Manchester Essex Regional School District

HVAC Assessment and Recommendations for School Building Re-Opening

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DRAFT

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HVAC Systems Assessment for School Building Re-Opening

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HVAC SYSTEMS SUMMARY

Prior to re-occupying buildings, it is recommended that existing building HVAC systems are evaluated, serviced and repaired as required to ensure the HVAC system is in proper working order and to determine if the existing system or its associated control operation can be modified as part of a HVAC system mitigation strategy. Any identified deficiencies should be repaired and corrected, and if the building HVAC system is a good candidate for modifications those measures should be implemented. A checklist of Preventative Maintenance (PM) verification tasks and potential HVAC system modifications and mitigation strategies have been included in the following report. If the following recommendations are adhered to then the building HVAC system would meet the State CDC guidelines for School Facilities Re-Opening.

In general HVAC system mitigation strategies include the following recommendations:

1. Potentially increase Outdoor Air (OA). The OA increase must be within equipment's capacity in order to provide adequate heating or cooling so that thermal comfort is not negatively impacted. Also use caution when increasing OA in polluted areas (e.g. High Traffic/City areas) and during times of high pollen counts. For heating and ventilation only systems, outdoor airflow rates may be increased during milder heating days, but outdoor airflow will need to be reduced to original design minimum outdoor airflow conditions during peak heating days in order to avoid freezing hot water coils and to provide adequate space heating.
2. Disable Demand Control Ventilation where present in order to provide more outdoor airflow.
3. Utilize high efficiency MERV-13 filtration for larger capacity central station indoor air handling and rooftop units if the unit (in terms of both fan power and associated filter rack) can accommodate these filters. Older Heating and Ventilation units and terminal equipment units such as Unit Ventilators, Fan Coil Units and small capacity air handling units may not be able to accommodate higher filtration levels due to their available fan horsepower. Seal edges of Filter sections with sheetmetal and foil type sheetmetal tape to avoid bypass of filters. Filter changes will likely need to occur on a more regular basis as higher efficiency filters have a higher initial and final pressure drop than older HVAC equipment was designed to operate with. Older heating and ventilation units equipped with belt driven fans were typically designed to operate with lower efficiency filters (MERV-8 equivalent and under) at their mid or end of life filter efficiencies that are slightly higher than the initial efficiencies of higher efficiency filters (MERV-11 & MERV-13). Therefore, when higher efficiency filters are used, they likely will need to be changed more often, particularly during times of high pollen counts. Refer to Building HVAC Existing Conditions and Filter Recommendations sections within this report for building specific filter recommendations.
4. Operate system in occupied mode for longer periods. In general operate systems in occupied mode for a minimum of 2 hours before and after normal building occupied periods.
5. Perform a building flush out, operating HVAC systems in occupied mode for 24/7 a minimum of one week prior to school building opening. Two weeks is preferred for most of the school building HVAC systems.
6. Install separate Portable Room HEPA Filter Units in Classrooms, office and other building areas that are served by older Unit Ventilator or Heating and Ventilation equipment that cannot meet MERV-13 filtration recommendation.
7. Existing ductwork distribution and air handling equipment should be cleaned if needed. If ductwork lining is present, then interior ductwork should not be cleaned with brushes/scrubbers as this could dislodge fiberglass duct lining. Instead duct cleaning disinfectant fogger cleaners could be used. Consult additional guidance from Industrial Hygienist or Duct Cleaning specialist before duct cleaning.
8. Consider addition of De-stratification Fans with UV-C technology for large double height areas such as Gymnasiums, Cafeterias. Gym Destratification fans should be provided with Cage Guards for protection. It should be noted that this technology is rather expensive, currently has long lead times

and requires annual maintenance. This technology is not required by guidelines if proper ventilation airflow with MERV-13 filtration is provided or ventilation air with lower filter efficiencies are provided and supplemented with room HEPA filters are utilized.

9. Consider use of natural ventilation when weather permits and will not negatively affect building HVAC performance. For Heating and Ventilation only systems, natural ventilation using operable windows may be used during spring, summer and fall months when outdoor air temperatures are generally above 65 degrees with minimal impact to heating system operation. During outdoor air weather conditions between 50-66 degrees operable windows for ventilation could be used but may cause slightly lower space temperatures at times and may lead to additional energy usage. When outdoor weather conditions are below 50 deg F, opening windows for most school building areas would generally not be advised as it may cause reduced indoor space temperatures and excess heating system energy expenditure. Some older heating systems that were designed with steam heating systems or hot water systems designed to operate above 180 deg f may have heating capacity to allow the use of operable windows during colder weather (below 50 deg F.), however this will come at the expense of additional energy use and could potentially lead to frozen piping systems if windows are opened during outdoor air conditions below 32 deg F.
10. When using operable windows for ventilation, portable space or window box fans could be used to promote a draft across rooms and airflow should be directed towards the room exhaust/return air register, and classroom doors should generally be closed when occupied. Caution should be given to using natural ventilation during times of high pollen conditions. Portable fans should be as quiet as possible to maintain lower noise levels in classrooms.
11. When utilizing additional outdoor airflow in air handling systems or through the use of operable windows during the heating season, boiler hot water supply temperatures should be monitored and adjusted by raising hot water supply temperatures higher if needed to maintain appropriate indoor space temperatures. Automatic boiler outdoor air reset controls may have to be over-ridden. Additional heating energy use will occur as the result of introducing additional outdoor ventilation airflow.
12. During past building renovation project, room partitions may have been added without consideration to heating and ventilation systems. Building areas that are not provided with appropriate natural ventilation, make-up air or exhaust air systems should not be used for classroom teaching and/or teacher workroom areas. These spaces could be utilized for storage areas.
13. Medical waiting areas – For each school it is recommended that a Medical waiting are is created or an existing area is designated for this use. These spaces should ideally have an operable window and exhaust air that exhaust directly to the outdoors. For improved ventilation these spaces should have the capability of increased exhaust ventilation (10 AC/HR recommended). While the room should be negatively pressurized when the exhaust fan is utilized, in order to avoid excess negative pressure, the operable window could be utilized to introduced additional make-up air ventilation. These spaces should also be provided with portable room HEPA filter units that are sized appropriately for the room area and volume. These areas should also have a dedicated heating and air conditioning system, which could supplemental the existing heating (and air conditioning if provided) system. Window or wall mounted slit heat pump AC units could be utilized for the Waiting room areas.

The above HVAC system modifications should be done on a building by building and zone/system by zone/system basis as not all buildings' and building area HVAC systems are not necessarily the same.

HVAC SYSTEM MAINTENANCE:

Performing preventative maintenance (PM) of HVAC systems prior to re-occupying buildings is highly recommended when scheduled maintenance on systems can be performed safely. The following are minimum HVAC system PM verification tasks which should be performed. The following are summaries of ASHRAE Standard 180 – 2018: Standard Practice for the Inspection and Maintenance of Commercial HVAC Systems. Preventative Maintenance checklists for different HVAC systems have also been included in Table form in Appendix A.

Hot Water Boiler Systems (Duration: Monthly):

1. Provide water chemical treatment and testing to ensure proper water treatment levels are maintained.
2. Check control system and control devices for proper operation.
3. Check pumps and variable-frequency drives (where installed) for proper operation.
4. For fuel oil systems; check operation of fuel system, including fuel pumps and tank monitoring systems.
5. For natural gas systems, check gas pressure, gas valve operation, combustion flue gas venting and combustion air systems (including combustion air fans if installed)
6. Ensure there are no leaks in fuel oil and/or gas lines.
7. Verify proper operation of all safety devices.
8. If necessary, vent air from distribution system high points
9. Verify expansion/compression tank pressures to ensure proper operations.

Steam Boiler Systems (Duration: Monthly):

1. Provide chemical treatment and testing for condensate and feedwater systems.
2. Check control system and control devices for proper operation.
3. Check condensate pump receivers for proper operation.
4. Check steam traps for proper operation.
5. For fuel oil systems; check operation of fuel system, including fuel pumps and tank monitoring systems.
6. For natural gas systems, check gas pressure, gas valve operation, combustion flue gas venting and combustion air systems (including combustion air fans if installed)
7. Ensure there are no leaks in fuel oil and/or gas lines.
8. Verify proper operation of all safety devices.

Chilled Water Systems (Duration: Monthly):

1. Perform chemical testing of system water. Verify water treatment target levels are being maintained.
2. Check control system and devices for proper operation.
3. Air Cooled Chillers:
   a. Check refrigerant system pressures for evidence of leaks
   b. Check/clean condenser fan blades and fan housing
   c. Check/clean for fin damage
   d. Check for proper fluid flow and for fluid leaks

4. Water Cooled Chillers:
   a. Check refrigerant system pressures for evidence of leaks
   b. Verify proper fluid flow and pressures
   c. Check compressor oil levels
5. Chilled Water Pump Systems
   a. Check Chilled Water Pump and VFD (if equipped) for proper operation
   b. Verify pump seals are packed and conform they are not leaking.
   c. If necessary, vent air from distribution system high points
   d. Verify expansion/compression tank pressures to ensure proper operations.

Air Handling Units (Duration: Monthly):

1. Check condition of filters and replace filter as needed.
2. Check condensate drain P-trap and ensure it is primed.
3. Check control system and devices for proper operation
4. Check fans and variable-frequency drive (where equipped) for proper operation
5. Check outdoor, relief and recirculation air dampers for proper operations
6. Check chilled water, hot water valves for proper operation.
7. Clean chilled water and hot water coil surfaces with coil cleaning solution at the start of cooling /heating season.
8. Check Energy Recovery Wheel (ERW) Operation (Where equipped).
9. Lubricate fan and ERW motor assemblies per manufacturer requirements.
10. For fans with belt drives, inspect belts and adjust or replace, as required.

Roof Top Units (Duration: Monthly):

1. Check condition of filters and replace filter as needed.
2. Check condensate drain P-trap and ensure it is primed.
3. Check control system and devices for proper operation
4. Check fans and variable-frequency drive (where equipped) for proper operation
5. Check outdoor, relief and recirculation air dampers for proper operations
6. Check chilled water, hot water valves (where equipped) for proper operation
7. Check DX refrigeration cooling system (and hot gas reheat if equipped) for proper operation. Check refrigerant pressures to ensure there are no leaks.
8. Check gas-fired heating furnaces (where equipped) to ensure proper gas valve and combustion operation.
9. Clean chilled water, DX coil, hot water coil (as equipped) surfaces with coil cleaning solution at the start of cooling /heating season.
10. Check Energy Recovery Wheel (ERW) Operation (Where equipped).
11. Lubricate fan and ERW motor assemblies per manufacturer requirements.
12. For fans with belt drives, inspect belts and adjust or replace, as required

Terminal Units (Fan Coils, Chilled Beams, Water-Source Heat Pumps, Unit Ventilators, Cabinet Unit Heaters) (Duration: Monthly)

1. Check condition of filters and replace filter as needed.
2. Check control system and devices for proper operation
3. For cooling units, check condensate drain P-trap and ensure it is primed.
4. Check fans/blowers for proper operation. Lubricate fan motor assemblies per manufacturer requirements. For fans with belt drives, inspect belts and adjust or replace, as required.
5. Check outdoor air dampers (if equipped) for proper operations.
    a. For typical classroom Unit Ventilators, the supply fans/motors should be check and repaired as necessary for proper operation and outdoor air damper position should be checked and set to a minimum position of 40-50% outdoor airflow in order to ensure compliance with IMC/ASHREA 62.1 ventilation requirements. Units equipped with economizer (100% outdoor air) controls should check/verify economizer operation to allow for additional ventilation airflow to be provided when weather conditions permit. Any unit ventilators equipped with CO2 demand controls should have CO2 demand controls over-ridden.
6. Check chilled water, hot water valves (if equipped) for proper operation.
7. Clean chilled water and hot water coil surfaces with coil cleaning solution at the start of cooling/heating season.
8. Check DX refrigeration cooling system (if equipped) for proper operation. Check refrigerant pressures to ensure there are no leaks. Clean DX coil surfaces with coil cleaning solution.

Air Distribution Systems

1. Check control system and devices for proper operation
2. Check outdoor air dampers (if equipped) for proper operations
3. Clean exterior surfaces of all registers, grilles and diffusers.
4. Consider internally cleaning ductwork as recommended by Industrial Hygienist on a building/system type by building/system type basis.

RECOMMENDED SEQUENCES OF OPERATION REVIEW AND MODIFICATIONS FOR TYPICAL HVAC SYSTEM TYPES:

General Recommendations:

1. Consider personal protection equipment (PPE) when maintaining ventilation materials, including filters and condensate. Consult additional guidance from Industrial Hygienist or Duct Cleaning specialist before duct cleaning.

2. Confirm occupancy schedule with building occupants and review the current programmed operation schedule in the Building Management System (BMS) and/or HVAC unitary thermostat controls. Modify control operation as required for the building's occupancy schedules and ventilation requirements and any implemented control system modifications.

3. Confirm that all modified programmed adjustments can be reversed back to normal operation.

4. Open outside air dampers to their maximum position, 100% preferred if the system is capable of doing so without causing overtly negative building temperature and humidity impacts, for a minimum of 7 days prior to School Building Re-Opening. Two weeks is recommended if possible and older school buildings with unit ventilators may benefit from even longer flush out periods. Note: The maximum position the outside air dampers may be opened will depend on the time of year, local climate, the temperature and humidity of the outside air and the capability of the HVAC equipment to condition the outside air so that the system is able to maintain acceptable indoor temperature and humidity. When operating in this "flush out" mode, the system should be monitored continuously to ensure that unacceptable temperature and humidity conditions do not develop inside the building. Upon completion of the flush, the damper control positions should be adjusted back to provide original design outdoor air ventilation levels. Disable any CO2 demand ventilation controls (if present) during this "flush-out" period.

5. The temperature and humidity control and ventilation parameters should be monitored and trended through the BMS. If a building does not have a BMS system installed, monitoring sensors and equipment could be installed to verify proper temperature and ventilation control. During this time, the HVAC equipment/systems may operate below design capacity, but sequencing and temperature control should still continue to properly function.

6. Verify that space temperature and relative humidity levels are being controlled to acceptable setpoints.

7. Verify Occupied / Unoccupied sequencing after measurement and verification of Occupied parameters is complete.

8. Check the status of any energy/heat recovery wheels, if present in the systems, for leakage and cross-contamination.

9. Consult with an HVAC Engineer, Commissioning Agent, or Contractor firm, as appropriate, to identify any areas of concern identified during any HVAC system preventative maintenance, verification, repairs and/or modifications. It is recommended that a list of issues is compiled, and that any outstanding issues are addressed in order to ensure that minimum occupancy ventilation requirements and occupant comfort / operational temperature setpoints are met prior to re-occupying the building.

RECOMMENDED SEQUENCES OF OPERATION REVIEW AND MODIFICATIONS FOR TYPICAL HVAC SYSTEM TYPES:

Re-circulation style air-handling unit with heating, cooling, supply fan, and separate associated exhaust system

1. Recommend unit operate in occupied mode 24/7 two weeks before school opening.
2. Supply Fan shall start or continue to run at full design speed.
3. Outside Air Damper & Re-circulation Air Damper shall modulate to the maximum occupied position as-balanced to allow the proper ventilation airflow to mix with the re-circulated room air.
4. Associated Exhaust system shall start or continue to run at a constant speed to maintain a slightly-positive space pressure, as-balanced.
5. Heating Section or Cooling section shall modulate/ stage as delegated by the unit controller to maintain the space temperature set-point.
6. Unit shall run constantly to deliver constant ventilation to the space.
7. Unit Freeze-stat, damper failure, duct-mounted smoke detector (As-applicable), high discharge air temp, or low discharge air temp shall shutdown the unit and generate an alarm.
8. Filter Section differential pressure sensors shall monitor the cleanliness of the filter section
9. CO2 control/ demand ventilation control, if present, shall be disabled in all rooms and units.

Unit Ventilators & separate associated Exhaust systems

1. Recommend unit operate in occupied mode 24/7 two weeks before school opening.
2. Supply fan shall start or continue to run at full design speed.
3. Face & Bypass dampers, if present, shall modulate to max occupied position as-balanced to allow the proper ventilation airflow to mix with the re-circulated room air.
4. Associated Exhaust system shall start or continue to run at a constant speed to maintain a slightly-positive space pressure.
5. For typical classroom Unit Ventilators, the supply fans/motors should be check and repaired as necessary for proper operation and outdoor air damper position should be checked and set to a minimum position of 40-50% outdoor airflow in order to ensure compliance with IMC/ASHREA 62.1 ventilation requirements. Units equipped with economizer (100% outdoor air) controls should check/verify economizer operation to allow for additional ventilation airflow to be provided when weather conditions permit. Unit Ventilators that are not equipped with automatic temperature controls in the Old Memorial School will require manual adjustments and monitoring to ensure proper heating and ventilation control.
6. Heating coil control valve shall modulate as delegated by the unit controller to maintain the discharge air temperature set-point when/if there is a call for heating from the space temperature sensor.
7. Unit shall run constantly to deliver constant ventilation to the space.
8. Unit Freeze-stat, damper failure, high discharge air temp, or low discharge air temp shall shutdown the unit and generate an alarm.
9. Filter Section differential pressure sensors shall monitor the cleanliness of the filter section
10. CO2 control/ demand ventilation control, if present, shall be disabled in all rooms and units.
11. Unit Ventilator Supply and Return Air Openings and Exhaust Grilles should not be blocked with books and materials.

Rooftop Unit/VAV system Start-up

1. Recommend unit operate in occupied mode 24/7 two weeks before school opening.
2. Outside air damper shall open to its max position allowed by the units' capacity.
3. The exhaust damper position (where applicable) shall match the outside air damper position.
4. The recirculation damper shall be closed if (and when) unit is capable of 100% OA.
5. The supply fan starts and adjusts its speed based on the duct mounted pressure sensor for 100% air flow. VAV dampers shall be forced to 100% open.
6. The exhaust fan (where applicable) shall start and modulate its speed to match the incoming outside air based on fan speed (hz) of the supply fan. A slight offset of 10% or less shall be provided to ensure a positive pressure is maintained within the building.
7. The energy recovery wheel (if present) will activate and pre-heat or pre-cool the incoming outside air depending on the outside air temperature.
8. The cooling section shall modulate to dehumidify the incoming air when the supply air humidity level is above 60% rh (adj.) and/or the supply air temperature is above the discharge air setpoint of 55 degrees.
9. The heating section shall modulate as required to provide heat to the supply air to maintain the supply air temperature setpoint. The heating section shall operate when cooling is not active or in use.
10. CO2 control/demand control ventilation, if present, in all rooms and units shall be disabled.

VAV with Radiant heating

1. The RTU supply and exhaust fan shall run constant. All VAV boxes shall be commanded to full open.
2. CO2 control/demand control ventilation, if present, in all rooms shall be disabled.
3. The rooftop unit shall maintain constant supply air temperature consistent with design setpoint, typically 55 degrees – 59 deg F.
4. The radiant heating panel control valve shall modulate to maintain the room heating set-point.

VAV with Reheat Coil

1. The RTU supply and exhaust fan shall run constant. All VAV boxes shall be commanded to full open.
2. CO2 control/demand control ventilation in all rooms shall be disabled.
3. The rooftop unit shall maintain constant supply air temperature consistent with design setpoint, typically 55 degrees – 59 deg F.
4. The VAV reheat coil control valve shall modulate to maintain the room heating set-point.

BUILDING HVAC EXISTING CONDITIONS:

The following are general HVAC system existing conditions summaries that provide HVAC system and equipment type information that can be referred to when determining HVAC Preventative Maintenance and Sequence of Operations adjustments described within this report.

"OLD" MEMORIAL ELEMENTARY SCHOOL:

Heating Plant: The school is heated by a hot water boiler plant and base mounted end suction hot water pumps. The boiler plant has recently experienced major water damage as the result of a building/site water infiltration issue. It is our understanding that temporary boilers will be provided to back feed the existing hot water system for the upcoming heating season if the existing boilers cannot be repaired in time.

Classrooms, Library and Cafeteria: These areas are provided with heating and ventilation from unit ventilators. The unit ventilators vary in age as some are circa 1954, others from the 1965 addition and the newest UVs from 1994. All unit ventilators should be serviced as recommended within this report, and new filters should be installed. These areas should also be provided with room HEPA filters to provide additional air exchange and higher filtration. The Pre-K Classroom does not appear to have adequate ventilation currently. Additional HVAC system modification should be performed, such as providing new supplemental heating, ventilation and exhaust air systems and a room HEPA filter unit if this space is to be utilized as a classroom.

Exhaust Fans: The classrooms and toilet rooms are served by exhaust air fans systems; the majority of exhaust fans were observed to be located on the roof. All exhaust fans should be serviced to ensure proper operation.

Gymnasium and Auditorium: These areas are served by indoor air handling units located in the fan room in the basement below. These units were installed during the 1994 renovation. These units should be serviced as recommended within this report, and new filters should be installed.

Controls: The existing school's automatic temperature control system is a pneumatic control system that has experienced operational issues in recent and past years. Therefore much of the equipment has been operated in hand mode. This method could be continued for the current school re-opening, but space temperatures and unit operation should be monitored by Staff to ensure proper heating and ventilation is provided to the occupied areas of the School building. Stand alone space temperature and humidity sensors could be used to manually monitor the thermal comfort conditions in the building in lieu of the building control system.

ESSEX ELEMENTARY:

Heating System: The elementary school is heated by a low pressure steam boiler plant, consisting of two (2) low pressure steam boiler, condensate pumps, and steam/condensate piping distribution system that is connected to the building heating equipment.

Administrative Offices: The offices are typically heated by perimeter steam fin tube radiation. The offices are ventilated naturally through the use of operable windows. Air conditioning is provided through the use of window air conditioners in some of the offices.

Classrooms: Wall mounted classroom unit ventilators are utilized for the heating and ventilation for classroom spaces. There a total of approximately eighteen (18) unit ventilators. Ventilation air is introduced to each of these units through a wall mounted louver. Each unit is equipped with a steam hot water coil, supply fan and filter. Some of the wall mounted unit ventilators have vegetative growth in front of their associated outside air louvers. All of these spaces are provided with exhaust grilles and exhaust fan systems that can remove air from the space. All unit ventilators should be serviced as recommended within this report, and new filters should be installed. These areas should also be provided with room HEPA filters to provide additional air exchange and higher filtration. The Basement Level OT/PT and Art Room classroom spaces do not appear to be provided with adequate ventilation currently. Additional HVAC system modification should be performed, such as providing new supplemental heating, ventilation and exhaust air systems and a room HEPA filter unit if these spaces are to be utilized as classrooms.

Cafeteria: The Cafeteria is heated and ventilated by two (2) ceiling suspended steam heating and ventilation air handling units. The units are provided with a steam coil, supply fan and filter section. The supply air discharges through a short section of ductwork to high wall supply diffusers into the space, and return. There is a galvanized sheet metal duct distribution system associated with the return and outdoor air intake sections of the units. The Cafeteria also has several ceiling mounted paddle type destratification fans that can be used to promote airflow movement within the space.

Gym: The Gym is heated and ventilated by two (2) ceiling suspended indoor steam heating and ventilation unit. The units are provided with a steam coil, supply fan and filter section. The supply air discharges at the face of the unit and into the space. There is a galvanized sheet metal duct distribution system associated with the outdoor air intake. Return air is located on the bottom of the units through a return grille on the unit itself. The units are controlled by a newer DDC (direct digital control) system. This space is also provided with two (2) roof exhaust air fans, one of the exhaust fans does not appear to be connected to the newer DDC control system.

Exhaust Systems: The classroom spaces are exhausted by exhaust fans. These exhaust fans should be serviced as indicated within this report.

Controls: The building HVAC systems and heating plant are controlled by a combination of pneumatic and DDC (direct digital controls) automatic temperature control system. The newer DDC system was installed by Guardian and controls nine (9) of the unit ventilators, and the Gym H&V units, and one (1) of the Gym exhaust air fans.

NEW MEMORIAL SCHOOL (PHASE 1 – A WING):

Heating Plant: The school is heated by a high efficiency gas fired hot water heating plant consisting of (2) high efficiency gas fired boilers and (2) hot water pumps equipped with VFD drives that distribute hot water to the building hot water heating equipment.

Ventilation and Air Conditioning: The building A Wing Classroom area is served by rooftop air handling units equipped with DX (direct expansion) cooling and hot gas reheat, hot water heating, energy recovery section, supply and exhaust fans equipped with VFD drives and filters. The units are equipped with MERV-13 efficiency filters.

Classrooms: The rooftop units (RTU-1,2) distribute supply air to the A Wing Classroom area via a sheetmetal ductwork distribution system to room displacement air diffusers. The low wall displacement supply air diffusers distribute the airflow in a displacement pattern in which airflow is not mixed with the room, but instead moves upward toward room exhaust registers that are connected with galvanized sheetmetal ductwork back to the rooftop units. Each classroom's supply airflow is controlled by a VAV (variable air volume) terminal box equipped with space temperature and CO2 demand ventilation controls. The CO@ controls should be over-ridden to additional outdoor airflow is provided to these spaces for the School's re-opening.

Exhaust Systems: Exhaust Fans EF-1,2&3 are installed as part of Phase I. EF-1 serves the Kiln and EF-2 & 3 serve Classroom Wing A toilet room areas.

Controls: The building HVAC systems are control by a new DDC (direct digital control) system manufactured and installed by Delta Controls.

MIDDLE HIGH SCHOOL:

Heating System: The school is primarily heated by a gas fired hot water heating plant that consists of (2) two high efficiency gas fired hot water boiler and two (2) hot water pumps equipped with VFD drives that distribute hot water to the building heating equipment.

Cooling Systems: The building is not fully air conditioned. The Administration offices, Auditorium and Stage, Media Center and select Classrooms are air conditioned by central station indoor air handling units that are connected to a roof mounted air cooled chiller and chilled water plant distribution system. The classrooms that are air conditioned are air conditioned by induction units and tempered ventilation air.

Air Handling Systems: There are (12) central station air handling units that provide ventilation air to the building areas. The air handling units are located in a combination of Roof penthouse and Mezzanine areas. The following is a summary of the air handling units:

AHU-1 serves the North Classrooms, is located in the North Penthouse and is a 100% outside ventilation air handling unit equipped with supply and exhaust fans with VFDs, energy recovery, hot water heating and 4" filters.

AHU-2 serves the South Classrooms, is located in the South Penthouse and is a 100% outside ventilation air handling unit equipped with supply and exhaust fans equipped with VFDs, energy recovery, hot water heating and 4" filters.

AHU-1 and 2 distribute supply ventilation air to overhead diffuser located in each classroom, and exhaust air is returned back to the unit from each classroom via exhaust register that is connected to an exhaust air ducted system.

AHU-3 is located in the Penthouse and serves the Chorus and Band Room areas. The unit has hot water heating, supply and return fans with VFDs, and filters. The unit is a variable air volume recirculation unit that is capable of 100% outside air in economizer mode. The unit has CO2 demand ventilation controls that should be over-ridden.

AHU-4 and 5 are located in the Penthouse and serve the Auditorium and Stage. The units have hot water heating, chilled water cooling, supply and return fans with VFDs, and filters. The units are variable air volume recirculation units that are capable of 100% outside air in economizer mode. The unit has CO2 demand ventilation controls that should be over-ridden.

AHU-6 is located in the Penthouse and serves the Gym. The unit has hot water heating, supply and return fans equipped with VFDs, and filters. The unit is a variable air volume recirculation unit that is capable of 100% outside air in economizer mode. The unit has CO2 demand ventilation controls that should be over-ridden.

AHU-7 is located in the Penthouse and serves the Media Center. The unit has hot water heating, chilled water cooling, supply and return fans equipped with VFDs, and filters. The unit is a variable air volume recirculation unit that are capable of 100% outside air in economizer mode. The unit has CO2 demand ventilation controls that should be over-ridden.

AHU-8 is located in the Penthouse and serves the Administration, Guidance and SPED areas. The unit has hot water heating, chilled water cooling, supply and return fans equipped with VFDs, and filters. The unit is a variable air volume recirculation unit that are capable of 100% outside air in economizer mode. The unit supplies air to a variable air volume ductwork distribution that has space/zone VAV (variable air volume boxes) equipped with hot water re-heat coils. The unit has CO2 demand ventilation controls that should be over-ridden.

AHU-9 is located in the Mezzanine and serves the Cafeteria. The unit has hot water heating, supply and return fans with VFDs, and filters. The unit is a variable air volume recirculation unit that is capable of 100% outside air in economizer mode. The unit has CO2 demand ventilation controls that should be over-ridden.

AHU-10 is located in the Mezzanine and serves the Locker Rooms, Wellness and Fitness areas. The unit has hot water heating, supply and return fans with VFDs, and filters. The unit is a dedicated outdoor air unit with heat recovery section that is capable of 100% outside air.

AHU-11 is located in the Mezzanine and serves the School Administration area. The unit has hot water heating, chilled water cooling, supply and return fans equipped with VFDs, and filters. The unit is a variable air volume recirculation unit that are capable of 100% outside air in economizer mode. The unit supplies air to a variable air volume ductwork distribution that has space/zone VAV (variable air volume boxes) equipped with hot water re-heat coils. The unit has CO2 demand ventilation controls that should be over-ridden.

AHU-12 is located in the South Penthouse and serves the Select Classroom areas that are provided with air conditioning by Induction Units. The unit has hot water heating, chilled water cooling, supply and return fans with VFDs, and filters. The unit is a dedicated outdoor air unit with heat recovery section that is capable of 100% outside air.

Exhaust Systems: The building has a total of twenty-nine (29) exhaust air fan systems. The majority of exhaust fans serve toilet rooms, storage and utility rooms.

Controls: The building HVAC systems are control by a DDC (direct digital control) system manufactured and installed by Delta Controls.

HVAC SYSTEM FILTER RECOMEMNDATIONS

The following are our recommendations for HVAC system filtration and alternative measures to comply with the State's guidelines and ASHRAE recommendations for Re-opening School buildings.

Central Station and Rooftop Air Handling Units @ Middle High School): MERV- 13 filters (Note 1)

Central Station and Rooftop Air Handling Units @Essex and Old Memorial School): MERV-8 (Note 1)

Unit Ventilators and Fan Coil Units: Essex and Old Memorial School: MERV-8 (Note 2)

Notes:

Note 1. Air Handling Units: The observed air handling units at the Old Memorial and Essex Elementary Schools are generally provided with 2" filter racks/trays that were originally designed for filters that would be similar to the filter efficiency equivalence of currently available MERV-8 filters. The Middle High School air handling units are generally equipped with 4" filter racks and were designed with MERV-10 filters for the Supply airstream, these units should be capable of accepting MERV-13 filters. The New Memorial Elementary School's air handling units are designed for MERV-13 filters.

It should be noted that installing higher efficiency MERV-13 filters and not changing them more often on a regular basis will result in added pressure drop to the system that could lead to reduced overall airflow and reduce thermal comfort within the building areas served by the air handling units. MERV-13 filters with low static pressure drop (typically under 0.24 – 0.30 in static pressure at initial clean and 0.50" at mid-life) should be selected in order to ensure airflow is not negatively reduced, all unit fans should be inspected and serviced prior to installing new high efficiency filters. This service should include fan/motor belt inspection, fan lubrication and adjusted and/or replacement of belts and sheaves as necessary to ensure fans are operating properly. Any malfunctioning fan motors or components should be replaced. These higher efficiency filters should also be inspected more regularly (minimum once a month) and may need to be changed more often than ASHRAE and unit manufacturer's recommended quarterly filter change in order to ensure filter loading does not exceed the unit's static pressure capability. MERV-13 filters would be preferred in terms of providing higher filter efficiency if available (currently there is an industry wide shortage. If MERV-13 filters are not available then we would recommend that MERV-11 filters are used, and the use of supplemental Portable Room HEPA filters and use of destratification fans (where equipped) should be used to supplement the airflow exchange rate and filtration effectiveness.

For older H&V units the existing fan capacity may not be able to support higher MERV-11 & MERV-13 filters; for these units MERV-8 filters should continue to be used, and portable space HEPA filters and/or additional outdoor air or natural ventilation should be provided to the spaces served by these units.

It should be noted that when units are operating in 100% outdoor airflow mode, the MERV filter efficiency rating could be lower because the higher MERV-13 efficiency ratings are recommended to better filter particulates during recirculation mode.

Note 2. Unit Ventilators/Fan Coil Units: Currently a combination of MERV-5,6 and 8 filters were observed to be installed in the existing Elementary School unit ventilators. We would recommend using MERV-8 filters if proper airflow and temperature control are being maintained. We would not recommend increasing filter efficiency beyond this MERV-8 filter as higher efficiency filters would have increased pressure drop (typically 0.30" initial static pressure drop for MERV-13 filters) which would result in lower airflow that could contribute to reduced indoor air quality and temperature control. In addition, unit ventilator hot water heating coils could potentially freeze if airflow was restricted, and cooling coils (where equipped) could potentially freeze with reduced airflow. The older building's existing Unit Ventilators were

originally designed to be used with filters with lower efficiencies (typically equivalent to current MERV-5 filters). Many unit ventilators at grade level are close to grass and plantings which will further increase filter loading during the spring and summer months when lawn are cut and plants pollinate. Therefore we would recommend that facilities' staff or contractor(s) confirm that the units have been providing proper airflow and temperature control with MERV-8 filters. Increasing filter efficiency beyond the existing MERV-8 filters could also potentially lead to fan/motor malfunction, which would require motor replacement. The unit ventilator motors are typically ¼ or ½ HP PSC (permanent split capacitor) motors that have limited torque and external static pressure capability (typically 0.15 in w.c.). Considering that Unit ventilator spare parts are becoming less available and more expensive, it would not be recommended to use filters with much higher efficiencies and pressure drops than the Unit Ventilators were designed to operate with. In order to increase the airflow filtration level and airflow exchange in spaces served by Unit Ventilators (and spaces served by terminal fan coil and radiation) we would recommend that Portable Room HEPA filters are used to supplement the airflow exchange rate and filtration levels. When Unit Ventilators are operating in 100% outdoor airflow mode, the MERV filter efficiency rating could be lower because the higher MERV efficiency ratings are recommended to better filter particulates during recirculation mode.

APPENDIX A – Preventative Maintenance Log

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HVAC Master – Recommended HVAC Equipment Maintenance Schedules

Equipment	Preventative Maintenance Time Periods				
	Weekly	**Monthly**	**Three to Six Months**	**Annually (Start of Cooling Season)**	**Approximate Annual Expense**
Air Handling Units	• Observe for any change in running condition and unusual noise.	• Clean or replace air filters if clogged or dirty; coat permanent filters with oil after cleaning; change bag filters when pressure drop is 1 in. w.g. • Belt-Drive Fans - Relubricate fan bearings if necessary and check and adjust fan belt tension.	• Belt-Drive Fans - Check fan bearing grease line connections (lines should be tight to the bearings). Check bearing bolt torque and bearing setscrew torque. Align fan and motor sheaves. Tighten sheave set screws to the proper torque. Check motor bracket torque. • Inspect and clean drain pans. Ensure drain p-trap is primed particularly at the start of the cooling season. • Tighten electrical connections. • Inspect coils for dirt build-up.	• Inspect the unit casing for corrosion, if damage is found, clean and repaint. • Check condition of gasketing and insulation around unit, door and dampers. Examine flex connections for cracks or leaks. Repair or replace damaged material. • Clean the fan wheels and shafts. Rotate the fan wheels and check for obstructions adjust the center if necessary. Lubricate motor bearings in accordance with motor manufacturer's recommendations. • Inspect and clean drain pans. • Check damper linkages, set screws, and blade adjustment. Clean, but do not lubricate, the nylon damper rod bushings. Clean damper operators. • Inspect electrical and control connections, wiring, and insulation.	• $2,000 for heating and cooling units 5,000 CFM and greater • $1,500 for heating only units 5,000 CFM and greater • $1,500 for heating and cooling units less than 5,000 CFM • $1,200 for heating only units less than 5,000 CFM

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	Weekly	**Monthly**	**Three to Six Months**	**Annually (Start of Cooling Season)**	**Approximate Annual Expense**
Energy Recovery Units	• Observe for any change in running condition and unusual noise.	• Clean or replace air filters if clogged or dirty; coat permanent filters with oil after cleaning; change bag filters when pressure drop is 1 in. w.g. • Belt-Drive Fans – Re-lubricate fan bearings if necessary and check and adjust fan belt tension.	• Belt-Drive Fans - Check fan bearing grease line connections (lines should be tight to the bearings). Check bearing bolt torque and bearing setscrew torque. Align fan and motor sheaves. Tighten sheave set screws to the proper torque. Check motor bracket torque. • Inspect and clean drain pans. Ensure drain p-trap is primed particularly at the start of the cooling season. • Tighten electrical connections. • Inspect coils for dirt build-up.	• Inspect the unit casing for corrosion, if damage is found, clean and repaint. • Check condition of gasketing and insulation around unit, door and dampers. Examine flex connections for cracks or leaks. Repair or replace damaged material. • Clean the fan wheels, energy recovery wheels, and shafts. Rotate the fan and energy recovery wheels and check for obstructions (the wheel should not rub), adjust the center if necessary. Lubricate motor bearings in accordance with motor manufacturer's recommendations. • Inspect and clean drain pans. • Inspect burners for rust, dirt, or signs of water. • Exhaust pipe must be inspected for signs of water, damage, rust, or disconnected joints. • Check damper linkages, set screws, and blade adjustment. Clean, but do not lubricate, the nylon damper rod bushings. Clean damper operators. • Inspect electrical and control connections, wiring, and insulation.	• $2,000 for heating and cooling units 5,000 CFM and greater • $1,500 for heating only units 5,000 CFM and greater • $1,500 for heating and cooling units less than 5,000 CFM • $1,200 for heating only units less than 5,000 CFM

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	Weekly	**Monthly**	**Three to Six Months**	**Annually (Start of Cooling Season)**	**Approximate Annual Expense**
Packaged Rooftop Units	• Observe for any change in running condition and unusual noise.	• Clean or replace air filters if clogged or dirty; coat permanent filters with oil after cleaning; change bag filters when pressure drop is 1 in. w.g. • Belt-Drive Fans – Re-lubricate fan bearings if necessary and check and adjust fan belt tension.	• Belt-Drive Fans - Check fan bearing grease line connections (lines should be tight to the bearings). Check bearing bolt torque and bearing setscrew torque. Align fan and motor sheaves. Tighten sheave set screws to the proper torque. Check motor bracket torque. • Inspect and clean drain pans. Ensure drain p-trap is primed particularly at the start of the cooling season. • Tighten electrical connections. • Inspect coils for dirt build-up.	• Inspect the unit casing for corrosion, if damage is found, clean and repaint. • Check condition of gasketing and insulation around unit, door and dampers. Examine flex connections for cracks or leaks. Repair or replace damaged material. • Clean the fan wheels, energy recovery wheels, and shafts. Rotate the fan and energy recovery wheels and check for obstructions (the wheel should not rub), adjust the center if necessary. Lubricate motor bearings in accordance with motor manufacturer's recommendations. • Inspect and clean drain pans. • Inspect burners for rust, dirt, or signs of water. • Exhaust pipe must be inspected for signs of water, damage, rust, or disconnected joints. • Check each circuit's refrigerant sightglass when the circuit is operating under steady-state, full load conditions. The sightglass should then be full and clear. If it is not, check for refrigerant leaks. • Check for proper superheat. • Check damper linkages, set screws, and blade adjustment. Clean, but do not lubricate, the nylon damper rod bushings. Clean damper operators.	• $2,000 for heating and cooling units 5,000 CFM and greater • $1,500 for heating only units 5,000 CFM and greater • $1,500 for heating and cooling units less than 5,000 CFM • $1,200 for heating only units less than 5,000 CFM

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				• Inspect electrical and control connections, wiring, and insulation.	

Equipment	Preventative Maintenance Time Periods				
	Weekly	**Monthly**	**Three to Six Months**	**Annually (Start of Cooling Season)**	**Approximate Annual Expense**

Air-Cooled Chiller	• Verify that compressor oil sump heaters are connected tightly around the compressor.
	• Operate chiller for approx. 30 min. and let the system stabilize, check the operating pressures and temperatures and complete the following checks:
	  • Check the evaporator and condenser refrigerant pressures.
	  • Check the electronic expansion valve sight glasses; the refrigerant flow through the sight glasses should be clear.
	  • Check the system superheat, subcooling, evaporator temperature drop (Delta-T), evaporator water flow, evaporator approach
		• Measure and record the evaporator superheat.
		• Measure and record the system subcooling.
		• Manually rotate the condenser fans to ensure that there is proper clearance on the fan shroud openings.
				• Complete all weekly and monthly maintenance checks.
				• Check the oil level and refrigerant charge. Routine changing of oil is not required for oil-less compressor chiller designs.
				• Have a qualified laboratory perform a compressor oil analysis to determine system moisture content and acid level. This analysis is a valuable diagnostic tool. (Not required for oil-less compressor chiller designs)
				• Contact a qualified service provider to leak test the chiller, check operating and safety controls, and to inspect electrical components for proper operation. Leak testing may be accomplished using soap solution or with electronic or ultrasonic leak detectors.
					• $1,500 for chilled water plant

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	temperature, compressor discharge superheat, condenser approach, and compressor RLA.			• Inspect all piping components for leaks and damage. Clean all water strainers. • Clean and repaint any components that show corrosion. • Clean the condenser coils. • Clean the condenser fans. Check the fan assemblies for proper clearance in the fan shroud openings and for motor shaft misalignment or abnormal end-play, vibration and noise. • Check chilled water (glycol) chemical treatment levels	

Equipment	Preventative Maintenance Time Periods				
	Weekly	**Monthly**	**Three to Six Months**	**Annually (Start of Cooling Season)**	**Approximate Annual Expense**
Water-Cooled Chiller	• Verify that compressor oil sump heaters are connected tightly around the compressor. • Operate chiller for approx. 30 min. and let the system stabilize, check the operating pressures and temperatures and complete the following checks: • Check the evaporator and condenser refrigerant pressures.	• Measure and record the evaporator superheat. • Measure and record the system subcooling.	• Check filter and replace if the pressure differential across the filter exceeds 2.1 bar.	• Complete all weekly and monthly maintenance checks. • Check the oil level and refrigerant charge. Routine changing of oil is not required. • Have a qualified laboratory perform a compressor oil analysis to determine system moisture content and acid level. This analysis is a valuable diagnostic tool.	• $1,000

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	• Check the electronic expansion valve sight glasses; the refrigerant flow through the sight glasses should be clear. • Check the system superheat, subcooling, evaporator temperature drop (Delta-T), evaporator water flow, evaporator approach temperature, compressor discharge superheat, condenser approach, and compressor RLA.			• Contact a qualified service provider to leak test the chiller, check operating and safety controls, and to inspect electrical components for proper operation. Leak testing may be accomplished using soap solution or with electronic or ultrasonic leak detectors. • Inspect all piping components for leaks and damage. Clean all water strainers. • Clean and repaint any components that show corrosion. • Clean the condenser coils.	

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	Weekly	**Monthly**	**Three to Six Months**	**Annually (Start of Heating Season)**	**Approximate Annual Expense**
Boiler	• Check low water cutoff daily and each time the boiler is shut down. • Confirm combustion and ventilation air intakes are not obstructed. • Confirm fuel supply is not restricted.	• Verify that the air separation, water treatment, and makeup/feed/condensate systems (steam boilers) are operating per manufacturer's instructions.	• Visually check main burner flames. A burner view port is located on the combustion chamber front door. If improper flame is observed, examine the venting system; ensure proper gas supply and adequate supply of combustion and ventilation air. • Inspect the direct spark igniter. Clean the direct spark igniter as required to maintain peak ignition efficiency. Check igniter ground wiring.	• Examine the venting system at least once a year (check more often in the first year to determine inspection interval). Check all joints and pipe connections for tightness, corrosion or deterioration. Flush the condensate drain hose with water to clean. Clean screens in the venting air inlet system as required. Have the entire system, including the venting system, periodically inspected by a qualified service agency. • Remove and inspect burner. (Inspect more frequently if in duct/dirt contaminated environment). • For steam systems, inspect all steam condensate pumps, boiler feed units, and steam traps. • Check hot water (glycol) chemical treatment levels	• $1,000 for gas-fired hot water plant • $1,200 for oil-fired hot water plant • $1,500 for steam plant

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Equipment	Preventative Maintenance Time Periods				
	Weekly	**Monthly**	**Three to Six Months**	**Annually (Start of Cooling or Heating Season)**	**Approximate Annual Expense**
Pumps	• Check to ensure pump is properly lubricated. • Check for unusual noise, vibration, and bearing temperatures. • Check the pump and piping for leaks. • Analyze any vibration observed. • Inspect the discharge pressure. • Inspect the temperature to confirm within design parameters. • Check the seal chamber and stuffing box for leaks. • Ensure that there are no leaks from the mechanical seal. • Adjust or replace the packing in the stuffing box if excessive leaking is noticed.		• Check that the pump hangers and supports are tight. • Check the mechanical seal if the pump has been left idle, and replace as required. • Lubricate motor in accordance with manufacturer's instructions. (Perform more often if recommended by manufacturer) • Check the shaft alignment, and realign as required.	• Check the pump capacity. • Check the pump pressure. • Check the pump power.	• $200 each

Equipment	Preventative Maintenance Time Periods				
	Weekly	**Monthly**	**Three to Six Months**	**Annually (Start of Cooling or Heating Season)**	**Approximate Annual Expense**
Heating/Chilled Water System Chemical Treatment				• Chemical treatment to be applied to heating/chilled water system annually	• $1,500-$3,000 dependent on piping volume

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Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Semi-Annually	Approximate Annual Expense
Expansion Tank				• Recommend replacing the bladder every 2 years (or as needed). When replaced, thoroughly clean and dry off the inside of the vessel. Check for signs of corrosion and obtain new vessel if so.	• N/A

Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually	Approximate Annual Expense
Strainer			• Inspect, clean, and flush every 90 days as required.		• N/A

Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually	Approximate Annual Expense
Combustion Air Fan		• Check belts periodically for wear and tightness. When replacing belts, use the same type as supplied with the unit.	• Re-lubricate fan bearings with quality manufacturer recommended grease.		• $150 each

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Equipment	Preventative Maintenance Time Periods				
	Weekly	**Monthly**	**Three to Six Months**	**Annually (Start of Cooling Season)**	**Approximate Annual Expense**
Induction Units		• Check all piping and connections for leaks.	• Clean the drain pan to ensure the unit drains condensate properly. Check the condensate drain pan and drain line to assure the condensate drains properly at least every six months or as dictated by operating experience. If evidence of standing water or condensate overflow exists, immediately identify and remedy the cause. Clean the drain pans of any moisture or debris.	• Remove center core of grille and vacuum off the internal heating and cooling coil with a soft vacuum brush. The removable grille can also be vacuumed as required. • Every 2-3 years vacuum induction unit nozzles.	• $25 each

Equipment	Preventative Maintenance Time Periods				
	Weekly	**Monthly**	**Three to Six Months**	**Annually**	**Approximate Annual Expense**
Unit Ventilators		• Change air filters every 4 to 8 weeks. (Filters require more frequent care under high load or dirty air conditions since a clogged filter reduces airflow) • Check all piping and connections for leaks.	• Clean the coil fins using steam with detergent, hot water spray and detergent, or a commercially available chemical coil cleaner. Be sure to rinse coils thoroughly after cleaning. Remove filters prior to cleaning. • Inspect insulation every 3 months; thoroughly clean as needed. • Inspect fan bearings and sheave alignment. Lubricate and adjust as necessary.		• $250 each

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Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually	Approximate Annual Expense
Variable Air Volume Boxes			• Inspect airflow sensor • Inspect damper leakage		• $50 each

Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually	Approximate Annual Expense
Fan Coil Units		• Check all piping and connections for leaks.	• Change or clean air filters at least twice a year. (Filters require more frequent care under high load or dirty air conditions since a clogged filter reduces airflow) • Clean the coil fins using steam with detergent, hot water spray and detergent, or a commercially available chemical coil cleaner. Be sure to rinse coils thoroughly after cleaning. Remove filters prior to cleaning. • Clean the drain pan to ensure the unit drains condensate properly. Check the condensate drain pan and drain line to assure the condensate drains properly at least every six months or as dictated by operating experience. If evidence of standing water or condensate overflow exists, immediately identify and remedy the cause. Clean the drain pans of any moisture or debris. • Inspect fan bearings and sheave alignment. Lubricate and adjust as necessary.		• $175 each

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Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually	Approximate Annual Expense
Hot Water Unit Heaters		• Check all piping and connections for leaks.	• Cabinet Type Unit Heaters - Change or clean air filters at least twice a year. (Filters require more frequent care under high load or dirty air conditions since a clogged filter reduces airflow) • Clean the coil fins using steam with detergent, hot water spray and detergent, or a commercially available chemical coil cleaner. Be sure to rinse coils thoroughly after cleaning. Remove filters prior to cleaning. • Inspect fan bearings and sheave alignment. Lubricate and adjust as necessary.		• $175 each for cabinet type unit heaters • $100 each for vertical unit heaters

Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually	Approximate Annual Expense
Gas-Fired Unit Heaters		• Check all piping and connections for leaks. • Check fuel and burner manifold pressure. • Clean flame sensors.	• Cabinet Type Unit Heaters - Change or clean air filters at least twice a year. (Filters require more frequent care under high load or dirty air conditions since a clogged filter reduces airflow) • Clean the coil fins using steam with detergent, hot water spray and detergent, or a commercially available chemical coil cleaner. Be sure to rinse coils thoroughly after cleaning. Remove filters prior to cleaning. • Inspect fan bearings and sheave alignment. Lubricate and adjust as necessary. • Inspect burner, automatic gas shut-off valves, and fan motor voltages.	• Ensure all vents to atmosphere are clean and free from obstruction.	• $150 each

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Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually (Start of Heating Season)	Approximate Annual Expense
Fintube Radiation and Convectors		• Check all piping and connections for leaks.		• Remove cover and vacuum off the internal coil with a soft vacuum brush. The cover can also be vacuumed as required.	• N/A

Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually (Start of Heating Season)	Approximate Annual Expense
Steam Radiators		• Check all piping and connections for leaks. • Ensure exterior surface is clean and paint any nicks or deep scratches with touch-up to prevent any surface rust.		• Remove cover and vacuum off the internal coil with a soft vacuum brush. The cover can also be vacuumed as required.	• N/A

Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually	Approximate Annual Expense
Exhaust Fans		• Check belts periodically for wear and tightness. When replacing belts, use the same type as supplied with the unit.	• Relubricate fan bearings with quality lithium base grease, conforming to NLGI Grade 2 consistency		• $75-150 each

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Kitchen Exhaust Systems		• Check fan belts periodically for wear and tightness. When replacing belts, use the same type as supplied with the unit.	• Relubricate fan bearings with quality lithium base grease, conforming to NLGI Grade 2 consistency • Have kitchen exhaust duct system inspected for grease buildup by an accredited professional.		• $300 each fan • Kitchen exhaust duct cleaning through maintenance service contract

Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually (Start of Cooling Season)	Approximate Annual Expense
Ductless Cooling Units		**Condensing (Outdoor) Unit** • Check unit wiring to ensure all connections are tight and that the wiring insulation is intact. • Inspect the condenser casing and coils for dirt and debris. If the casing and/or coils appear dirty, clean them.	**Evaporating (Indoor) Unit** • Change or clean air filters at least twice a year. (Or when unit screen "Filter" display is present) • Clean the drain pan to ensure the unit drains condensate properly. Check the condensate drain pan and drain line to assure the condensate drains properly at least every six months or as dictated by operating experience. If evidence of standing water or condensate overflow exists, immediately	**Condensing (Outdoor) Unit** • Ensure refrigerant pressure levels are per manufacturer's requirements. • Remove corrosion from any surface and repaint. Check the gasket around the control panel door to ensure it fits correctly and is in good condition to prevent water leakage. • Inspect the control panel wiring to ensure that all connections are tight and that the insulation is intact. • Check refrigerant piping and fittings for leaks.	• $150 each for evaporators • $300-$500 each for condensing units

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			identify and remedy the cause. Clean the drain pans of any moisture or debris.	• Inspect the condenser coils for dirt and debris. If the coils appear dirty, clean them.	

Equipment	Preventative Maintenance Time Periods				
	Weekly	**Monthly**	**Three to Six Months**	**Annually**	**Approximate Annual Expense**
Dust Collector System	• Examine air outlet for possible dust or smoke accumulation. • Inspect filter envelope for leaks and ensure the filter envelope is securely fastened. • Examine the automatic shaker mechanism for any unusual noise or vibration, broken parts, or loose components.		• Examine, clean, and apply paint touch ups if necessary. • Lubricate the shaker and shaft rocking system using manufacturer recommended grease if needed.		• $150

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Variable Frequency Drives	• Check environment ambient temperature, humidity, vibration and atmosphere (dust, gas, oil mist, or water drops) are at acceptable levels. • Check for proper voltage readings. • Check display and for missing parts in the characters. • Check structure of unit for cleanliness and missing parts. • Check for excessive noise or vibration.	• Check common, conductor and wire, terminal block, filtering capacitor, transformer and reactor, and magnetic control and relay of main circuit. • Check printed circuit board of control circuit. • Check cooling fan and ventilation path of cooling system.			• $100

Equipment	Preventative Maintenance Time Periods				
	Weekly	Monthly	Three to Six Months	Annually	Approximate Annual Expense
Automatic Temperature Control System				• Check/calibrate valves and damper actuators • Calibrate CO2 sensors (every 5 years)	• Varies. Largely dependent on building size and type of system (e.g. DDC, electronic, pneumatic). • Majority of maintenance cost should be provided as part of ATC service contract.

Note: Preventative maintenance tasks obtained from basis of design equipment manufacturer's Installation, Operation and Maintenance Manual. Contractor to revise/edit based upon actual installed equipment Installation, Operation and Maintenance Manual submittal.