BALA

TOWN OF NEW BEDFORD SCHOOLS

HVAC SYSTEM ASSESSMENT REPORT FOR SCHOOL RE-OPENING

A. General:

1. The purpose of this report is to provide an overview of the potential measures that may be applied to the building HVAC systems and spaces to make a safer environment for students, teachers and staff to return to school this year. The diversity of space types and systems require several 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 School is urged to seek guidance from the state on these and other issues.

3. Buildings included within this report are:

   a. Parker Elementary School; visited on 8/21/2020; 8:00 AM. Parker school delegate present during site tour: Ms. Jennifer Mainelli.

   b. Pacheco Elementary School; visited on 8/21/2020; 11:00 AM. Pacheco school delegate present during site tour: Ms. Justine Medina.

   c. Hathaway Elementary School; visited on 8/21/2020; 2:00 PM. Hathaway school delegate present during site tour: Mr. Alex Pella.

B. Potential Strategies:

1. Enhanced Filtration:

   a. The ability to add higher efficiency filters in air systems can provide some level of protection, however most systems are limited. The thickness of the existing filter systems is one factor that can limit the level of efficiency that can be achieved. Another consideration is that higher efficiency filtration typically has a higher pressure drop when compared to the same air flow.

   b. Where filters are limited to 2-inch thickness, a filter efficiency rating of MERV 8 is typically used. The highest efficiency level that can be achieved with 2-inch filters is MERV 13, but these filters must be stored in a dry location to maintain their effectiveness. Filters with a MERV 13 rating can capture up to 75% of aerosolized virus particles.

   c. Where systems have 12-inch cartridge or bag filters, efficiencies of at least MERV 16 may be possible. These filters can capture up to 95% of viruses carried by aerosols.

   d. The high pressure drop associated with higher efficiency filters will cause a reduction in the air handling system air flow capacity. This may not be significant for larger systems but can be noticeable on smaller systems. Variable air volume systems can overcome this additional loss to some degree, but the peak capacity will still be somewhat limited.

   e. HEPA filters would offer even more protection, but they come with an even higher pressure drop and they typically require twice the filter area.

f. It is recommended that appropriate precautions be taken when dirty filters are removed from the systems, since active viruses may be present.

2. UV-C Irradiation:

a. Ultraviolet germicidal irradiation (UVGI) using UV-C lamps is one strategy that can be applied to kill viruses in the air stream. These systems may be applied in-duct or inside air handling units. Other systems are available for treatment at the space level, but these are not viewed as a primary method for UV-C application.

b. Prior to the advent of the pandemic, UV-C systems had typically been applied as a treatment for irradiating coils in air handling units to eliminate microbial growth that causes a biofilm to develop which leads to reduced coil efficiency. As a result, many companies have not fully developed and tested in-duct applications. Companies that provide fully developed commercial solutions should be considered over companies that specialize in residential solutions.

c. Properly designed systems can be installed in the supply ductwork where sufficient straight ductwork exists. Systems can also be installed inside air handling units where space permits.

d. 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.

e. 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.

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

g. 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. Consider de-activating economizer mode when the UV-C system is in operation.

3. Bipolar Ionization:

a. The application of bipolar ionization (BPI) is more developed for in-duct applications and provides an effective means for deactivating airborne viruses by attraction to positive and negative ions which then aggregate into larger particulates in the air and are then either filtered out or drop out of the airstream. In-duct installations for BPI have little restrictions.

b. BPI systems utilize needlepoint ionization or ionization tubes. Like UV-C lamps, ionization tubes have a useful operating life of approximately two years depending on conditions and will therefore need to be replaced periodically. Needlepoint systems also require regular maintenance to clean the elements.

c. 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 the room air.

d. 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.

e. As with UV-C systems, BPI systems should be interlocked to deenergize when the air system is shut down. An airflow switch may be used for this purpose.

f. BPI systems are also available for small air systems such as fan coil units, unit ventilators, ductless split units. These systems can be installed on the fan housing near the air inlet inside the unit.

4. Control Strategies:

a. Control strategies can be used to help reduce the level of virus concentration in occupied spaces. These strategies can include the following: Pre-occupancy and post-occupancy flush-out, extended hours of system operation, override of variable air volume controls, override of demand ventilation controls.

b. In addition to supply air and ventilation air strategies, exhaust systems can also help to reduce the level of virus contamination in spaces. Setting toilet room exhaust systems to operate continuously should be considered, since these spaces can potentially be a source for high contamination. Hands-free faucets and toilet fixtures should also be considered.

c. Classroom exhaust systems can be set to run continuously or at least operate for extended hours before and after occupancy to help flush the space. This should be done in conjunction with the operation of ventilation systems that deliver a corresponding amount of outside air to prevent negative pressurization and associated problems.

5. Other Strategies:

a. Other strategies include humidification, increased outside air flow, and airflow pressurization.

b. 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. Generally, humidification is not considered to be a primary mitigation strategy, unless there are other reasons for requiring humidification.

c. Increasing the minimum outside airflow settings for air handling systems 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 cooling. Increasing minimum outside air settings only provides a marginal improvement at the space level. Where other technology-based solutions are applied, there would be little reason to increase outside air flow.

d. Controlling pressure relationships between spaces can provide a small measure of protection but would require a detailed evaluation to determine if there is an overall benefit.

C. Strategies for Various System Types:

1. Mixed/Recirculation Air Systems:

a. These systems typically provide supply air to multiple spaces using 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. Since these systems recycle air and serve multiple spaces, they provide an opportunity to apply centralized solutions. Rooftop units fall into the category or mixed air systems.

b. Provide enhanced filtration wherever possible. Since these systems at the school have 2-inch filters, MERV 13 filters should be considered. Note that these filters will collect more particulates and may tend to load up quicker than low efficiency filters. Therefore, more frequent filter changes should be planned.

c. Bipolar ionization systems should generally be considered over UV-C systems. These can be readily applied to all different system sizes with little restrictions.

d. Consider extended hours of operation after occupancy to further reduce airborne concentrations, especially where bipolar ionization is applied. 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 are typically connected to an exterior louver to bring in fresh air. Outside air control includes minimum outside air and 100% outside air economizer.

b. The filters for these units are 1-inch or 2-inch thick. Where they are 2-inch thick, consider installing MERV 13 filters. While 1-inch MERV 13 filters are available, but they have a higher pressure drop than the 2-inch filters and may degrade the air performance to an unacceptable level.

c. Small bipolar ionization units are available for installation inside unit ventilators. These are typically mounted on the fan housing near the fan inlet.

d. It is recommended that the damper operation and linkages be inspected for each unit to verify that the outside air function is operating properly.

3. DX Split Fan Coil Units:

a. Fan coil units with DX coils connected to outside condensing units are essentially recirculation air systems. These systems deliver supply air to the space through ductwork and return ductwork recirculates air back to the unit. Fan coil units do not inherently provide outside ventilation air. The return ductwork may be connected to a small outside air duct from an exterior vent, delivered by a separate ventilation system or delivered separately to the space. Fan coil units do not typically have a 100% outside air economizer.

b. The filters for these units are typically 1-inch thick. Where return air filter grilles are provided, they may have 2-inch thick filters. Consider installing MERV 13 filters wherever 2-inch filters exist. Like unit ventilators 1-inch MERV 13 filters are available, but they have a higher pressure drop than the 2-inch filters and may degrade the air performance to an unacceptable level.

c. Like unit ventilators, small bipolar ionization units are available for installation inside unit ventilators and are typically mounted on the fan housing near the fan inlet.

4. 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 do not provide outside ventilation air.

   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 of these units in the supply air stream.

D. Parker Elementary School:

1. HVAC systems description (based on room type):

   a. Typically, all classrooms are lined along the exterior walls of the building. Classrooms are served by unit ventilators which utilize exterior louvers to bring in fresh, outside air, to the classroom. Classrooms are also provided with finned tube radiation that spans the exterior walls. All classrooms utilize operable windows. The unit ventilators utilize 1-inch thick, Merv7 or 8, filtration.

Picture #1: Typical Classroom Unit Ventilator

   b. Corridors are provided with no means of ducted or natural ventilation (outside air). The only HVAC system that was readily apparent were wall mounted cabinet unit heaters which simply recirculate air within the space for heating purposes.

Picture #2: Typical Corridor Cabinet Heater

c. The auditorium / cafeteria is served by a vertical heating and ventilating unit (H/V) located on the second floor of the building. This H/V unit brings in 100% outside air from the outdoors, filters and heats the air and then distributed the air via side wall supply grilles mounted near the top of the auditorium / cafeteria. A separate exhaust fan extracts air from the auditorium / cafeteria near the floor of the space and rejects this air to the outdoors via a roof mounted exhaust fan.

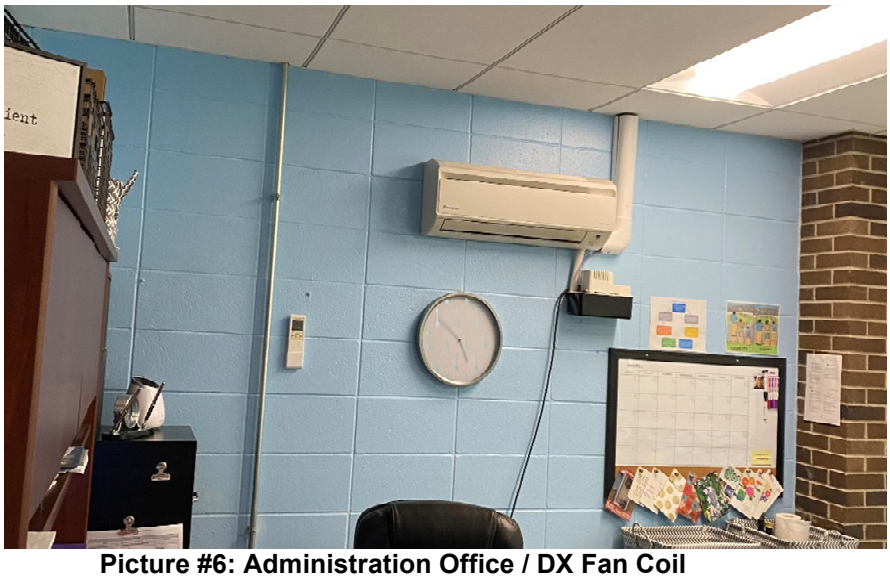
Picture #3: Auditorium / Café Supply Grille

Picture #4: Auditorium / Café Exhaust Grille

Picture #5: Auditorium / Café Heating Ventilating Unit

d. Gymnasium HVAC system is the same as described for the Auditorium / Café; however, served by its own, dedicated H/V unit and exhaust fan.

e. Administrative spaces are typically served by split DX systems for air conditioning, finned tube radiation for heating and operable windows for ventilation



Picture #6: Administration Office / DX Fan Coil

f. There are some classrooms that utilize DX split systems.

Picture #7: Miscellaneous Classroom / DX Fan Coil

2. COVID Mitigation Measures to implement:

   a. Classrooms with unit ventilators are recommended to apply strategies above for Unit Ventilators. In addition, the unit ventilators, classroom exhaust fans and transfer fans are recommended to run for extended hours.

   b. The DX fan coil units serving Administrative spaces and miscellaneous classrooms are recommended to follow the strategies for DX Split Fan Coil Units above. In addition, these systems are recommended to operate for extended hours along with any associated outside air ventilation systems.

   c. The corridor/ lobby space does not appear to have any ventilation system. It is recommended that an energy recovery ventilator (ERV) be installed to provide the code required ventilation air or greater to offset any exhaust systems in the building with makeup air. A BPI unit is recommended to be provided in the supply air from the ERV and the unit is recommended to include 4-inch MERV 13 filters if possible, or 2-inch MERV 13 at a minimum.

   d. Heating and Ventilating units and exhaust fans serving the Auditorium/ Café and Gymnasium are recommended to apply the strategies above for enhanced ventilation, bipolar ionization, pre and post occupancy flush-out, recalibration of existing outside air control damper to ensure the H/V units are being provided with 100% outside air. Additionally all exhaust fans are recommended to utilize enhanced ventilation and pre / post occupancy flush-out control strategies.

E. Pacheco Elementary School:

1. HVAC systems description (based on room type):

a. Typically, all classrooms are provided with steam radiators (without protection covers) for heating and operable windows for natural ventilation. The original building design utilized vertical shafts to convey naturally ventilated air upwards through the building utilizing the natural buoyancy of air. Bala could not ascertain if the natural ventilation shafts were still in use. Upon gaining roof access Bala photographed the inside of one of the vertical shafts and found metal panels that appeared to be hard caps to the vertical shafts. Upon further review of the photo the metal caps appear to have pivot hinges along the centerline of the cap which could indicate that the caps are infact operable dampers that can be opened to allow the natural ventilation system to operate.

Picture #8: Typical Classroom Steam Radiator and Operable Windows

Picture #9: Photo taken of inside Natural Ventilation Shaft on Roof.

b. Corridors are provided with no means of ducted or natural ventilation. The only HVAC system that was readily apparent were wall mounted steam radiators for heating purposes.

Picture #10: Typical Corridor Steam Radiator (with safety cabinet)

c. Toilet rooms and janitor closets located on the third floor possess no means of exhaust air either via natural ventilation or forced air ventilation. Girls and boys toilet rooms on the bottom floor utilized a ducted means of exhaust air.

d. The Cafeteria and Auditorium spaces are provided with operable windows for natural ventilation and steam radiators for heat. The Café seating area windows are obstructed by an existing ceiling soffit that may prevent the windows from being opened fully. The Auditorium windows do not have any such obstruction and appear to be free to open fully.

e. The combined gymnasium and library are provided with sidewall mounted grilles for natural ventilation and steam radiators for heating. It was not apparent to the reviewing engineer if the natural ventilation system was working.

Picture #11: Gymnasium Grille

Picture #12: Gymnasium Grille

f. Administrative spaces are served by steam radiators for heat and operable windows for natural ventilation. Some offices also utilize potable cooling units.

Picture #13: Administrative Office

2. COVID Mitigation Measures to implement:

   a. Open operable windows to increase natural ventilation to the classrooms and administrative space. Employ the use of potable, floor mounted, air filtration devices. Re-commission the existing natural ventilation shafts to supplement the natural ventilation from the operable windows.

   b. The corridor / lobby space does not have any ventilation system other than 2 operable windows, positioned at opposite ends of the building long axis corridor (approximately 200 feet apart). It is recommended that an energy recovery ventilator (ERV) be installed to provide the code required ventilation air or greater to offset any exhaust systems in the building with makeup air. A BPI (bipolar ionization) unit is recommended to be provided in the supply air from the ERV and the unit is recommended to include 4-inch MERV 13 filters if possible, or 2-inch MERV 13 at a minimum. It may also be possible to increase the overall size of the ERV to provide forced (ducted) ventilation air into the classrooms.

   c. Gymnasium, Cafeteria, and Auditorium are recommended to also install energy recovery ventilators (ERV) to provide the code required ventilation air to the spaces, or greater, to offset any exhaust systems in the building with makeup air. A BPI (bipolar ionization) unit is recommended to be provided in the supply air from the ERV and the unit is recommended to include 4-inch MERV 13 filters if possible, or 2-inch MERV 13 at a minimum.

F. Hathaway Elementary School:

1. HVAC systems description (based on room type):

a. Typically, all classrooms are lined along the exterior walls of the building. Classrooms are served by unit ventilators which utilize exterior louvers to bring in fresh, outside air, to the classroom. Classrooms are also provided with finned tube radiation that spans the exterior walls. All classrooms utilize operable windows. The unit ventilators utilize 1-inch thick, Merv7 or 8, filtration. Classrooms are also provided with exhaust air grilles and ductwork.

Picture #14: Typical Classroom Unit Ventilator

b. Modular / Temporary classrooms are located on school grounds but are not connected to the main school building. These classrooms are served by split DX air conditioning and heating systems. No means of outside air / ventilation could be identified.

Picture #15: Modular Classrooms

Picture #16: Modular Classrooms

c. Corridors within the main school building are provided with no means of ducted or natural ventilation (outside air). The only HVAC system that was readily apparent were wall mounted cabinet unit heaters which simply recirculate air within the space for heating purposes.

d. The gymnasium / cafeteria and auditorium are all served by dedicated heating and ventilating units located within a mechanical mezzanine directly above each room. Reviewing engineer opened the filter access section for each of the 3 units located on the mezzanine. Reviewing engineer found that the units utilize 1-inch thick, MERV 7 or 8 filters. Reviewing engineer noted that the outside air dampers were in their fully closed positions not allowing outside into the building. Additionally the reviewing engineer observed that the exhaust fan serving both spaces was 'off'.

e. Administrative spaces are typically served in a similar way as are the classrooms, unit ventilators with finned tube radiation and exhaust fans.

2. COVID Mitigation Measures to implement:

a. Classrooms / areas with unit ventilators are recommended to apply strategies above for Unit Ventilators. In addition, the unit ventilators, classroom exhaust fans are recommended to run for extended hours.

b. The corridor/ lobby space does not appear to have any ventilation system. It is recommended that an energy recovery ventilator (ERV) be installed to provide the code required ventilation air or greater to offset any exhaust systems in the building with makeup air. A BPI unit is recommended to be provided in the supply air from the ERV and the unit is recommended to include 4-inch MERV 13 filters if possible, or 2-inch MERV 13 at a minimum.

c. Heating and Ventilating units and exhaust fans serving the Auditorium/ Café and Gymnasium are recommended to apply the strategies above for enhanced ventilation, bipolar ionization, pre and post occupancy flush-out, recalibration of existing outside air control damper to ensure the H/V units are being provided with 100% outside air. Additionally all exhaust fans are recommended to utilize enhanced ventilation and pre / post occupancy flush-out control strategies.