

DISINFECTION IN A FLASH

# The ABC's of UV Light



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# Existing Antibiotics and Cleaning Solutions are Not Sufficient



Without effective interventions, antimicrobial resistance may result in 10m deaths per year by 2050 and an economic loss of \$100 trillion.

Globally, infection control is an \$18 billion industry with projected growth of another \$10 billion in the next 5 years.<sup>1</sup> This is in large part due to growing concerns over foodborne and other illnesses caused by bacteria and viruses, such as Norovirus, *E. coli*, and Salmonella that sicken over half a billion people each year worldwide.<sup>2</sup>

And this is before the worldwide appearance of the SARS-CoV-2 and the resulting COVID-19 pandemic outbreak. The challenges of COVID-19 will increase the need for quick and effective disinfection of indoor spaces exponentially.

“Superbugs,” which are bacteria that have grown resistant to a majority of current antibiotics, have raised further alarm. Antimicrobial resistance is leading to approximately 700,000 deaths per year, and could increase to 10 million deaths per year worldwide by 2050 according to the World Health Organization.<sup>3</sup>

Cross-resistance where microbes resistant to certain antibiotics may then also experience increased resistance to certain biocidal agents has now emerged as an additional threat.<sup>4</sup> All of this culminates in the need for better disinfection solutions to help prevent the spread of illnesses.

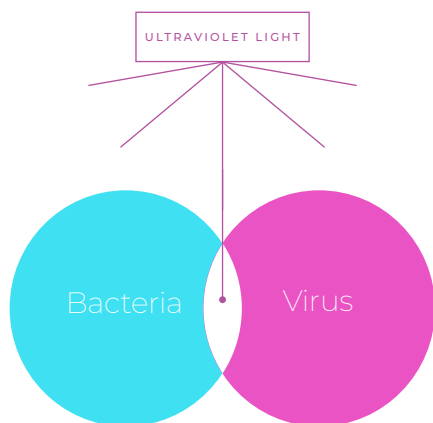
Studies have shown that traditional cleaning is often insufficient with reports of more than 50% of surfaces not being disinfected properly after terminal cleaning.<sup>5</sup> This fact has forced the healthcare industry to take this issue seriously, researching and implementing new solutions as part of their infection prevention protocols. As a result, there has been a resurgence of UV light solutions, as well as other enhanced disinfection products, over the past several years.

Germ-killing lighting products aimed at the broader consumer marketplace have also begun to emerge. For example, at the CES show in Las Vegas in January 2020, Delta airlines announced it would be incorporating antibacterial lights into its airplane cabins. A rideshare company in 2019 planned to integrate a UV surface sanitizer into its “Wellness Pods.”<sup>6</sup>

Kickstarter and other similar campaigns have funded the development of germ-killing robots and balls to clean everything from inside of your sneakers to the sheets on your next hotel stay.

While increased adoption of germ-killing lights will ultimately benefit people and spaces around the globe, it has also led to confusion and sometimes misleading information about the benefits, effectiveness, and other elements of UV and blue light for disinfection.

## Bacteria vs. Viruses — Not All Germs Are the Same



Ultraviolet light has been researched and proven to kill bacteria, mold, fungi, and viruses, helping protect people from all types of harmful pathogens.

While much attention has been given to antibiotic-resistant bacteria, viruses are a threat that cannot be ignored. Worldwide, Norovirus causes 685 million cases of gastrointestinal illnesses each year, which have caused over 50,000 deaths and cost the economy \$60 billion. In the last flu season alone, the influenza virus caused over 35 million illnesses in the United States, resulting in 34,200 deaths.<sup>7</sup>

Additionally, the COVID-19 virus continues to spread across the world, and potentially can come back seasonally, while the world waits for the appropriate vaccine.

The CDC consistently must educate people about the difference between bacteria and viruses, particularly when it comes to the use of antibiotics. Antibiotics can only treat infections caused by bacteria, not those caused by viruses.<sup>8</sup>

Similarly, bacteria and viruses are susceptible to germ-killing light in different ways. Studies have demonstrated that near-UV blue light (405 nm) can kill certain bacteria if exposed long enough, but it is ineffective against viruses.

Alternatively, ultraviolet light has been researched and proven to kill bacteria, mold, fungi, and viruses, helping protect people from all types of harmful pathogens.

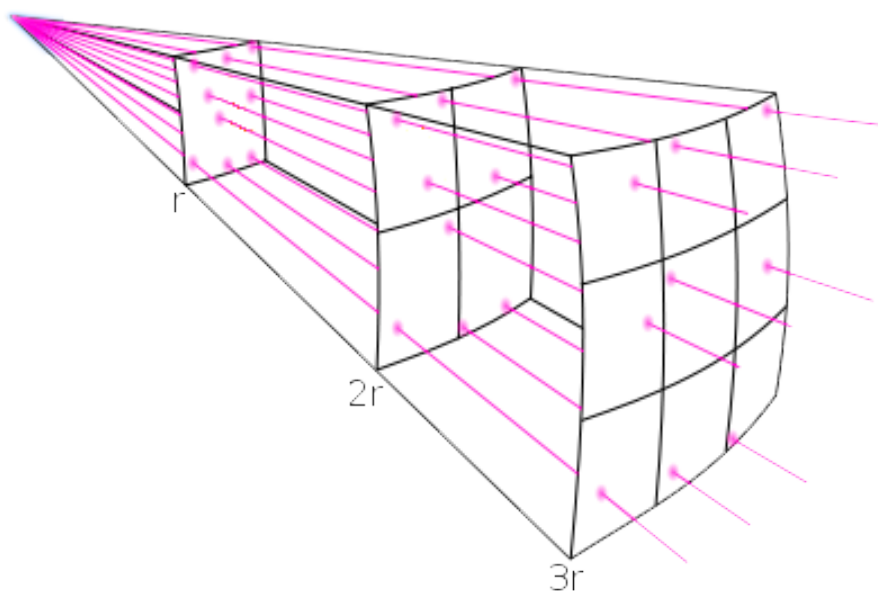
# Time, Distance and Spectrum Matter

Light is subject to Newton's Inverse Square Law, which states that the intensity of light is inversely proportional to the square of the distance from the light source. This means that as you double the distance from a light source, the intensity of the light is reduced to  $\frac{1}{4}$ . Therefore, when reviewing efficacy of germ-killing lights (both UV and near-UV blue), review carefully both the time needed to disinfect according to the manufacturer, but also the distance at which the results were achieved. For example, hand-held germ-killing wands require holding the device  $\frac{1}{2}$ " to 1" from surface and hold it there for 10 seconds — covering approximately 12" wide area at a time. To disinfect surfaces in a 100 square foot room would take approximately 6.7 hours at that rate. They don't tell you that in the instruction manual.

On the other end, PURO Lighting pulsed Xenon UV disinfection products, powered by Violet Defense technology, have been independently validated to kill up to 99+% of *E. coli*, Salmonella and MRSA at distances of 3 meters (~10 feet), which translates to disinfecting the air and surfaces in 100 square feet area in 30 minutes.

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While visible light disinfection technologies can operate continuously even when a room is occupied, the time to achieve effective kills (bacteria only) is extremely lengthy. Manufacturers of these types of lights have cited that they can "continuously reduce harmful bacteria by 70%+" or that "statistically significant reductions can occur in a matter of weeks." When rooms are





occupied, these systems usually activate an antimicrobial “white” light version and offer an enhanced “blue light” version used when rooms are empty.

A study conducted by researchers at Duke University and UNC Schools of Medicine found that the “white light demonstrated no statistically improved reduction at any time point compared to control die-off for VRE, MDR-Acinetobacter and C. diff.”<sup>9</sup> The study did show effectiveness against MRSA and that the inactivate was more significant with blue light, though 90+% reduction still required 24-48 hours and was not achieved for C. diff.

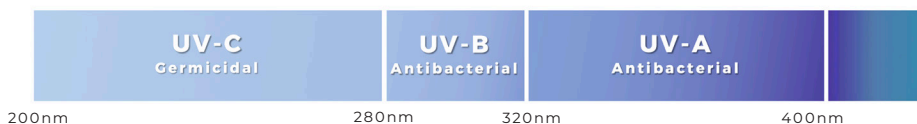
Therefore, in evaluating germ-killing UV and near-UV blue lights, one must account for desired pathogen reduction, available time, and space for disinfection.

## Broad Spectrum UV vs. UV-C

The ultraviolet spectrum has three primary bands: UV-C (100-280 nm), UV-B (280-320 nm) and UV-A (320-400 nm). Low pressure mercury vapor lamps have a peak at 253.7 nm within the UV-C band that is very close to DNA absorption peaks of various pathogens, making it highly effective. However, these peaks vary depending on species, such that *E. coli*'s peak absorption occurs at 265 nm versus *Cryptosporidium parvum* oocysts whose optimal wavelength is 271 nm. Medium pressure mercury bulbs produce a broad but flatter spectrum (200-400 nm) than low-pressure mercury bulbs and “have approximately 15 to 20 times the intensity of low-pressure lamps.”<sup>10</sup>

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Certain manufacturers of single wavelength UV-C (254 nm) products have claimed that broad spectrum, pulsed Xenon UV devices (200-400 nm) produce UV energy that is not useful. However, studies have shown that UV-B<sup>11</sup> and UV-A wavelengths<sup>12</sup> also have antimicrobial benefits. UV-A and UV-B light causes oxidation of proteins and lipids causing cell death. Beyond the scientific studies, simply consider the fact that the ozone layer blocks nearly all UV-C light from reaching earth, yet there are clearly antimicrobial effects of the sunshine (i.e. mold typically grows where the antimicrobial benefits of sunlight don't reach).



Researchers have also concluded that certain viruses could be inactivated with doses of UV-B comparable to UV-C. Duizer et al. found *canine calicivirus* and *feline calicivirus* could be inactivated with about 113 J/m<sup>2</sup> of UV-B, compared to UV-C doses of 67 J/m<sup>2</sup> for *canine calicivirus* and 185 J/m<sup>2</sup> for *feline calicivirus*.<sup>11</sup>

Furthermore, broadband UV lamps have been shown to inhibit photo-reefaction, the process that can result in self-repair of damaged microbes. Kalisvaart found that *E. coli* O175:H7 was “able to repair the damage caused by low-pressure UV.”<sup>13</sup>

## Safety of UV Disinfection Systems

UV disinfection systems are designed to help protect people against dangerous pathogens that can cause unnecessary illnesses and even deaths. Therefore, safety is of utmost importance to any germ-killing lighting system, but they must still be effective.

Visible/blue light disinfection systems boast that they can continuously and safely disinfect, operating even when room is occupied, yet they take extended periods of time to partially reduce bacterial loads and cannot inactivate viruses.



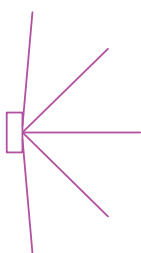
UV devices do not directly emit the ozone, regardless of bulb type.

UV disinfection systems can disinfect an environment much more quickly, including tackling any viruses in the air or on surfaces, but they are designed to only be used when a room is unoccupied due to concerns over negative impacts that UV light may have on skin and eyes. However, due to these concerns, the UV disinfection systems also typically incorporate motion detection systems that will suspend or discontinue disinfection until safe to do so.

Another safety concern frequently raised is the production of ozone by UV lights. Some companies claim that Xenon-based lamps, but not mercury-based lamps, emit ozone. However, the fact is that UV devices do not directly emit the ozone, regardless of bulb type. Rather the ozone is actually created when ultraviolet radiation, typically below 240 nm (produced by any source) interacts with oxygen in the air. The peak creation of ozone occurs at 185 nm. While low pressure mercury bulbs do not have a peak at 185 nm, they may still produce some ozone (though certain models may specifically block this wavelength if bulb is made of glass or fused quartz doped to block radiation below 200 nm).

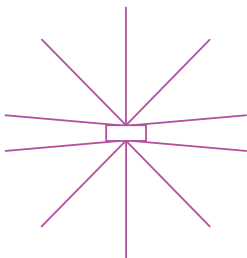
UV light itself (240-280 nm) can also destroy ozone, with peak absorption at 254 nm, thereby self-limiting the net ozone creation. While high levels of ozone have been linked to health concerns, “in general the levels (of ozone) produced are low, the concentrations dilute, and these byproducts of the UVGI process tend to break down or dissipate rapidly”<sup>11</sup>. The half-life of ozone is only about 15 minutes in the air.

## Installation Locations Matter



PERPENDICULAR LIGHT SOURCE

Not only does the distance of a UV light source from the targeted area of disinfection matter, but the location of that light source will also impact effectiveness. There is much discussion over the relationship between shadowing and UV disinfection technology, which frequently leads to requiring multiple placements of a device within a room or extended run times to ensure enough UV dosage was delivered to areas not in direct line of sight. However, these discussions primarily center around mobile solutions where a single unit is stationary and vertical in orientation, positioned perpendicular to most high-touch areas in each space. This can lead to another effect, particularly for textured surfaces, referred to as the “Canyon Wall Effect.”



PARALLEL LIGHT SOURCE

Installed solution positioned above and parallel to contaminated surfaces could provide significantly higher disinfection outcomes than the current mobile solutions.

To understand this effect, Jaffe describes a hiker in a canyon relative to the sun’s position, where at certain times (i.e. the canyon at 9 a.m.), the canyon walls will not be exposed to direct sunlight. However, if the sun is directly overhead (i.e. at noon), the entire canyon will be flooded with light. This is comparable to a UV source being positioned directly overhead (i.e. the canyon at noon) versus a UV source being positioned perpendicular and to the side of the disinfection area (i.e. the canyon at 9 a.m.).<sup>14</sup>

Jaffe compared the kill rates of a UV disinfecting light positioned parallel to and above smooth and textured tiles with light versus one positioned in a vertical orientation, perpendicular to the tiles. It was found that for smooth surfaces, “the kill rate was >150 times greater with the lamps parallel and above than with the lamps vertical and to the side.” The difference on textured surfaces was >500 times greater.<sup>14</sup>

Therefore, an installed solution positioned above and parallel to contaminated surfaces could provide significantly higher disinfection outcomes than the current mobile solutions.



# Choose the UV Disinfection System Right for You

Sunlight has been killing germs since the beginning of time, but we are just now beginning to fully tap into the power of light to bring this proven technology indoors. As the UV disinfection and germ-killing light industry continues to expand, there will continue to be advancements to the deployment of this technology and the types of products available. It is critical that users do their homework to make sure they have the facts about the products they are considering so that they end up with solutions that are safe, proven and effective.



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### ABOUT PURO UV DISINFECTION LIGHTING

Launched in 2019 in Lakewood, Colorado, PURO™ Lighting products, powered by Violet Defense™ technology, have set out to take proven UV light disinfection technology to the next level by making it more powerful, more affordable and most importantly, smaller and easier to utilize. PURO Lighting products can rapidly disinfect any room of any size and at any time using the proprietary miniaturized, pulsed Xenon Light Engine System. Our high intensity broad-spectrum UV disinfection units rapidly kill up to 99.9% of viruses and bacteria and can significantly reduce the growth of fungi such as yeasts and molds. All in remarkably small, yet powerful fixed or mobile units designed for any sized space. For more information, visit [www.purolighting.com](http://www.purolighting.com).

### ABOUT VIOLET DEFENSE

Founded in 2012, Violet Defense is on a journey to find new ways to protect people from harmful germs that have grown resistant to traditional forms of cleaning and disinfecting. Its patented technology is the only known Pulsed Xenon UV solution that can be installed into a room full-time, creating continuous way to address disinfection needs of all types of settings, including healthcare and non-healthcare alike. Designed to bring hospital-grade disinfection to everyday spaces, Violet Defense has cost-effective solutions to kill up to 99.9% of bacteria and viruses, including *E. coli*, Salmonella, MRSA, Norovirus and *C. diff*. For more information, visit [www.violetdefense.com](http://www.violetdefense.com).



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