BALA

PULASKI ELEMENTARY SCHOOL

HVAC ASSESSMENT REPORT FOR SCHOOL RE-OPENING

General:

1. The purpose of this report is to give an overview of the potential measures that may be applied to the building HVAC systems and spaces to provide a safer environment for students, teachers, and staff to return to school this year. The diversity of space types and systems require different solutions and strategies to be considered to improve the interior environment.

2. This report does not make recommendations on occupant density, reconfiguration of spaces, cleaning procedures, or implementation of touch-free procedures. The District is urged to seek guidance from the Massachusetts Department of Elementary and Secondary Education (DESE) and the Centers for Disease Control (CDC) on these and other issues related to the COVID-19 virus.

Potential HVAC Strategies:

1. Increased Ventilation:

    a. Increasing outside air ventilation rates can be an effective strategy to reduce airborne concentrations of viruses, bacteria, and other contaminants.

    b. Operable windows provide a good source of fresh air, which at times can provide a significantly higher amount compared to mechanical ventilation systems. Since this air cannot be filtered directly, the surrounding environment must be low in airborne contaminants to avoid bringing in unhealthy air which could lead to other issues.

    c. Since the use of operable windows is manually controlled by the space occupants, some discretion must be used in determining when to apply this measure. Opening windows during cold weather can lead to loss of space temperature control and increased heating energy consumption. Where mechanical systems have cooling capabilities, the cooling system should be turned off where possible when the windows are open. The amount that a window should be opened should also be considered based on wind speed and outside air temperature to help prevent uncomfortable conditions.

    d. Wherever technology-based strategies are installed such as bipolar ionization systems described later, opening windows for increased ventilation should not be used as it will reduce the effectiveness of the system.

    e. Increasing the minimum outside airflow settings for classroom unit ventilators and air handling systems can be considered but would generally be limited to a 10% to 30% increase at the expense of higher energy use and a reduction in system capacity available for space conditioning. Increasing minimum outside air settings only provides a marginal reduction in the concentration of contaminants in the space compared to normal ventilation levels. Adjustment of outside air damper positions to achieve an increased ventilation rate should only

be done by a qualified air balancing technician. Unintentional over-adjustment can lead to an excessive reduction in system capacity or freeze-up problems. Generally, the use of operable windows is expected to provide a higher benefit than increasing mechanical ventilation rates albeit under less controlled conditions that may still lead to comfort issues.

2. Enhanced Filtration:

   a. The ability to add higher efficiency filters in air systems can provide an added level of protection depending on the efficiency level that can be achieved. The thickness of the existing filter systems is the primary factor that limits the level of efficiency that can be attained. The second consideration is that higher efficiency filtration typically has a higher initial resistance to airflow which has an effect on a system's air capacity.

   b. Mechanical systems in the district generally have classroom unit ventilators with 1-inch thick filters and air handling units with 2-inch thickness. In both cases a filter efficiency rating of MERV 8 would typically be used.

   c. Filters with a higher efficiency rating will remove particles of smaller sizes, which is necessary to remove aerosolized virus particles from the air stream. Filters with a MERV 13 rating are capable of capturing up to 75% of aerosolized virus particles. One-inch and 2-inch filters are available with MERV 11 and 13 ratings which incorporate an electrostatic charge to help obtain their rating. Therefore, these filters must be stored in a dry location to maintain their effectiveness.

   d. The availability of higher efficiency 1-inch filters for unit ventilators is limited. Filters with an efficiency level of MERV 13 are available but the airflow rating is not high enough to handle the amount of supply air that a unit ventilator needs. The use of MERV 11 filters may be an acceptable alternative. With the higher potential for removal of small sub-micron particles, these will be significantly more effective than MERV 8 filters.

   e. Two-inch MERV 13 filters for air handling units is more practical. The air flow resistance of these filters is still higher than MERV 8, but they are not expected to cause a significant loss of unit capacity.

   f. It is important to note that the 1-inch and 2-inch MERV 11 and MERV 13 filters should be changed every 90 days, since the electrostatic charge will lose effectiveness over time. This translates to at least 3 filter changes per year where schools are not occupied during the summer months.

   g. It is recommended that appropriate personal protection (PPE) procedures be exercised when dirty filters are removed from the systems, since active viruses may be present. The dirty filters should be bagged immediately when removed from the system to prevent particles from being dispersed back into the space.

3. Control Strategies:

    a. The operation of the minimum outside air damper settings for the classroom unit ventilators and school air handling systems is recommended to be verified including operation of economizer outside air controls. Dampers should be verified to operate freely without sticking or being locked in one position.

    b. Ventilation control strategies can be used to help reduce the level of virus concentration in occupied spaces. These strategies help to increase the effectiveness of the existing ventilations systems.

    c. It is recommended that the operation of the building ventilation systems be extended beyond normal occupied hours. Systems are recommended to be started 2-hours before occupancy and continue for at least 2-hours after occupancy, preferably for 4-hours.

    d. In addition to extended hours for outside ventilation air, ventilation control strategies also include operation of the building exhaust systems. Verifying the operation of the toilet room exhaust systems and setting them to operate for at least 4-hours after occupancy should be considered, since these spaces can potentially be a source for high contamination. This should be done in conjunction with the operation of the building ventilation systems to help maintain the building under neutral or slightly positive pressure conditions. Operating continuously may also be considered to provide additional dilution of airborne contaminants that may linger overnight. Installation of hands-free faucets and toilet fixtures should also be considered as a long-term measure to reduce the potential of spread by touching surfaces.

    e. Classroom exhaust systems are recommended to be set to operate for extended hours before and after occupancy in conjunction with operation of the building ventilation systems to help prevent the spread of contaminants to spaces outside the classroom. Classroom exhaust systems are typically set to operate only when the unit ventilators are operating in the economizer cooling mode. If so, this mode of operation should be disabled to allow the exhaust systems to run on a time schedule when the unit ventilators are providing ventilation air. The amount of classroom exhaust may exceed the amount of outside air normally supplied by the ventilation systems leading to a negative pressurization condition, although not by a large amount. As a short-term operation, it is better to operate the exhaust systems than to not operate them. The ventilation and exhaust systems should be properly balanced to maintain a neutral to slightly positive room pressure in which case this operation can be used as a long-term strategy.

4. Long-Term Strategies:

    a. Long-term strategies include the installation of airflow system technologies and space treatments. These strategies generally have a higher cost than short-term strategies.

b. Bipolar Ionization:

1) The application of bipolar ionization (BPI) for in-duct applications provides an effective means for deactivating airborne viruses in the space by reaction to positive and negative ions. In-duct installations for BPI systems are straightforward and have little restrictions.

2) BPI systems utilize needlepoint ionization or ionization tubes. Like UV-C lamps discussed below, ionization tubes have a useful operating life of approximately two years depending on conditions and will therefore need to be replaced periodically. Needlepoint systems require little to no maintenance.

3) In-duct BPI systems should be installed in the supply air duct to deliver the ionized molecules to the occupied space where they can interact with contaminants in the room air.

4) BPI systems are not reduced in effectiveness when the respective system is operating in economizer mode since it is acting downstream in the space. Therefore, systems with economizer outside air control can continue to benefit from the free cooling as well as the higher amount of outside air.

5) As with UV-C systems, BPI systems should be interlocked to deenergize when the air system is shut down. A relay interlocked to the fan operation may be used for this purpose.

6) BPI systems are available for duct mounting in large systems as well as for small air systems such as fan coil units, unit ventilators, and ductless split units. Devices for small systems are installed inside the unit on the fan housing near the air inlet.

c. UV-C Irradiation:

1) Ultraviolet germicidal irradiation (UVGI) using UV-C lamps is one strategy that can be applied to deactivate viruses in the air stream. These systems may be applied in-duct or inside air handling units.

2) Systems are available for treatment in the space when the space is unoccupied, but this method does not proactively treat the air in the space when it is occupied.

3) Properly designed systems can be installed in the supply ductwork where sufficient straight ductwork exists for the installation of the UV lamps. Systems can also be installed inside air handling units where space permits.

4) In-duct systems require high intensity UV lamps to be effective due to the limited amount of exposure time as air flows through the system. Manufacturer's data should support the application of UV system installation specifically for disinfection in moving air streams.

5) UV lamp life is typically about 19,000 hours or two years. Depending on the hours of use the lamps may last longer, but their effectiveness will degrade over time which should be monitored.

6) UV-C systems should be interlocked to deenergize when the air system is shut down.

7) In-duct UV-C systems become less useful when the respective system is operating in economizer mode since larger amounts of outside air means less recirculated air to be disinfected. Consider de-activating economizer mode when the UV-C system is in operation.

d. Portable Air Filtration Units

1) Portable filtration units are available in various sizes that can be used in areas that do not have sufficient air circulation or outside air ventilation systems.

2) These units can include multiple levels of filtration including HEPA filers as well as bipolar ionization, and UV-C technologies.

e. Humidification

1) Maintaining humidity levels above 40% RH has shown to limit the survival time of viruses and more importantly can help occupants by increasing their immune system response. Many factors need to be considered for the Installation of humidification systems including a suitable water source, energy source, and a distribution method. These systems also require a high level of maintenance.

2) Generally, humidification is not considered to be a primary mitigation strategy, unless there are other reasons for requiring humidification and should not be applied in older buildings without a proper building air barrier.

f. Pressure Control

1) Controlling pressure relationships within spaces and between spaces can help to prevent the spread of viruses. Application of this strategy requires a detailed analysis for each building to determine specific measures needed to accomplish the desired result.

2) Air handling systems and classroom systems should be balanced to provide neutral to slightly negative pressurization relative to surrounding spaces to help prevent the movement of viruses throughout the building. Where spaces are negatively pressurized, the building air balance should be reviewed to make sure the overall building pressure is preferably slightly positive. This may require the addition of outside air ventilation systems in common corridors noted below.

3) Common corridor spaces in schools often have little to no outside air ventilation. Ventilation codes do not require a large amount of outside air for corridors even if it is present, but they may not be sufficient to provide enough makeup air to balance the negative pressure from bathroom exhaust systems. Therefore, the addition of a permanent ventilation system should be considered to offset the exhaust air and to help provide a higher level of air movement and dilution of contaminants in the space.

Strategies for Various System Types:

1. Mixed/Recirculation Air Systems:

   a. Supply air from these systems can be delivered to one space, such as a cafeteria, or to multiple spaces distributed by supply ductwork. A portion of the supply air includes outside air that is mixed with return air in the air handling unit before it is delivered to the space. These systems may also provide economizer cooling using up to 100% outside air when ambient conditions permit and when the space needs cooling. Since these systems recycle air and may serve multiple spaces, they provide an opportunity to apply centralized solutions. Rooftop units fall into the category or mixed air systems. All the systems at the school are heating only.

   b. Provide enhanced filtration wherever possible. The systems in the school have 2-inch filters, therefore MERV 13 filters are recommended.

   c. Bipolar ionization (BPI) systems are recommended to be installed in the supply ductwork of all mixed air systems wherever possible. BPI should generally be considered over UV-C systems as a long-term strategy due to the ability of BPI to work within the space where the source of the viruses is located. These can be readily applied to all different system sizes with little restrictions.

   d. Consider extended hours of operation before and after occupancy to further reduce airborne concentrations. Up to four hours of extended operation should be considered.

2. Unit Ventilators:

   a. Unit ventilators are mixed air systems, but they deliver supply air to the space directly without ductwork. These systems will typically be connected to an exterior louver to bring in fresh air, which is then mixed with return air from the space. Outside air control typically includes minimum outside air and 100% outside air economizer. A classroom exhaust system is typically provided to operate when the unit ventilator is in the occupied mode and typically during the economizer free-cooling mode to help relieve excess building pressurization.

b. The filters for these units are 1-inch thick. While 1-inch MERV 13 filters are available, they do not have an air flow rating high enough to be used in unit ventilators. Therefore 1-inch filters with a MERV 11 rating should be considered wherever possible. If these are applied, it is important to plan on changing the filters after about 90 days. Longer periods may be possible, but this should be monitored.

c. Small bipolar ionization units are available for installation inside unit ventilators. These are typically mounted inside the unit on the fan housing near the fan inlet where the ions are injected into the supply air stream. Installation will require a relay to turn the device off when the fan is not on and a transformer may also be needed. It should be noted that where BPI devices are installed, it is not necessary to install MERV 11 filters, since the BPI device is more effective than the filters. In this case, MERV 8 filters may be used.

d. Consider extended hours of operation before and after occupancy to further reduce airborne concentrations. Up to four hours of extended operation should be considered. Classroom exhaust fans should be set to operate during occupied hours and extended hours.

e. It is recommended that the damper operation and linkages be inspected for each unit to verify that the outside air function is operating properly. Ideally, the systems should also be balanced to make sure the outside air damper and air flows are set properly.

3. Ductless Split Systems:

   a. Ductless split or mini-split indoor fan coil units are connected to outside condensing units and are recirculation air systems. These systems deliver supply air directly to the space and air is recirculated directly back to the unit. Ductless fan coil units may or may not provide outside ventilation air. Wall-mounted units are typically not provided with outside air connection. Units that are provided with outside ventilation air will have a small round duct connection near the back of the unit.

   b. The filters for these units are typically a permanent washable media and are not capable of being upgraded to higher efficiency.

   c. Small bipolar ionization units are available for installation on the outside surface of these units near the supply air stream.

4. Dedicated Outside Air Systems:

   a. This type of system does not exist at the school, so it is not discussed here.

Strategies by Building:

1. Pulaski:

    a. Classrooms

        1) Ventilation for the classrooms is provided by seven roof mounted heating and ventilating units originally installed in about 1974. Each unit serves each pod of classrooms with ductwork distributed to supply and return grilles in each space.

Roof Mounted Heating and Ventilating Unit (RTU)

RTU Filter and Internals

Classroom Supply Diffusers

Classroom Return Grille

        2) The units appear to be capable of 100% outside air, but this is believed to be for economizer cooling purposes and not for normal ventilation. Normal minimum outside air ventilation during heating conditions is believed to be 25% to possibly as much as 50% of the supply air. Approximately 35% would be needed to satisfy the current ventilation code. Many of the dampers appear non operational and are frozen in position.

        3) Heating is provided by hot water coils in the unit.

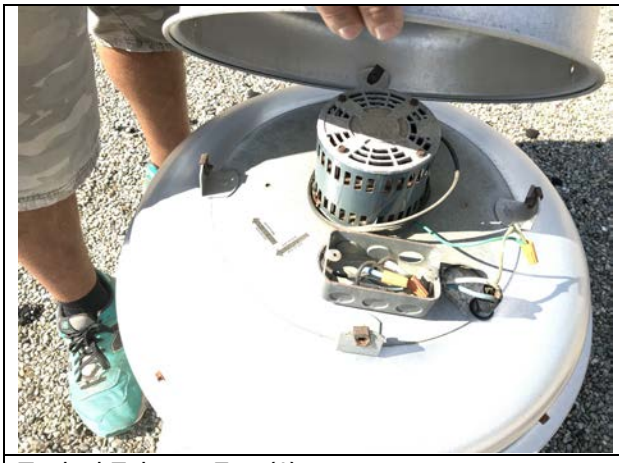
4) The primary recommendation for these systems is to verify that they operate correctly with the dampers in the minimum outside air position when in the occupied mode and close during unoccupied made. Damper operators and linkages should be checked, and dampers lubricated. It is highly recommended that the outside air quantity be checked and reset to the code required outside air quantity by a qualified air balancing technician. The systems can be reviewed in more detail to determine if it is possible to set the outside air rate higher than the code minimum without creating a potential for the hot water coils to freeze during cold weather.

5) Verification that the systems operate in economizer mode is recommended to help provide free cooling with higher amounts of outside air during mild weather (approx. 50 to 75 degrees) on a sunny day when spaces would benefit from cooling. This will also help to provide more outside air to the classrooms when conditions permit to help offset the loss of ability to open windows.

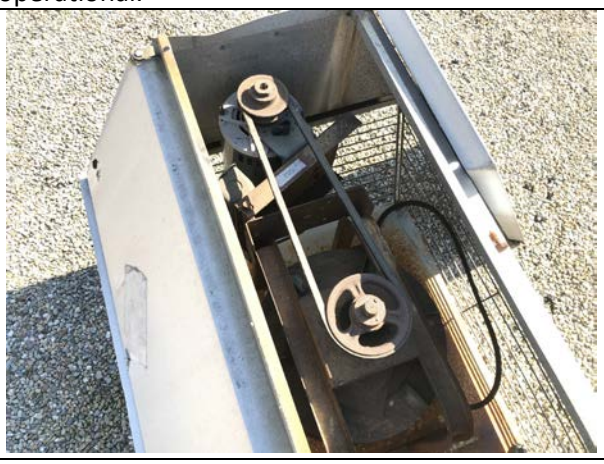
6) The 2-inch MERV 8 pleated filters that are used currently are recommended to be changed to MERV 13 filters.

7) The operation of the seven units should be programmed through the digital control system to start the occupied mode 2 hours early and to run for 4 hours beyond normal occupancy time.

8) Bathroom exhaust fans are recommended to operate concurrently with the ventilation systems wherever possible.
    a. These exhaust fans (approximately 50) should be verified for correct operation Some were noted to be non-operational.



Typical Exhaust Fan (1)



Typical Exhaust Fan (2)

9) Additional protection beyond the recommendations above could include the installation of bipolar ionization devices in the supply air ducts at each floor. Multiple units may be needed on each floor for each unit depending on duct configuration.

10) The classrooms all have supply and return diffusers/grilles. The return grilles are near the floor and can be easily obstructed by furniture and other items. These areas should be kept clear so that airflow is not impeded.

b. Common Central Areas (Media, Nurse, Conf Room, Teachers' Lounge, Lilly Pad, etc)

	
Common Area	Common Area

1) These common areas are air conditioned by air heating only air handling unit AH-1C .

2) Outside ventilation for this area is provided by AH-1C economizer dampers. This unit provides minimum required ventilation air only.

	
AH-1C – Library Unit	AH-1C – Mixed Air Plenum

3) The unit appear to be capable of 100% outside air, but this is believed to be for economizer cooling purposes and not for normal ventilation. Normal minimum outside air ventilation during heating conditions is believed to be 25% to possibly as much as 50% of the supply air.

4) Heating is provided by hot water coils in the unit.

5) The primary recommendation for this system is to verify that it operates correctly with the dampers in the minimum outside air position when in the occupied mode and close during unoccupied made. Damper operators and linkages should be checked, and dampers lubricated. It is highly recommended that the outside air quantity be checked and reset to the code required outside air quantity by a qualified air balancing technician. The systems can be reviewed in more detail to determine if it is possible to set the outside air rate higher than the code minimum without creating a potential for the hot water coils to freeze during cold weather.

6) Verification that the system operates in economizer mode is recommended to help provide free cooling with higher amounts of outside air during mild weather (approx. 50 to 75 degrees) on a sunny day when spaces would benefit from cooling. This will also help to provide more outside air to the classrooms when conditions permit to help offset the loss of ability to open windows.

7) The 2-inch MERV 8 pleated filters that are used currently are recommended to be changed to MERV 13 filters.

8) The operation of this unit should be programmed through the digital control system to start the occupied mode 2 hours early and to run for 4 hours beyond normal occupancy time.

9) Bathroom exhaust fans are recommended to operate concurrently with the ventilation systems wherever possible.

    a. Additional protection beyond the recommendations above could include the installation of bipolar ionization devices in the supply air duct

c. Locker Rooms

	
AH-2D (Girls Locker-room)	AH-3D (Boys Locker-room)

1) The girl's and boy's locker rooms are each served by two heating and ventilating units located in the roof MER. The units have economizer dampers and are capable of supplying 100% outdoor air.

2) The operation of these two systems is recommended to be verified including the damper operators and linkages as well as the heating operation.

3) The filters are recommended to be changed to 2-inch pleated MERV 13 filters, if possible.

4) The operation of the two units should be programmed through the digital control system to start the occupied mode 2 hours early and to run for 4 hours beyond normal occupancy time.

5) The locker rooms can benefit greatly from the installation of bipolar ionization equipment due to the nature of the space. Besides treating the air in the space, the ions will interact with bacteria and viruses on surfaces and be neutralized. One device is sufficient for each air handling unit.

d. Cafeteria Unit, (Heating & Ventilating Unit)

1) The cafeteria is served by a 100% outdoor air unit. This unit was designed to be capable of delivering 100% outdoor air throughout the heating season.

2) Heating is provided by hot water coils in the unit.

3) The primary recommendation for this system is to operate it continually when possible as the system delivers fresh air to the interior spaces.

4) The 2-inch MERV 8 pleated filters that are used currently are recommended to be changed to MERV 13 filters.

5) The operation of this unit should be programmed through the digital control system to start the occupied mode 2 hours early and to run for 4 hours beyond normal occupancy time.

e. Auditorium (Heating & Ventilating Unit)

	
Auditorium HV Unit	Auditorium HV Unit

1) The Auditorium is served by an indoor heating and ventilating unit located in the rooftop MER

2) It is recommended that dampers be verified to operate correctly in the minimum outside air position when in the occupied mode and close during unoccupied made. Damper operators and linkages should be checked, and dampers lubricated. The occupied damper position is recommended to be set to about the 20% position based on a lower occupant density. Heating conditions should be monitored since the heating coil has a diminished capacity due to repairs that disconnected portions of the coil.

3) The filters are recommended to be changed to MERV 13 filters.

4) The operation of the unit should be programmed through the digital control system to start the occupied mode 2 hours early and to run for 4 hours beyond normal occupancy time.

5) Additional enhanced protection beyond the recommendations above could include the installation of bipolar ionization devices in the supply air ductwork.

https://balaconsultingengineers-my.sharepoint.com/personal/pas_bala_com/Documents/School Assessments/60-20-424_New Bedford/New Bedford Pulaski- HVAC Review_PAS.docx