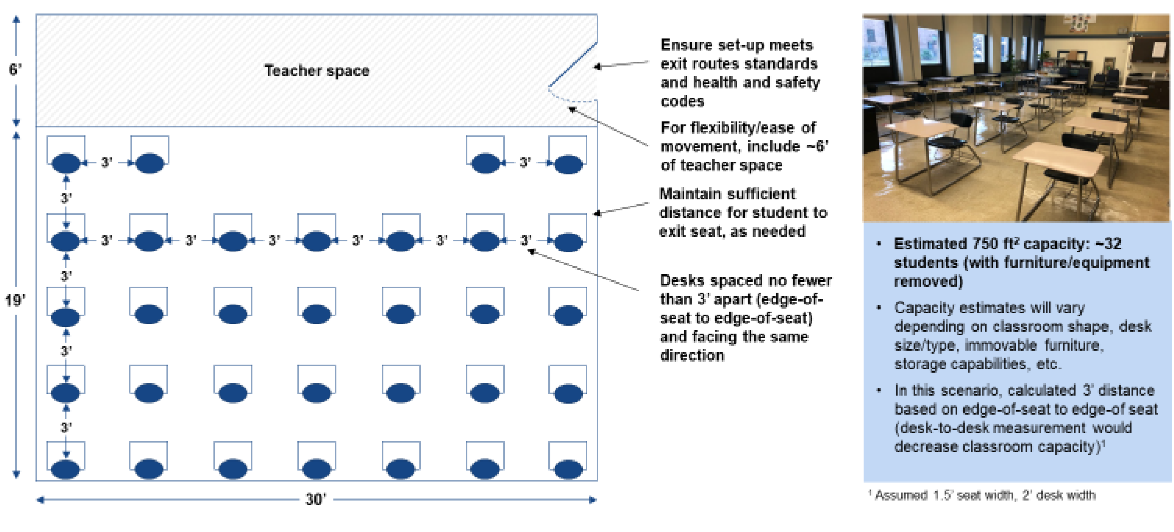
The diagrams below outline best practices for classroom setup in order to maximize capacity while adhering to health and safety requirements. We have included sample classroom diagrams, based on common desk dimensions and several classroom tours, that outline important considerations such as health and safety codes, teacher movement, and immovable furniture or equipment. We encourage schools to physically measure each classroom in addition to using [this parametric tool] to make sure that space is being maximized to the extent possible.

Best Practices for Classroom Setup:

- **Physical distancing:** With masks, 3 feet is the minimum physical distancing. For planning purposes, this distance refers to the distance between seat edges. Spaces where masks are not worn (e.g. eating and mask break areas), 6 feet is the minimum physical distancing.
- **Teacher space:** Allow adequate **space for teachers** to ensure safe physical distance from students.
- **Furniture:** Consider **removing non-essential furniture** from classrooms. Explore **storage options** in advance.
- **Communal areas:** Consider **repurposing communal areas** for additional classrooms.
- **Other constraints:** When estimating capacity, consider additional constraints that reduce usable desk space (e.g., emergency fire egress, radiators, immovable furniture, desk/furniture size and type, camera angles for synchronous learning).

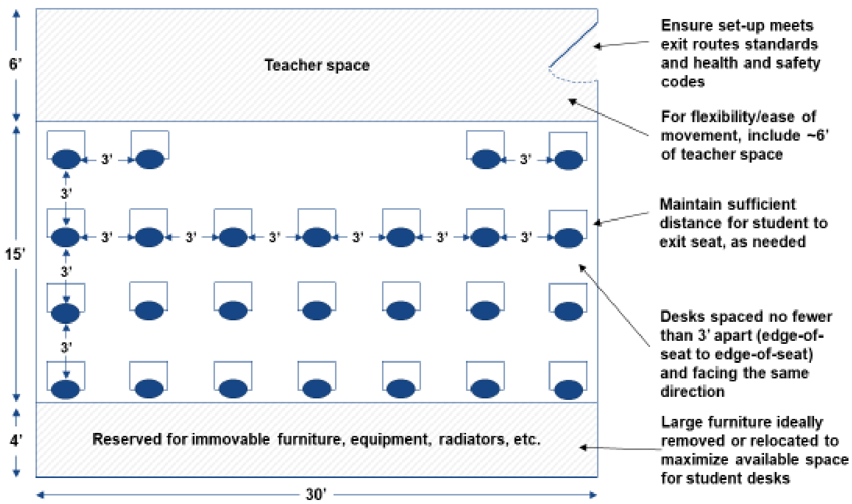
Example A1: Fits ~32 individual desks with 3' physical distancing

(Dimensions: 750 sq. ft., 25' x 30'); with all furniture/equipment removed



Example A2: Fits ~25 individual desks with 3’ physical distancing

(Dimensions: 750 sq. ft., 25’ x 30’)



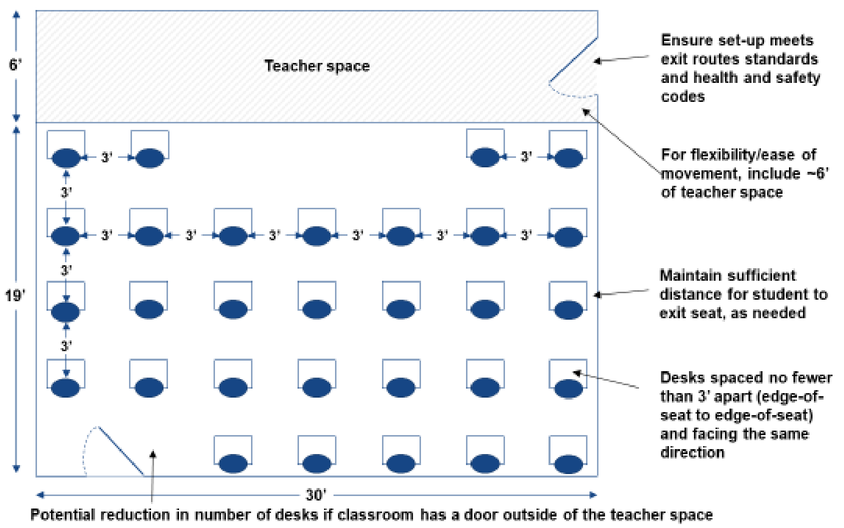
- **Estimated 750 ft² capacity: ~25 students**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3’ distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5’ seat width, 2’ desk width

2

Example A3: Fits ~30 individual desks with 3’ physical distancing

(Dimensions: 750 sq. ft., 25’ x 30’); with all furniture/equipment removed



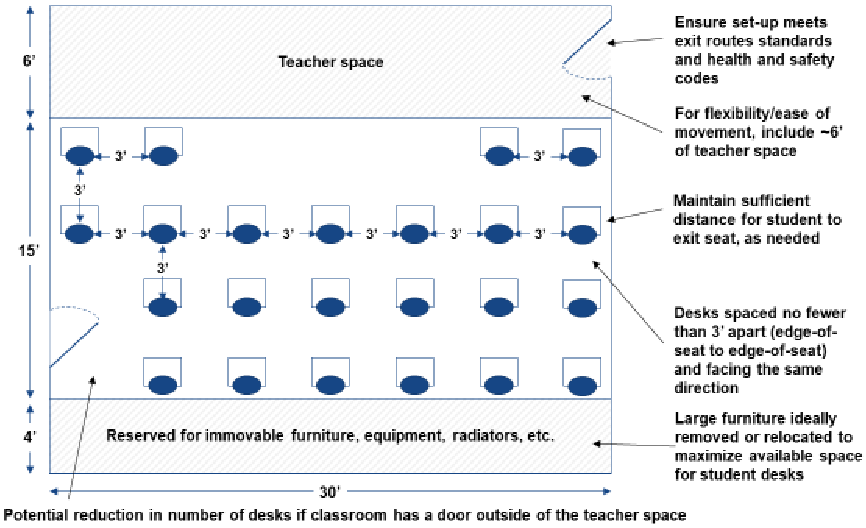
- **Estimated 750 ft² capacity: ~30 students (with furniture/equipment removed)**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3’ distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5’ seat width, 2’ desk width

3

Example A4: Fits ~23 individual desks with 3’ physical distancing

(Dimensions: 750 sq. ft., 25’ x 30’)



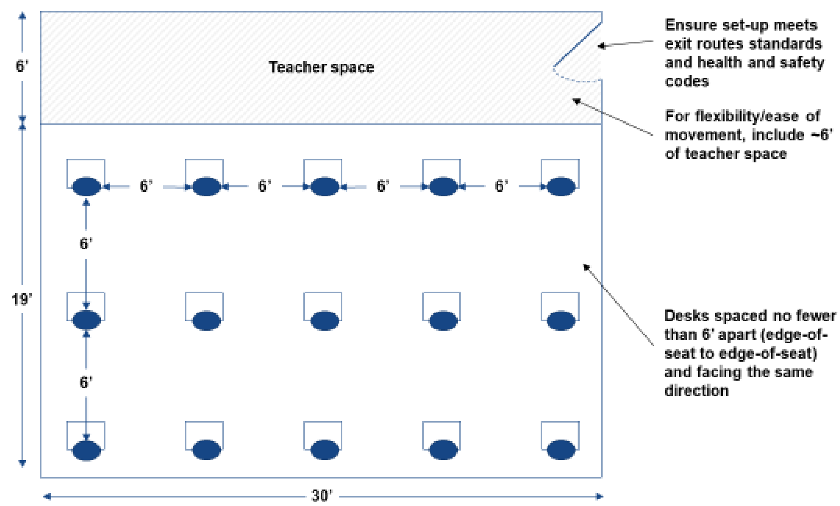
- **Estimated 750 ft^2 capacity: ~23 students**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3’ distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5’ seat width, 2’ desk width

4

Example A5: Fits ~15 students with 6’ physical distancing

(Dimensions: 750 sq. ft., 25’ x 30’)



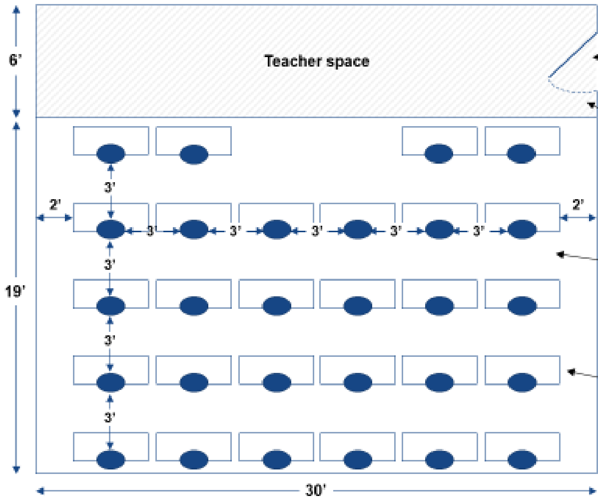
- **Estimated 750 ft^2 capacity: ~15 students**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 6’ distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5’ seat width, 2’ desk width

5

Example B1: Fits ~28 4’ dual desks with 3’ physical distancing

(Dimensions: 750 sq. ft., 25’ x 30’); with all furniture/equipment removed



Ensure set-up meets exit routes standards and health and safety codes

For flexibility/ease of movement, include ~6’ of teacher space

Desks spaced no fewer than 3’ apart and facing the same direction

4’ desks intended for two students can only accommodate one under distancing requirements

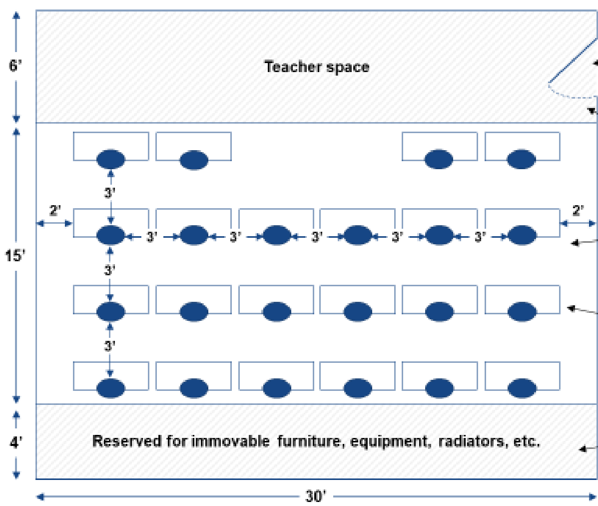
- **Estimated 750 ft² capacity: ~28 students (with furniture/equipment removed)**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3' distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5' seat width, 4' desk width

6

Example B2: Fits ~22 4’ dual desks with 3’ physical distancing

(Dimensions: 750 sq. ft., 25’ x 30’)



Ensure set-up meets exit routes standards and health and safety codes

For flexibility/ease of movement, include ~6’ of teacher space

Desks spaced no fewer than 3’ apart and facing the same direction

4’ desks intended for two students can only accommodate one under distancing requirements

Large furniture ideally removed or relocated to maximize available space for student desks

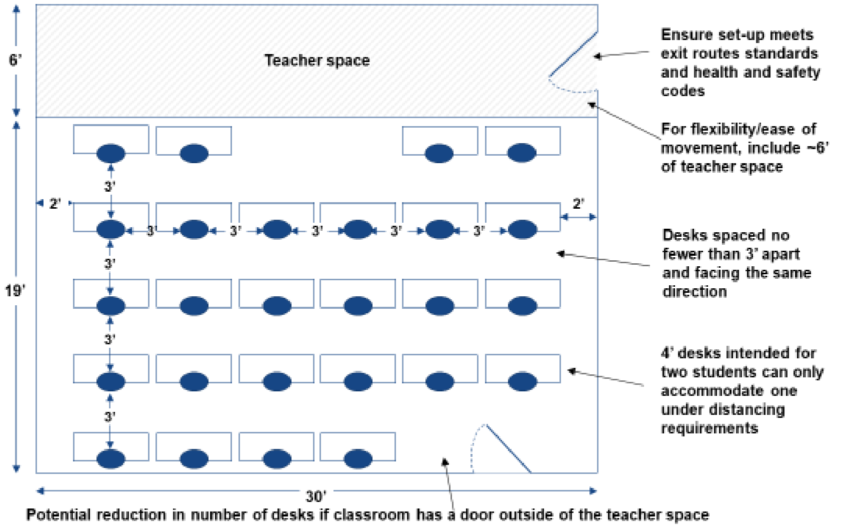
- **Estimated 750 ft² capacity: ~22 students**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3' distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5' seat width, 4' desk width

7

Example B3: Fits ~26 4' dual desks with 3' physical distancing

(Dimensions: 750 sq. ft., 25' x 30'); with all furniture/equipment removed



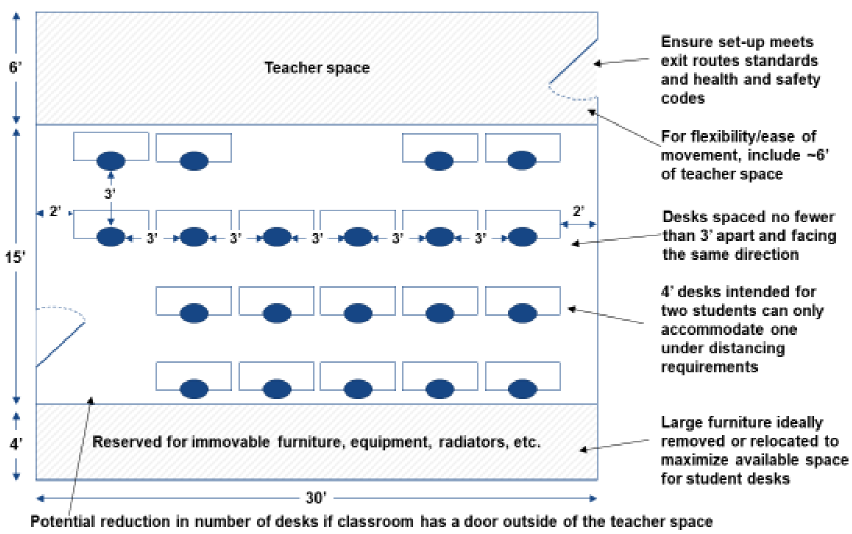
- **Estimated 750 ft² capacity: ~26 students (with furniture/equipment removed)**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3' distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

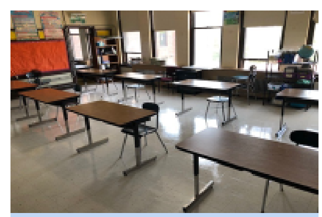
[1] Assumed 1.5' seat width, 4' desk width

8

Example B4: Fits ~20 4' dual desks with 3' physical distancing

(Dimensions: 750 sq. ft., 25' x 30')





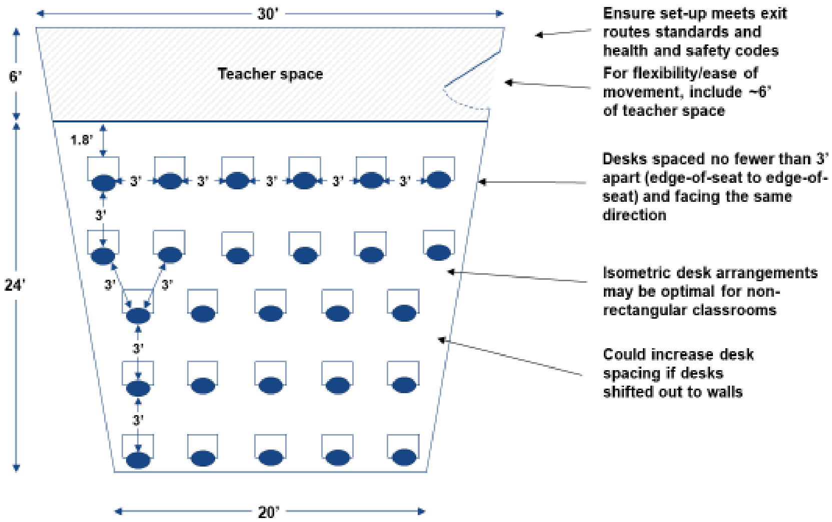
- **Estimated 750 ft² capacity: ~20 students**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3' distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5' seat width, 4' desk width

9

Example C1: Fits ~27 individual desks with 3’ physical distancing

(Dimensions: 750 sq. ft., 30’ at widest / 20 at narrowest x 30’)



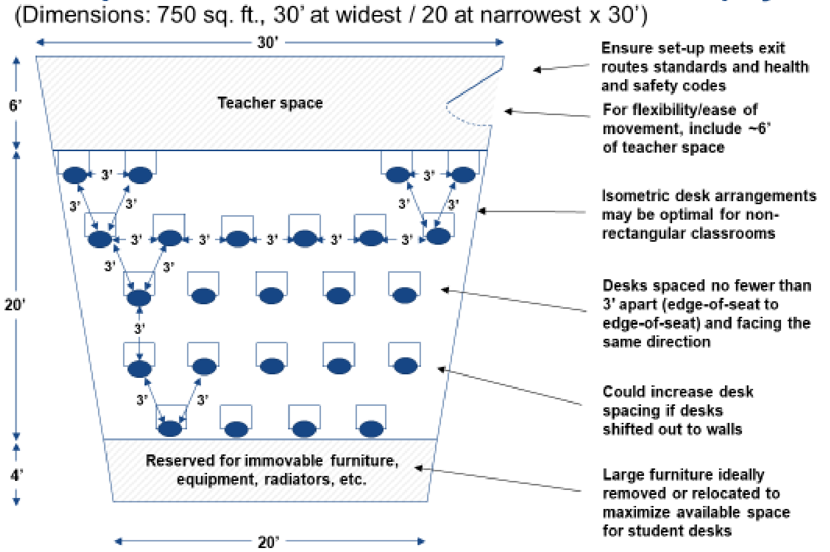
- **Estimated 750 ft² capacity: ~27 students**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3’ distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5’ seat width, 2’ desk width

10

Example C2: Fits ~24 individual desks with 3’ physical distancing

(Dimensions: 750 sq. ft., 30’ at widest / 20 at narrowest x 30’)



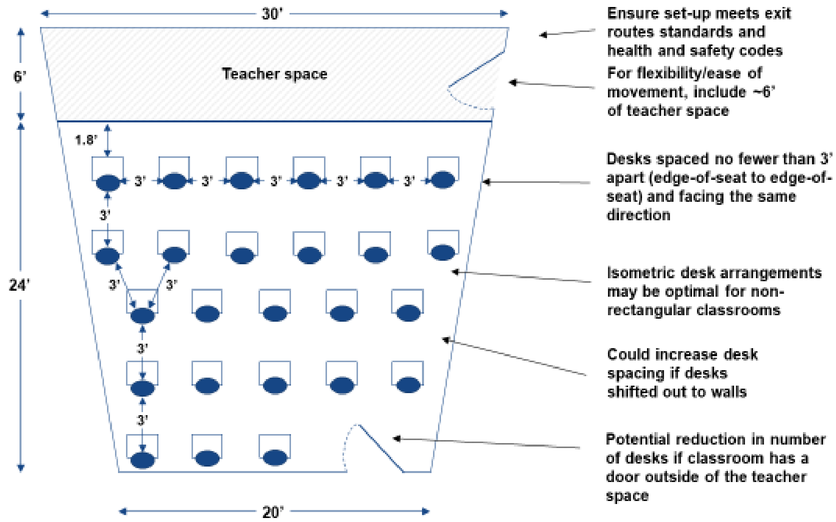
- **Estimated 750 ft² capacity: ~24 students**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3’ distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5’ seat width, 2’ desk width

11

Example C1: Fits ~25 individual desks with 3' physical distancing

(Dimensions: 750 sq. ft., 30' at widest / 20 at narrowest x 30')



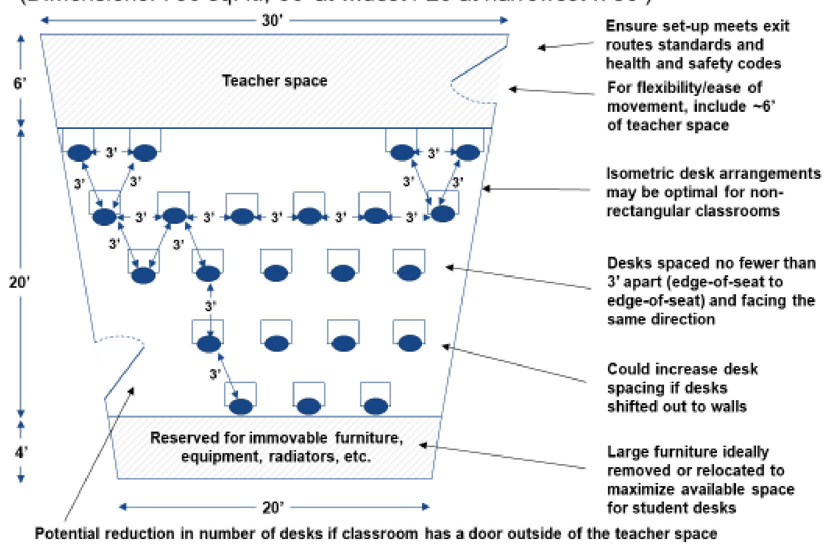
- **Estimated 750 ft² capacity: ~25 students**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3' distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5' seat width, 2' desk width

12

Example C2: Fits ~22 individual desks with 3' physical distancing

(Dimensions: 750 sq. ft., 30' at widest / 20 at narrowest x 30')



- **Estimated 750 ft² capacity: ~22 students**
- Capacity estimates will vary depending on classroom shape, desk size/type, immovable furniture, storage capabilities, etc.
- In this scenario, calculated 3' distance based on edge-of-seat to edge-of seat (desk-to-desk measurement would decrease classroom capacity)[1]

[1] Assumed 1.5' seat width, 2' desk width

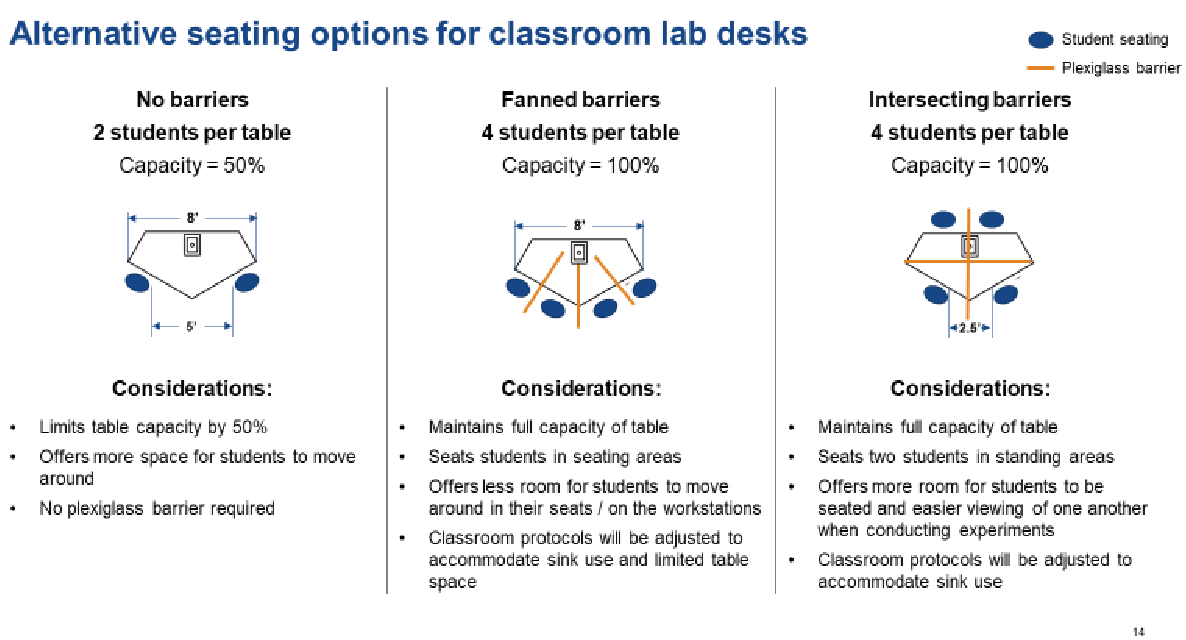
13

Appendix B: Laboratory seating

The diagrams below outline options for laboratory seating in order to maximize capacity while adhering to health and safety requirements. Use the following guidelines and considerations when developing laboratory seating layouts. Work closely with teachers and administrators to comply with fire and safety codes and adjust curriculums as necessary to accommodate capacity and physical changes.

Plexiglass barriers:

- Usage: Barriers should only be used in laboratory settings where desks are unable to be moved or cannot be replaced with moveable desks.
- Height: Barriers should be tall enough to extend beyond a student's standing height
- Width: Barriers should extend at least one foot past the edge of the table and abide by fire and safety regulations
- Cleaning: Barriers should be properly cleaned between uses
- Rubber edges: Consider use of rubber edges to avoid risk of injury when plexiglass extends beyond tables
- Classroom protocols: Make sure that plexiglass barrier use is aligned to safety procedures and consider adjusting classroom experiments to avoid potential fire hazards

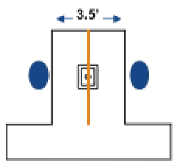


Alternative seating options for perimeter lab desks

Student seating
Plexiglass barrier

2 students per table

Capacity = 50%

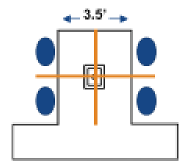


Considerations:

- Barrier usage enables students to face one another in this seating option
- Offers more space for students to move around
- Reduces total plexiglass usage
- Classroom protocols will be adjusted to accommodate sink use

4 students per table

Capacity = 100%



Considerations:

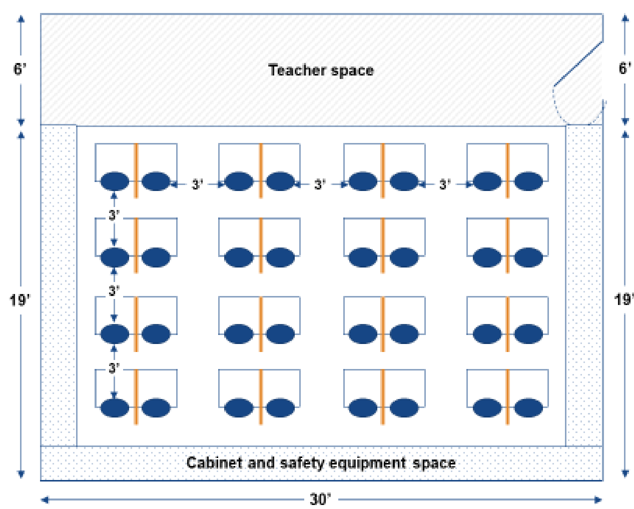
- Barrier usage enables students to face one another in this seating option, and be side-by-side
- Maintains full capacity of table
- Reduces room for students to move around
- Classroom protocols will be adjusted to accommodate sink use

15

Alternative seating options for movable lab desks

(Dimensions: 750 sq. ft., 25' x 30'; laboratory safety equipment space included but not pictured)

Student seating
Plexiglass barrier



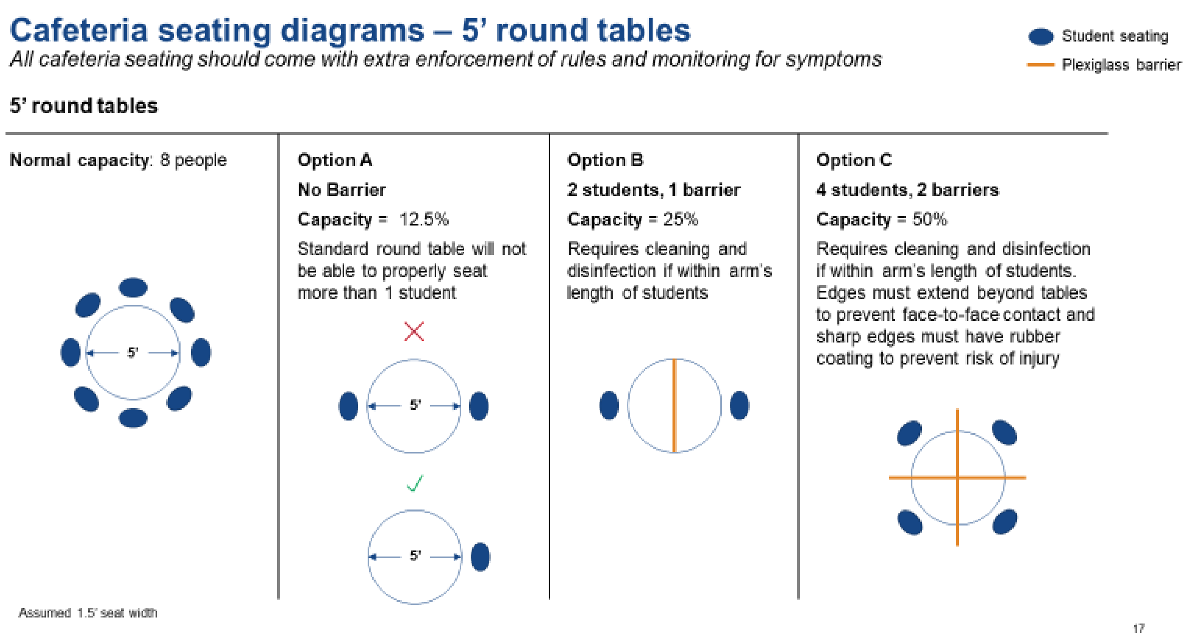
16

Appendix C: Cafeteria seating

The diagrams below outline options for cafeteria seating based on four common cafeteria tables. Use the following guidelines and considerations to determine the most feasible way to utilize cafeteria space (e.g., for classrooms or for eating). Work closely with facility departments to comply with fire and safety codes.

Considerations for plexiglass barriers:

- Usage: Barriers may be used to increase cafeteria capacity during meals.
- Height: Barriers should be tall enough to extend beyond a student's standing height
- Width: Barriers should extend at least one foot past the edge of the table and abide by fire and safety regulations
- Cleaning: Barriers should be properly cleaned between uses
- Rubber edges: Consider use of rubber edges to avoid risk of injury when plexiglass extends beyond tables
- Classroom protocols: Make sure that plexiglass barrier use is aligned to safety procedures and consider adjusting classroom experiments to avoid potential fire hazards



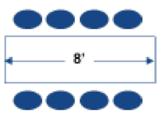
Cafeteria seating diagrams – 8’ rectangular tables

All cafeteria seating should come with extra enforcement of rules and monitoring for symptoms

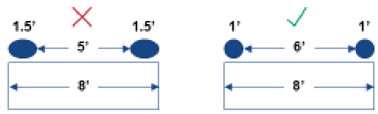
Student seating

8’ rectangular tables

Normal capacity: 8 people

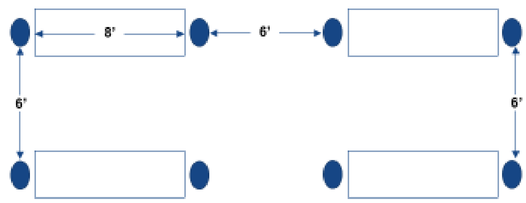


Option A 1’ seating space: 8’ tables will not be able to accommodate 2 students seated in the same direction unless assumed seat width is reduced to 1’ (instead of 1.5’)



Capacity = 25%

Option B Distanced face-to-face seating (no barriers): To fit more students on a table, it may be for students to sit face-to-face 8’ apart, while maintaining 6’ of distance in other directions



Capacity = 25%

Additional considerations:

Students will be directly facing one another and must refrain from shouting, singing, sneezing, or coughing

May require chairs if benches are not built on short ends

Assumed 1.5’ seat width

Cafeteria seating diagrams – 8’ rectangular tables

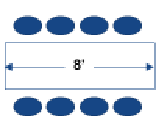
All cafeteria seating should come with extra enforcement of rules and monitoring for symptoms

Student seating

Plexiglass barrier

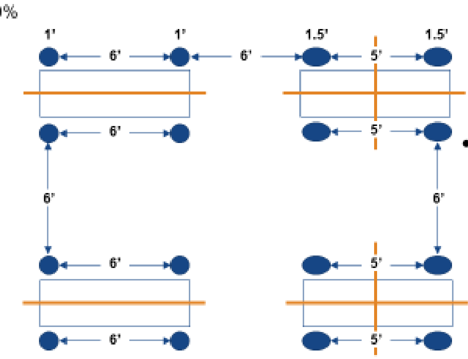
8’ rectangular tables

Normal capacity: 8 people



Option C Barriers: Adding a horizontal barrier allows students to sit face-to-face on opposite sides of the table. If students require more than 1’ of seating space, consider adding a vertical barrier that extends beyond the table and includes necessary rubber coating to prevent risk of injury. Barriers will require cleaning and disinfection between uses if within arm’s length of students.

Capacity = 50%



Additional considerations:

Tables will require further spacing than Option B to meet 6 feet distance requirements

Assumed 1.5’ seat width

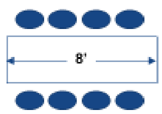
Cafeteria seating diagrams – 8' rectangular tables

All cafeteria seating should come with extra enforcement of rules and monitoring for symptoms

Student seating
Plexiglass barrier

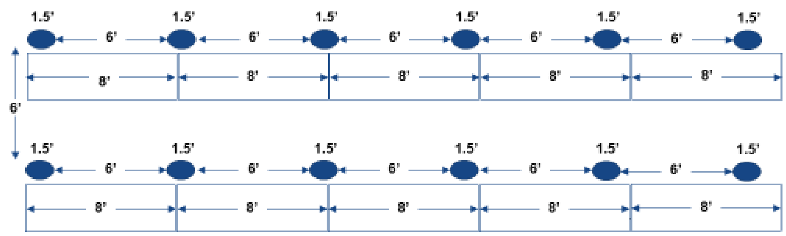
8' rectangular tables

Normal capacity: 8 people



Option D Combine Tables: Depending on the cafeteria layout, consider placing 8' next to each other to allow distanced seating to occur with adequate individual space.

Capacity = 19%



Assumed 1.5' seat width

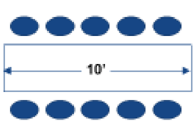
Cafeteria seating diagrams – 10' and 12' rectangular tables

All cafeteria seating should come with extra enforcement of rules and monitoring for symptoms

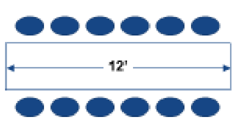
Student seating

10' and 12' rectangular tables

Normal capacity: 10 people



Normal capacity: 12 people



Option A No Barrier: Without barriers, two students may be seated at a time

Capacity = 20%

Capacity = 17%

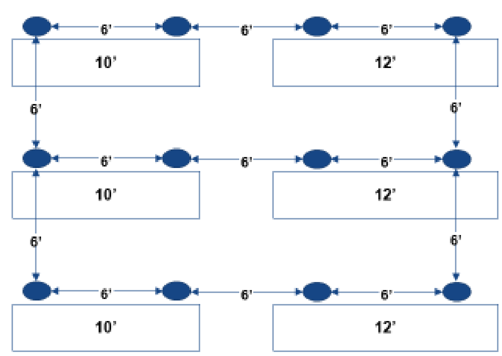


Table spacing: Ensure that 6 feet distance is still maintained between students sitting at other tables

Student seating: Both 10' and 12' cafeteria tables may seat 2 students maximum spaced 6 feet apart. All students should sit on the same side of the table and face the same direction

Assumed 1.5' seat width

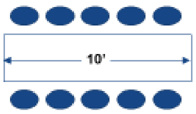
Cafeteria seating diagrams – 10’ and 12’ rectangular tables

All cafeteria seating should come with extra enforcement of rules and monitoring for symptoms

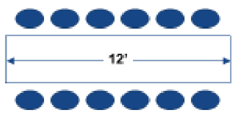
Student seating
Plexiglass barrier

10’ and 12’ rectangular tables

Normal capacity: 10 people



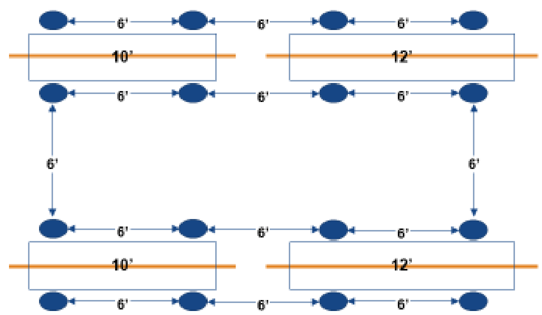
Normal capacity: 12 people



Assumed 1.5’ seat width

Option B Horizontal Barrier: Adding a horizontal barrier allows students to sit face-to-face on opposite sides of the table. Barriers will require cleaning and disinfection between uses if within arm’s length of students.

Capacity = 40% **Capacity** = 33%



Student seating: Both 10’ and 12’ cafeteria tables may seat 2 students maximum spaced 6 feet apart

Table spacing: Ensure that 6 feet distance is still maintained between students sitting at other tables

Additional considerations:

Tables will require further spacing than Option A to meet 6 feet distance requirements

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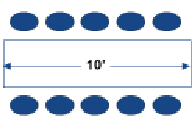
Cafeteria seating diagrams – 10’ and 12’ rectangular tables

All cafeteria seating should come with extra enforcement of rules and monitoring for symptoms

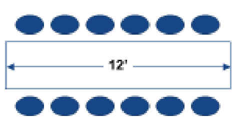
Student seating
Plexiglass barrier

10’ and 12’ rectangular tables

Normal capacity: 10 people



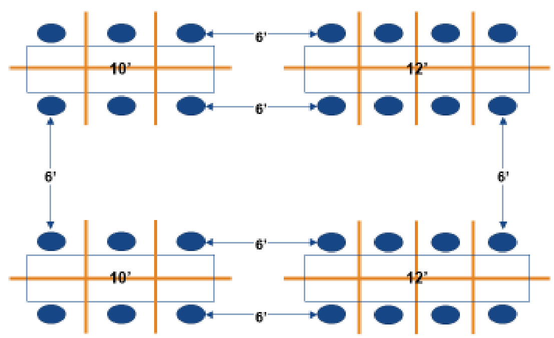
Normal capacity: 12 people



Assumed 1.5’ seat width

Option C Horizontal & Vertical Barriers: Adding vertical barriers that extends beyond the table and includes necessary rubber coating to prevent risk of injury will further increase table capacity. Barriers will require cleaning and disinfection between uses if within arm’s length of students.

Capacity = 60% **Capacity** = 67%



Student seating: Both 10’ and 12’ cafeteria tables may seat 2 students maximum spaced 6 feet apart

Table spacing: Ensure that 6 feet distance is still maintained between students sitting at other tables

Additional considerations:

Tables will require further spacing than Option A to meet 6 feet distance requirements

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[3] CDC. (2020). Considerations for Schools. Available at https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/schools.html

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[14] CDC. (2020). Considerations for Schools. Available at https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/schools.html

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[16] Melnick, H., & Darling-Hammond, L. (with Leung, M., Yun, C., Schachner, A., Plasencia, S., & Ondrasek, N.). (2020). Reopening schools in the context of COVID-19: Health and safety guidelines from other countries (policy brief). Available at https://learningpolicyinstitute.org/product/reopening-schools-covid-19-brief

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Appendix 7 – Filtration Chart

	Particle Size Efficiency				
MERV Rating	0.3 - 1 micron (tiny particles)	3 - 10 microns (large particles)	Typical Particles	Typical Filter Type	Suggested For
18	> 99.99%	> 99.99%	Bacteria, Fine Dust, All Mold, All Pollen, Asbestos, Copier Toner, Some Viruses.	Better than HEPA	Mild-High Allergy, Asthma Sensitivity & COPD
17	> 99.97%	> 99.97%	Bacteria, All Mold, All Pollen.	HEPA	Mild-High Allergy
16	>95%	>95%	Small to large pollen, dust, mold	Box Filter	Mild-Moderate Allergies
15	85% - 95%	>90%	Mid to large pollen, dust, mold	Box Filter	Low-Mild Level Allergies
14	75% - 85%	>90%		Box & Tower Filter	
13	< 75%	>90%		Box & Tower Filter	
12	na	>90%	Large pollen, dust	Box & Tower Filter	High End Home air filters & pleated pre-filters in air purifiers
11	na	>85%			
10	na	>85%			
9	na	>85%			
8	na	>70%	Large pollen, dust mites	Pleated Filter	Mid Range Home air filters (HVAC) & pleated pre-filters in air purifiers
7	na	50% - 70%			
6	na	35% - 50%			
5	na	20% - 35%			
4	na	< 20%	Hair, large dust	Foam Filter	Low End Home air filters (HVAC) & foam pre-filters in air purifiers
3	na	< 20%			
2	na	< 20%			
1	na	< 20%			

Appendix 8 - ICC / IMC 2015 Section 403.3.1.1 – Ventilation Table

IMC-2015

403.3.1.1 Outdoor airflow rate. Ventilation systems shall be designed to have the capacity to supply the minimum outdoor airflow rate, determined in accordance with this section. In each occupiable space, the ventilation system shall be designed to deliver the required rate of outdoor airflow to the *breathing zone*. The occupant load utilized for design of the ventilation system shall be not less than the number determined from the estimated maximum occupant load rate indicated in Table 403.3.1.1. Ventilation rates for occupancies not represented in Table 403.3.1.1 shall be those for a listed *occupancy* classification that is most similar in terms of occupant density, activities and building construction; or shall be determined by an *approved* engineering analysis. The ventilation system shall be designed to supply the required rate of *ventilation air* continuously during the period the building is occupied, except as otherwise stated in other provisions of the code.

IMC 2015 - TABLE 403.3.1.1
MINIMUM VENTILATION RATES

OCCUPANCY CLASSIFICATION	OCCUPANT DENSITY #/1000 FT^2 [a]	PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_p CFM/PERSON	AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_a CFM/FT^2 [a]	EXHAUST AIR Flow RATE CFM/FT^2 [a]
Education				
Art classroom[g]	20	10	0.18	0.7
Auditoriums	150	5	0.06	—
Classrooms (ages 5-8)	25	10	0.12	—
Classrooms (age 9 plus)	35	10	0.12	—
Computer lab	25	10	0.12	—
Corridors (see public spaces)	—	—	—	—
Day care (through age 4)	25	10	0.18	—
Lecture classroom	65	7.5	0.06	—
Lecture hall (fixed seats)	150	7.5	0.06	—
Locker/dressing rooms[g]	—	—	—	0.25
Media center	25	10	0.12	—
Multiuse assembly	100	7.5	0.06	—
Music/theater/dance	35	10	0.06	—
Science laboratories[g]	25	10	0.18	1.0
Smoking lounges[b]	70	60	—	—
Sports locker rooms[g]	—	—	—	0.5
Wood/metal shops[g]	20	10	0.18	0.5