Nashoba Regional Schools

Center Elementary School
Stow, MA

2020

HVAC System Evaluation

Prepared For:

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September 4, 2020

EXECUTIVE SUMMARY

General

The Nashoba Regional School District engaged BLW Engineers to evaluate the HVAC systems serving these buildings relative to their current operating conditions, re-opening of the building to the public and potential considerations related to Covid-19.

While at the site, BLW Engineers met with the facilities operator who reported the HVAC systems receives regular preventative maintenance which includes filter replacement, grease motors and bearings, replace fan belts and verify damper and valve operation.

The Center Elementary School is located at 403 Great Road in Stow. The school comprises approximately 34,000 square feet of educational space with enrollment of approximately 300 students. The building was originally constructed in 1954, underwent a major renovation and addition in 2011 with most of the current HVAC systems and equipment having been replaced or installed at that time.

Center Elementary School Planned Reopening

The Nashoba Regional School District plans on the following school re-opening for the Center School:

- School is to be occupied by students and teachers in the hybrid model with 50% occupation Monday/Tuesday; Wednesday disinfection/cleaning; 50% occupation Thursday/Friday; Saturday disinfection/cleaning.
- Classrooms seating will be reorganized to provide recommended social distancing.
- Cafeteria will not be used in normal fashion; students will eat lunches at their desk.
- Gym will not be used in normal fashion.
- Library and Auditorium will not be used in normal fashion; they will be used primarily as classroom space.

Recommendations

Based on applicable guidelines (ASHRAE, State of Massachusetts Re-opening Guidelines, Massachusetts Teachers Association, etc.), the Center Elementary School is safe to occupy and should consider the following best practice operation of the current HVAC system in an effort to provide an environment to best protect the occupants and visitors to the building during the pandemic:

Tier 1 Recommendations: Tier 1 recommendations are immediate revisions to system operation prior to start of classroom and until the start of the heating season.

1. Create an "Epidemic Mode" Building Management System sequence of operation that can be turned on, shut down or override, if needed, by manual selection of the operator.
2. Replace the unit filters with the best filters available that will not impact the heating capacity of the units and develop a filter replacement plan; the existing rooftop units and air handling units will not be able to accommodate MERV13 filters without significantly impacting system operation, outdoor air delivery to the space and equipment component failures.

3. Filter upgrades will require more frequent changes due to pressure drop of filter and particulates that “dirty” the filters.
4. Continued operation of heating and cooling systems is recommended.
5. Operate toilet exhaust fans 24 hours a day, 7 days a week.; other fans shall operate two hours prior and two hours post occupied hours.
6. Monitor Carbon Dioxide (CO2) levels in occupied areas of the building.
7. Should building exhaust exit building through sidewall louvers subject to pedestrian traffic, provide warning signs and consider diverting or rearranging the exhaust air discharge locations so that they would pose no opportunity to cause harm.
8. Operate the building in occupied mode with mechanical ventilation prior and two hours post occupied hours; where mechanical ventilation and exhaust are not currently provided, utilize operable windows.
9. Operate the building in the occupied mode during disinfection and cleaning operations.
10. Operate building air handling equipment with highest percentage of outdoor air possible without adversely affecting the occupied environment; outdoor air percentage will be dependent on outdoor air temperature and allowable indoor air temperatures above/below normal operation.
11. Operate Classroom unit ventilators with ventilation as originally designed. Based on reduced classroom sizes, the classroom current system can provide more than 25 CFM/occupant which exceeds current code requirements (10 CFM per occupant plus 0.12 CFM/SF) and can be supplemented by operable windows.
12. Operate Classroom energy recovery units (ERV-1, 2, 6, 7) with ventilation as originally designed. Based on reduced classroom sizes, the classroom current system can provide more than 25 CFM/occupant which exceeds current code requirements (10 CFM per occupant plus 0.12 CFM/SF) and can be supplemented by operable windows.
13. Operate Media Center energy recovery unit (ERV-3) at maximum design air flow; the units have the capability of providing 20/CFM per occupant for 166 occupants.
14. Operate Gym energy recovery unit (ERV-4) at maximum design air flow; the units have the capability of providing 20/CFM per occupant for 300 occupants.
15. Operate Gym energy recovery unit (ERV-5) at maximum design air flow; the units have the capability of providing 20/CFM per occupant for 202 occupants.
16. Operate Administration rooftop unit (RTU-1) at maximum design air flow; the unit has the capability of providing 20/CFM per occupant for 28 occupants.
17. Operate Office rooftop unit (RTU-2) at maximum design air flow; the unit has the capability of providing 20/CFM per occupant for 44 occupants.
18. Operate Office air handling unit (AHU-1) at maximum design air flow; the unit has the capability of providing 20/CFM per occupant for 44 occupants.
19. At the commencement of school and until the heating season and when outdoor air temperature conditions allow, the air handling equipment can be operated with recirculated air can be run in the “economizer mode” with 100% outdoor air and no recirculation.
20. Reset discharge air setpoint as high as possible for variable air volume systems to encourage variable air volume dampers to maximized outdoor air into the building.
21. Disable any CO2 demand control ventilation sequences of operation and occupancy setback controls; operate units at maximum outdoor air capacity.
22. Eliminate outdoor air to zones that are not occupied to better use in occupied areas.
23. Relocate occupants from areas that do not have mechanical ventilation or operable windows.
24. Use operable windows when outdoor air conditions allow.

25. Keep conference room doors open as much as possible or open windows when feasible.
26. Increase regular maintenance of all mechanical heating, ventilating and air conditioning equipment.
27. Monitor the heating, ventilating and air conditioning operation of the building on a continual basis.
28. Follow recommendations of holistic view of building recommendations in General Recommendations.

Tier 2 Recommendations: Tier 2 recommendations are supplemental revisions/additions to the existing systems that may be required for the heating season when systems will need to utilize recirculated air to maintain space temperature setpoints.

1. Provide additional filtration with portable HEPA filter units or UV filtration units for areas that might have multiple occupants served by units (unit ventilators, rooftop units, heating/ventilating units, fan coil units, air conditioning units) that utilize recirculated air.
2. Install portable humidifiers or retrofit existing heating/ventilating equipment with humidifiers for local humidity control.
3. Add plug-in type supplemental electric heat as required for increased ventilation requirements.
4. Apply and use outdoor air quality sensors or reliable web-based data for outdoor pollution information as part of the new ventilation operation.
5. Consider UV decontamination lights on highly touched surfaces.

Notes:

1. While there is ventilation air and return air associated with each classroom unit ventilator, the units only recirculate air within each classroom and do not recirculate air between classrooms. The ventilation and exhaust systems for the typical classroom is continuous and separate.
2. While there is ventilation air and return air associated with Classroom fan powered boxes served by energy recovery units, the boxes only recirculate air within each space and do not recirculate air between other spaces.
3. While there is ventilation air and return air associated with Media Center, Office, Administration fan powered boxes served by energy recovery units, rooftop units or air handling units, the VAV/FPBs only recirculate air within each space and do not recirculate air between other spaces.
4. There is no recirculation air for Gymnasium and Cafeteria energy recovery units.
5. While there is ventilation air and return air associated with Cafeteria heating/ventilating unit, the unit only recirculate air within each space and do not recirculate air between other spaces.
6. While there is ventilation air and return air associated with Teacher’s Room fan coil units, the unit only recirculate air within each space and do not recirculate air between other spaces.
7. While there is ventilation air and return air associated with Computer Lab air conditioning unit, the unit only recirculate air within each space and do not recirculate air between other spaces.
8. These recommendations are based on guidance provided by applicable agencies and publications for best practices for protection of occupants and visitors to the building but do not provide absolute protection from the pandemic.

9. These recommendations will have a significant impact on the operating and maintenance related costs of the HVAC systems.

HVAC SYSTEM EVALUATION

Existing Conditions

The majority of the heating for the buildings is provided through a hydronic system consisting of a four-pipe distribution that is fed from two natural gas-fired, condensing boilers, two natural gas-fired non-condensing boilers and variable speed circulation pumps. The distribution piping supplies energy recovery units (ERV), rooftop units (RTU), make-up air unit (MAU), fan powered boxes (FPB), variable air volume terminal units (VAV), unit ventilators (UV), indoor air handling units (AHU), unit heaters (UH) and various smaller convective heaters throughout the building. Single zone and multi-zone split heat pump systems provide cooling in some corridors and various tele/data rooms throughout the building.

The classrooms in the original 'A' portions of the building are served by floor mounted unit ventilators and general exhaust fans which provide constant ventilation and air exchange throughout the spaces during occupied hours. The UV's draw ventilation air through a directly connected wall louver, the air is mixed with return air from the space, is filtered then heated to maintain space temperature. The UV's are designed for a total supply airflow of 750 CFM and ventilation air flow of 200 CFM, with capacity of 28 MBH heating and 18 MBH cooling. The UV's are controlled through the building energy management system and are capable of operating with 100% ventilation air under appropriate weather conditions. Exhaust air is drawn from each space at ceiling registers and discharges through roof mounted exhaust fans which operate on a scheduled basis. The typical classroom is served by a pair on UV's providing a total ventilation airflow of 400 CFM and are continuously exhausted at a rate of 250 CFM. The original ventilation design appears to meet current code requirements, which would be 370 CFM for such a classroom size (Ventilation = 10 CFM x 25 Occupants + 0.12 CFM x 1000 SF).

The energy recovery unit ERV-7 is located in a mechanical room in the original 'A' portion of the building, serving the music rooms, corridor and restrooms. The unit provides conditioned ventilation air through a system of supply and return distribution ductwork to series fan powered boxes and variable air volume boxes serving the spaces. The ventilation air enters ERV unit, is pre-conditioned by the exhaust air through the enthalpy wheel, filtered and then heated or conditioned for supply to the building, with final tempering of the air being controlled by the individual FPB units. The primary ventilation air from the ERV's is fed to FPB's where it is mixed with return air and heated as necessary to maintain space temperature based on local thermostat/sensor. Exhaust air is drawn from the spaces at wall and ceiling registers, transferred through the ceiling plenum then returns via ductwork and is discharged from the ERV unit through the roof. The ERV supply fan modulates speed to maintain a constant duct static pressure with the return/exhaust fan tracking the supply fan to maintain positive pressurization of the space. The design documents indicate that ERV-7 is a 100% outdoor air unit with a maximum supply air flow of 4,050 CFM and a maximum exhaust air flow of 4,050 CFM. This unit was designed with capacity for 93 MBH of heating and 111 MBH of total cooling, an external static pressure capacity of 1.75" w.c. through the supply fan and 1.25" w.c. through the exhaust fan with MERV 8 pre-filters on both air streams and MERV 13 ventilation air finishing filters. The supply air flow to the Music Studios, practice rooms, offices and associated storage spaces corresponds to a ventilation air flow of 1,000 CFM which appears to meet current code requirements for each individual space and the approximate total floor area of 3,500 SF. The OT/PT office is provided with 300 CFM ventilation air flow which meets the current code requirements for the total approximate floor area of 1,000 SF. The ERV's, FPB's and VAV's are controlled through the building energy management system.

The rooftop unit RTU-1 and associated air-cooled condensing unit are located on the roof above the original 'B' portion of the building. The unit serves offices, corridor and meeting areas below, utilizing hot water coil for heating and direct expansion (DX) coil for cooling. It provides ventilation and conditioned supply air through a system of supply and return distribution ductwork to the FPB's serving the various spaces. The ventilation air enters the RTU, mixes with return air from the space, is filtered and then heated or conditioned to maintain discharge temperature set point. The supply air is delivered to the FPB's, mixes with return air from the space and is heated as necessary to maintain space temperature set point based on local thermostat/sensor. Return air is drawn from the spaces at ceiling registers, transferred through the ceiling plenum to the FPB's or returns via ductwork to the RTU for recirculation or discharge to outdoors. The RTU and FPB's are controlled through the building energy management system. The design documents indicate that RTU-1 is a 45% outdoor air unit with a maximum supply air flow of 1,200 CFM and a maximum ventilation air flow of 575 CFM. This unit was designed with capacity for 52 MBH of heating, 47 MBH of total cooling and an external static pressure capacity of 1.5" w.c. through the supply fan with MERV 8 pre-filters and MERV 13 finishing filters. The original ventilation air design for the administrative offices and support spaces varies based on type and size. The total ventilation air flow does appear to meet current code requirements for the approximate total floor area of 2,000 SF and for the individual typical offices (Ventilation = [5.0 CFM x 0.005 Occupant/SF + 0.06 CFM/SF] x SF).

The air handling unit AHU-1 is located in a mechanical room and serves office areas in the original 'B' portion of the building. The unit provides ventilation and conditioned supply air through a system of supply and return distribution ductwork to series fan powered boxes and variable air volume boxes serving the spaces. The ventilation air enters the AHU unit, mixes with return air from the spaces, is filtered and then heated or conditioned for supply to the building, with final tempering of the air being controlled by the individual FPB units. The primary ventilation air from the AHU is fed to the FPB's which mix in return air from the space by modulating fan speed then heat the air as necessary to maintain space temperature based on local thermostat/sensor. Return air is drawn from the spaces at ceiling registers via ductwork to the AHU. The AHU is controlled through the building energy management system. The design documents indicate that AHU-1 is a 50% outdoor air unit with a maximum supply air flow of 2,380 CFM and a maximum ventilation air flow of 1,400 CFM. This unit was designed with capacity for 123 MBH of heating and 111 MBH of total cooling, and an external static pressure capacity of 1.5" w.c. through the supply fan with MERV 8 pre-filters and MERV 13 finishing filters. The perimeter offices are also served by ceiling mounted radiant panels and fin tube radiation which provide supplemental heat as necessary. The total ventilation air flow does appear to meet current code requirements for the approximate total floor area of 2,000 SF and for the individual typical offices (Ventilation = [5.0 CFM x 0.005 Occupant/SF + 0.06 CFM/SF] x SF).

The energy recovery unit ERV-3 is located on the roof above the 'D' portion of the building and serves the media center. The unit provides conditioned ventilation air through a system of supply and return distribution ductwork to series fan powered boxes serving the interior and perimeter zones in the double-height space. The ventilation air enters ERV unit, is pre-conditioned by the exhaust air through the enthalpy wheel, filtered and then heated or conditioned for supply to the building, with final tempering of the air being controlled by the individual FPB units. The primary ventilation air from the ERV's is fed to the FPB's which mix in return air from the space then heat the air as necessary to maintain space temperature based on local thermostat/sensor. Return air is drawn from the space at ceiling registers, transferred through the return plenum to the FPB's or returns via ductwork and is discharged through the ERV unit. The ERV supply fan modulates speed to maintain a constant duct static pressure with the return/exhaust fan tracking the supply fan to maintain positive pressurization of the space. The design documents indicate that ERV-3 is a 100% outdoor air unit with a maximum supply air flow of 3,320 CFM and a maximum exhaust air flow of 3,320 CFM. This unit was designed with capacity for 105 MBH of heating and 110 MBH of total cooling, an external static pressure capacity of 1.5" w.c. through the supply fan and 0.85" w.c. through the exhaust fan with MERV 8 pre-filters on both air streams and MERV 13 ventilation air finishing filters. The media center is served by perimeter fin tube heat which provides supplemental heating as necessary. The ERV, FPB's and FTR's are controlled through the building energy management system. The design ventilation air flow to the computer lab and media center appears to meet or exceed current code requirements (Ventilation = [10 CFM x 0.025 Occupants/SF + 0.12 CFM] x SF) for the approximately total floor area of 4,000 SF.

The energy recovery unit ERV-4 and ERV-5 are located on the roof above the boiler room in the new 'C' portion of the building, serving the gymnasium and cafeteria respectively. The units provide conditioned ventilation air through a system of supply and return distribution ductwork to the spaces. The ventilation air enters the ERV units, is pre-conditioned by the exhaust air through the enthalpy wheel, filtered and then heated or conditioned as necessary to maintain space temperature based on local thermostat/sensor. Exhaust air is drawn from the spaces through registers and ductwork then is discharged through the ERV units. The ERV supply fans modulate speed to maintain a constant duct static pressure with the return/exhaust fans tracking the supply fans to maintain pressurization of the spaces. The design documents indicate that ERV-4 is a 100% outdoor air unit with a maximum supply air flow of 6,000 CFM and a maximum exhaust air flow of 6,000 CFM. This unit was designed with capacity for 348 MBH of heating and 207 MBH of total cooling, an external static pressure capacity of 1.5" w.c. through the supply fan and 1.5" w.c. through the exhaust fan with MERV 8 pre-filters on both air streams and MERV 13 ventilation air finishing filters. ERV-5 is a 100% outdoor air unit with a maximum supply air flow of 4,900 CFM and a maximum exhaust air flow of 4,050 CFM. This unit was designed with capacity for 323 MBH of heating and 180 MBH of total cooling, an external static pressure capacity of 1.5" w.c. through the supply fan and 1.5" w.c. through the exhaust fan with MERV 8 pre-filters on both air streams and MERV 13 ventilation air finishing filters The gymnasium and cafeteria are also served by perimeter, wall mounted radiant panels which provide supplemental heating as necessary. The ERV's, FPB's and RP's are controlled through the building energy management system. The design ventilation air flow to the Gymnasium will vary based on the proportioning of play area and spectator area but does appear to exceed current code requirements corresponding to an approximate total floor area of 3,200 SF. The design ventilation air flow to the Cafeteria also appears to exceed current code requirements corresponding to an approximate total floor area of 2,800 SF.

The energy recovery unit ERV-6 is located on the roof above the boiler room in the new 'C' portion of the building, serving the art rooms and lobby. The unit provides conditioned ventilation air through a system of supply and return distribution ductwork to series fan powered boxes serving the spaces. The ventilation air enters ERV unit, is pre-conditioned by the exhaust air through the enthalpy wheel, filtered and then heated or conditioned for supply to the building, with final tempering of the air being controlled by the individual FPB units. The primary ventilation air from the ERV's is fed to the FPB's which mix in return air from the space by modulating fan speed then heat the air as necessary to maintain space temperature based on local thermostat/sensor. Exhaust air is drawn from the spaces at ceiling registers, transferred through the ceiling plenum then returns via ductwork and is discharged through the ERV unit. The ERV supply fan modulates speed to maintain a constant duct static pressure with the return/exhaust fan tracking the supply fan to maintain positive pressurization of the space. The design documents indicate that ERV-6 is a 100% outdoor air unit with a maximum supply air flow of 5,400 CFM and a maximum exhaust air flow of 5,200 CFM. This unit was designed with capacity for 98 MBH of heating, 167 MBH of total cooling, an external static pressure capacity of 1.5" w.c. through the supply fan and 1.0" w.c. through the exhaust fan with MERV 8 pre-filters on both air streams and MERV 13 ventilation air finishing filters. The lobby is also served by perimeter fin tube and cabinet unit heaters at the main entry which provide supplemental heating as necessary. The ERV's, FPB's, FTR's and CUH's are controlled through the building energy management system. The Art rooms with combined floor area of approximately 1,800 square feet are supplied with 375 CFM of ventilation air respectively which meets the current code requirement (Ventilation = 10 CFM x 40 Occupants + 0.18 CFM x 1,800 SF).

The make-up air unit MAU-1 is located on the roof above the boiler room in the new 'C' portion of the building and serves the kitchen. The unit provides tempered ventilation air through a system of supply distribution ductwork to the space. The unit operation is interlocked with the kitchen hood exhaust fan and controlled through the building energy management system. The design documents indicate that MAU-1 is a 100% outdoor air unit with a maximum supply air flow of 1,800 CFM with capacity for 120 MBH of heating and an external static pressure capacity of 0.75" w.c. through the supply fan with MERV 7 pre-filters and MERV 13 finishing filters.

The rooftop unit RTU-2 is located on the roof above the boiler room in the new 'C' portion of the building, serving offices, corridor and support areas below. The unit provides ventilation and conditioned supply air through a system of supply and return distribution ductwork to variable air volume boxes serving the various spaces. The ventilation air enters the RTU, mixes with return air from the space, is filtered and then heated or conditioned for supply to the building, with final tempering of the air being controlled by the individual VAV units. At the VAV's airflow is modulated and heated as necessary to maintain space temperature based on local thermostat/sensor. Return air is drawn from the spaces at ceiling registers, transferred through the ceiling plenum then returns via ductwork to the RTU for recirculation or is discharged to outdoors. The RTU fan modulates speed to maintain a constant duct static pressure and the unit is controlled through the building energy management system. The design documents indicate that RTU-2 is a 60% outdoor air unit with a maximum supply air flow of 1,450 CFM and a maximum ventilation air flow of 880 CFM. This unit was designed with capacity for 78 MBH of heating, 47 MBH of total cooling and an external static pressure capacity of 1.5" w.c. through the supply fan with MERV 8 pre-filters and MERV 13 finishing filters. The total ventilation air flow does appear to meet current code requirements for the approximate total floor area of 2,000 SF and for the individual typical offices (Ventilation = [5.0 CFM x 0.005 Occupant/SF + 0.06 CFM/SF] x SF).

The energy recovery units ERV-1 and ERV-2 are located on the roof above and serve the typical classrooms in the new 'D' portion of the building. The two units provide conditioned ventilation air through a system of supply and return distribution ductwork to series fan powered boxes serving the individual classrooms on the both stories of the building. The ventilation air enters each unit, is pre-conditioned by the exhaust air through the enthalpy wheel, filtered and then heated or conditioned for supply to the building. The unit supply air set points are established by the control programming to satisfy cooling demand in the worst-case zone on each system, with final tempering of the air being controlled by the individual FPB units. The primary ventilation air from the ERV's is fed to the FPB's which mix in return air from the space by modulating fan speed then heat the air as necessary to maintain space temperature based on local thermostat/sensor. Exhaust air is drawn from each space at ceiling registers, transferred through ductwork to the return plenums over the corridors then returns and is discharged through the ERV units. The ERV supply fans modulate speed to maintain a constant duct static pressure with the return/exhaust fans tracking the supply fans to maintain positive pressurization of the building. The design documents indicate that ERV-1 is a 100% outdoor air unit with a maximum supply air flow of 11,100 CFM and a maximum exhaust air flow of 9,900 CFM. This unit was designed with capacity for 429 MBH of heating, 363 MBH of total cooling, an external static pressure capacity of 2.0” w.c. through the supply fan and 1.25” w.c. through the exhaust fan with MERV 8 pre-filters on both air streams and MERV 13 ventilation air finishing filters. ERV-2 is also a 100% outdoor air unit with a maximum supply air flow of 12,500 CFM and a maximum exhaust air flow of 11,300 CFM. This unit was designed with capacity for 445 MBH of heating, 407 MBH of total cooling, an external static pressure capacity of 1.75” w.c. through the supply fan and 1.25” w.c. through the exhaust fan with MERV 8 pre-filters on both air streams and MERV 13 ventilation air finishing filters. The typical classrooms in this portion of the building are also served by ceiling mounted radiant panels (RP) which provide supplemental perimeter heating. The ERV’s, FPB’s and RP’s are controlled through the building energy management system. The typical classroom in this portion of the building is designed for a total supply airflow of 640 CFM and a ventilation airflow of 375 CFM. The original ventilation design appears to meet current code requirements, which would be 360 CFM for such a classroom size (Ventilation = 10 CFM x 27 Occupants + 0.12 CFM x 750 SF).

The corridors in the original ‘A’ portion of the building are conditioned through ceiling mounted, cassette style fan coils which are interconnected with a roof mounted, multi-zone heat pump by refrigerant piping. The heat pump serves multiple fan coil units and the system is controlled through space thermostat/sensor and operates per the manufacturer’s packaged control sequences.

Several tele/data and electric equipment rooms throughout the building are served by ductless split fan coil units which are interconnected with roof mounted, single-zone heat pumps by refrigerant piping. Each split systems is controlled through a space thermostat/sensor and operates per the manufacturer’s packaged control sequences.

Bathrooms, Janitor’s Closets, Storage, etc. are exhausted through registers and ductwork connected to roof mounted exhaust fans. Bathrooms are provided with hot water heating terminal equipment.

Specialty exhaust systems have been provided for the Science Rooms, Art Room and Storage.

The electric room has been provided with heat dissipation systems including an exhaust fan, a gravity intake with motor operated damper and a temperature sensor to maintain a maximum space temperature.

Miscellaneous spaces have been provided with hot water terminal equipment interconnected with the hot water distribution piping system.

The building is monitored and operated electronically by a system of direct digital controls (DDC).

GENERAL PUBLICATION RECOMMENDATIONS

Publications referenced include ASHRAE and State of Massachusetts Re-opening Guidelines for schools.

Operating school buildings under epidemic conditions requires a holistic framework during the crisis and the restoration to potentially a new “normal” after the public health emergency has ended. Considerations include:

- Review of current operational practices
- Holistic view for owner/operator

Review of current operational practices

- Modes of operation of HVAC systems
    - sequences of operations
    - set points
    - schedules
- Verification that equipment and systems are properly functioning and have the enhanced capabilities to address public health considerations, with a focus building air circulating systems.
- Understanding that infected people who are asymptomatic may enter buildings, increasing the likelihood of the spread of virus through air systems to other occupants.

Holistic view for owner/operator

Owners and operators should take a holistic view of their buildings and:

1. Develop a pandemic preparedness plan
2. Review indoor and outdoor environment
3. Review the space types
4. Operate and maintain HVAC
    - Air-Conditioning and Ventilation systems
    - Exhaust systems
5. Check Elevator Control
6. Check BAS and Access Control Systems

Develop a Pandemic Preparedness Plan

Consider these possible goals:

- Reduce the spread of infection among building occupants,
- Maintain HVAC and Building Service Systems in safe and healthy conditions,
- Minimize impact on building occupants and visitors,
- Communicate risks and precautions being taken with occupants transparently
- Implement measures that help make occupants feel secure:
    - Require occupants, visitors and maintenance personnel to wear appropriate PPE per CDC,
    - Screen, monitor and control the circulation of occupants and guests to help avoid transmission of disease,
    - Increase frequency for surface disinfection on frequently touched surfaces, such as door handles, handrails, door bells and elevator buttons.

Ensure continuity of supply chains and have backup plans.

- Identify your critical suppliers, e.g. filters, cleaners, disinfectants, parts, PPE, etc.,
- Identify vendors who could negatively affect your operation if they fail to deliver,
- Review current service provider agreements to see if alternate suppliers can be engaged in the event of a supply disruption, for example, equipment service providers, and understand contract limitations and restrictions on using alternative providers,
- Ask critical suppliers to share their pandemic plans:
    - What does their plan include?
    - Have they tested their plan? When was it updated?
    - Set boundaries with suppliers – ask that they do not send staff who may be showing signs of illness to your property.

Review contract agreements:

- Review contract agreements: Review contracts with service providers, utilities, and suppliers to determine what rights and remedies they have because of disruptions due to unforeseeable circumstances that prevent fulfillment of a contract.

Establish a communication protocol and continuity of operations plan:

- Identify key contacts and publish normal and emergency contact information,
- Document the chain of command and communication requirements, and provide instructions and outline expectations for how all responses are to be documented and what records shall be maintained and distributed.

Provide staff with:

- PPE per CDC and OSHA requirements,
- Training on the proper use and disposal of PPE and waste,
- Training on infection prevention and control measures,
- Cross training to ensure critical building functions are maintained in an emergency, and
- Instruction to staff to stay at home if they are feeling sick.

Check with insurance providers to determine whether there are special measures that can be taken to preserve coverage or lower premiums.

Next Steps:

1. Notify staff, tenants and visitors about the plan
2. Follow all local, state and federal executive orders, statutes, regulations, guidelines, restrictions and limitations on use, occupancy and separation
3. Follow OSHA Guidelines, especially the portion in the guide regarding filter and outside air.
4. Ensure that custodial staff and service providers job descriptions includes performing proper cleaning procedures based EPA and CDC guidance using approved products and methods:
    - Disinfect high touch areas of HVAC and other Building Service systems such as on/off switches, and thermostats;

- Consider UV light disinfection devices of high touch counters in public spaces.
- Disinfect interiors of refrigerated devices, such as refrigerators, coolers and vending machines where the virus can survive for potentially long periods of time.

5. Consider installing a thermal camera at building entrances to help screen visitors for elevated body temperatures. Note that that infected individuals may show no signs of being ill, including having no fever, and can be responsible for much of the transmission. In such cases, thermal imaging may not be effective.
6. Provide MERV13 or higher filters for air handling equipment that recirculate air when equipment has the capacity.
7. The HVAC systems that are physical or capacity limited for better filtration and UV decontamination systems in the return airstream, consider installing portable filtration and air cleaning devices such as UVGI (Ultraviolet Germicidal Irradiation), especially if seniors or anyone with other health issues or compromised immune systems may be located, or, in mission critical areas where required.
8. Provide automatic hand sanitizer dispensers in the high touch areas and other common areas, including spaces where equipment where frequent maintenance is required, and ensure dispensers are serviced often and remain operational.
9. Post signage in prominent locations that contain information and instructions to educate and remind staff about proper procedures to maintain personal protection while cleaning, replacing filters and moving or using other equipment that maybe contaminated
10. Consider providing antimicrobial door mats at high traffic entrances to the building.
11. Institute additional cleaning procedures to ensure proper disinfection of bathrooms, kitchens and common areas. Educate cleaning and maintenance staff on proper personal protection and PPE use including following OSHA worker exposure guidelines.

Review Indoor and Outdoor Environment

- Maintain dry bulb temperatures within the comfort ranges indicated in ANSI/ASHRAE Standard 55-2017
- Maintain relative humidity between 40% and 60% through the use of the air conditioning systems.

In Cold Climates
i. HVAC systems with no humidification may not achieve the minimum humidity indicated, ii. Observe building assemblies and finishes frequently for condensation when indoor dew points rise above the surface temperatures of the assemblies and finishes, iii. Excessive humidity may lead to condensation, indoor mold growth, and degradation of indoor air quality.

Review the space types

Conference Rooms	Keep doors to be opened to promote good ventilation where possible. If doors must be closed, consider local air filtration and cleaning devices and appliances such as portable air filters, or provide local exhaust fans discharging directly to the outside to improve ventilation.
Pantries/Storage Rooms	Provide local exhaust, or portable air filtration and cleaning appliances, especially if refrigerators, or similar appliances, are presented.
Public/Large Assembly Spaces	Where there can be a large assembly of people, consider air treatment, e.g. upper-room UVGI lamps.

Operate and maintain the HVAC system

Building owners and service professionals should follow the requirements of ASHRAE Standard 180-2018, Standard Practice for the Inspection and Maintenance of Commercial HVAC Systems which has tables to show the typical maintenance required for equipment that has been in operation. Consider PPE when maintaining ventilation materials including filters, condensate. Consult additional guidance before duct cleaning. Check specifically:

- Dampers, filter, and economizers seals and frames are intact and clean, are functional and are responding to control signals. MERV13 or higher filters are required for capture of airborne viruses; however, most existing equipment will not be able to support the associated pressure drop of these filters and equipment should be provided with only the highest MERV rating that does not affect the heating and cooling capacity of the units.
- Zone and air temperature are calibrated and accurately reporting environmental conditions to the BAS or local controllers.
- Exhaust fans are functional and venting to the outdoors.
- Check outside air intake regularly for any potential risk such as exhaust nearby and provide proper clearance if assessible by pedestrians, etc.

Operate and maintain the HVAC system – Air conditioning and ventilation systems

- Continued operation of all systems is recommended.
- For offices with fan coil units, open windows 2 hours before and after occupied periods.

Centralized and floor-by-floor Variable Air Volume (VAV) systems: General information

- For central or floor-by-floor VAV systems that have the capacity to operate with 100% outside air, such as an economizer cycle, close return air dampers and open outdoor air dampers to 100% or to the maximum setting that the HVAC system can accommodate and still maintain acceptable indoor conditions.

- If there are heating and cooling coils to temper the air, it can provide comfort and eliminate recirculation (in the mild weather seasons this will have smaller impacts to energy consumption, thermal comfort, or humidity control, however, using 100% outside can be more difficult in extreme weather conditions).
- Considerations also should be given in areas with dry outside air that may lower the relative humidity to below 40%.
- Prioritize increasing outside air over humidity (see concerns about operating at indoor humidity outside the range of 40%-60%).

Centralized and floor-by-floor Variable Air Volume (VAV) systems: Floor-by-floor

- In floor-by-floor VAV systems that have only minimum outside air damper positions or openings, open outside air damper to its maximum position (the same cautions and concerns stated above apply).
- If outside air is supplied centrally from outside air handling units (typically at mechanical levels) to all floors, and there are unoccupied tenant floors, divert the outside air to the occupied floors.
- Consider changing the floor level VAV air handling units' discharge air temperature setpoint the maximum (typically no higher than 60º F).
- This will cause VAV terminal units (boxes) to open to try and satisfy space cooling loads which will increase the number of air changes in the space being served.

Centralized and floor-by-floor Variable Air Volume (VAV) systems: Cooling coils

- Cooling coils, heating coils and condensate drain pans inside air handling equipment can become contaminated.
- Therefore, consider adding UVGI for coil surface and drain pan disinfection are encouraged as it will reduce the needs and frequency for in-person coil surface disinfection.
- These devices and systems should be monitored often and regular and emergency maintenances should continue.
- Provide PPE protection for building operators, maintenance technicians and anyone else who must inspect or come in contact with the device or equipment.

Centralized and floor-by-floor Variable Air Volume (VAV) systems: Operable windows

- In buildings with operable windows, when outside air thermal and humidity conditions and outdoor air quality are acceptable, open windows where appropriate during occupied hours.
- Disabling the interlock between opening windows and air conditioning system lockout or shut down if this feature is provided for in the Building Automation System.
- Monitor indoor spaces for possible contaminants entering through the windows such as toilets exhaust located nearby or for windows accessible to public and high traffic on adjacent streets and walkways.
- Exposure to seasonal and other outdoor allergens (pollen and mold spores) may occur with windows opened.
- Special ductwork cleaning, or, changing filters more often than normal is not necessary.

Domestic Heating Water systems:

- Keep heating water systems circulating and maintain temperatures above 140°F to avoid microbial incursion. Do not let water temperature to drop below 120°F.

Operate and maintain the HVAC system - Exhaust systems

- Exhaust system for toilets should run 24/7. Do not open operable windows in toilets.
- Other exhaust systems should continue to run as normal. Run exhaust systems 2 hours before and after occupied periods.
- If there are exhaust outlets located in pedestrian areas outside, provide warning signs and consider diverting or rearranging the exhaust air discharge locations so that they would pose no opportunity to cause harm.

Elevator Control

1. Turn on elevator cab (lift) ventilation fans, where possible
2. Encourage occupants to take stairs, where possible, especially when elevator lobbies are crowded.
3. Allow elevators to run at high speed to minimize time in elevator.
4. Close elevator lobby vestibule doors, if available.
5. Consider local air treatment devices in frequently used lifts.

Building Automation System and Access Control System Programming

Building Automation Systems:

- Automate the control sequences in this document as a "Epidemic Mode" operation that can be turned on, shut down or override, if needed, by manual selection of the operator.
- Provide remote access to staff and trusted service providers who are responsible for operating and maintain Building Automation Systems, security, access control, information technology, fire alarm and life safety systems. Have written procedures and test remote access and secure access levels and permissions for all individuals prior to an emergency, if possible.

Access Control Systems:

- Post signage and communicate to tenants, and post visitors' procedures for entering and leaving the building that will minimize the time spent in public spaces.
- Use touchless assess control system if available and where possible.
- Require and enforce social distancing within public and shared spaces using signage.
- Ensure that workspaces are situated to accommodate social distancing recommendations