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UV Light Disinfection* Technology
Frequently Asked Questions

Acuity Brands UV Technology Partners

1. **Who is Ushio America?**
   Ushio America (Ushio) manufactures the Care222® module using an excimer lamp. Ushio is a vertically integrated solutions company that makes lamps and other components for lighting systems and other numerous applications utilizing: xenon short arc, lasers, ultra-high-pressure UV, excimer, metal halide, LEDs (specialty sensing and general illumination), halogen, fluorescent, and miniature incandescent. Established in 1967 as a subsidiary of Ushio Inc., in Tokyo, Japan, Ushio America offers a full spectrum of over 2,500 products and services to its customers. http://www.ushio.com

2. **What is the agreement between Acuity Brands and Ushio America?**
   The strategic alliance agreement between Acuity Brands and Ushio America, Inc. grants Acuity Brands exclusive rights in North America to incorporate Ushio's Care222 far-UVC disinfection* module into Acuity Brands luminaires that will be installed and operated in spaces when they are occupied and unoccupied. Acuity Brands also has non-exclusive rights to use the Care222 far-UVC disinfection module worldwide (except Asia) for lighting and other uses.

3. **Who are Violet Defense and PURO Lighting?**
   Violet Defense, an innovator of germicidal UV lighting technology that kills bacteria and inactivates viruses[1], was founded in 2012 to research and develop new products based on pulsed xenon technology. Its first line of patented products entered the market in May 2017. https://www.violetdefense.com Launched in 2019 in Lakewood, Colorado, Puro Lighting is a lighting and technology company that uses Violet Defense® technology to create UV disinfection solutions for many different industries and categories. https://purolighting.com

4. **What is the agreement among Acuity Brands and Violet Defense and PURO Lighting?**
   The strategic alliance that includes Acuity Brands and Violet Defense LLC and Puro Lighting, LLC gives Acuity Brands access to patented UV technology from Violet Defense®. This UV technology delivers high intensity full spectrum UV light using a pulsed xenon lamp and UV transmissive lens. In collaboration with these organizations, Acuity Brands will offer UV disinfection luminaires that can be used in unoccupied

spaces to quickly kill bacteria and inactivate viruses[1]. Acuity Brands products utilizing this technology are offered by Healthcare Lighting® under the PulseX™ brand.

5. **Who is UV Angel?**
   UV Angel is a leading pathogen control technology company creating innovative technologies and products to provide UV light pathogen control[1] in spaces focused on healthcare, food service, corporate, education and other industries. Product categories include those focused on treatment of air or surfaces as well as environmental testing services for air quality and equipment surfaces. https://uvangel.com

6. **What is the agreement between Acuity Brands and UV Angel?**
   Acuity Brands has a private label supply agreement with UV Partners, Inc. (dba UV Angel) to enable Acuity Brands to purchase and resell the UV Angel Clean Air™ pathogen control system, as well as pursue joint developments of UV light disinfection products. The UV Angel Clean Air system integrates UVC light technology into a ceiling-mount luminaire that offers an unobtrusive environmental treatment system that uses concealed ultraviolet light to treat air automatically and continuously to neutralize pathogens[1] without exposure of the ultraviolet light to occupants. The agreement provides Acuity Brands with limited exclusivity for certain private label products throughout North America. Acuity Brands products utilizing this technology are offered by our Healthcare Lighting® brand under the EvōlAIR UV™ brand.

The Fundamentals of UV Light Disinfection* Technology

1. **What is ultraviolet (UV) light?**
   Ultraviolet light (UV) is a form of electromagnetic radiation with a wavelength from 100nm to 400nm. The UV spectrum is further broken down into 3 bands known as UVC, UVB, and UVA. UVC wavelengths are from 100-280nm, UVB wavelengths are from 280-315nm, and UVA wavelengths are from 315-400nm. UV is present naturally in solar radiation. Radiation is the emission energy in the form of waves or particles through space or through a material medium, and includes, among other forms, ultraviolet, visible light, and infrared emission. Above the Earth's atmosphere, solar radiation is 10% UV (UVC, UVB & UVA), 40% visible, and 50% infrared. After passing through the Earth's atmosphere, radiation is 5% UV (UVB & UVA only), 43% visible, and 52% infrared. All UVC is absorbed by the Earth's atmosphere, which notable as it relates to UV light disinfection technology because most UV light disinfection technology is based on UVC wavelengths and must be electrically generated. See other FAQs for more information on specific UVC sources.

2. **Is UV light visible?**
   UV light is not generally visible to the human eye. There are some UV sources that also emit part of their light inside the visual spectra, so we can see some light, but it is only generally the non-UV part. Note that due to individual differences, certain individuals may have some perception into the UVA range.

3. **Why is UV light used for germicidal applications?**
   English scientists W.B. Hugo Downes and Thomas Porter Blunt are credited with making the first scientific claims regarding the antimicrobial properties of UV in sunlight in 1877.[2] Since then, scientific understanding of how the intensity, duration, and wavelength of UV affect how it works as a germicidal aid has advanced significantly. In general terms, UVC (with the shortest UV wavelength) is much more efficient as a germicide than UVA or UVB. This shorter wavelength also means that UVC light is less harmful to our skin and eyes than UVB or UVA.

4. **How does UV work as a disinfection technology?**
   How UV works as a disinfection technology depends upon the wavelength(s) being employed. UVC (200-280 nm) has the ability to inactivate bacteria, viruses, mold, and fungi. In this wavelength range, photons are highly energetic and work by causing photochemical reactions in the nucleic acids (DNA & RNA) of the pathogenic microorganisms. These photochemical reactions create what's called a DNA or RNA lesion, which prevents a pathogen from being able to replicate, thus rendering it harmless. The longer UVB (280-320nm) and UVA (320-400 nm) wavelengths have also demonstrated the ability to kill certain bacteria (but not viruses, mold and fungi). These wavelengths cause oxidation of proteins and lipids, resulting in cell death, and, hence, work only on bacteria. Violet light in the 405 nm to 470 nm wavelengths has also been shown to kill bacteria at the proper doses. The violet light causes photoexcitation of endogenous porphyrins that leads to the generation of reactive oxygen species, which are toxic to bacterial cells.[2]

5. **Where is UV used as a disinfection aid?**
   UV is used in air, water and surface disinfection. UV disinfection products from Acuity Brands focus on pathogen control[1] in the air and on surfaces in interior architectural settings.

6. **Why is UVC used as a disinfection strategy?**
   UVC, particularly the wavelengths from 200-280nm, is known to be an effective technology for inactivation of many viruses and bacteria[2]. UVC is straightforward to apply in a defined area and its expected effectiveness can be predetermined within a set of application design parameters and in reference to measured output data and laboratory test data. With an adequate dose applied, UVC light can treat the area quickly. Utilizing UVC for pathogen control can reduce the amount of chemicals that need to be used for disinfection purposes.

7. **Is UVC effective against SARS-CoV-2?**
   Yes, studies[5] have demonstrated that, in laboratory testing, UVC has inactivated known viruses and other pathogens, including SARS-CoV-2[3], on surfaces and in the air. The germicidal effectiveness of UVC is dependent upon a variety of factors including, but not limited to, the amount of time the pathogen is exposed to the UVC light and the distance of the light from the surface intended to be treated. In addition, the pathogen must actually be exposed to the UV light, meaning that the pathogens in areas that fall in the shadow of the UV are not inactivated, which is why UV light disinfection technology

should be used in conjunction with chemical cleaning. Doses required to achieve a specific level of inactivation are wavelength and pathogen specific[1].

8. **How quickly does UVC work to inactivate viruses and bacteria?**
   It is possible to inactivate viruses and bacteria in seconds using UVC; however, it is critical to understand the power level requirements to provide rapid inactivation. There is no set time to deliver an effective dose; determining an effective dose will depend on multiple application factors and the pathogen(s)[1] being targeted and will be customized to the space to be treated.

9. **In general, how can UV products be installed and used safely?**
   First and foremost, the necessary safety precautions with respect to application of UV products is determined by the technology involved. Second, the UV products selected must be differentiated according to whether they are designed with direct, indirect or mixed UV light. When human exposure to the UV light is expected it is critical that installations operate within applicable safety guidelines.

   In situations where potential UV exposure poses a risk that exposure will exceed safety guidelines (i.e., in systems not intended for use when spaces are occupied), the apparatus and/or installations must be equipped with safety and warning elements as described in applicable UL standards. These elements should include movement or presence sensors, visual and sound signals. etc., as well as a backup mechanism which, if any of the safety or warnings systems fail, would activate another method of protection. In these cases where safety and warning systems are required to avoid unwanted UV exposure, the installer must perform a risk analysis of the installation and use of the system. Systems must incorporate at least two independent electrical or mechanical safeguards (i.e., primary and secondary) to reduce the overexposure risk if the system is inadvertently or intentionally activated while the treated space is occupied. This may be accomplished with any combination of site and equipment safeguards. Safeguards must be installed near or within the treated space to reduce the likelihood of occupancy immediately before or during operation of the system. Signage, product markings and operating instructions are not sufficient for the purpose of complying with this requirement.

10. **Does UV light cause risk to human health?**
    In the case of UV, there are two possible sources of hazards: irradiance, which is invisible to the eye, and ozone, which produces a distinct odor making it possible for humans to detect a potentially hazardous situation.

    Since UV is not visible, individuals may be overexposed without realizing it until the potentially adverse health effects become apparent hours later. Understanding these hazards and how to prevent them is essential for designing the appropriate UV light disinfection system for the application. See additional FAQs for a discussion of the specific potential for adverse health effects.

11. What are the irradiance hazards for UV?

With UVC, the two known photobiological risks are photokeratitis and erythema. Photokeratitis is an eye condition resulting from damage to the cornea caused by overexposure to UVC light. Erythema is redness of skin, caused by increased blood flow in capillaries, that can also result from overexposure to UVC light. These effects are usually temporary but can be quite severe and painful.

Photokeratitis and erythema may also be induced by overexposure to UVB, and overexposure to UVB and UVA may lead to additional effects. UVB and UVA may be a source of tanning and thermal skin burns, possible cataracts, and, as wavelengths approach the visible range, retinal burns and color and night vision degradation. Visible light may be a source of thermal skin burns, retinal burns, color and night vision degradation, and cataracts. Overexposure to UVB and UVA may also increase the risk for skin cancers. This risk is also present, but greatly reduced, in the UVC range. UVC is principally absorbed in the superficial layers of the skin and eye. In comparison, UVB and UVA can reach the germinative layer (basal layer of the epidermis), thereby having more risk present in the case of cumulative long-term exposures.

12. What are the ozone hazards for UV?

UV emission below 240nm can produce ozone at low levels. Wavelengths from 160 to 200nm can produce higher levels of ozone. Ozone is created by the photolysis of the oxygen molecule (O_2) that disrupts the molecule and creates valent oxygen atoms (O) that will then attach to any individual oxygen molecules (O_2) to create ozone (O_3).

When inhaled, ozone can damage the lungs and is potentially toxic to pulmonary function. Relatively low amounts can cause chest pain, coughing, shortness of breath and throat irritation. Ozone may also worsen chronic respiratory diseases such as asthma and compromise the ability of the body to fight respiratory infections. The Occupational Safety and Health Administration (OSHA) regulates employee exposure to ozone gas through its Air Contaminants Standard, 29 CFR 1910.1000. The permissible exposure limit for workers is a maximum time-weighted average (TWA) level for ozone exposure of 8 hours at 0.10 part of ozone per million parts of air (ppm) for “light” work, and 8 hours at 0.05 ppm for “heavy” work. The National Institute of Occupational Safety and Health (NIOSH) recommends an upper limit of 0.10 ppm, not to be exceeded at any time. Acuity Brands tests its products for ozone production in accordance with UL standards.

13. What role does ACGIH® play in evaluating these potential human hazards?

The ACGIH®, the American Conference of Governmental Industrial Hygienists, is a charitable scientific organization advancing occupational and environmental health. As part of its mission it reviews published, peer-reviewed scientific literature to determine levels of exposure to various chemical and physical agents found in the workplace that do not create an unreasonable risk of disease or injury. These guidelines are designed for use by industrial hygienists in making decisions regarding safe levels of exposure to hazards in the workplace.

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To provide guidance on levels of UV exposure considered to be within acceptable limits, the ACGIH has published guidelines for the level of UV irradiance exposure that a typical worker can be exposed to without adverse health effects. The level of exposure in the guidelines are quantified as Threshold Limit Values, or TLVs®, and are expressed as Time-Weighted Averages, or TWAs, and are wavelength dependent. These TLVs have been adopted into safety standards worldwide, from bodies such as the American National Standards Institute (ANSI), the International Electrotechnical Commission (IEC), and the International Commission on Illumination (CIE). IEC 62471 is the standard employed by UL for testing and certifying UV light disinfection products for photobiological safety. The ACGIH also adopts and publishes TLV-TWA values for ozone production. These values form the basis for OSHA and NIOSH standards.

14. What is the role of the U.S. Food & Drug Administration (FDA) in the regulation of UV light disinfection products?

The Food and Drug Administration is responsible for protecting the public health by ensuring the safety, efficacy, and security of human and veterinary drugs, biological products, and medical devices; and by ensuring the safety of our nation's food supply, cosmetics, and products that emit radiation.

When UV products are intended for medical purposes, such as products that disinfect other medical devices, irradiate parts of the human body to cure diseases, or are marketed to prevent disease, they meet the definition of medical device under section 201(h) of the Federal Food, Drug, and Cosmetic Act, and these products typically require FDA clearance, approval, or authorization prior to marketing. Neither the UV light disinfection technology as incorporated in Acuity Brands products nor the products themselves are intended for use in the cure, mitigation or prevention of disease nor for the disinfection of medical devices and therefore are not regulated by the FDA.

In addition, the FDA regulates electronic products that emit radiation (both non-medical and medical products) through the Electronic Product Radiation Control Provisions, which were originally enacted as the Radiation Control for Health and Safety Act. UVC lamps are electronic products that are regulated by the FDA, and manufacturers are subject to certain safety reporting requirements, but there are currently no specific FDA performance standards that apply to non-medical electronic products.

15. What is the role of the U.S. Environmental Protection Agency (EPA)?

The EPA regulates UV light systems that claim to inactivate, entrap or suppress the growth of fungi, bacteria or viruses in various sites as pesticide devices. A pesticide device is an instrument or other machine that is used to destroy, repel, trap or mitigate any pests, including bacteria and viruses. Pesticide devices are not required to be registered with the EPA under Federal Insecticide, Fungicide, and Rodentside (FIRA) Act, 40 C.F.R. §152.500(a). However, distribution or sale of a misbranded device is prohibited under FIFRA.

To avoid being considered misbranded, pesticide devices must be marketed in compliance with the FIFRA Section 12(a)(1)(F), which prohibits false or misleading claims about the effectiveness or safety of the devices. If a manufacturer is making claims about a device, they should have scientific data to support the claims. Unlike chemical pesticides, EPA does not routinely review the safety or efficacy of pesticide devices, and therefore cannot confirm whether, or under what circumstances, such products might be effective against SARS-CoV-2 or against any other pathogen. UV devices must be produced in an EPA-registered pesticide producing establishment, and must be labeled pursuant to federal regulations, which includes warning and caution statements, and directions for use, among other requirements. Some states have additional requirements, which may include registration of the devices themselves.

16. What is the role of Underwriters Laboratories (UL)?

UL addresses the risk of electric shock, fire and personal injury including the risks associated with UVC. With respect to photobiological risk assessment of UVC products, UL utilizes published standards from the International Electrotechnical Commission (IEC), specifically the published standard IEC 62471. IEC 62471 assigns a Risk Group category ranging from Exempt to Risk Group 3, based on the potential photobiological hazard of the source of optical radiation. This assessment will determine product labeling requirements and limitations on use required to obtain a safety certification. For more information, consult the UL website.

17. What is the role of the Illuminating Engineering Society (IES)?

In response to the COVID-19 pandemic, the IES Photobiological Committee has prepared several resources, including a fact sheet and webinars. The IES Photobiological Committee publishes ANSI IES RP-27-20 Photobiological Safety for Lighting Systems and is working on new resources and standards to address this important topic.

18. Are there new UVC standards in development?

The Illuminating Engineering Society and the International Ultraviolet Association (IUVA) have partnered to develop American National Standards for the measurement and characterization of UVC device performance. Through this partnership, IES and IUVA aim to cooperatively promote awareness of and improve the application of UV light disinfection technology.

A series of standards adopted by the American National Standards Institute (ANSI) are envisioned, beginning with two slated for publication by the end of 2021. The first standard, Approved Method for Electrical and Ultraviolet Measurement of Discharge Sources, will detail laboratory procedures for the measurement and characterization of low-pressure mercury and other discharge sources. The second, Approved Method for Electrical and Ultraviolet Measurement of Solid-State Sources, will do the same for UV-LED components.

19. Does UVC impact materials?

UVC light may cause the photodegradation of materials (interior finishes and objects) and this should be considered when installing and using UVC where susceptible materials, such as plastics, textiles, paints etc. are in the space being treated. The degree of photodegradation is a function of UVC technology, intensity, and duration of exposure. Look for test data to be published by Acuity Brands.

20. Can UVC be reflected from ceilings and walls?

Generally speaking, wall and ceiling materials are not highly reflective of UVC. There are exceptions, however, and it is important to understand the reflective properties of materials. Note that reflectance varies by wavelength, and it is critical to understand material reflectance properties to evaluate the performance of a UVC light disinfection system. Look for test data to be published by Acuity Brands.

21. How does UV Light Disinfection Technology compare to Bipolar Ionization Technology?

Air cleaners using reactive ions and/or reactive oxygen species (ROS) have become prevalent during the COVID-19 pandemic. Technologies utilize various methods to create reactive ions in air that react with airborne contaminants, including viruses. The design of the systems can be modified to create mixtures of reactive oxygen species (ROS), ozone, hydroxyl radicals and superoxide anions. Systems are reported to range from ineffective to very effective in reducing airborne particulates.

Convincing scientifically rigorous, peer-reviewed studies do not currently exist on this emerging technology, and manufacturer data should be carefully considered. Systems may emit ozone, some at high levels. Manufacturers should be asked for their ozone generation test data. For more information, see the ASHRAE Position Document on Filtration and Air Cleaning and CDC Response to ASHRAE ETF on Bipolar Ionization. The California Air Resources Board registry of certified air cleaners may also be consulted.

22. How does UV light disinfection relate to energy codes and standards?

At this time, the **ASHRAE/IES 90.1, The International Energy Conservation Code (IECC),** and **California Title 24 Part 6** energy standards consider germicidal irradiation either exempt or not regulated. The National Electrical Manufacturers Association (NEMA) soon will be publishing an Engineering Report that will provide additional guidance regarding each of these standards. A link to the NEMA report will be included once available.

23. What is the process for designing a UV light disinfection system?

The method of design for a UV light disinfection system will depend upon the technology and design approach. Software tools such as Visual® by Acuity Brands provide the ability to perform detailed analysis prior to installing a system. Much like performing lighting calculations, the software models and evaluates the intended application space and irradiance from UV light disinfection products, providing designers and their clients in-depth understanding of how the UV light disinfection system may reduce pathogens[1].

24. Determining the appropriate UV dosage is essential.

When designing a space incorporating a UV disinfection technology -- especially any spaces intended for occupants – it is important to use software modeling tools to simultaneously evaluate the safety considerations as well as the locations where the pathogens are to be targeted. Other input needs include good data on reflectance values, time of operation, data on pathogens of interest (e.g., types of bacteria, viruses) and the previously referenced ACGIH guidelines. Visual® software is tuned to specifically analyze a proposed space, the proposed UV technology, and the operating characteristics of the UV system in order to get to that all-important dose quantity.

In an **occupied space**, a good first step is to review the areas where people will be interacting and the areas to target for pathogen reduction. What are the patterns of occupancy? Is the priority reduction of harmful pathogens in the air, on surfaces, or both?

To consider as a holistic design, evaluate the visible lighting alongside the UV intended for pathogen reduction. This should be coupled with an analysis of the UV technology being considered and the inherent operating characteristics involved such as dosing cycle, technology type, etc. And on the safety side, the system should be designed so that occupant exposure does not exceed the ACGIH guidelines, which are defined for an eight-hour window of time.

The exposure calculations make the assumption that an individual occupant is going to be in the area of greatest exposure to UV for the entire period of time that individual is in that room. Evaluating the system in this way enables occupants to come and go in the space and use the space freely without thinking about how long they are in the space or where they are standing in the space, and still be within the exposure threshold limit value (per the ACGIH guidelines).

After the overall exposure calculations have been made, review levels of expected pathogen reduction at different locations within the room calculated using the same modeling process on that same design. For example, look at the table surface, determine how much planar irradiance is hitting that surface and then convert that value to a dose based on the intended operating characteristics. Finally, map the delivered dose to laboratory testing and research data to arrive at the predicted level of effectiveness in targeting specific pathogens[1].

Designs for technology approaches for **unoccupied space** consider the pathogen reduction portion of the analysis while the safety considerations are addressed by controls.

25. Can UVC wavelengths treat both air and surfaces?

UVC wavelengths can treat both air and surfaces. In order to be effective, the UV light must strike a pathogen for a sufficient length of time at the requisite power density to deliver a lethal dose for inactivating pathogens[1].

Care222® UV Light Disinfection* Technology

1. **What is the Care222 far-UVC disinfection lamp?**
   The Care222 far-UVC disinfection lamp from Ushio America is a krypton-chloride excimer lamp that operates in the photobiological ultraviolet spectral band known as UVC and employs a short pass filter to remove all but a narrow band of 222 nanometer (nm) UV light, which is capable of inactivating viruses and bacteria[1] on indoor surfaces and in air in occupied and unoccupied spaces.

2. **What is an excimer lamp?**
   Excimer lamps are a source of UV light, specifically an arc discharge light source with a special chamber filled with noble gas, completely mercury-free and without electrodes. The Care222 excimer lamp technology allows for a lower temperature operation compared to other conventional lamps and fast on/off times with no-warm-up required.

3. **What is different about the Care222 far-UVC disinfection lamp for use in the reduction of pathogens[1] and why is the filter important?**
   Results from laboratory testing and clinical studies[5] suggest that the filtered 222nm far-UVC light emitted from the Care222 far-UVC disinfection lamp will not cause burns to human skin or damage to eyes when used with appropriate parameters because it minimally penetrates into the biologically sensitive nucleus of human cells. Yet, the 222nm wavelength easily penetrates and inactivates a wide range of pathogens including bacteria and viruses[1], because of their microscopic dimensions. The short pass filter removes UV wavelengths that would potentially penetrate the living tissue in skin or beyond the tear layer in eyes.

4. **Is Care222 technology effective against SARS-CoV-2?**
   In a 2020 study, Hiroshima University confirmed that under laboratory conditions, a dose of 3 mJ/cm^2 of 222nm UVC irradiation, with an exposure time of 30 seconds, inactivated 99.7% of SARS-CoV-2on a surface[3]. Ushio's Care222 UVC disinfection lamp was placed 24 cm above the surface of the plates in which the viral samples were placed. The Care222 far-UVC disinfection lamps are also effective against a wide range of other bacterial and viral pathogens[1].
   Reference: *Kitagawa, Hiroki. (2020). Effectiveness of 222-nm ultraviolet light on disinfecting SARS-CoV-2 surface contamination. DOI: 10.1016/j.ajic.2020.08.022*

5. **How does 222nm far-UVC light inactivate pathogens[2]?**
   The 222nm far-UVC light penetrates the outer layers of the pathogen structure to render it harmless through disrupting the nucleic acids (DNA and RNA), resulting in the disruption of vital functions, stopping the ability of the pathogen to replicate.

6. **Why can 222nm far-UVC light be used in occupied spaces?**
   Because 222nm far-UVC light can be effective against wide range of bacterial and viral pathogens[1] in relatively low doses, it can be used in occupied spaces and still fall within current exposure guidelines for human occupancy, as established by the American Conference of Governmental Industrial Hygienists (ACGIH®).

7. **What is potentially harmful about other germicidal UV wavelengths?**
   Certain wavelengths more easily penetrate the biologically sensitive nucleus of human cells and more deeply penetrate tissues than at 222nm, potentially causing short- and long-term damage. Eyes and skin are more sensitive to longer wavelengths in the UVC range (above 230nm to 280nm) and in the shorter UVB wavelengths (280 to 315nm). Above 315nm and into the UVA range, eyes and skin are less sensitive. ACGIH establishes guidelines for acceptable levels of exposure for all germicidal UV wavelengths.

8. **Do other germicidal lamps have the same capability as filtered excimer lamps?**
   No. Filtered excimer lamps using 222nm far-UVC light require relatively small doses of radiant energy to inactivate bacterial and viral pathogens[1] while also avoiding penetration of the living tissue in skin or beyond the tear layer in eyes[5]. The 254-274nm wavelength range is much more problematic for direct view exposure and levels of exposure with potentially adverse health effects are much more quickly reached. See the ACGIH guidelines for additional information about the level of UV exposure that a typical worker can be exposed to without adverse health effects.

   Germicidal lamps generating 254-274nm UV wavelengths can be used in **upper room** germicidal UV applications for occupied spaces when properly designed and maintained to mitigate the health hazards of direct exposure. A newer method of reducing active pathogens in the air is using concealed 254nm in onboard air fixtures and luminaires. Systems with 254-274nm UV sources have also been historically used to treat spaces when they are unoccupied or in applications that avoid human exposure such as in air handling equipment or water filtration systems.

   While acceptable for use in occupied spaces, germicidal lamps in the 405nm UV wavelength range are effective against a range of bacterial pathogens (at significantly higher doses than required with the 254-274nm UV wavelengths), but are not as effective against viruses as lamps with lower-range UVC wavelengths[6].

9. **How will the Care222 far-UVC disinfection technology be used in luminaires (and why in lighting)?**
   Acuity Brands far-UVC products incorporate the Care222 excimer lamp into a module that includes dosing electronics. Because lighting is necessary for occupied spaces, integrating Care222 far-UVC disinfection modules into lighting systems where reduction of pathogens[1] is desired makes practical sense. Using luminaires as a delivery system allows facilities to take advantage of locations where power is already distributed. This enables the disinfection technology to be added as a layer of functionality to necessary illumination using the luminaire's intelligent control capabilities. Acuity Brands plans to seamlessly incorporate the Care222 far-UVC disinfection modules in familiar luminaires and stand-alone products from its lighting brands such as Mark Architectural Lighting™, Lithonia Lighting®, Healthcare Lighting®, and others.

10. **How effective is 222nm far-UVC in inactivating bacteria/viruses when compared to other UV technologies?**

The level of reduction of specific pathogens will depend upon the dose delivered, measured in mJ/cm^2, which is a measure of radiant energy per unit area. Since the dose is an energy quantity, effectiveness[1] against a particular pathogen will depend on both the irradiation quantity and time of exposure.

Effectiveness of inactivation of particular bacteria and viruses[1] is measured in either log reduction or percentage. A 3-log reduction is equivalent to a 99.9% reduction in the applicable active pathogens. At 222nm, relatively small doses over time are needed to inactivate bacteria and viruses to achieve the 3-log reduction of such active pathogens on the surface that is in contact with the UV light.

In contrast, the 254-274nm range of UV wavelengths, while also effective at inactivating bacteria and viruses, requires generally somewhat higher doses of radiant energy (UV light) directed at most pathogens to achieve equivalent reductions. Moving into the 405-430nm range, these wavelengths are effective against a range of bacterial pathogens at even higher doses of UV light, but are not effective against viruses[4].

11. What is the science/research behind the 222nm far UVC wavelength?

Columbia University's David Brenner, PhD, and his team developed a patented approach using shorter wavelengths in the UVC range that selectively kill bacteria and inactivate viruses[1] without damaging human cells/tissues, permitting prolonged human exposure. Dr. Brenner is the Higgins Professor of Radiation Biophysics in Radiation Oncology and Director of the Center for Radiological Research at Columbia University Medical Center. One system discussed in connection within this approach uses the 222nm far-UVC generated by filtered KrCl (222nm) excimer lamps. Multiple studies[5] show that such usage of the specified radiated energy provides the anti-microbial advantages of conventional 254nm UV lamps, while avoiding reaching into the sensitive cells in the skin epidermis or the eye lens .

12. What are some of the potential applications?

When used in Acuity Brands fixtures and luminaires, the technology will offer supplemental pathogen control[1] treatment in all types of high-interaction applications, including offices, conference rooms, meeting spaces, classrooms, public restrooms, restaurants/hospitality, performing arts and sports events, public transit, retail, health clubs, and healthcare settings.

13. Do all UV wavelengths have the same effectiveness?

No. Some wavelengths require lower doses to inactivate a particular pathogen, while others may not be effective at all against that pathogen[2].

14. Do all UV wavelengths have the same safety issues?

No. The 222nm wavelength inactivates viruses and bacteria at energy levels that do not penetrate living tissue in skin or beyond the tear layer in eyes, allowing the space to remain occupied during use. 254 and 274nm wavelengths do reach the sensitive cells in the skin epidermis and the eye lens; requiring that the space be evacuated during use, used in upper room germicidal UV applications or in concealed applications.

15. **The lifecycle of UVC sources appears very short. How frequently will the Care222 lamp module need to be replaced?**
    The Care222 lamp module is warranted for 2 years or 1500 hours of active operation, whichever comes first. Complete Acuity Brands UV Lighting warranty terms located at: www.acuitybrands.com/support/warranty/terms-and-conditions. While this sounds like a relatively short period of time, the Acuity Brands products operate the lamp intermittently utilizing electronics to appropriately dose the space at a level of exposure that meets the ACGIH guidelines. Actual dosing times are programmed to be around 100 minutes per 24-hr day, or less. With a rated lifetime of 3,000 hours and taking into consideration the actual dosing times, the expected operating lifetime is approximately 5 years or more. In other words, expected time to replace modules as part of system maintenance under normal operation would be every 5 years. Since many dose times are programmed to be shorter than 100 minutes per 24-hour day, the time between module replacement for system maintenance could be longer than 5 years, depending on the specific programming implemented in the electronics for the specified/installed fixture. To facilitate system maintenance, the Care222 lamp module is field-serviceable.

16. **Are 222nm LEDs available?**
    The technology to manufacture a 222nm LED light source does not currently exist outside the laboratory. It is possible that LEDs or other light sources may become technically and economically feasible for 222nm UV light disinfection applications.

PulseX™ UV Light Disinfection* Technology

1. **What is PulseX?**
   "PulseX" is the brand identifier for Acuity Brands products that incorporate a pulsed xenon broadband UV germicidal source powered by Violet Defense® technology. Acuity Brands has two pulsed xenon product offerings under its Healthcare Lighting® brand: HXMS (single unit) and HXMD (double unit) UV disinfection luminaires. Typical spacing for the HXMS fixture is 10' x 10' on center. Typical spacing for the HXMD fixture is 12' x 12' on center.

2. **What is meant by Broadband UV as produced by a pulsed xenon lamp?**
   The pulsed xenon lamp emits a powerful, broad-spectrum light that includes germicidal UVC and UVB and antibacterial UVA, in addition to wavelengths through the visible spectrum to 1000nm. Because of the broadband nature of this source, pathogens are targeted with multiple inactivation effects, increasing their susceptibility. Combined with its high power, PulseX acts quickly against pathogens[1].

3. **What is a pulsed xenon lamp?**
   A pulsed xenon lamp is a confined arc flashlamp which produces microsecond to millisecond duration pulses of high radiant intensities capable of operating at high repetition rates. Xenon is an inert, non-toxic gas used for excitation inside the glass enclosure, which is the lamp in this case.

4. **Does a pulsed xenon lamp emit 222nm and 254nm wavelengths?**

The xenon lamp emits broadly in the UVA, UVB and UVC spectrum which does include 222nm and 254nm wavelengths.

5. **How are PulseX fixtures operated in a space during a treatment cycle?**
   PulseX fixtures will emit a 1-second flash, every 6 seconds. Units are factory programmed to operate for 30 minutes per treatment cycle.

6. **What pathogens will broadband UV be targeting?**
   PulseX fixtures, powered by Violet Defense technology, have been clinically proven to rapidly inactivate over 99% of tested bacteria, viruses and fungi, specifically E. coli, MRSA, Salmonella enterica, Feline calicivirus, human coronavirus 229E, Influenza A H1N1, and Candida aurus, at a distance of 1-4m, depending on the specific pathogen and lab test[1]. The independent lab test studies that produced these results utilized modified ASTM International Standard Test Method E1153.

7. **Are PulseX fixtures effective against SARS-CoV-2?**
   Yes. PulseX fixtures, powered by Violet Defense technology, have been clinically proven to inactivate >99.9% of live SARS-CoV-2 virus[3] on glass, stainless steel, and plastic in 5 minutes or less at a distance of 1m.
   Reference: *Pulsed broad-spectrum UV light effectively inactivates SARS-CoV-2 on multiple surfaces, Alexander S. Jureka, Caroline G. Williams, Christopher F. Basler, bioRxiv 2021.02.12.431032; doi: 10.1101/2021.02.12.431032*

8. **What types of spaces are PulseX fixtures intended for?**
   PulseX fixtures are intended for unoccupied spaces and can be used in a variety of applications such as hospitals, acute care clinics, veterinarian hospitals, classrooms and public restrooms. These fixtures can be installed in drop-in ceilings, recessed hard ceilings, or surface ceiling/wall mount applications.

9. **Do PulseX fixtures have safety features to prevent use in occupied spaces?**
   While occupants cannot safely be exposed to the emissions from PulseX products while in use, these products utilize built-in redundant protection features (motion sensor, LED indicator, safe stop) that will cycle the unit off if motion or technical issues are detected. Also, the fixtures can be combined with an nLight® UV controls solution from Acuity Brands as an additional means to stop operation of the unit to protect occupants from accidental exposure if they inadvertently enter the space during a treatment cycle.

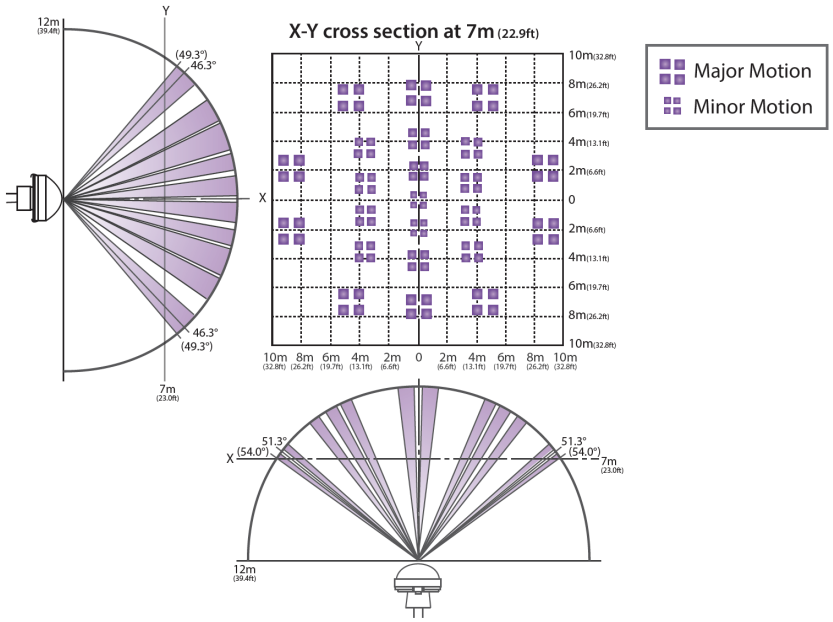
10. **What is the typical PulseX fixture mounting height?**
    Typical distances from target surfaces are 2-4m (6.56-13.2 ft) depending on the level of pathogen reduction[1] required and the physical parameters of the space being considered. Consult with your local Acuity Brands representative for layout guidance.

11. **How are PulseX fixtures being controlled?**
    PulseX fixtures have a standard PIR sensor to detect anyone entering the space while a cycle is in session. Additionally, PulseX fixtures must be controlled with a lockable line voltage switch on the exterior of the space where the product is located. nLight® control

solutions can also be incorporated. Always consult your local Acuity Brands representative for any nLight controls solution option.

12. What is the coverage pattern of the embedded PIR motion sensor?

The embedded PIR motion sensor in PulseX fixtures actively monitors the space and does not allow the unit to activate when motion is detected. The coverage pattern for the sensor is indicated in the following chart. Detection distance is up to 12m with object speed of 1m/s and size of 700mm x 99mm crossing two of 92 detection zones. Field of view is 108° x 99°. In the cross-section view, per NEMA 7 guidelines, major motion detection is indicated by the large squares. Minor motion detection is indicated by the small squares.



13. What is the life of a lamp life in a PulseX fixture?

The pulsed xenon lamp is rated for > 2 million UV flashes. Operating life is dependent on frequency and duration of operating cycles and number of operating cycles per day. For an application using two, 30-minute cycles daily, the approximate expected life would be 9 years.

14. Are you offering PulseX mobile units?

No, Acuity Brands will not be offering mobile units at this time. PulseX technology fixtures are intended for permanent installation applications.

15. Who will be doing installation and commissioning of PulseX products?

Installation of this equipment should be performed by a **qualified licensed electrician**. If installed with an nLight controls system, commissioning must be done by Acuity Brands field service personnel.

16. **Is the PulseX unit field serviceable?**
    No. The unit will need to be returned to Acuity Brands Lighting for repair or replacement in the event of a covered warranty claim. Acuity Brands is offering a 1-year limited warranty on PulseX products. Complete Acuity Brands UV Lighting warranty terms are located at: www.acuitybrands.com/support/warranty/terms-and-conditions. A unit must be replaced when it reaches the end of its operating life.

Onboard Air UV Light Disinfection* Technology

1. **What is Onboard Air UV light disinfection technology by Acuity Brands?**
   EvōlAIR UV™ with UV Angel Clean Air™ Technology delivers a modern approach to UV germicidal upper air room treatment. Engineered with advanced UVC based pathogen control technology powered by UV Angel Clean Air™ Technology, EvōlAIR UV products use 254nm UV light in a patented engineered air purification technology system to reduce levels of harmful viruses, bacteria and fungi by automatically and continuously treating the air[1].

   These products provide an environmental treatment system in a traditional light fixture design. Unlike other 254nm devices, Onboard Air UV light disinfection technology may be used in occupied rooms, allowing for 24 hours per day of concealed ultraviolet germicidal irradiation (UVGI). This device uses fans to draw room air through a filter into a hidden UVC neutralization chamber mounted inside a standard ceiling panel size fixture, with or without integrated ambient illumination. The treated air is then returned to the room as the cycle continues.

2. **What types of applications are good candidates for the Onboard Air UV light disinfection solution?**
   Onboard Air UV light disinfection products are suited for any commercial indoor space where a reduction in harmful pathogens[1] is desired or required. Examples include healthcare, education, commercial office, hospitality, retail, manufacturing (e.g., food processing plants), and general public and customer indoor gathering spaces at airports, restaurants and theatres.

   The integrated fans move the air at 50 cubic feet per minute (cfm), providing a 10’ x 10’ room with an 8-foot ceiling a calculated equivalent of almost 4 air cycles per hour (i.e., 800 cf of air every 16 minutes). If used in higher ceilings, the area of coverage in square feet is less but the cubic volume remains the same.

3. **How does the Onboard Air UV light disinfection technology work?**
   The Onboard Air UV light disinfection system is designed to work in standard grid ceiling construction for either new or existing projects. This simple system operates without interruption 24/7/365 and does not interfere with how people use the space. In other words, the system can be operated during occupancy.

   The embedded, patented treatment technology quietly draws air into a sealed 254nm UVC air chamber with a series of fans and filters. Air is circulated through the UVC air chamber where it is treated with an enclosed high intensity 254nm light to inactivate bacteria, fungus and viruses in the air[1]. Treated air is then returned to the room creating a cleaner environment. Available for pathogen control only or with

integrated ambient illumination, this system is unobtrusive, works continuously within the ceiling design, and maintains the valuable floor space in occupied areas.

4. **How does the Onboard Air UV light disinfection technology compare to traditional UV disinfection technology within the HVAC system?**
   Due to the very high velocity of air in most commercial HVAC systems (e.g., 400 to 1,000 cfm) it is difficult to design UV systems for high-volume air handlers. Generally, it is impractical to effectively treat the airstream and produce high rates of inactivation of airborne pathogens for each individual room. As such, UV in air handlers is generally not as an effective method for eliminating pathogens shed by occupants or from environmental sources found in commercial building air streams.

   Instead, properly installed UV disinfection products in HVAC systems, along with a strict filter change regimen, primarily reduce the potential for growth of pathogens occurring within the air handler. The advantage of Onboard Air UV light disinfection technology is that it can inactivate harmful pathogens[1] as they are introduced in the room and **before** they enter the HVAC air filtration system.

5. **How is the Onboard Air UV light disinfection product maintained?**
   The integrated MERV 6 filter and 254nm UV lamp should be changed annually. More detailed instructions for maintenance may be found in published installation manuals.

6. **What is the EvōlAIR UV™ warranty?**
   Acuity Brands is offering a 5-year limited warranty for UV device housing, mechanical, white light-emitting components, ballast, and driver, and a 2-year limited warranty on UV device fans, switches, and other electrical components. No warranty is offered on UVC lamps and filters. Complete Acuity Brands UV Lighting warranty terms are located at: www.acuitybrands.com/support/warranty/terms-and-conditions.

Footnote References

[1] *Refer to product specification sheets at www.acuitybrands.com/UV-Products for efficacy claims and claim substantiation regarding specific products and pathogens.*

[2] *Wladyslaw Kowalski. (2009). UVGI for Air and Surface Disinfection. Ultraviolet Germicidal Irradiation Handbook. DOI: 10.1007/978-3-642-01999-9_15*

[3] *The references listed below apply to SARS-CoV-2, providing data on inactivation under specific test conditions. Level of inactivation in application will be based on dose/distance/time as delivered from a specific UV technology/product and will vary based on environmental conditions of the installation.*

- *Storm, Nadia. (2020). Rapid and complete inactivation of SARS-CoV-2 by ultraviolet-C irradiation. DOI: 10.21203/rs.3.rs-65742/v2*
- *Kitagawa, Hiroki. (2020). Effectiveness of 222-nm ultraviolet light on disinfecting SARS-CoV-2 surface contamination. DOI: 10.1016/j.ajic.2020.08.022*
- *Jureka, Alexander S. (2021). Pulsed broad-spectrum UV light effectively inactivates SARS-CoV-2 on multiple surfaces. DOI: 10.1101/2021.02.12.431032*

[4] *Maclean M, McKenzie K, Anderson JG, Gettinby G, MacGregor SJ. 405 nm light technology for the inactivation of pathogens and its potential role for environmental disinfection and infection control. J Hosp Infect. 2014;88(1):1-11. doi*: 10.1016/j.jhin.2014.06.004

[5] UV Published Research References

**All references to "disinfection" are referring generally to the reduction of pathogenic bioburden and are not intended to refer to any specific definition of the term as may be used for other purposes by the U.S. Food and Drug Administration or the U.S. Environmental Protection Agency. Reduction of the pathogenic bioburden is a function of fixture run time, distance to the UV light source, airflow, room size and/or other factors, and the level of reduction will vary within a specific space. Neither the disinfection technology as incorporated in Acuity Brands products nor the products themselves are intended for use as a medical device or for the disinfection of medical devices.*