BALA

COVID-19 and the Impacts to Higher Education Buildings
Bala Consulting Engineers COVID-19 Task Force
June 10, 2020 *(updates will follow as necessary)*

This report is a continuation of our research on COVID-19 and how it impacts facilities across all market sectors. This paper focuses on strategies and recommendations for Higher Education facilities, as well as some general information on the COVID-19 virus and building systems recommendations that are applicable for many types of facilities.

EXECUTIVE SUMMARY

As all industries assess how to maintain operations during the COVID-19 pandemic, Colleges and Universities are probably facing the most complex operational challenges. Senior school leaders are addressing an extremely broad and diverse range of issues—guidance/compliance with Federal, State and Local programs, Admissions, Teaching/Learning Options, Funding, Facilities, etc.--all with the final goal of returning students, faculty, administration, and employees to the campus.

The challenge for the college or university campus is the wide variety of spaces, and the diversity of people on a campus. The types of buildings: classrooms, residential, offices, student union, lecture halls, libraries, athletic facilities, dining halls and student health centers, all present unique challenges as they have a wide variety of mechanical (HVAC), electrical, plumbing (MEP) and technology systems with varying service requirements and capabilities to assist in reducing the spread of COVID-19 and other viruses. To enable the return to campus life students, faculty, administration, maintenance/operations staff, vendors and visitors will need an education on the campus requirements for Personal Protective Equipment (PPE), social distancing and space modifications, as well as MEP and technology modifications. One of the most important facilities that every institution will need to re-visit is the creation or upgrade of the Student Health Center.

Bala has researched and consulted with industry leaders in higher education, government agencies and health experts to present some of the most effective ways to make higher education buildings safer. This document illustrates building strategies to improve our environments, as well as government recommendations for PPE, social distancing, and sanitizing.

THE VIRUS

COVID-19 (or 2019-nCoV), as named by the World Health Organization (WHO), is the disease caused by the new coronavirus that emerged in China in December 2019. COVID-19 is caused by the SARS-CoV-2 virus. As a result, parallels are being drawn between the 2003 SARS outbreak and the spread of COVID-19.

Researchers know that the new coronavirus is spread through direct contact with an infected person or by touching a surface or object that has the virus on it and then touching your eyes, nose, or mouth. It can also be spread through larger droplets released into the air when an infected person coughs, sneezes or talks.

According to new a study from National Institutes of Health, CDC, UCLA and Princeton University scientists in The New England Journal of Medicine, scientists found that severe acute respiratory syndrome coronavirus (SARS-CoV-2) was detectable for up to three hours in aerosols, up to four hours on copper, up to 24 hours on cardboard and up to two to three days on plastic and stainless steel. Recent updates from the CDC indicate that the virus quickly loses its ability to remain viable and replicate over time on surfaces. The incubation period (or when symptoms appear) is within 14 days of exposure. As a result, staff, faculty and students can be on campus without knowing they are infected, contagious or exposed to the virus in the air or on surfaces. Additionally, research from China indicates that the novel coronavirus is also spread by fecal-oral transmission.

STUDENT HEALTH SERVICES-ISOLATION SPACES

The pandemic has sparked an increased interest in Student Health Center facilities. Over the past decade, these facilities have been minimized, but now many schools are considering how to renovate and expand these spaces. These facilities will need to accommodate people who may be infected with COVID-19 as well as students seeking other medical assistance.

One of the most effective ways an HVAC system may be used to help stop the spread of a virus is to keep it contained to a specific area and utilize pressure zones. If students become infected with a virus, separating them from others who are not infected as quickly as possible will help to reduce the spread of the virus.

Dedicated exam rooms or patient care rooms may be fashioned as Airborne Infectious Isolation (AII) rooms that are common in healthcare and long-term care facilities to help keep airborne pathogenic organisms from spreading throughout the facility and infecting others. The Facility Guidelines Institute (FGI) Guidelines for Design and Construction of Residential Health, Care, and Support Facilities provides requirements for the construction of an AII room such as requiring 2 air changes per hour (ACH) of outside air and a total of 12 ACH. The elevated air changes are implemented to capture and contain contaminants with proper filtration.

Anterooms installed to serve individual rooms or isolation wings, while not required by the FGI Guidelines, provide multiple advantages. First, they provide an airlock chamber that can be used to help maintain pressure control between the corridor and the patient care rooms. Second, they provide a location for the healthcare worker to don personal protective equipment (PPE) prior to entering the room or wing as well as remove the PPE upon leaving. Typically, separate “clean” and “dirty” anterooms are maintained to avoid cross contamination.

An alternative to installing fixed in place, dedicated infectious disease rooms would be to develop flexible spaces that allow rooms or blocks of rooms to be converted into an infectious disease area. Some important considerations for identifying potential AII spaces include:

- Identify an area of the facility whose HVAC system is either already separate or can be easily segregated from other areas.
- Evaluate the system(s) that could be utilized to provide outside air in sufficient amounts to address the planned operations. Central and/or local systems that supply outside air will need to be reviewed to verify their ability to accommodate increased outside air during peak cooling and heating seasons.
- Dedicated outside air systems (DOAS) may need to be rebalanced to distribute air in sufficient quantities to all spaces. A review of occupants and usage may be performed to verify minimum outside air quantities and how air may be shifted around the system to areas that require additional amounts of outside air for the new or temporary operations planned. Note, DOAS systems that serve multiple spaces, including new temporary AII rooms, may continue to remain in operation without the need to separate the systems. However, to maintain pressurization and potential for cross contamination, the system must operate 24/7. Positive airflow through the duct system will prevent possible cross contamination through the duct system.
- Balancing will need to be adjusted to make the resident rooms negative to the corridor or anteroom if one exists or is provided as a temporary measure.
- If recirculating HVAC systems, such as fan coil units or water source heat pumps, are being used within the AII room to provide heating and cooling to the space and these are the sole source of outside air to the room, they will likely be required to operate continuously. In this scenario, the exhaust from the room will likely need to be increased to make the room negative with respect to the corridor. In systems where the exhaust fan airflow cannot be increased by balancing, a separate exhaust system will need to be investigated.

HVAC SOLUTIONS

The diversity of spaces and buildings found on a college campus present unique challenges and solutions. However these buildings share some commonality, and we can define the HVAC systems most common to specific buildings and identify modifications and enhancement for those systems. The following chart presents campus buildings/spaces, typical-HVAC systems found there and potential strategies to modify or enhance those systems to improve indoor air quality and reduce the spread of infection. Many of the following recommendations are in conformance with the ASHRAE EPIDEMIC TASK FORCE document published May 5, 2020 for Schools & Universities.

BUILDING	SPACE TYPE	SYSTEM(S)	UVC IN HVAC	UVC IN ROOM	ENHANCED FILTRATION	BI-POLAR IONIZATION	PRESSURIZATION & AIRFLOW	HUMIDIFICATION
LEARNING CENTERS	Classroom	AHU, FCU	Yes	Yes - Upper Room	In AHU	Yes	Positive	Central
	Lecture Hall	AHU, FCU	Yes	No	In AHU	Yes	Positive	Central
RESIDENCE HALL	Single/Multi-Unit	VRF/FC	Yes	Yes - Upper Room	N/A	Possible	Negative	Portable
	Single/Multi-Unit	VTAC/PTAC	N/A	Yes - Upper Room	Portable	Portable	N/A	Portable
STUDENT UNIONS	Communal	AHU, FCU	Yes	N/A	In AHU	Yes	Positive	Central
DINING HALLS	Kitchen	AHU/ RTU	Yes	No	Unnecessary	Unnecessary	Negative	Central
	Dining	AHU, FCU	Yes	N/A	In AHU	In AHU	Positive to kitchen	Central
ATHLETIC CENTERS	Fitness/Aerobics/ Weight Training	AHU, FCU	Yes	Yes - Upper Room	In AHU	In AHU	Negative	N/A
	Gym	AHU, FCU	Yes	No	In AHU	In AHU	Negative	N/A
STUDENT HEALTH CENTER	Exam Room	AHU, FCU	Yes	Yes - Upper Room	In AHU	Yes	Negative	Central
	Isolation Space	AHU, FCU	Yes	Yes - Upper Room	In AHU	Yes	Negative	Central
OFFICES	Faculty/ Admin.	VRF/FC/ PTAC/AHU	Yes	N/A	In AHU	Possible	Negative	N/A
RESTROOMS/ LOCKER ROOMS	Public, Private, Shared Restrooms/ Showers	Exhaust	N/A	Yes - Surfaces	N/A	N/A	Negative	N/A

In the HVAC sections below we have identified the specific HVAC strategy and the building types that can use that strategy using the color blocks illustrated in the table above.

Enhanced Filtration

Classroom Buildings	Student Union Centers	Dining Halls	Athletic Centers	Student Health Centers	Offices

All HVAC systems have filters to catch particles and contaminants, but typical filters are not able to capture smaller particles that could be carrying the COVID-19 virus. ASHRAE's position is that "Transmission of SARS-CoV-2 through the air is sufficiently likely that airborne exposure to the virus should be controlled. Changes to building operations, including the operation of heating, ventilating, and air-conditioning systems, can reduce airborne exposures." Since the COVID-19 virus is transmitted and carried by occupants and may be in the air stream, installing HEPA and ULPA in the mixed air streams (return & outside air) provides the best method for capturing contaminants. Each HVAC system should be analyzed to determine if the air handling units have sufficient capacity to add filtration and/or increase the MERV rating of existing filters. Physical space for enhanced filters within the units should also be evaluated.

In common spaces and amenity areas supplemental recirculation equipment can be installed to filter and recirculate the air. Depending on the system type, additional levels of filtration may also be added to the equipment serving the common areas.

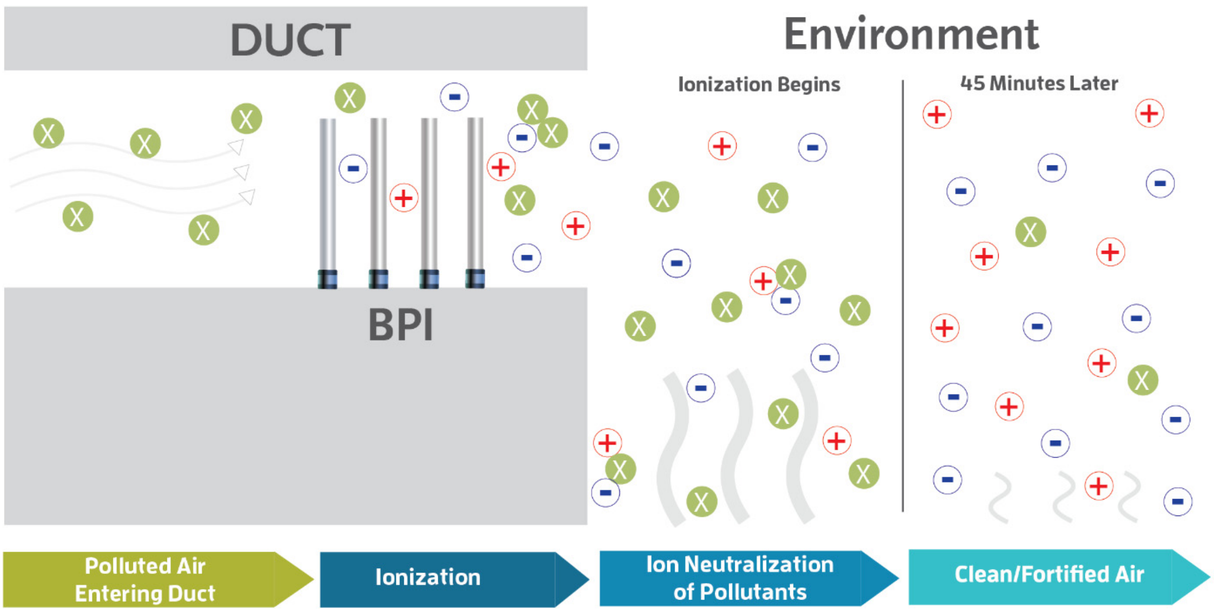
Classrooms are typically conditioned with central air handling units. Each unit should be analyzed to determine if HEPA filters can be added to enhance the air quality and filter a larger number of contaminants compared to standard filters.

To further enhance the effectiveness of filters, it is advisable to utilize filters with antimicrobial coatings which kill dangerous microbes on contact.

Bi-Polar Ionization

Classroom Buildings	Student Union Centers	Dining Halls	Athletic Centers	Student Health Centers	Offices	Residence Halls

Bi-polar ionization could have wide use in campus buildings. This technology can be deployed in Lecture Halls and Classrooms, Administrative Buildings, Student Health Centers and Communal spaces with central HVAC systems that have the space in the AHU's to accommodate this technology. This technology works by releasing positive and negative ions into the airstream as noted on the diagram below. Air flows along the ionization tube and oxygen from the air is charged to form ions. The ions are attracted to airborne particles like dust, smoke, VOCs, allergens and other air pollutants. Charged particles are drawn together, forming clusters, which become heavy enough to drop out of the air. These ions work to deactivate single-celled, carbon-based organisms such as fungi, viruses and bacteria whether they're in the air or resting on surfaces. Bi-Polar Ionization can be installed in ductwork or deployed in spaces like common areas. To maximize effectiveness, the air circulation and BPI systems should operate continuously.



UVC Light

Classroom Buildings	Student Union Centers	Dining Halls	Athletic Centers	Student Health Centers	Offices	Residence Halls	Restrooms

UVC lamps have multiple potential uses throughout a campus, such as the student union building and other buildings with a large central air conditioning system. UV light within the duct system can be used to kill microorganisms in the airstream. However, placement is important since the coronavirus must be exposed for a period that requires multiple UVC lamps within the airstream. Manufacturers recommend exposure of 10 seconds within proximity of the UVC bulb with some suggesting spacing lamps every 12 inches. Properly applied, UV lamps may reduce active coronavirus up to 90% as indicated in emerging research.

Areas where UVC lighting could effectively deactivate the virus within the ductwork/HVAC system are areas that may trap particulate containing the coronavirus. These include sound attenuators, filters, energy recovery wheels, coils, and fans. However, if effectively applied, it may only be necessary and cost effective to treat one specific location within an air handling unit. For example a central AHU serving a classroom building would need the existing space or space in the mechanical room to add ductwork to meet UVC lamp space requirements.

Widespread use of UVC Light in common settings is limited because conventional UVC light sources are both carcinogenic and cataractogenic. However, it has been determined that far-UVC light (207–222 nm wavelength) efficiently inactivates bacteria without harm to exposed human skin, when the proper filters are applied. This is because far-UVC light cannot penetrate even the outer (non-living) layers of human skin, due to its strong absorbance in biological materials. However, because bacteria and viruses are of micrometer or smaller dimensions, far-UVC can penetrate and inactivate them. Far-UVC efficiently inactivates airborne aerosolized viruses, with a very low dose of light inactivating >95% of aerosolized H1N1 influenza virus.

Special consideration is needed for student residences using a dedication outdoor air unit (DOA) with energy recovery. All of these units have, at least, one energy recovery wheel, and some have a second energy recovery wheel used for reheat. For this application UVC lights should be placed in the unit to disinfect the surface of the heat recovery wheel(s) to avoid cross contamination.

The viability of far-UVC light for direct surface disinfection within occupied spaces is still being researched. The current restrictions and concerns of far-UVC light on human eyes is under review by the governing bodies. It is possible far-UVC light will be deemed as safe for occasional direct exposure, as long as no direct light is received by the eyes.

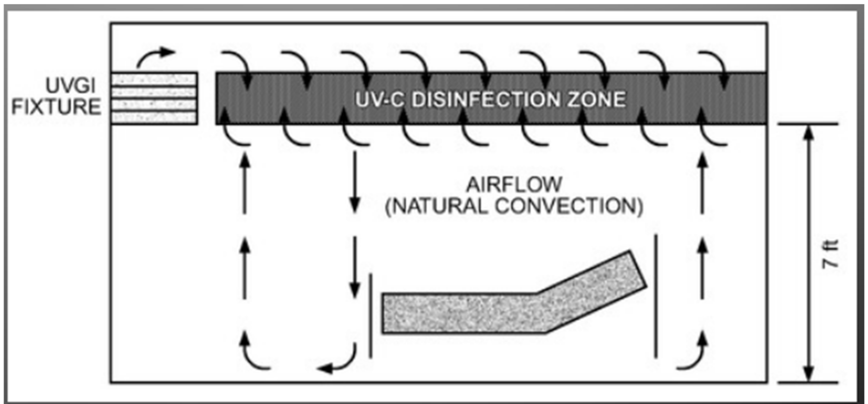
Portable UVC lighting systems are affective in deactivating the virus. Lamp placement, intensity, distance from the virus and duration of light exposure must be considered to use these systems properly. Portable UVC systems can be placed in the space for the required amount of time to deactivate the virus, then moved to other locations throughout the space. All UVC lighting works with the line of sight principle, the virus is deactivated wherever the light is shining, but is not deactivated in the shadows. Also, care should be taken to prevent these portable UVC lighting units from shining on people. Some units have built in controls that turn the units off when a person enters the area. These units are also available in a robotic configuration to travel through multiple spaces.

For Student Health Service facilities, standard UVC lights that emit at 253.7nm, may also be applied within an exam or patient rooms for upper room disinfection as long as the proper precautions are taken. Upper room disinfection utilizes natural or forced air to bring contaminated air into the UVC light disinfection zone.

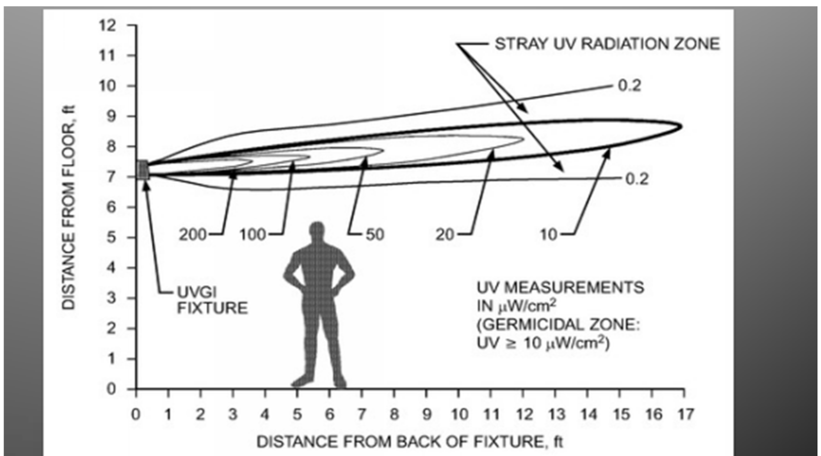
The disinfection zone needs to be properly planned and tested to ensure that it is above the acceptable occupied zone exposure since UVC light can be very harmful to an occupant's skin and eyes. Shown in the table here are the National Institute for Occupational Safety & Health UVC dosage limitations. As shown, the 8 hour limit can be considered the standard limit for continuous disinfection of an occupied space. A recent study which monitored workers and patients in a space with a continuous upper-air germicidal ultra-violet (GUV or UVC) installation demonstrated that no one exceeded 1/3 of the 8-hour limit.

NIOSH Limits for 253.7 nm UVC

- 1 s: 600 $\mu W/cm^2$
- 1 min: 100 $\mu W/cm^2$
- 1 hour: 1.7 $\mu W/cm^2$
- 8 hours: 0.2 $\mu W/cm^2$ (standard for upper–air)



ASHRAE Handbook – 2019 HVAC Applications, Ch. 62, Fig. 5



2019 *ASHRAE Handbook—HVAC Applications*, Ch. 62, Fig. 6

Pressurization and Airflow

Classroom Buildings	Student Union Centers	Dining Halls	Athletic Centers	Student Health Centers	Offices	Residence Halls	Restrooms

In general, all buildings should be under a slight positive air pressure. A building under negative air pressure will allow unfiltered air to enter and bring contaminants that are typically filtered by the air-handling equipment. Pressurization techniques may be employed to minimize the risk of outside contamination that is not carried in with people or materials. Changes in the pressurization relationships may require modifications and/or rebalancing of the central makeup air equipment and fans.

In residence halls, the common areas should remain positive while the individual units/suites are kept neutral or negative. The units should remain negative to prevent any contaminants from the units to enter the corridors. Trash and recycling rooms should also remain in negative air pressure mode.

Application of more frequent cleaning procedures within building areas will release chemicals into the air. In buildings with a central HVAC system, the implementation of flush-out cycles will dilute the air of these chemicals. Flush out cycles may be operated for short durations, multiple times per day, to match the frequency of cleaning. During unoccupied periods, the amount of outside air may be increased beyond minimum outside air setpoints. If interior conditions (temperature and relative humidity) are relaxed during this flush-out period, it will be possible to further increase the amount of outside air during peak cooling and heating months when utilizing HVAC equipment that was not originally designed for these greater outside air percentages. Depending upon existing controls in place, it may be possible to enact automatic reset of outside air volume, based upon a scheduling or monitoring of interior conditions during these flush out cycles, by simple reprogramming of the control sequences.

Humidification

Classroom Buildings	Student Union Centers	Dining Halls	Student Health Centers	Residence Halls

Humidification should also be considered to help minimize the spread of contagions. Early research showed humidity levels above 40% deactivates almost 80% of viruses within 15 minutes. More recent research has shown that humidity may not directly affect the virus itself, but it does help humans fight-off the virus. The moisture generated by the humidity level allows our cilia and mucus membranes to capture and repel the virus. Maintaining a relative humidity of 40-60% RH helps to contain the virus and promotes efficient immune system response. Maintenance issues should be examined for all humidification systems because of the increased risk of indoor air quality issues with these systems. Classroom and campus office buildings with a central system can benefit from increased humidification depending on the building envelope and interior finish requirements depending on the season. Student residences may be fitted with portable humidification units. Alternately, since most student residences' HVAC systems may not utilize humidification, these systems may be retrofitted in the existing system.

Portable Air Purification

Classroom Buildings	Student Union Centers	Dining Halls	Athletic Centers	Student Health Centers	Offices	Residence Halls	Restrooms

Another option to increase air changes within a space while treating the airflow is the use of multiple local air purifiers. These provide the ability to increase air changes when the existing HVAC systems are unable to increase airflow. There are a wide variety of portable units that use UV lights in an enclosure with a fan to move room air across the light. As an alternate, bi-polar ionization can be deployed in the same portable manner for air purification. Other portable units use a media of activated carbon and potassium permanganate as a sorbent to absorb the contaminants in combination with a HEPA filter. These units employ a fan to move room air thru the multi-stage filter. Portable units are easier to deploy and may be moved as needed to accommodate changes within the environment, including common spaces and dormitory rooms.

Sanitizing Ductwork

Classroom Buildings	Student Union Centers	Dining Halls	Athletic Centers	Student Health Centers	Offices

The process of sanitizing HVAC equipment and ductwork warrants careful consideration. Ductwork systems may be sanitized with aerosol sprays of disinfectant solutions in unoccupied spaces. During treatment by aerosol disinfectant solution, outside air should be closed to allow 100% recirculation of the disinfectant to minimize dilution and increase its effectiveness. Because the viability of the virus is diminished on surfaces, ongoing or continuous sanitizing of ductwork is not necessary.

PLUMBING SOLUTIONS

Since coronavirus may be transmitted through respiration, touch, and fecal-oral transmission, restrooms and locker rooms require special attention. Though surfaces may be cleaned as previously noted and HVAC systems enhanced, additional measures are recommended to maintain functional spaces for students and faculty. The following strategies may be applied:

- Far-UVC lamps under lids of water closets. For water closets without lids, lids would need to be added. An occupancy sensing system would be installed that would inactivate the UVC system upon entry into the water closet stall.
- Spray disinfectant applied to bowl of water closet during and after each flush.

- Far-UVC lamp to disinfect stall after each usage. The UVC system could be mounted on top of the partition wall opposite toilet paper dispenser and at a height so that no portion of far-UVC light would emit above the top of the partition to the adjacent stall. An occupancy sensing system could be installed to deactivate the UVC system upon entry into the stall.
- Hands free toilet fixtures and faucets.
- Adopt procedures to minimize the dispersion of the virus in the restroom, such as limiting use of stalls with adjacent occupancy and closing lids when flushing toilets.
- Far-UVC lamps in lids of waste bins. An occupancy sensing system could be installed to deactivate the UVC system upon opening of the lid.

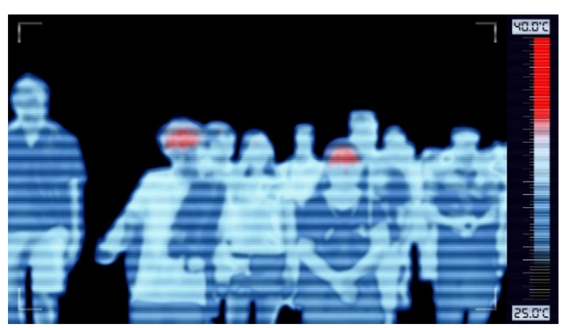
Since it is not proven that COVID-19 is transmitted thru domestic water, the interface with the occupant and plumbing devices needs to be minimized. These recommendations will apply to all public toilet facilities on campus.

TECHNOLOGY SOLUTIONS

When students return to the classroom, maintaining access to critical digital teaching tools and resources will require reducing the number of common touch points and creating a cleaning program for shared technology devices.

Consider the following upgrades or modifications to existing technologies:

- **Reduced Touch Interfaces** – While students in Higher Education rely on shared devices less than a K-12 classroom; specialty computing technologies for STEM or media applications in lab environments should be reviewed and options like remote desktop or multiple Bluetooth peripherals rotated through a cleaning schedule should be considered.
- **The Split Classroom –** Many institutions are considering options to split classes with on and off days for in person and remote attendance. While this may help to re-engage students and offer some of the traditional learning environment back that has been lost during social distancing, it is critical to provide high quality capture capabilities so when students are remote they don’t suffer from a loss of intelligibility or classroom experience. Anticipate a need to retrain instructors on how to effectively teach to both in-room and remote participants simultaneously and train them on how to use the AV capture systems provided.
- **Guest and Visitor Screening** – Consider deploying small formal thermal screening appliances to help with access control. These systems speed the temperature checks and reduce staff contact during screening. Cameras are best deployed as standalone monitoring stations and some manufacturer options allow for group screening under specific conditions which could be used to evaluate the change in



population health. Note that environmental factors can greatly affect the accuracy of these devices and guidelines for distance, number of persons being scanned, and other calibration factors must be followed.

- **Access Control –** Explore mobile credentialing options with your existing security platform for reduced touch access control. Provide a simple non-contact stylus to users for opening doors and pushing elevator buttons while evaluating options for automatic door openers.
- **Learning Continuity –** Future lesson plan development should focus on the ability to deliver in person and remotely. This will ease future transitions to fully remote teaching which may be required due to increased infection rates or changes in stay-at-home orders.
- **Training & Adoption -** With the increased adoption of collaboration technology that most educators are experiencing, continuing to use those technologies, and improving the effectiveness of the platforms will require ongoing training and process improvement. Expect adoption to slip when reentering the classroom and adjust feature sets and educational materials as staff come to understand the limitations of social distancing within the classroom.

This quick shift to remote learning has shown us what systems are truly critical and necessary for education. Take stock of systems disabled or underperforming during the stay-at-home period and focus on addressing their connection and feature issues or begin to sunset their use. Likewise, increase the capabilities and deployment level of platforms that users heavily adopted while working and teaching remotely. Lastly, and most importantly, evaluate and examine the long-term benefits of technology platforms which remain tied to physical teaching spaces.

OTHER STRATEGIES

The primary source of the coronavirus entering the campus is people. As a result, the most effective method to help reduce the spread of the virus on campus is to control access to facilities. The number and types of barrier control necessary will be influenced by the type of building. Some barrier control solutions require careful coordination and adherence to life safety codes. For example, if you create a single access point for a building, secondary access points will need to be converted to exit only, self-locking type to maintain egress. An architect or other life safety professional should be consulted to ensure adherence to the applicable codes.

Based on current CDC recommendations to maintain 6 feet separation, queue lines for entry points may need to be used with appropriate spacing to relieve congestion at entrances. Elevators are also a challenge for spacing and reducing touchpoints. At least one manufacturer of elevators is offering enhanced ventilation, far-UVC lights, face recognition, and voice-controlled floor request to enhance the air quality in the elevator and eliminate direct contact with the elevator surfaces.

Because the virus can survive on packages and materials**,** these should be wiped down with sanitization solution. This procedure will require space and time to process receipt of materials. Assuming materials will enter through a central mail room facility on the campus, preliminary steps such as fogging shipments in small contained spaces with disinfectant may help, but recipients will need to take responsibility and steps to disinfect the contents of all packages.

Conclusion

The higher educational campuses faces many challenges from the COVID-19 pandemic. Implementation of the strategies discussed above to reduce exposure and spread of the virus requires consideration of the existing systems, spaces and impacts to occupants. These strategies are most effective when combined with guidelines from government and health officials for social distancing and PPE requirements. Each day we learn more about the COVID-19 virus, how it behaves, and the best recommendations and strategies for dealing with it on campus. This information will continue to be monitored and evaluated to present the latest insights and approaches with the goal of preparing campuses for safe and productive return of their people.