Massachusetts Trial Court
1 Pemberton Square, Boston MA

STUDY AND DESIGN SERVICES OF MECHANICAL and ELECTRICAL SYSTEM UPGRADES / REPLACEMENT OF VARIOUS SYSTEMS STATEWIDE

OVERVIEW OF RECOMMENDATIONS

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Tighe&Bond

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Section 1 Introduction

1.1 Purpose

The purpose of this document is to give an overview of the potential recommendations that may be suggested in various Courthouses for improvements or modifications to existing HVAC systems relative to the COVID-19 pandemic. We've created a "Master HVAC Systems Recommendations List" that gives further guidance on each recommendation. The specific report for each Courthouse references our recommendations noted in this master list.

1.2 Background

In an effort to assist the Massachusetts Office of Court Management in providing recommendations for improvement to their heating, ventilation, and air conditioning systems during the COVID-19 pandemic, Tighe & Bond has reviewed various resources for recommendations and best practices to develop a more concise set of action items tailored to the Courts existing systems and facilities management team.

Tighe & Bond is drawing on guidance and recommendations from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the U.S. Environmental Protection Agency (EPA), the U.S. Centers for Disease Control and Prevention (CDC), as well as best practices learned from the firm's collective experience designing heating, ventilating, and air conditioning (HVAC) systems for numerous building types. Attached in Appendix B are publications from ASHRAE's Epidemic Task Force for reference, including "Core Recommendations for Reducing Airborne Infectious Aerosol Exposure".

According to the CDC and EPA, SARS-CoV-2, the virus that causes the COVID-19 disease is thought to spread mainly through close person-to-person contact. The more closely a person interacts with others and the longer the interaction, the higher the risk of COVID-19 spread. The CDC reports this generally includes,

- Between people who are in close contact with one another
- Through respiratory droplets produced when an infected person coughs, sneezes, or talks
- These droplets can land in the mouths or noses of people who are nearby or possibly be inhaled into lungs
- COVID-19 may be spread by people who are not showing symptoms

The CDC reports that the virus may be spread in other manners such as a person touching a surface or object that has the virus on it and then touching their own mouth, nose, and possibly their eyes. The CDC acknowledges they are still learning more about how this virus can spread. As of mid-September 2020, the "How COVID-19 Spreads" CDC webpage does not list HVAC systems as the *"main"* cause of how the disease may spread. The degree to which HVAC systems play a role in spreading the virus is still uncertain.

The EPA acknowledges that there is growing evidence that the virus can remain airborne for longer times and further distances than originally thought. They also suggest implementing improvements to HVAC systems cannot alone eliminate the risk of transmission. The EPA states the following on their "Indoor Air and Coronavirus (COVID-19)" webpage,

> *"The layout and design of a building, as well as occupancy and type of heating, ventilating, and air conditioning (HVAC) system, can all impact potential airborne spread of the virus. Although improvements to ventilation and air cleaning cannot on their own eliminate the risk of airborne transmission of the SARS-CoV-2 virus, EPA recommends precautions to reduce the potential for airborne transmission of the virus."*

A concern associated with allowing public buildings to be open during the COVID-19 pandemic is indoor air quality (IAQ). Environmentally sensitive spaces such as laboratories, medical examination rooms, and hospital operating rooms have significant outdoor air change rates to dilute and remove potential contaminants. Public buildings are generally not designed with high outdoor air changes rates similar to these types of spaces. Given the constraints of existing systems originally designed to meet space heating or cooling loads and to deliver code-minimum ventilation rates for human occupancy, there are limited opportunities to substantially increase the outside airflow and outside air change rate. We recognize that it is not practical to ventilate Courthouses as we would these environmentally sensitive rooms. However, there are incremental improvements that can be made that may help reduce the risk of transmission.

Please note that this report mainly provides recommendations to HVAC systems to help reduce the risk of spreading the virus. Implementing these strategies will help reduce, but not eliminate the risk of transmission of the virus. We urge the Office of Court Management to review CDC, EPA, State of MA, and other disease control agencies' recommendations and requirements for other measures to implement inside of their buildings. These measures include social distancing, frequent handwashing, limiting occupancy in spaces, use of facemasks and Personal Protective Equipment (PPE), cleaning and disinfecting high-touch surfaces on a regular basis, health screening, self-certification, etc.

Section 2
Overview of Recommendations

This section describes possible recommendations that may be implemented in various Courthouses throughout Massachusetts that are within Tighe & Bond's scope of work. Refer to the specific recommendations noted in each Courthouse report.

2.1 Increasing Filtration Efficiency

The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) recommends increasing filtration in air handling units to at least a Minimum Efficiency Reporting Value (MERV) of 13, or MERV 14 if possible. Filtration is used to clean the air by trapping viruses and bacteria that could be recirculated through an air handler or brought in from outdoors.

MERV-13 filters are available in 1", 2" and 4" thicknesses. Central station air handling systems and rooftop units serving commercial or municipal type buildings are typically designed with a 2" filter, with varying MERV ratings, usually not exceeding MERV 8. Fan coil units typically contain 1" filters, but the MERV ratings are highly variable between manufacturers and are often less than MERV 8. Unit ventilators can contain 1" or 2" filters, also with varying MERV ratings.

The higher the MERV rating of a filter, the higher efficiency and also the pressure drop across the filter. In comparing the pressure drop between a MERV 8 and MERV 13 filter for two filter manufacturers, we found the difference in pressure drop (ΔP) is generally not significant. However, how significant this pressure drop is on the system highly depends on the current performance of the air handling system, the available static pressure, and the size of the fan motor. Table 1 contains pressure drop data published by two manufacturers. The pressure drop of other filter manufacturers may vary.

TABLE 1

Manufacturer	MERV 8 ΔP			MERV 13 ΔP		
	Filter Model	Initial Resistance (in. w.g.)	Final Resistance (in. w.g.)	Filter Model	Initial Resistance (in. w.g.)	Final Resistance (in. w.g.)
American Air Filter Company, Inc.	VP-MERV8 SC	0.30	1.0	PREpleat M13	0.30	1.0
Camfil	Farr 30/30	0.31	1.0	AP-Thirteen	0.41	1.0

Notes:
1. Data based on 2" pleated panel filters at an air velocity of 500 feet per minute (FPM).
2. Filter pressure drop is measured in inches of water gauge (w.g.).

The manufacturer's recommended "final" resistance for both MERV 8 and 13 filters is 1.0" w.g. The final resistance is the point at which the filter should be changed. MERV 13 filters will become loaded with debris and require changing more frequently than MERV 8 filters. Installing a differential pressure gauge and/or a pressure switch across the filter bank will help identify when filters reach 1" w.g. of resistance and when they should be changed. A switch can be tied into an existing BMS to send an alarm to the operator's workstation. If a BMS does not exist, it can be tied into a local visual alarm within the mechanical room.

Taking the action of not rebalancing the fan to accommodate the higher pressure drop will not present a danger of overloading the fan motor, but will result in decreased airflow. Reducing the airflow in a building may cause side effects such as a reduction in ventilation, and a lack of cooling or heating in some areas. A lack of cooling airflow may cause mold growth. It must be determined what effect changing filters will have on system airflow, and what changes are required to maintain the design airflow. Pressure drop and filter efficiency vary with face velocity. Pressure loss and the resulting decrease in airflow will also depend on the total pressure drop in the system. Systems may need rebalancing, and it is possible that re-establishing the design airflows in conjunction with a higher filter pressure drop could overload the fan motor.

We recommend following ASHRAE's "Practical Approach to Increase MERV in an AHU" directive to help determine the effect of replacing filters with MERV 13 filters on fan motors. Highlights from this directive include:

1. *Prior to replacing the filters, test the outside air, return air, and supply airflow, supply air temperature, etc. of the unit with the existing filters in place.*
2. *Install MERV 13 filters and re-test the airflows.*
3. *Determine if the loss in airflow due to the higher-pressure drop is acceptable (assess pressure drop assuming the filters are dirty). If the answer is yes, then set a "dirty filter" setpoint alarm. If the answer is no, adjust fan speed (without overloading the motor) to deliver more air, if feasible. Fan speed may be increased by adjusting variable frequency drives or a sheave change.*
4. *If motor speed cannot be increased safely, determine if fan and/or motor replacements are viable.*

We recommend visiting ASHRAE's website for further direction and for the most up to date information on the "Practical Approach to Increase MERV in an AHU". ASHRAE continuously updates information on this webpage. This approach can be found at https://www.ashrae.org/technical-resources/building-readiness#upgrading.

In buildings that are currently unable to satisfy cooling or heating needs due to a lack of airflow, installing MERV 13 filters may further exacerbate the issue. A further lack of cooling may cause uncomfortable working conditions and mold growth on surfaces. If a building is already experiencing a lack of cooling or heating in some or most spaces, we request that the Office of Court Management make us aware of these issues. Several factors may be contributing to this issue and further investigation would be required.

If it is found that the air handling unit cannot handle the pressure drop associated with MERV 13 filtration, it may be possible it to install MERV 13 filtration in the return duct instead of within the air handling unit itself, if the system contains an adequately sized return fan. The virus is more likely to enter the air system from within the building versus from the outdoors, depending on the location of the outdoor intake. Adding filtration to the return duct would be a viable alternative. However, it may still be possible for the virus to enter from the outside. Rebalancing the return fan may be warranted to accommodate the pressure drop. In some cases a fan motor replacement may be necessary.

Operationally, filter changing procedures should follow best practices, including proper PPE and bagging the removed units. Care needs to be taken when performing filter maintenance or replacement to avoid releasing particulates captured in filters within air handling equipment or air systems. We suggest shutting the entire system down, including supply and return fans, to prevent re-entrainment of particles into the air handler and vacuum cleaning any debris that falls off the filters.

2.2 Optimizing Outdoor (Ventilation) Air Rate

2.2.1 Minimum Outdoor Air

Air handling units are typically designed to provide a minimum quantity of outside (a.k.a. ventilation) air based on the International Mechanical Code and ASHRAE Standard 62.1 minimum flow rates during occupied periods. ASHRAE Standard 62.1 is the Standard for Ventilation for Acceptable Indoor Air Quality. Minimum code and ASHRAE ventilation rates for a Courthouse are primarily determined by the number of people in a given space, airflow per person, and airflow per square foot. Occupant density for each type of room varies, based on the activity in the room. For example, a Courtroom will have a much higher occupant density than an office, and will require more ventilation air. Airflow is measured in cubic feet per minute (CFM).

To ensure the proper amount of minimum outside air is being delivered to each air handler, we recommend rebalancing the outdoor and return air flow rates to either the original designed outside air flow rate or to the latest code and ASHRAE Standard 62.1 values, whichever is higher.

2.2.2 Additional Outdoor Air

The ASHRAE Epidemic Task Force "Building Guide" recommends increasing the outdoor air delivered to the building, beyond the minimum requirements. This not only helps reduce the recirculation rate of the virus back into the occupied space, but also has a strong positive effect on the cognitive function, productivity, and well-being of building occupants.

Two key drawbacks are that the air handling equipment heating and cooling coils may not be able to maintain the design supply air temperature and relative humidity under all conditions, and this strategy will expend more energy tempering the additional outdoor air.

Peak design conditions are the outside air conditions that are used to design and select air handling equipment. For example, ASHRAE's climatic design data for Boston, MA at Logan International Airport is 90.6°F/72.6°F dry bulb/wet bulb (DB/WB) in the summer and 8.5°F in the winter. This corresponds to an annual cumulative frequency of occurrence of 0.4% for cooling and 99.6% for heating. Common supply air temperatures that air handlers are designed to deliver to buildings are is 55°F/54°F (DB/WB) during the cooling season and between 65°F - 95°F DB during the heating season. The more outside air that is introduced into the system, the more load is imposed on the heating and cooling coils, and the harder it may be to maintain these temperatures. As the colder winter months set in, the more difficult and costly it is to heat the increased outside air, and the risk of freezing the coil becomes a concern

Under non-peak conditions however, air handling equipment is more likely to be able to maintain the correct supply air temperature if some excess outside air in introduced. The majority of the time, the system operates under non-peak conditions, therefore we recommend increasing the quantity of supply air beyond the minimum along with controls to help automate this process.

It is difficult to understand how much more outside air the existing air handling units are capable of handling. In our experience, performance information for older units is generally not retained by the air handler manufacturer, therefore it is difficult to verify this information. How the current condition of the heating and cooling coils effects the performance is another unknown. Damaged and dirty coil fins, scale on the inside of the piping, etc. will reduce the performance output.

Two approaches can be taken to introduced more outside air into the building.

1. Introducing up to a maximum of 10-20% more outside air over the minimum and modulate the unit to run the airflow either at this set value or the minimum flow rate. The value will be building dependent. The return fan may also have to be rebalanced to reduce the quantity of return air to the air handler by the same quantity of additional outdoor air being introduced. This may require the installation of VFDs on the return fan and additional control sequences to implement this strategy. If the return fan has the ability to exhaust air to the outdoors in addition to returning air to the air handler, the return fan total air airflow can remain the same, however more air should be exhausted while the return airflow is reduced.

   This strategy will require monitoring supply air and the mixed air (the mixture of outdoor air and return air) temperature. If the air handler cannot maintain the required discharge air temperature setpoint, the outdoor air damper will revert back to the minimum position.

2. Introduce more outside air in a stepped approach, meaning to gradually increase the outside air to a higher value, perhaps 30% or 40% outside air, based on the ability to maintain discharge air temperature. The benefit is this approach will allow more outside air to be supplied on a more regular basis. The downside is this will require additional controls and cost to implement. The risk of mechanical failure of actuators also increases, which may cause supply air temperatures to fluctuate and cause uncomfortable temperatures.

   We recommend this approach be considered in buildings with systems in good condition and an existing BMS. We also recommend setting limits on this type of sequence, based on outdoor air temperature, to prevent a situation that would put the coils at risk of freezing.

We recommend installing controls to monitor the supply air humidity and temperature and revert back to the minimum outdoor air flow rate if the supply air cannot maintain the setpoint.

It should be noted that the recommendation is not to increase the total airflow in systems, but to maintain the design airflow and increase the fraction of outdoor air. Increasing total airflow would increase discharge velocity at the diffusers, which creates the potential for noise and further tax the heating and cooling capacity of the air handling equipment.

We also have to be cautious on how much outdoor air to introduce into an air handler to prevent building over pressurization and rain and snow intake. Excessive building pressurization can result if outdoor air is increased but exhaust and return air systems remain as designed, causing exit doors to stay open, temperature control issues, and moist indoor air to enter the building envelope during the winter.

As the quantity of outside air increases through an outdoor air intake louver, the air velocity also increases. If the air velocity is too high, rain and snow may enter the system. In systems that operate on economizer sequences, the outside air louvers should already be sized to accommodate 100% outside air, so this is less of a concern. Implementing this strategy in systems that do not operate on an economizer sequence is more of a concern. During our onsite observations of the air handling units, we measured the area of the intake air louvers to gain a general understanding of how much intake air the louver can accommodate, and where it is applicable, which has been noted within our findings of each of the Courthouse reports. We recommend that Courthouse facilities staff periodically check for rain and snow inside the louver to verify this is not an issue while introducing more volumes of outside air.

2.3 Equipment Maintenance & Upgrades

2.3.1 Control Dampers and Actuators

Control dampers and damper actuators regulate the quantity of outdoor air entering an air handling unit. Dampers, actuators, and in most cases, a return fan regulate the quantity of return air. When systems are originally installed, a testing and balancing (TAB) Contractor sets the positions of the dampers and speed of the supply and return fan to achieve the desired amount of outside air, return air, and supply air. In many cases, air handlers operate on an occupancy schedule and close the outside air damper during unoccupied periods and open the outside air damper when the building is occupied. As dampers and actuators age, wear and tear from cycling open and closed may prevent the dampers from returning to their original setpoints set by the air balancer, allowing more or less outside air to enter the air handler. Replacing existing dampers and actuators that are not working correctly, and re-balancing the associated system dampers by a TAB Contractor, will help maintain the correct quantity of outside air. We recommend testing dampers and damper actuators for proper operation. If they are not operating correctly, we recommend they be replaced. Prior to replacing control valves and actuators, we recommend verifying the controls serving the actuators are working correctly.

2.3.2 Clean Heating Coils, Cooling Coils, and Drain Pans

Proper filtration is the single most important factor in keeping heating and cooling coils clean. One aspect is to ensure that filters fit tightly, using spacers or gaskets to minimize gaps around the edges where air can bypass the filter. The locations most likely to harbor microbial growth in HVAC systems are cooling coils and drain pans. Coil fin type, drain pan design, and drain pan condensate trap design affect the potential for microbial growth and ease of cleaning. Regular cleaning of the coils and drain pans is recommended, and should be performed based on hours of operation and periodic visual inspections.

Cleaning both heating and cooling coils within air handling units may help reduce the overall pressure drop within the system and may help offset the increase in pressure drop associated with MERV 13 filters. We recommend that dirty coils and drain pans be thoroughly cleaned and regularly maintained.

2.3.3 VAV Boxes

Variable air volume (VAV) air handling systems that serve many different zones generally include VAV boxes to help regulate airflow to each zone. Depending on how the system was originally designed, VAV boxes contain dampers that regulate airflow between a maximum and minimum position, and may also contain fans. Fans and dampers in older VAV boxes may not be functioning, possibly reducing the quantity of air being delivered to the space. Also, when VAV boxes are first installed, the supply air is set and balanced based on the design airflows. Similar to actuators serving air handling units, over time the actuators that regulate the airflow may not be working properly and not allow the proper amount of air be supplied to each zone. VAV box controllers may also be functioning incorrectly due to their age.

In systems with aging VAV boxes, we recommend inspecting the VAV box fans (if appliable), controllers, and actuators and replacing them if they are not in working condition. We also recommend testing and rebalancing the supply airflow rate from each VAV box to ensure the proper amount of air is being delivered to each space. The VAV boxes should be balanced to their original design airflows.

2.3.4 Fan Coil Units and Unit Ventilators

Some buildings do not have central or rooftop air handlers that supply air to spaces. In these cases, fan coil units and unit ventilators are designed to deliver conditioned air, including outside and return air, to the space to maintain space temperature and humidity. This equipment is often installed at the perimeter of each room, or in some cases above the ceiling, and is ducted to an outside air louver. These units contain a fan, filter, and heating and cooling coils.

We recommend these units be cleaned and filters be changed. Unit ventilators often have a more robust fan system, potentially allowing the use of MERV 13 filters. Fan coil units typically have less static pressure capacity available in their fans, making the use of MERV 13 filters more challenging. Upgrading filters in FCUs and UVs should be evaluated on a case by case basis. As an alternative to upgrading the filters, bipolar ionization units can be installed inside this equipment. Refer to Section 2.5 for further information on bipolar ionization technology.

We also recommend that older units be tested and balanced to the correct quantity of outside air to ensure the proper amount of ventilation air is being delivered to the space. The airflow rate should be balanced to the original values noted on the original design drawings.

2.3.5 Control Valves and Actuators

ASHRAE generally recommends maintaining an indoor air temperature between 70°F and 75°F, and a relative humidity between 40% and 60%. Chilled and hot water control valves control the flow of water to air handling equipment coils. If control valves or control valve actuators are faulty and not allowing the appropriate water flowrate to the coils, the air handling equipment cannot condition the supply air appropriately. This can cause the supply air temperature and humidity to fall out of the design parameters and reduce the ability to keep the building within these temperature and humidity ranges. Replacing control valves and actuators may help achieve the design water flow rates through the coils, improve the condition of the supply air and allow the building to maintain the recommended indoor air temperature and humidity setpoints. Prior to replacing control valves and actuators, we recommend verifying the controls serving the actuators are working correctly.

If valves and actuators are replaced and the air handling equipment still cannot maintain the designed supply air temperature, other factors may be responsible such as fouled coil piping, poor pumping performance, or an issue with the chiller or boiler plant.

We recommend testing control valves and actuators and replace if they are not in working condition. We recommend balancing new and existing control valves to the flow rates noted in the record drawings or most recent testing and balancing report.

2.4 Control System

Building control systems may consist of standalone pneumatic or electronic controls; or may contain a Building Management System (BMS), also known as a Direct Digital Control (DDC) system. Standalone pneumatic control systems are being used less frequently and are being replaced by DDC systems for new construction and renovation type projects. Pneumatic systems are arguably less reliable and require more maintenance. Equipment is controlled by air that travels in small pneumatic tubing around the building. Over time, this tubing can develop leaks, causing the control system to malfunction or underperform.

2.4.1 Replace Pneumatic Controls with Electronic/Digital Controls

Replacing an entire control system within a building is a labor intensive, expensive undertaking, therefore, we are not recommending this for immediate COVID-19 response, but rather should be considered for longer term capital improvements We recommend limiting the replacement of pneumatics with electronic or digital controls to when equipment is being replaced or upgraded due to age or poor condition. For example, if pneumatic damper actuators are being replaced, replacing the actuator with an electronic type may be appropriate. An alternative is to have an HVAC Controls Contractor test the existing pneumatic system to ensure that it is in good operating condition.

2.4.2 Implement a Pre and Post-occupancy Flush Sequence

Outdoor air ventilation and at times, air handling units, are typically shut down when the building is not occupied. Typically, the outdoor air damper is closed to help save energy when conditioning the building overnight and, on the weekends and opens at the start of building occupancy. A "flush sequence" will introduce outside air before occupancy to help improve indoor air quality. Equipment can be run continuously, and outdoor air dampers can be commanded to open to maintain ventilation during unoccupied periods, or schedules and sequences can be changed to incorporate ventilation air flush periods pre-and post-occupancy. The current ASHRAE recommendation is for a pre-occupancy flush period long enough to provide three air changes of outdoor air. For most spaces this equates to a two or three hour period.

2.4.3 Economizer Sequence

Another method to introduce more outside air during occupied hours is to utilize the existing economizer control sequence. The economizer sequence is also referred to as a "free cooling" sequence to minimize cooling energy. During the cooling season, if the outdoor air is cooler and/or less humid than the return air, as determined by comparing the enthalpy of the return air vs. the outside air, then the OA damper is fully opened, allowing 100% outdoor air to be supplied to the building, and exhausting all return air to the outside. If air handling systems have an existing economizer sequence, we recommend confirming this sequence is operational and to correct any issues if it's not. It may be difficult and expensive to implement an economizer sequence in systems that do not already contain this control strategy.

2.4.4 Disable Demand Control Ventilation Sequences

Demand control ventilation (DCV) control sequences adjusts the quantity of outside air based on carbon dioxide (CO_2) levels inside a room. A measure of CO_2 inside a space is an indication of the level of occupancy. The purpose of this sequence is to reduce outside air when occupancy reduces below the design levels, to save on the energy costs. We recommend temporarily disabling this sequence during the pandemic period to allow maximum outside air to enter the space. Tighe & Bond is not aware of any DCV sequences in place in the Courthouses observed, but the Office of Court Management should be aware of this strategy should these sequences exist.

2.4.5 Recommissioning

Recommissioning of control systems can verify that the sequences of operation and control of temperature and humidity are working correctly. We recommend this option be explored in buildings with known control issues, prior to replacing automated dampers valves and actuators. During our site visits, we questioned facility staff if there were any substantial control issues known at the Courthouses and noted our findings in each report, however we request the Office of Court Management also verify if this is a concern in each building.

2.5 Additional Filtration and Air Cleaning

In addition to upgrading filters in air handling units, other types of filtration and air cleaning technologies are available.

2.5.1 Portable HEPA Filter Units

High-Efficiency Particulate Air (HEPA) filter units have an efficiency of 99.97% at 0.3 μm particle size. Portable, free-standing HEPA filter units (also referred to by some as air purifiers) have been proven effective in filtering room air. ASHRAE recommends the use of portable HEPA filter units if:

1. An increase in air filtration MERV level cannot be accommodated by existing air handling and ventilation equipment
2. In areas with no mechanical ventilation
3. If removal of containments near a specific source is needed

4. Where higher risk activities occur

The CDC recommends the use of portable HEPA filter units "*to enhance air cleaning (especially in higher risk areas such as a nurse's office or areas frequently inhabited by people with a higher likelihood of having COVID-19 and/or increased risk of getting COVID-19).*" The CDC also states,

> *"Portable HEPA filtration units that combine a HEPA filter with a powered fan system are a preferred option for auxiliary air cleaning, especially in higher risk settings such as health clinics, vaccination and medical testing locations, workout rooms, or public waiting areas. Other settings that could benefit from portable HEPA filtration can be identified using typical risk assessment parameters, such as community incidence rates, facemask compliance expectations, and room occupant density. While these systems do not bring in outdoor dilution air, they are effective at cleaning air within spaces to reduce the concentration of airborne particulates, including SARS-CoV-2 viral particles. Thus, they give effective air exchanges without the need for conditioning outdoor air."*

It should be noted that these devices clean the air in the space, but do not act as an air barrier between people or should be used as an alternative to PPE. An example of where the existing mechanical system cannot accommodate a MERV 13 filter would be a building served by fan coil units. Fan coil units generally do not have adequate fan capacity and in some instances space to install a MERV 13 filter, however, this should be evaluated on a case-by-case basis.

We recommend installing portable HEPA filter units in select spaces in buildings with no mechanical ventilation and in buildings where the existing mechanical systems cannot accommodate MERV 13 filters. At a minimum, portable filters should be considered in high traffic areas or spaces with a dense occupant load. With the public traveling in and out of these types of spaces throughout the day, these areas can arguably be considered as "higher risk" spaces. It should be noted that these floor mounted units may be prone to tampering by the public. The following high traffic and densely occupied areas, assuming a Courtroom is not operating at a reduced capacity, are examples of where portable HEPA filters may help reduce airborne containments:

1. Public circulation spaces such as lobbies and main public hallways
2. Public waiting areas
3. Public side of Clerk, Probation, and other Office Counters
4. Courtrooms
5. Elevator lobbies
6. Jury Pool rooms
7. Jury Deliberation rooms
8. Kitchen/Break rooms
9. Open office areas where occupant load cannot be significantly reduced

HEPA filters should be considered in other high traffic or density occupied spaces not listed above. It would also be beneficial to install portable HEPA filter units in holding cell common areas, i.e. corridors, however there is generally not enough space to install a portable HEPA filter unit that could be located out of egress pathways. The filtration units and associated power cords may also create a hazard to prisoners and security staff.

The noise generated from the portable HEPA filter units may prevent them from being used in noise sensitive areas such as Courtrooms, however noise does reduce when they are operated at medium or low speed. If units operate at lower speeds, more units may be required to provide the same cleaning effect. Noise levels produced vary by manufacturer. Manufacturers' recommendations for sizing the portable filter units are typically based on air change rates, which is how many times the air is replaced in a room each hour. Sizing may also be based on square footage of floor space. Several units will be required in large spaces such as Courtrooms. The generated noise will increase as the number of units increase in each space. Some HEPA filter units are assigned a Clean Air Delivery Rate (CADR) if the manufacturer is certifying the performance of their portable filter units by means of an independent testing laboratory. The larger the CADR, the faster it will clean the room air. CDC's website contains further information on this rating system and how to select portable filtration units. Given the presumed sensitivity of increased noise in certain areas of a given building, we recommend that a few different manufacturers and sizes of HEPA filter units be installed in select courthouses and a noise test be performed. Since multiple units may be required in larger rooms such as courtrooms, a few units should be tested concurrently in such areas to determine if the increased noise levels are acceptable.

Installation of portable HEPA filter units in small, individual office spaces occupied by a single person presents challenges such as a inadequate space to install the unit, excessive noise generation for the small space, and may be cost prohibitive. An alternative to portable HEPA filters in small areas with no mechanical ventilation is bipolar ionization units (which also may be cost prohibitive), or mandating that single or small offices only be occupied by one person.

In addition to installing portable HEPA filters in buildings with no mechanical ventilation or buildings with systems that cannot accommodate MERV 13 filters, these devices can be provided in buildings with adequate mechanical ventilation systems containing MERV 13 filters as an additional safety measure. If high traffic areas are considered "high risk" or if spaces will be densely occupied, installing portable HEPA filter units in the spaces noted above should be considered. If courtrooms have adequate and effective mechanical ventilation and filtration and the HPEA filters are found to be too noisy and disruptive to court proceedings, while they would provide an added safety measure, may not necessarily be warranted.

Attached for reference in Appendix B is a document from ASHRAE describing guidance for using in-room air cleaning devices.

2.5.2 Bipolar Ionization

Another technology available is bipolar ionization, which creates reactive ions in the air that react with airborne contaminants, including viruses. The airborne particles are charged by the ions, causing them to cluster and be caught in filters. Also, as the particles divide to reproduce, bacteria and virus cells bond with oxygen ions and are destroyed.

Bipolar ionization can be deployed in the airstream by installing in ductwork; in smaller scale applications, such as in unit ventilators or fan coil units; or installed directly in the ceiling of a room. Placement of these units in air systems must be analyzed. Ions are found to be absorbed by wet, cooling coils and by internal duct lining causing this technology to be less effective or the need to oversize the equipment to accommodate the lost ions. These systems must be designed and specified on a per-system basis for proper sizing, and physical location. Further investigation of the ductwork to determine if there is internal lining may be required.

The Office of Court Management should be aware that this type of technology is reported to range from ineffective to very effective in reducing airborne particulates and acute health systems. The position of the CDC on bipolar Ionization is,

> *"Relative to other air cleaning and disinfecting technologies, bipolar ionization has a less documented track record in regard to cleaning/disinfecting large and fast volumes of moving air within heating, ventilation, and air conditioning systems. This is not to imply that the technology doesn't work as advertised, only that in the absence of an established body of evidence reflecting proven efficacy under as-used conditions, the technology is still considered by many to be an "emerging technology".*

Any air cleaning technology should be evaluated for ozone emissions. The California Air Resources Board (CARB) mandates device testing for ozone production following UL Standard 867, but currently no national regulation or voluntary programs require independent measurement and certification. UL2998 is a newer and more stringent standard than UL867, reducing the threshold ozone level from 50 ppb to 5 ppb. Some systems on the market emit ozone, some at high levels. The systems that emit ozone should be avoided.

ASHRAE and the CDC do not provide an opinion on the use of this technology. Bipolar ionization is considered an "emerging technology, and there is no standardized testing to prove its effectiveness. We recommend this be considered to be installed as a second tier approach to help improved indoor air quality (IAQ). Providing adequate ventilation air and filtration take precedence over installing bipolar ionization units.

The installation of bipolar ionization units serving cell blocks would potentially help increase IAQ. This technology may want to be considered in heavily occupied lock up areas. An alternative is to try to minimize the occupancy of cells as much as possible.

We recommend bipolar ionization be considered in spaces that are not served by central air handling units, but are served by terminal equipment, such as fan coil units where a MEV 13 filter cannot be installed and outside air cannot be increased. As an alternative, portable HEPA filters may be used. Both technologies may be used together, but the decision on how many technologies to implement as a "belt and suspenders" approach should be further reviewed and discussed on a case-by-case basis.

2.5.3 Ultraviolet Disinfection – HVAC System Surface Treatment

Ultraviolet germicidal irradiation is used to degrade organic materials and inactive microorganisms. UV-C radiation (wavelength between 220 and 300 nm, peak effectiveness ~265 nm) is reported to be the most effective type of UV disinfection. UV-C may be installed inside HVAC systems, irradiated air near the ceiling or be incorporated in a stand-alone portable air cleaner. This technology is more readily designed for healthcare applications and rarely used for Courthouse applications.

ASHRAE's *Position Document on Filtration and Air Cleaning* (reaffirmed in 2018) contains opinions on the effectiveness of the use of ultraviolet light in killing virus and bacteria.

There is evidence that UV-C radiation provides the best results when emitted on wet coil surfaces to avoid fungal growth. This document also states, *"Experience suggests that control of a moving airstream does not provide favorable killing rates because of the short dwell time"* and that the effectiveness is highly dependent on many factors.

If fungal growth is a reoccurring issue on coiling coils or if future evidence suggests that the SARS-CoV virus (that causes the coronavirus disease (COVID-19) flourishes on wet cooling coils is discovered, we would suggest the installation of UV-C lamps inside air handling units be considered. Otherwise, it appears this technology is not effective at removing the virus from the airstream.

2.5.4 Upper-Air UV-C Devices (Fixtures)

Upper-air UV-C devices are fixtures that are mounted within a space that generate a controlled UV-C field above the heads of occupants and minimizes UV-C in the lower, occupied area of the room. The purpose of these units is to interrupt the transmission of airborne infectious pathogens within the indoor environment. Studies have shown that person-to-person outbreaks occur within room exposure such as congregate spaces. It is reported that the effectiveness of upper air UVC systems improves significantly when the air in the space is well mixed via mechanical air handling systems.

ASHRAE is recommending the usage of this technology in congregate type spaces or in spaces with poor ventilation. We strongly recommend Courthouses do not allow heavy occupancy in order to eliminate "congregate" type areas to maximize the effectiveness of the existing ventilation systems. If the Courthouses decide to allow the building to be heavily occupied, we recommend this technology be considered for use as a temporary basis in congregate type spaces like courtrooms, waiting areas, and lobbies. If the Courts will impose aggressive occupancy restrictions, limiting the number of people in the building and in a single room, and if the building contains adequate mechanical ventilation and filtration, we do not recommend this technology. We suggest further discussion with the Office of Court Management on a case by case basis to determine if this technology should be used.

2.6 Humidity Control

The *ASHRAE Position Document on Infectious Aerosols*, dated April 14, 2020, encourages careful review of humidity control. Midrange humidity levels are noted to correlate with improved immunity against respiratory infections. Studies show the lowest survival rate for microorganisms is when relative humidity (RH) is between 40% and 60%. The accepted range for thermal comfort in Courthouses, per the ASHRAE Applications Handbook, is generally between 20% in and 50% RH, depending on the season.

The lower range is of concern for the New England climate zone during the winter for buildings without active humidification systems. This concern will be compounded to some extent if outdoor air ventilation is increased, since outdoor air is typically drier in winter months. It is common for non-humidified buildings in New England to have the RH between 20% and 30%, or lower for extended periods during winter.

Also stated in the *ASHRAE Position Document on Infectious Aerosols, s*tudies have shown that low humidity (below 40% RH) exacerbates three factors that increase infections. First, infectious aerosols (such as from a cough or sneeze) shrink rapidly to become droplet nuclei, which remain suspended in the air and are able to travel greater distances. These droplets are dormant yet remain infectious, are able to rehydrate when they come in contact with another host and propagate the infection. Second, many viruses and bacteria have increased viability in low-humidity environments. Third, immunobiologists have stated an RH below 40% impairs mucus membrane barriers and other protections of the human immune system.

Humidity can be maintained in winter by installing duct-mounted humidifiers in air systems. The amount of humidity that can be added to any space will be limited by the building envelope. At some level, elevated humidity can damage buildings because of the vapor barrier, level of insulation, air tightness, or lack thereof. Humidity control equipment is generally installed to serve spaces that require tight humidity control throughout the year, outside of a pandemic, like in hospital and pharmaceuticals for example. Humidifiers are not typically seen in systems serving Courthouses or office buildings.

These systems must be engineered, integrated into the building control system, tested, and commissioned. Humidifiers are available in many configurations, but all require substantial maintenance, additional controls, and capital costs. They also run the risk of adversely affecting IAQ, from growing microorganisms, or leaking water into the ducts and onto ceilings. Because of these reasons, we do not recommend installing permanent humidification equipment in the air handling systems. An alternative is to install stand alone, space mounted humidifiers.

2.7 Other Recommendations

2.7.1 Duct Cleaning

According to the EPA, duct cleaning has never been shown to prevent health problems, and studies have not conclusively shown that dust levels in spaces increase because of dirty air ducts. Duct cleaning should be considered if there is excessive buildup of dust, debris, or microbial growth.

2.7.2 Rebalancing Entire Air Systems

Supply, return, and exhaust outlets and inlets deliver air to each space. The air through these devices is regulated with volume dampers mounted in the ductwork. When the systems were originally installed, a TAB Contractor should have balanced the flow rate to designed values for each outlet and inlet. Rebalancing all supply, return, and exhaust diffusers, registers and grilles can verify that the designed supply airflow rates are still being achieved, or identify discrepancies that should be addressed.

Regular comfort control complaints in buildings or spaces may be attributed to a lack of proper airflow, however other factors may be contributing to the issue as well such as poor chilled and hot water temperature control.

We recommend this option be explored on a case-by-case basis and further discussion with facility personnel from each Courthouse to determine if a lack of airflow is suspected.

Appendix A

Master HVAC System Recommendations List

This document includes a list of HVAC system improvements that are potential recommendations for the Courthouses evaluated by Tighe & Bond. Refer to the Courthouse evaluation reports to determine which recommendations apply specifically to each Courthouse.

Filtration Recommendations	
RF-1	*Replace filters with a MERV-13 filter.* Ensure filters have a tight fit to filter frames and eliminate gaps. With the existing filters in place and prior to changing the filters, have a testing and balancing (TAB) Contractor perform a static pressure and temperature profile of the unit per ASHRAE Standard 111-2208 (RA 2017) and per standard TAB practices. Document supply air, outside air, and return airflow rates; outside air and supply air temperature and relative humidity; fan RPM; motor RPM and amp draw, power supply voltage; VFD hertz (if applicable), and the static pressure drop across the filters. All supply air terminal units (i.e. VAV boxes) shall be fully opened prior to testing airflow rates. Replace existing filters with MERV 13 filters. Perform the testing requirements noted above for the new filters. Insert cardboard over filters to simulate a "dirty" filter pressure drop of 1" w.c. Perform the testing requirements noted above for the simulated dirty filters. TAB Contractor shall calculate changes in airflow caused by the change in filters from existing filters to new MERV 13 filters, and from clean MERV 13 filters to a simulated dirty MERV 13 filter. TAB Contractor shall report if the motor speed can be increased either by the VFD or a sheave and belt change without overloading the motor. Report findings to Engineer for further analysis. If the TAB Contractor indicates the motor is overloaded with the MERV 13 filter, we recommend an increase in motor size.
RF-2	*Install a MERV 13 filter in the return duct.* Refer to the design drawings for location. Prior to installing the filter, have a testing and balancing (TAB) Contractor test the return fan airflow rate, static pressure, motor RPM, amp draw, power supply voltage; VFD hertz (if applicable) per standard TAB practices. TAB contractor shall report if the motor speed can be increased either by the VFD or a sheave and belt change without overloading the motor. Report findings to Engineer for further analysis.

RF-3 **RF-3a**	*Install a differential pressure sensor with a display across the filter bank.* *Connect the pressure sensor to the BMS system and/or a local alarm.*

Testing & Balancing Recommendations	
RTB-1	*Test and rebalance air handling unit supply air and minimum outside air flow rates.* Refer to the individual Courthouse report for specific flow rates. On peak design days, we recommend checking the supply air temperature to ensure it is being maintained.
RTB-2	*Rebalance system return and/or exhaust air flow rate.* Rebalance to accommodate change in outdoor air flow rate.
RTB-3	*Increase outside air flow rate beyond the minimum under non-peak conditions.* Refer to the individual Courthouse report for specific flow rates. Refer to Controls Recommendations **RC-2** or **RC-3** for other requirements.
RTB-4	*Test and balance VAV box flow rates.* Test and balance the maximum and minimum flow rates. Confirm that the boxes are modulating correctly between maximum and minimum settings.
RTB-5	*Test and balance all air inlets and outlets.* Prior to air balancing, verify the correct chilled and hot water temperatures are being provided to the air handling units.
RTB-6	*Test and balance hot water and chilled water control valves.* The coils should be balanced to the flow rates noted in the record drawings or most recent Testing and Balancing report.

Equipment Maintenance & Upgrades	
RE-1	*Test existing air handling system dampers and actuators for proper operation.* Test outdoor air, return air, and exhaust air dampers. Mark the initial position of the dampers. Cycle the dampers open and closed a minimum of eight cycles. Visually inspect the damper position to determine if they return to the same position. If it’s determined that the dampers and/or actuators are not functioning properly, replace dampers and/or actuators, and rebalance airflow rates.
RE-2	*Clean air handler coils and drain pans.*
RE-3	*Replace air handler motor.* Refer to Courthouse report for motor size.

RE-4	*Inspect VAV boxes and controllers*. Ensure they are in working condition. Replace components as required.
RE-5 **RE-5a** **RE-5b**	*Install freeze stat on the upstream coil.* If the freeze stat trips, close the outside air damper and shut the unit down. *Provide a local freeze stat alarm* *Provide a local freeze stat alarm and an alarm signal to the BMS.* *If a freeze stat alarm is the result of introducing excess outside air beyond the minimum requirement, revert back to providing minimum outside air.*
RE-6	*Install portable, in room humidifiers.*
RE-7	*Test the existing control valves and actuators for proper operation.* Replace control valves and actuators that are not functioning. Balance the new valves to the original design flow rates. If the existing control valves and actuators are in working condition, a second-tier recommendation is to test and balance the valves to their original water flow rates. This will help the air handler maintain the proper supply air temperature.

Control System Recommendations	
RC-1	*Implement a pre and post-occupancy flush sequence.* Revise start/stop air handling schedule: Enable occupied mode three hours *before* current occupied mode setting. Extend occupied mode to three hours after the end of the current occupied mode setting. The air handling system can enter unoccupied mode three hours after all building occupants (including afterhours faculty, maintenance staff, etc.) exit the building.
RC-2	*Install controls required to introduce outside air beyond the minimum requirements.* Install or utilize the existing humidity and supply air temperature sensor in the air handler supply duct. Install or utilize the existing outdoor air temperature and humidity sensors. Install freeze stat on the heating coil or utilize the existing stat. Implement a sequence to increase outside air by 10-15% over minimum if the outdoor air dry bulb (DB) and wet bulb (WB) conditions allow. Refer to the Courthouse reports for specific DB and WB outdoor temperature requirements.

	Monitor supply air temperature and humidity. If supply air temperature deviates from the ranges noted below, revert back to the original minimum OA damper position. Revert to the minimum outdoor air flow rate if, Supply Air Dry Bulb Temperature (DB): • Summer: DB ≥ 55°F • Winter DB ≤ 65°F Supply Air Wet Bulb Temperature (WB): • Summer: WB ≥ 54°F • Winter: N/A
RC-3	*Install controls required to introduce outside air beyond the minimum requirements in a stepped approach* Install or utilize the existing humidity and supply air temperature sensor in the air handler supply duct. Install or utilize outdoor air temperature and humidity sensors. Install freeze stat on the heating coil or utilize the existing stat. Implement a sequence to increase outside air in a stepped approach, up to 35% over minimum, or to the rates noted in the Courthouse reports, if the outdoor air dry bulb (DB) and wet bulb (WB) conditions allow. Refer to the Courthouse reports for specific DB and WB outdoor temperature requirements. Monitor outdoor air and supply air temperature and humidity. Monitor mixed air temperature. If supply air temperature deviates from the ranges noted below, revert back to the original OA damper position to allow the minimum outdoor airflow rate. Supply Air Dry Bulb Temperature (DB): • Summer: DB ≥ 57°F • Winter DB ≤ 50°F Supply Air Wet Bulb Temperature (WB): • Summer: WB ≥ 56°F • Winter: N/A
RC-4	*Confirm economizer control sequence is operational.* Replace control components, such as outdoor and return air enthalpy sensors, as required.
RC-5	*Disable demand control ventilation sequences.* These sequences may be enabled once COVID-19 is no longer a health concern.
RC-6	Monitor space relative humidity. Refer to the Courthouse reports for specific installation locations.

RC-7	*Recommission controls.* Refer to the individual Courthouse report for specific recommissioning recommendations.

Additional Filtration & Air Cleaning Recommendations	
RFC-1	*Install portable HEPA filters*. Refer to Courthouse reports for recommended locations.
RFC-2	*Install bipolar ionization units.* Confirm internal duct lining does not exist downstream of the location of these units. Refer to the Courthouse report and/or drawings for recommended locations.
RFC-3	*Install upper-air UV-C devices in spaces.* Refer to the individual Courthouse report and/or drawings for specific locations.
RFC-4	*Install UV disinfection on air handler chilled water coils.*

Appendix B

ASHRAE Guidance Documents

ASHRAE EPIDEMIC TASK FORCE

Core Recommendations for Reducing Airborne Infectious Aerosol Exposure

The following recommendations are the basis for the detailed guidance issued by ASHRAE Epidemic Task Force. They are based on the concept that within limits ventilation, filtration, and air cleaners can be deployed flexibly to achieve exposure reduction goals subject to constraints that may include comfort, energy use, and costs. This is done by setting targets for equivalent clean air supply rate and expressing the performance of filters, air cleaners, and other removal mechanisms in these terms.

1. *Public Health Guidance* - Follow all regulatory and statutory requirements and recommendations for social distancing, wearing of masks and other PPE, administrative measures, circulation of occupants, reduced occupancy, hygiene, and sanitation.

2. *Ventilation, Filtration, Air Cleaning*
   2.1 Provide and maintain at least required minimum outdoor airflow rates for ventilation as specified by applicable codes and standards.
   2.2 Use combinations of filters and air cleaners that achieve MERV 13 or better levels of performance for air recirculated by HVAC systems.
   2.3 Only use air cleaners for which evidence of effectiveness and safety is clear.
   2.4 Select control options, including standalone filters and air cleaners, that provide desired exposure reduction while minimizing associated energy penalties.

3. *Air Distribution* - Where directional airflow is not specifically required, or not recommended as the result of a risk assessment, promote mixing of space air without causing strong air currents that increase direct transmission from person-to-person.

4. *HVAC System Operation*
   4.1 Maintain temperature and humidity design set points.
   4.2 Maintain equivalent clean air supply required for design occupancy whenever anyone is present in the space served by a system.
   4.3 When necessary to flush spaces between occupied periods, operate systems for a time required to achieve three air changes of equivalent clean air supply.
   4.4 Limit re-entry of contaminated air that may re-enter the building from energy recovery devices, outdoor air, and other sources to acceptable levels.

5. *System Commissioning – Verify that HVAC systems are functioning as designed.*

IN-ROOM AIR CLEANER GUIDANCE FOR REDUCING COVID19 IN AIR IN YOUR SPACE/ROOM

What is an In-Room Air Cleaner? An in-room air cleaner is installed within occupied space rather than in an HVAC system. They are also known as portable, stand-alone, plug-in, or room air cleaners or as air purifiers. In-room air cleaners come in several types and sizes ranging from miniature desktop units to portable units designed to be operated on the floor or tabletop, to larger fixed units that can be permanently installed on ceilings, walls, or floors. In some cases, larger fixed units use ducts for air distribution across larger spaces.

In-room air cleaners may contain one or more technologies designed to remove or inactivate air contaminants. Media filters, including high efficiency particulate air (HEPA) filters, can remove particles, including those containing viruses and other microorganisms. UV-C (ultraviolet light in the germicidal wavelengths) kills or inactivates viruses and microorganisms to make them non-infectious but does not remove them from the air. Technologies such as ionizers, UV-PCO, and many called by other names may claim to remove or destroy multiple types of contaminants but may convert them to other compounds that might be harmful. These technologies are designated by CDC as emerging technologies without an established body of evidence reflecting proven efficacy under as-used conditions. For more information, see the Epidemic Task Force Filtration & Disinfection Guide.

When should in-room air cleaners be used? When HVAC equipment does not meet ASHRAE recommendations for ventilation and filtration, removal of contaminants near a source is needed, or where higher risk activities occur.

What do I need to know to choose an In-Room air cleaner?

1. Contaminant(s) to be controlled – Airborne virus particles can be captured or inactivated.
2. Space size – How much floor area is served? What is the ceiling height?
3. Space layout – How is the space arranged? Is there power access? Are there safety issues?
4. Noise – How much noise is acceptable? Is a noise rating at a specific fan speed reported for the device?
5. Air distribution – How is air distributed in the space? Can the air cleaner be placed so its air intake is unobstructed by furniture and its outlet is able to move air as far as possible before being deflected or drawn into a return or exhaust grille. Multiple units may be a better option than one.
6. Ventilation (outdoor air) – How much comes in through HVAC system or windows? If unknown, assume none.
7. Amount of clean air needed – What flow rate of clean air is needed? Is there a target for the clean-air equivalent number of air changes per hour (ACH) needed between ventilation and filtration combined (e.g., 3, 6, or 12 ACH equivalent)?

Example of how to choose the right size: A 45 x 20 ft (14 x 6 m) room (900 ft^2 [84 m^2]) classroom with 9 ft (3 m) ceilings (8100 ft^3 [229 m^3]) has a HVAC system with a supply airflow rate of 1,200 cfm (0.57 m^3/s) of which 350 cfm (0.17 m^3/s) is outdoor air and a MERV 8 filter. The HVAC system provides 2.6 ACH of outdoor air. Since the MERV 8 is ~35% efficient for 1-6 µm particles (where most SARS-CoV-2 is assumed to be present), the HVAC system airflow of 850 cfm of recirculated air provides 2.2 equivalent ACH. The owner wants 6 equivalent ACH total. Therefore, the in-room device needs to provide about 1.2 equivalent outdoor ACH, which for this space would need to be 165 cfm (0.08 m^3/s) clean air delivery rate (CADR) at a fan speed that meets the space noise level target of < NC 30/40 dBA for a classroom.

How do I select the right one? In the preceding example, a small device will do. Search for an in-room air cleaner that:

1) Confirm the CADR of the unit is equal to or higher than needed (165 cfm in the example above) at the fan speed and associated noise level that is acceptable in the space.
2) Removes particles or inactivates viruses. A HEPA air cleaner or high MERV (Minimum Efficiency Reporting Value) of 13 or more is recommended.
3) Check for additional technologies you do not want or need. Avoid added technologies that may cause problems or costs more to maintain.
4) Check for noise/sound levels (decibel or DB_A). The unit may have a high speed and lower speed options. You may consider buying one to run at a lower speed some or most of the time.
5) Confirm that you can locate the unit in your space without the air inlet or outlet being blocked or causing gusts of air that may reintroduce previously settled dust from surfaces or cause discomfort.
6) Look for prices and availability. Be sure to check on the prices and expected lifetimes for replacement filters.

FOR MORE INFORMATION: https://www.epa.gov/indoor-air-quality-iaq/air-cleaners-and-air-filters-home

Noise Calculation Tools: https://www.noisemeters.com/apps/db-calculator/ and http://www.sengpielaudio.com/calculator-spl.htm