Pathogen Disinfection in Schools

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Introduction

Prior to the COVID-19 global pandemic, most bipolar ionization and UV disinfection applications were located within hospitals and medical facilities. One notable exception involved the Norman, Oklahoma public school system that borrowed area hospital UVC carts and deployed them in public schools to combat a particularly nasty influenza outbreak in the winter of 2018.

With schools suffering from high absenteeism in that difficult season, Norman Public Schools sourced disinfecting robots from a local hospital, put the carts to work in the hardest-hit schools, and greatly reduced flu-related illness in the district.

Beginning in March 2020, however, a growing number of K-12 schools and universities began utilizing UV and ionization disinfection methods in classrooms, offices, libraries, and gymnasiums. For these educational facilities and the organizations that manage them, the consensus of thought is that even after a vaccine for COVID-19 is widely available, disinfecting public spaces will remain a concern for years to come.

As the CDC has stated from the outset of the COVID-19 pandemic, the best solutions will involve multiple means of disinfection and protection. These will likely include Needlepoint Bipolar Ionization (NPBI), UVC, chemical disinfetants, HEPA filtration, the use of masks, and appropriate social distancing during seasons of illness. While it is impossible to provide a 100% germ-free environment within occupied spaces, NPBI and UVC solutions can be part of a Constant Viral Load Reduction (CVLR) program.

For most facility managers, choosing between technologies can be confusing. To combat that situation, this report will examine both NPBI and UVC solutions for typical K-12 classroom applications.

Needlepoint Bipolar Ionization

Over the past 150 years, the process of ionization has been widely understood and adapted for both environmental and therapeutic purposes. With the advent of bipolar ionization, the generation of both positive and negative ions was seen to be a step forward for air disinfection technology. However, as the harmful effects of ozone - a natural byproduct of ionization - became more widely understood, it appeared that the technology had reached a practical limit for interior space disinfection.

Fortunately, the advent of NPBI technology has changed the conversation entirely. Unlike unipolar ionization, and earlier bipolar ionization technologies (Corona Discharge), NPBI technology delivers all the disinfection benefits without generating ozone. NPBI uses an electronic charge to create a plasma field of both positive and negative ions that travels within the air stream, attaches to pathogens, particles, and gas molecules, breaks them down, and renders them ineffective. This technology has been in use since the 1970's, and there are hundreds of thousands of installations worldwide. Independent testing from April 2020 showed that NPBI deactivated 99.4% of SARS COVID-2 (the virus that causes COVID-19) in 30 minutes. Importantly, NPBI technology safely deactivates pathogens in the air and on surfaces in real time, while spaces are occupied.

For school administrators, the installation of NPBI technology within existing HVAC system ductwork would provide clear and immediate indoor air quality (IAQ) improvements. As government and industry experts continue to formulate precise recommendations and guidelines for system sizing and configuration, some facility owners are choosing to proactively integrate systems that demonstrably improve IAQ.

UVC/GERMICIDAL UV (GUV)

Ultraviolet (UV) light is a component of the electromagnetic spectrum that falls between visible light and X-Rays. UV light exists on the spectrum at wavelengths between 100 and 400 nanometers (nm). UVC is one of four sub-groups of UV light - UVA, UVB and UVC (which includes Far UV) - and it exhibits wavelengths between 200 and 280 nm. UVC is often referred to as Germicidal UV (GUV), as it effectively kills bacteria and deactivates viruses. Because of its known disinfection qualities, UVC has been used widely for that purpose since the 1930's. The use of UVC light does carry human exposure risks, however. Unprotected exposure to UVC can result in reddening of the skin and irritation of the eyes. For this reason, safety control systems are designed within UVC disinfec-tion units to prevent the system operating while the space is occupied. Studies have shown that UVC and Far UV light effectively inactivates the SARS-CoV-2 virus responsible for the novel coronavirus COVID-19. Successful elimination of the virus occurs when it is directly illuminated by UVC at the effective dose level.

School administrators can confidently employ UVC disinfection technologies, but unlike NPBI, 254nm UVC can only be utilized in uninhabited spaces such as within enclosed HVAC ductwork to disinfect air and after hours to disinfect surfaces within verifiably empty buildings. Initial studies have shown Far UV safe for use in occupied spaces.

Portable UVC Units vs. Permanent Fixtures

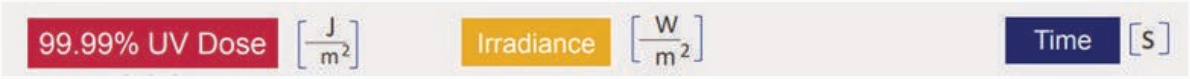
Initial interest has been high for portable UVC disinfection units. They allow end users to leverage their spend, using the same fixture for several rooms and moving the portable unit to different locations in a larger space to provide complete disinfection. Portable units come in a variety of sizes, from small 38W tabletop units suitable for disinfecting small areas to large 1,000W carts that can disinfect 20,000 square feet of open space in 60 minutes. There is a linear correlation between the power of the unit, the cost of the unit, and the speed at which it will disinfect a space.

Time Vs. Money

When comparing a GUV solution to chemical disinfection, we compare the upfront cost of GUV equipment to the ongoing cost of chemicals. Disinfectants can be much more expensive than cleaners, costing as much as $8.00 a gallon. In addition, we need to consider the ongoing cost of labor to apply the disinfectants at an estimated rate of 350-400 square feet per hour. Similarly, once we decide on a path to utilize GUV, we must consider both the capital budget required to purchase GUV equipment as well as the labor cost associated with operating the GUV equipment.

Operating Times

Whether using permanently mounted fixtures or portable disinfection units, specification of the proper disinfection to inactivate 99.99% of viruses and bacteria involves a combination of UV intensity, irradiance distribution, and delivered UV dosing to all areas to be disinfected. Based on the product we specify, we need to be able to confidently identify the run time required to eliminate pathogens in a specific space.



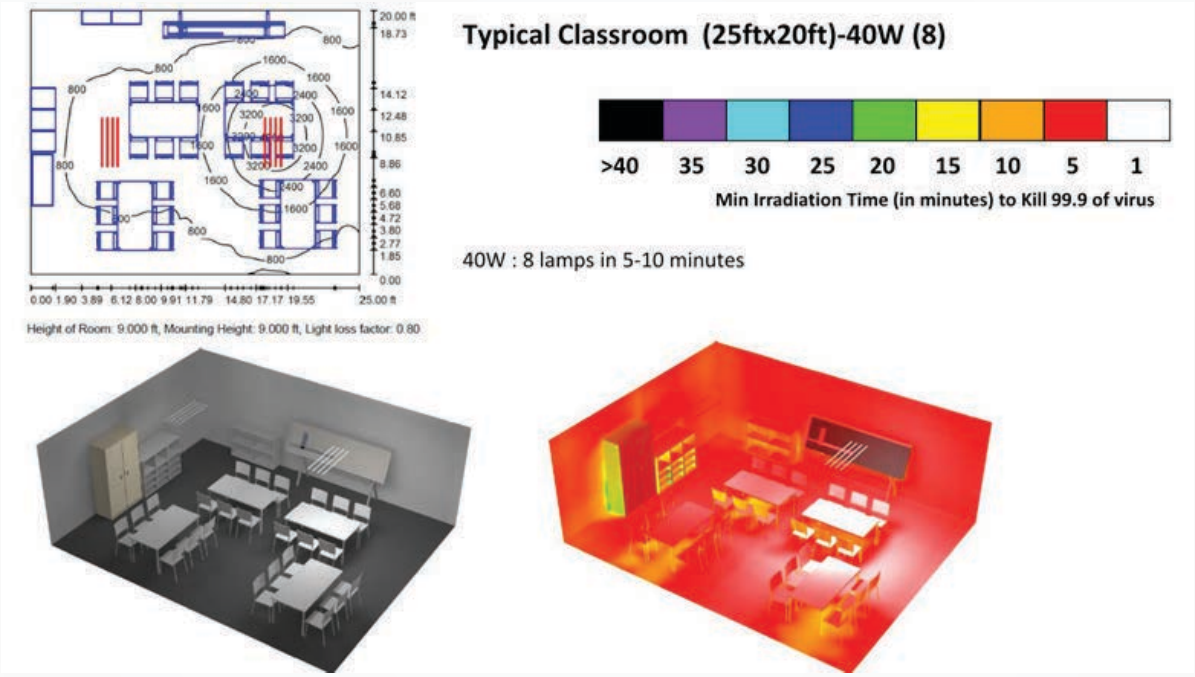
A Classroom Example

The following examples highlight several solutions to disinfect a typical school classroom. The examples illustrate different solutions to accomplish the same task, each requiring different capital and labor investments.

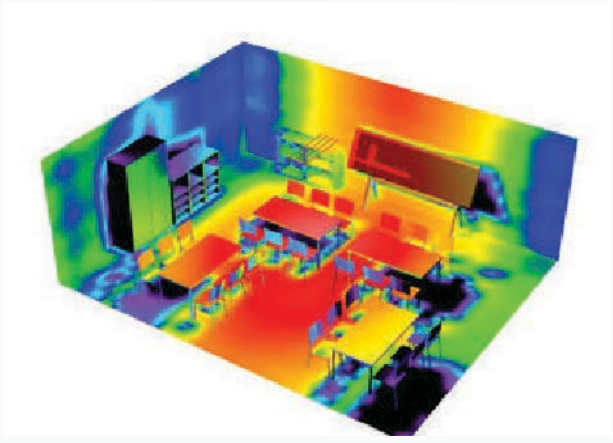
Permanently Mounted Fixtures 254nm

One option would be to install 2X4 grid troffers utilizing 4 UVC lamps, each producing 117 uW/cm2 for a total UVC irradiance of 468 uW/cm2. As shown below, if we install two fixtures in the classroom, we can disinfect the space in 5-10 minutes. While some surfaces such as the desk directly beneath the fixture are disinfected

in one minute, we need to keep the fixtures on for 10 minutes to expose the areas receiving the lowest exposure to the required 5mj/cm2 that has been shown to deactivate SARS COVID-2. These fixtures could only operate when the space is vacant and would require a safety control system to insure it would not operate when the room is occupied.



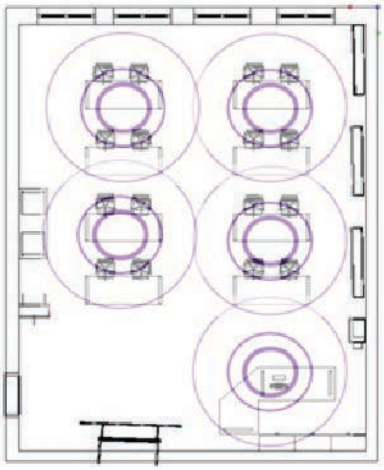
To illustrate the linearity previously discussed, if the number of fixtures is reduced from two to one it will take twice as long, or 20-25 minutes, to disinfect the space



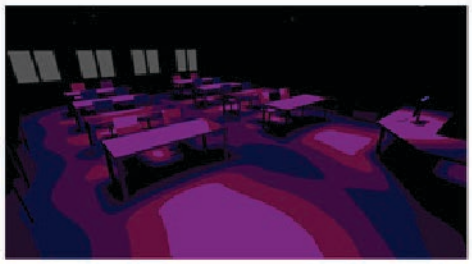
Permanently Mounted Fixtures 222nm

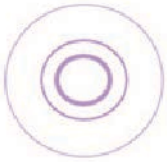
Another fixture option would be to install 222nm or FAR UV fixtures. Initial studies have shown that FAR UV does not penetrate human or animal skin or eyes, so fixtures could provide continuous disinfection of occupied spaces without the safety concerns associated with 254nm UVC. Utilizing five fixtures delivers a very comprehensive disinfection that is continuous all day as the space is occupied. The installed cost is higher than the 254nm solution due to the additional fixtures required, but other options can include just one fixture over the teacher's desk for partial area disinfection.

25' x 20' Classroom
9' ceilings
5 Krypton-11 fixtures
or 1 fixture for teacher



90% Disinfection at head height every 27.2 minutes



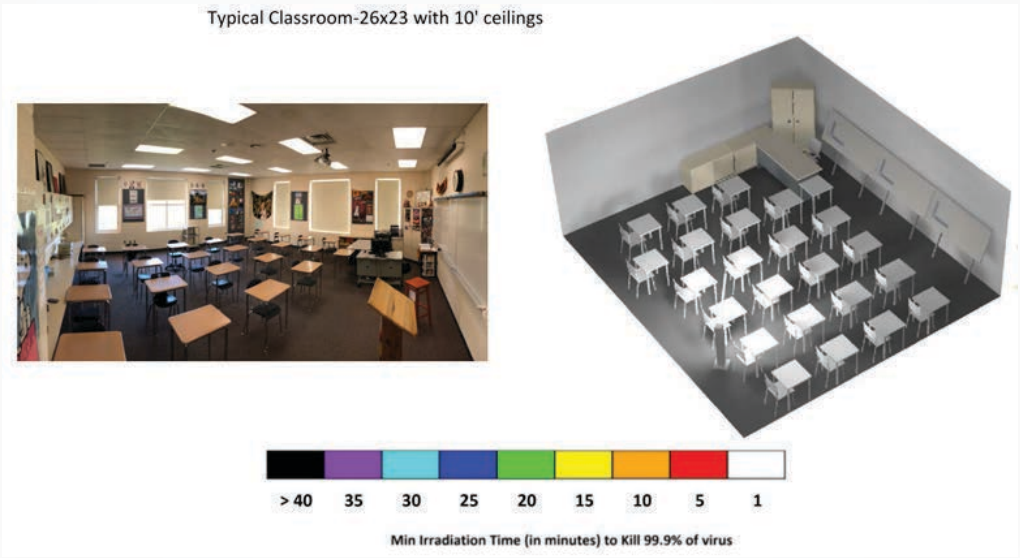


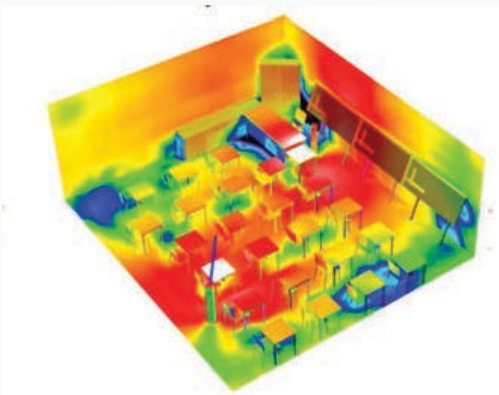
Disinfection OD at desk height

- 99.9% - 3.24ft
- 90% - 4.22ft
- 30% - 12.63ft

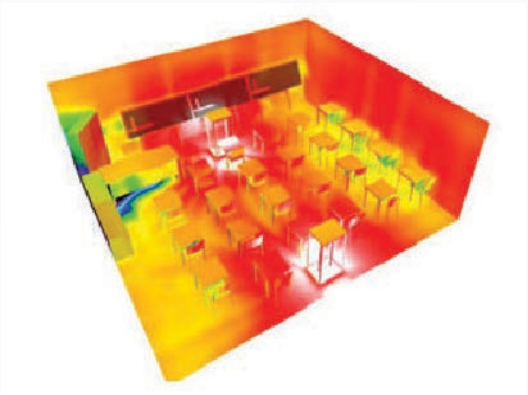
Portable Carts 254nm

Portable carts offer a way for end users to leverage their capital spend, since a portable cart can do multiple rooms. However labor costs increase since the cart needs to be moved from room to room, and also within the room. With carts you also have the option of investing in more powerful units that can disinfect a space more quickly. Of course, these units cost more money. In the example pictured the standard 300W cart produces 640 uW/cm2. It would disinfect the classroom in one hour and would need to be moved across the room after 30 minutes. The more powerful 300W Plus unit produces more than twice the amount of UV irradiance as the standard unit but would still need to be moved across the room once for the quickest disinfection time.





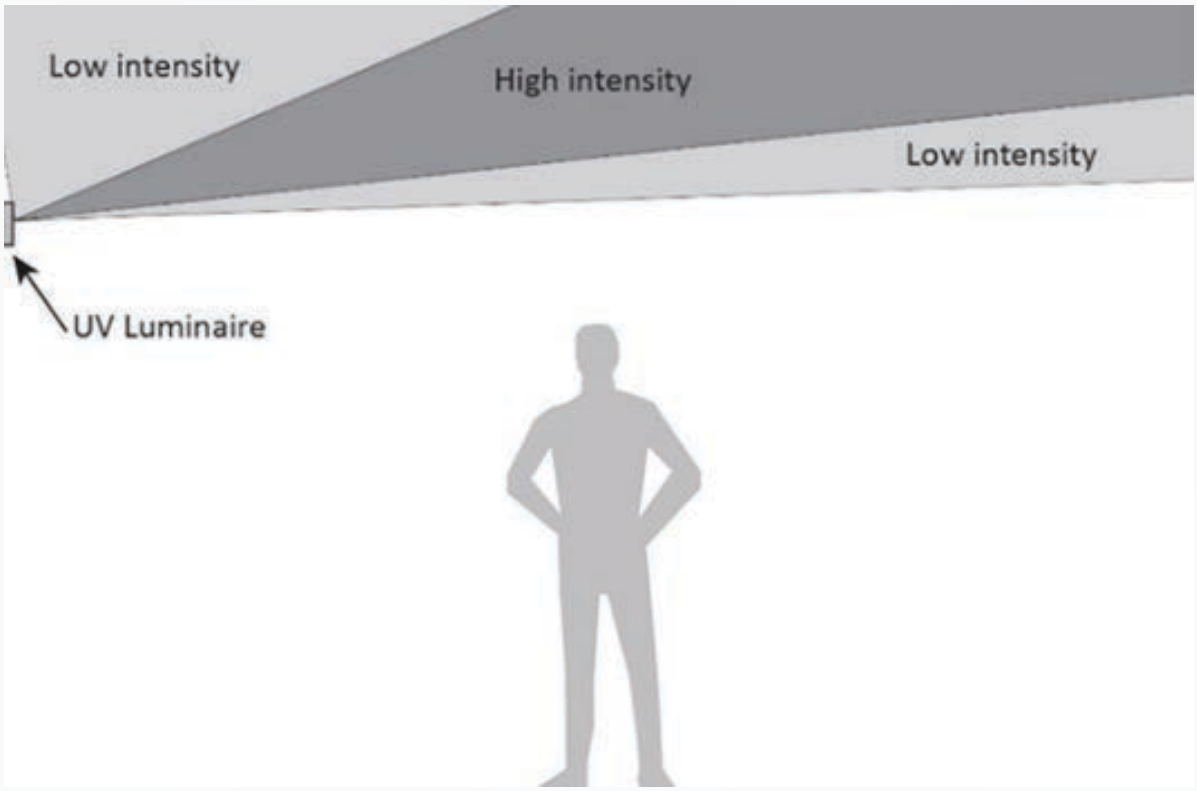
Standard 300W 640 uW/cm2
2 Steps 1 Hour



300WPlus 1,300 uW/cm2
2 Steps 30 Minutes

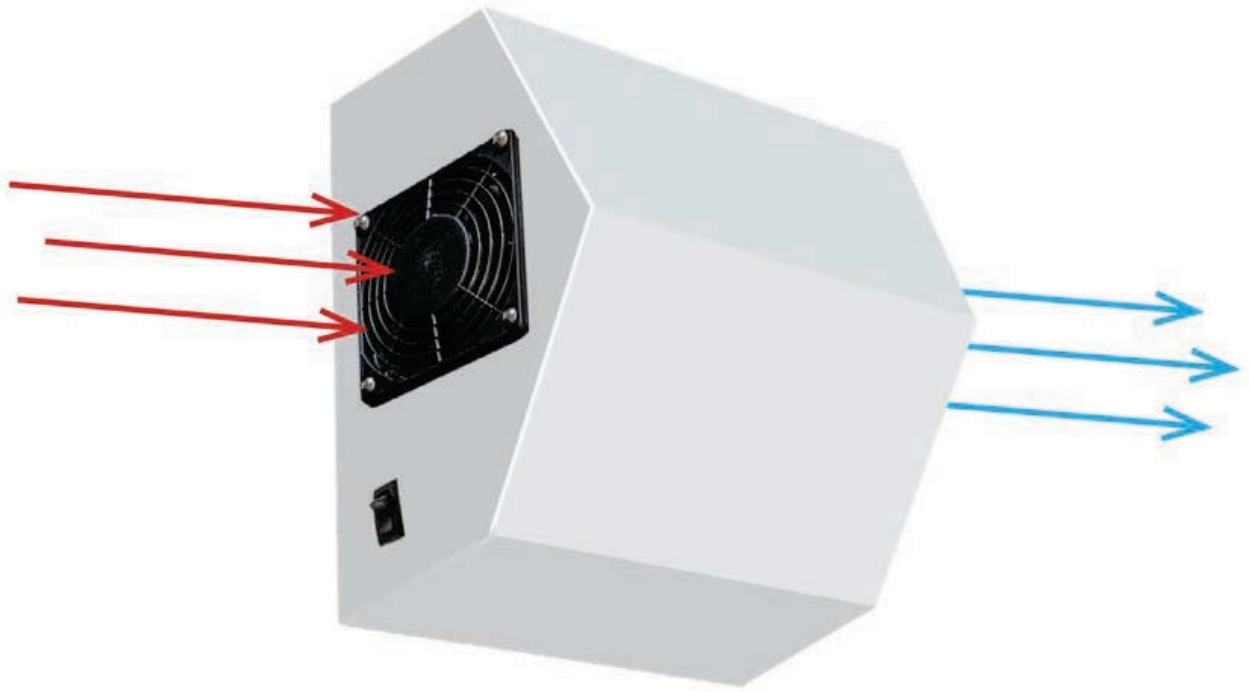
Upper Air Disinfection

Another way to deploy UVC in a room would be to install upper air disinfection fixtures. These fixtures utilize UVC lamps that deactivate pathogens and viruses in the air while the room is occupied. Unlike direct UVC irradiance, upper air units disinfect air only. They do not disinfect surfaces. The UVC lamps are angled up to the ceiling so they do not irritate the skin or eyes and create a disinfection zone. Air is naturally circulated through the zone through convec-tion. In the case of the 20x25 classroom, we could utilize two 4-foot UVC fixtures, each having one lamp producing 115 uW/cm2.



Needle Point Bipolar Ionization

As we discussed, NPBI can be mounted in a central HVAC system. Additionally, NPBI units can also be mounted in individual rooms. The unit shown below can be mounted on a wall and has a built-in fan to move the ions into the space. It is more than sufficient to do an entire classroom and can actually cover rooms up to 3,000 square feet. The unit can operate while the area is occupied deactivating viruses and bacteria in the air and on surfaces.

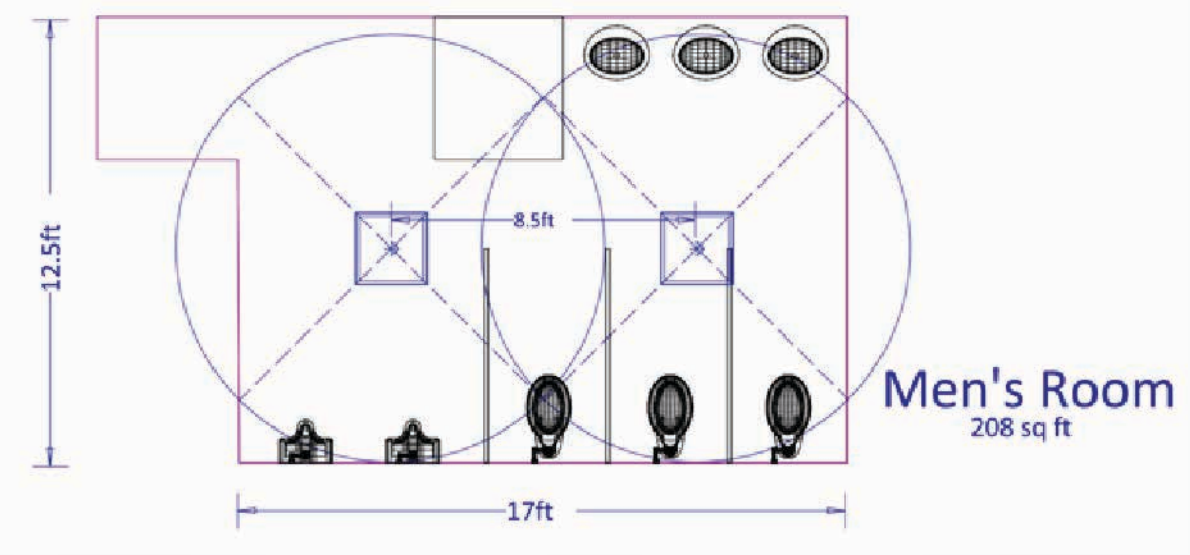


Air is pulled in from the fan on the left side. The air flows in front of the bipolar ionization unit inside before it is recirculated into the room via the vents on the opposite side of the PIC housing.

Other Applications

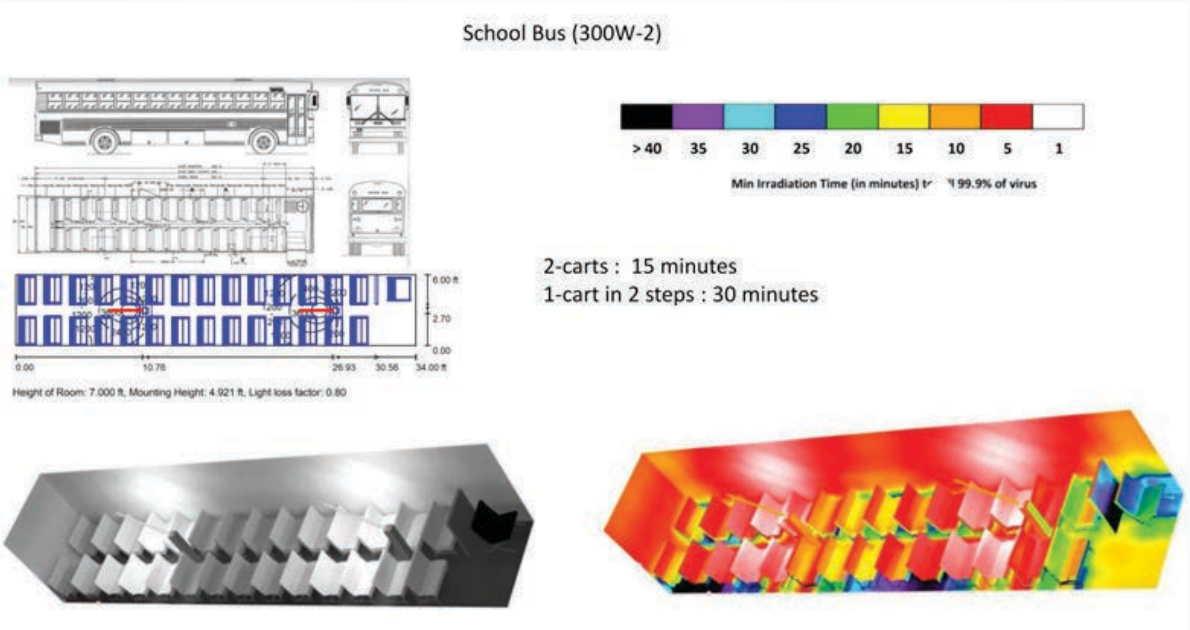
Restrooms

Restrooms are always a focus where germs and pathogens are concerned. Stalls and dividers create obstacles for UVC irradiance, often necessitating the installation of multiple fluorescent style UVC fixtures. This added load can sometimes require additional wiring and capacity. Pulsed Xenon UVC fixtures can be a good option here. Pulsed Xenon uses a powerful, broad-spectrum light, including germicidal UV-C, UV-B, and anti-bacterial UV-A to optimize germ-killing efficiency. The restroom below requires two fixtures consuming 100 watts to disinfect the space in 30 minutes.



Mobile Equipment

UVC can be used to disinfect transportation vehicles such as school buses and ambulances. This is where portable carts come in handy, serving the dual purpose of disinfecting inside buildings as well as within mobile applications. The standard 300W cart used in a school classroom can also disinfect school buses. As shown below, a single 300W cart can disinfect a school bus in 30 minutes, with two steps.



NPBI vs. UVC

Which is the better solution...NPBI or UVC? Like so many different things, there are experts lined up on both sides of the aisle to declare their technology the clear winner. Benefits of NPBI include the ability to disinfect both surfaces and air when spaces are occupied. Full pathogenic deactivation takes 30 minutes. UVC deactivates viruses within seconds of exposure to the lamp, and completely once 5mj/cm2 of irradiance is reached on a surface. However, when sanitizing the air it may take a period of time for the infected air to pass over the UV source, and surfaces cannot be disinfected when a space is occupied. Both are excellent products in their own right, and become very powerful when used together.

Dual Technology Devices Combining NPBI and UVC

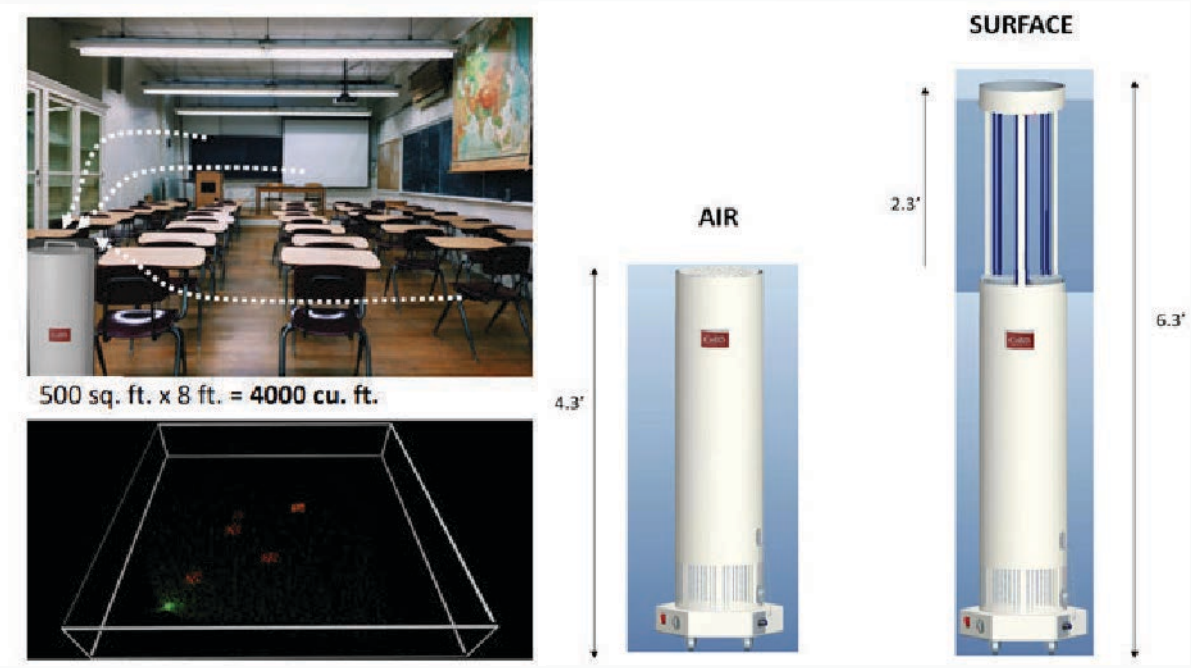
Dual technology devices are available that offer the best of both NPBI and UVC technology. The upper air fixture pictured below can be mounted on a wall. It contains a UVC lamp that creates an upper air disinfection zone as discussed earlier. It also contains two fans that help increase airflow in the classroom and complement natural convection. Importantly, the fixture also contains a NPBI unit. The fans deliver the ions to the space, which help to clean surfaces and air within the room. The unit can be operated when the space is occupied.

A portable multi-technology unit arguably offers one of the most cost effective and comprehensive solutions available. The unit pictured below actually combines three technologies into one unit. It contains three UVC lamps creating a total intensity of 600 uW/cm2, a NPBI unit with an output of 60 million ions/cc/sec, and a

The AirFocus ("AF") option provides added fans to help maximize air flow, and allow a greater percentage of air and pathogens to traverse the eradication zone.

a HEPA filter. The unit disinfects both surfaces and air in several ways, giving you the best attributes of other products:

- With a built-in 800 cfm fan the unit can be used when the classroom is unoccupied, completely disinfecting all of the air in a typical classroom more than 10 times an hour with UVC
- The NPBI unit releases ions to also disinfect the air and surfaces when the room is occupied
- The HEPA filter continuously traps pathogens
- The cart can transform into a deep disinfection portable unit to clean multiple rooms after hours when rooms are unoccupied
- With WIFI communication, the unit can automatically deep clean the classroom after hours with UVC, then retract its cover automatically and turn on NPBI air disinfection the next morning



Conclusion

As this report illustrates, there are many ways to approach classroom disinfection. All solutions help reduce viral loads, and each solution has a different economic impact in terms of initial capital cost and associated labor costs. As government and industry experts continue to formulate precise recommendations and guidelines for system sizing and configuration, some school administrators are choosing to proactively integrate systems that demonstrably improve IAQ and disinfect surfaces as well as air today. After all, even as new vaccines are coming on line to address the current COVID-19 public health crisis, most experts agree that the future will likely contain new viral threats to challenge us, and the health and safety of our children will continue to be of paramount importance for years to come.

About the Author: Bernie Erickson is Executive Vice President of Facilities Solutions Group, and has over 40 years' experience in the lighting and electrical industry. He has been a member of the Board of the National Council on Qualifications for the Lighting Professions (NCQLP) for 13 years and currently serves as its President.