UV TECHNOLOGY

Application Design Guide: Classroom

AcuityBrands.

Why UV in a K12 School Facility?

- Decades of research and history support the use of UV as a disinfection aid. See a collection of published research on our website.
- UV solutions can reduce pathogens[1] and aid in your cleaning protocols.
- Address both lighting and treatment needs with solutions that combine white light and UV light or solutions that are UV only.
- Each solution is equipped with a set of safety features and controls designed to prevent accidental UV exposure.
- Products have been rigorously tested to limit UV dosage in accordance with the American Conference of Governmental Industrial Hygienists guidelines[2] and are UL Certified to meet U.S standards for germicidal equipment for use in occupied spaces. with the American Conference of Governmental Industrial Hygienists guidelines[2].

How this guide can help you

This guide provides you with the data required to design real-world spaces using the most modern UV light disinfection* technologies available today.

- Learn the guiding design principles that apply to your space.
- Compare and contrast various solutions.
- Select your solution based on the robust data presented here .

Design Considerations

The method of design for a UV light disinfection system will depend upon the technology, products, and the specific space being designed.

Care222® and PulseX™scenarios presented in this guide are modeled in Visual® Lighting software. This software allows for several baseline calculation parameters to automatically adjust for source types and product types utilized in the design, and designers can tailor how the data is presented.

When designing, think about ….

- Materials in the space and their reflectance values
- Occupancy patterns and/or room schedules
- Operating characteristics of the UV technologies and products
- Types of bacteria and viruses most important to target
- Safety guidelines and standards
- Variations in room type, time of year, occupancy schedules or other project specific considerations

* 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. Reference page 23 of this document for full disclaimer.

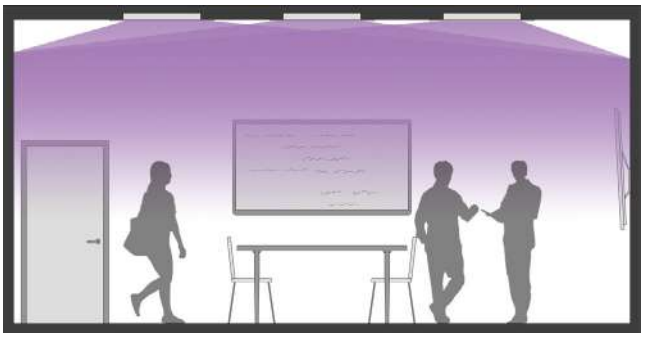
Design Approach by Technology

Filtered 222nm Far-UVC powered by Care222® Technology

When designing a space that will have UV technology operating while people are present, the design and analysis needs to evaluate human exposure together with pathogen inactivation effectiveness.

UL8802 and IEC62471 guide the design process for evaluating human exposure in occupied space. Per UL8802, occupied space is defined as the volume of the room that is 7' above finished floor (AFF) and below. From that definition, a calculation plane is defined at 7' AFF, and the maximum exposure dose can be calculated. This calculated maximum exposure dose represents the dose an individual would receive over an 8-hour period even if stationary in the location of maximum dose. The maximum exposure dose is then compared against the exposure guidelines established and published by the American Conference of Governmental Industrial Hygienists (ACGIH®)[2]. For the UV exposure dose to remain within the ACGIH guidelines for the level of UV exposure a typical worker can be exposed to without adverse health effects, the maximum exposure dose must not exceed 23 mJ/cm^2 (millijoules per square centimeter) for an 8-hour period. This threshold limit value (TLV) applies specifically to filtered 222nm far-UVC, which is used in our Care222 products.

This above method of determining the maximum dose that an occupant might be exposed to assumes that the occupant is stationary at the point of greatest exposure and is well taller than average head height. Making these assumptions enables a system to be designed so occupants can use the space freely while staying below recommended exposure limits. Lighting fixtures with Care222 technology that are UL listed and meet the requirements of UL 8802 for use in occupied space are classified as



photobiological Risk Group Exempt.

In designing and reviewing how to target pathogens in a space, either the air volume or specific surfaces can be evaluated through the calculation modeling process available within the Visual Lighting® Software. Pathogenic bioburden reduction projections can be generated based on calculations generating the dose applied within a specific design, over a given timeframe. When creating designs for fixtures that use Care222 technology, the dose is calculated over 24 hours of operation of continuously powered fixtures. Once the dose has been calculated, it is correlated with laboratory testing and research data[3]. This leads to projected inactivation effectiveness for specific pathogens in designated locations. For products utilizing Care222 technology, the key objectives are to focus on high-touch surfaces and locations where people congregate. Calculations for projected pathogen inactivation are always pathogen-specific, and any air volume calculations assume perfect air mixing**.

Visual Lighting Software makes it easy to see all of the essentials:

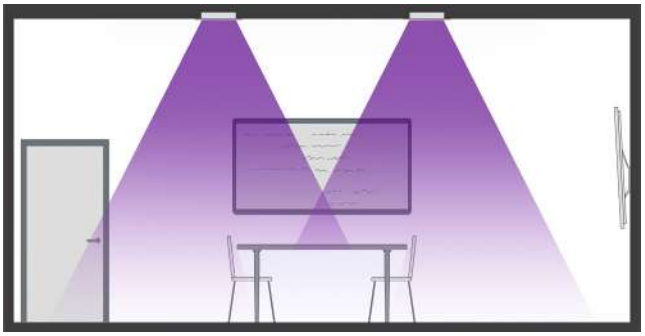
- Human exposure levels, compared to human exposure limits – the TLVs
- Levels of projected pathogen inactivation at any location looking at a wide range of bacteria and viruses

Design Approach by Technology

PulseX™ powered by Violet Defense® Technology

Designs for PulseX product installations recognize that controls are utilized to prevent products from operating when occupants are present. Therefore, it is not necessary to evaluate human exposure during the calculation process. Instead, the focus is on rapid treatment to allow occupants to come back in the room as quickly as possible. Not only is the downtime during treatment short, when occupants return the active pathogens will have been reduced.[1] Visual® Lighting Software can predict the amount of pathogen inactivation that can occur in a particular layout.

For this technology, a report of the calculated results from Visual Lighting Software provides results for one treatment cycle at a time,

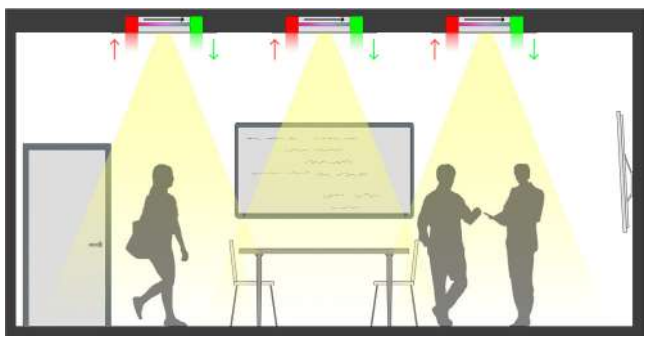


a 30-minute cycle for PulseX. Simply set up the parameters for the calculation model, place the single or dual units in the space, determine where you want to predict pathogen inactivation, and activate the calculations. The dose is calculated for that 30-minute treatment cycle. Once the dose has been calculated, it is correlated with laboratory testing and research[3] to derive the level of inactivation projected to be achieved against specific pathogens in designated locations. For many project types and spaces where this technology and product could be utilized, the key objective is to focus on high-touch surfaces and the air where pathogens are likely to have collected while occupants were using the space. Calculations for projected pathogen inactivation are always pathogen-specific and any air volume calculations assume perfect air mixing.**

EvolAir UV™ powered by UV Angel Clean Air™ Technology

EvolAir UV air disinfection* technology is specifically designed to remove and treat airborne microbes, including bacteria, viruses, and fungi[1] in rooms. Microbe removal rates for a single pass of an airstream through an EvolAir UV fixture are easily projected based on the combined effects of the particle removal efficiency of the filter in the EvolAir and UV treatment by the 254nm UV lamp enclosed in the product. The projected effect of the filtering is based on EvolAIR UV filter testing conducted by Blue Heaven Technologies in Louisville, Kentucky in accordance with ANSI/ASHRAE 52.2-2017. For the UV treatment, the airstream receives a dose of 302 mJ/cm^2 of 254nm UV. Given the UV dose, the projected inactivation rate for various pathogens is determined by applying data from the **Acuity Brands Pathogen Inactivation Dose Reference List.** The effect of the filter and the effect of the UV treatment are combined to provide a total projected pathogen inactivation.

A detailed explanation of the EvolAIR UV projected effectiveness methodology and calculations can be found in our "**EvolAIR UV Application Methodology for determining Projected Levels of Pathogen Inactivation**.



Occupied Spaces with 222nm Filtered Far-UVC Technology for Surface Air Treatment

2'x4' BLT with Care222® Technology

Design Intent	Design Approach by Technology
Address lighting and treatment needs in a single fixture	The BLT with Care222 combines white light and UV light technology
Lighting controls for dimming and ability to utilize natural light when possible	Wired and wireless control through our nLight® platform offer occupancy sensing, daylight harvesting and more
Treatment of desks, chairs and other high touch surfaces in the space by using a continual air and surface treatment strategy	Integral Care222 modules deliver a dose of UV for a few minutes every hour throughout the entire day to continually reduce the level of active pathogens[1] using a dosing module that is a UL recognized component to emit 222nm wavelengths that do not penetrate the living tissue of the skin or beyond the top later of the cornea in the eyes allowing occupants to be present

Discover BLT with Care222® ›

Reflected Ceiling Plan*

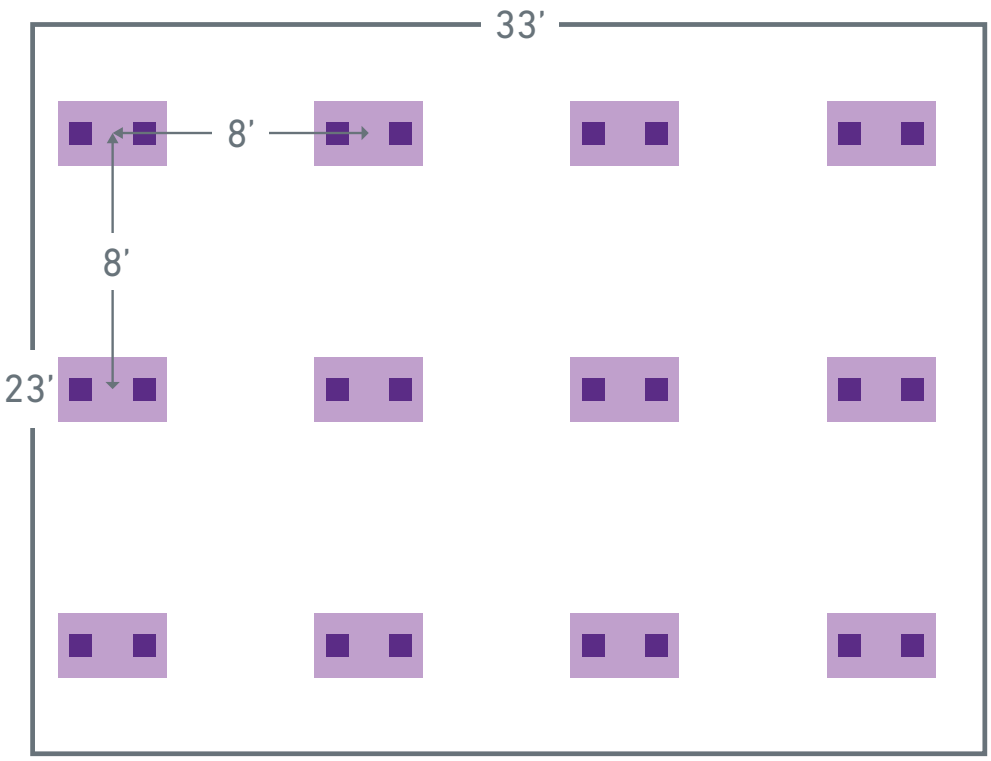
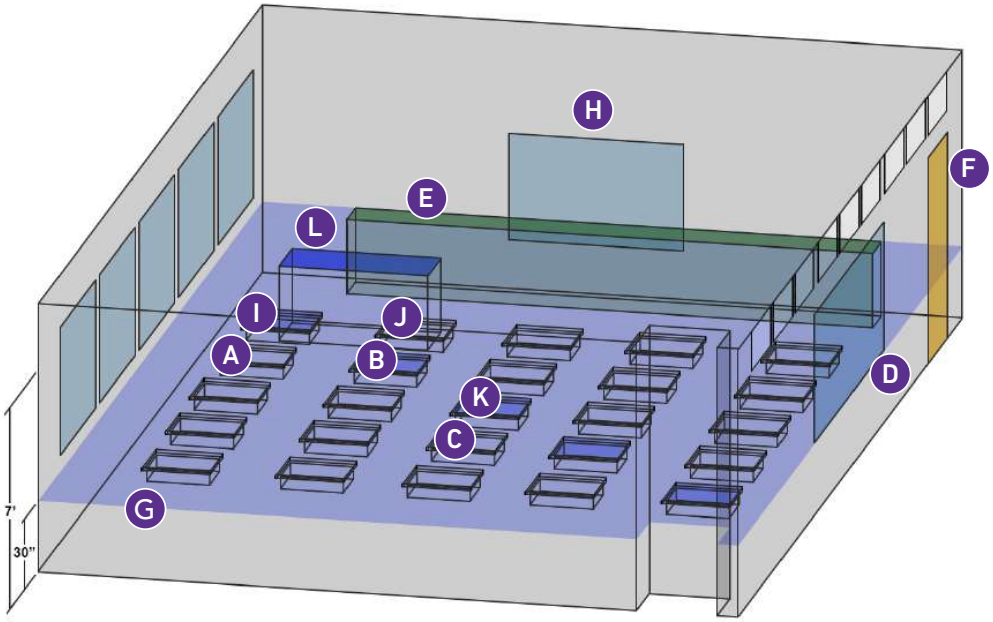


*illustration may not be to scale

BLT with Care222® Technology		
EXAMPLE ROOM SPECS	Ceiling Height	11’
	Room Reflectance for Illumination	80% ceiling, 50% walls, 20% floor, 30% other surfaces
	Room Reflectance for 222nm	5% ceiling, walls, floors and other surfaces
	Fixture type and quantities	(12) 2BLT4 2UV222 D132 40L ADSMT LP840
BLT WHITE LIGHT ILLUMINATION METRICS	Average Illumination at 2.5’ AFF	41 FC
	Uniformity	2.5:1 Max:Min
	Lighting Power Density	0.49 W/sq. ft.
	Annual Energy Use 10hrs/day 5 days/week	967 kWh
	Annual Energy Cost at $0.1062 per kWh[4] (national commercial average)	$102.72
CARE222 UV METRICS	Maximum 8-hr. dose at 7’ AFF head height[5]	19.49 mJ/cm^2
	UV power density	0.52 W/sq. ft.
	Annual energy use based on dose scheme	188.9 kWh
	Annual energy cost at $0.1062 per kWh[4] (national commercial average)	$20.06

Care222® Technology Projected Pathogen Inactivation on Surfaces

Use the chart below to estimate the effectiveness of the design shown in the Reflected Ceiling Plan on page 6 using dual-module BLT with Care222 technology products in inactivating the listed pathogens on surfaces. The calculated average dose for each location within the room is determined from Visual® Lighting Software radiometric modeling** and is then correlated with laboratory research[3] to derive projected inactivation effectiveness for specific pathogens. For illustration purposes the calculations include illustrated objects combined with surfaces highlighted as a calculation zone. For different designs, consult an Acuity Brands UV Lighting Specialist surfaces designated for calculation.



Calculation Zones[3]		
ZONE	**TARGET OBJECTS**	**DOSE**
A	CHAIR 1 TOP RAIL	22.0 mJ/cm^2 over 24 hr
B	CHAIR 2 TOP RAIL	21.3 mJ/cm^2 over 24 hr
C	CHAIR 3 TOP RAIL	23.4 mJ/cm^2 over 24 hr
D	CORK BOARD	5.0 mJ/cm^2 over 24 hr
E	CREDENZA	15.3 mJ/cm^2 over 24 hr
F	DOOR VERTICAL	4.9 mJ/cm^2 over 24 hr
G	LEVEL 2.5' AFF	19.4 mJ/cm^2 over 24 hr
H	SMART BOARD	5.6 mJ/cm^2 over 24 hr
I	STUDENT DESK 1	21.8 mJ/cm^2 over 24 hr
J	STUDENT DESK 2	21.3 mJ/cm^2 over 24 hr
K	STUDENT DESK 3	23.4 mJ/cm^2 over 24 hr
L	TEACHER DESK	22.2 mJ/cm^2 over 24 hr

** As a result of the computational limitations and simplifying modeling assumptions in Visual Lighting Software, variations in actual product performance from tested product samples and/or variation in field conditions from laboratory testing conditions, the accuracy of calculated output values identifying radiometric quantities and any resulting derived radiation dose predictions may be adversely affected. See Complete Disclaimer.

[3] See pathogen inactivation dose reference list – 222nm, 254nm, & Pulsed Xenon UV Light Sources

Care222® Projected Pathogen Inactivation on Surfaces

SARS-CoV-2[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	1.3 hr	3.9 hr
B	>99.9 %	1.3 hr	4.0 hr
C	>99.9 %	1.2 hr	3.7 hr
D	>99.9 %	5.8 hr	17.3 hr
E	>99.9 %	1.9 hr	5.7 hr
F	>99.9 %	5.9 hr	17.6 hr
G	>99.9 %	1.5 hr	4.4 hr
H	>99.9 %	5.1 hr	15.3 hr
I	>99.9 %	1.3 hr	4.0 hr
J	>99.9 %	1.4 hr	4.1 hr
K	>99.9 %	1.2 hr	3.7 hr
L	>99.9 %	1.3 hr	3.9 hr

Influenza A (H1N1)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	2.2 hr	6.5 hr
B	>99.9 %	2.2 hr	6.7 hr
C	>99.9 %	2.0 hr	6.1 hr
D	99.7 %	9.6 hr	28.8 hr
E	>99.9 %	3.1 hr	9.4 hr
F	99.6 %	9.8 hr	29.4 hr
G	>99.9 %	2.5hr	7.4 hr
H	99.8 %	8.5 hr	25.5 hr
I	>99.9 %	2.2 hr	6.6 hr
J	>99.9 %	2.3 hr	6.8 hr
K	>99.9 %	2.1 hr	6.2 hr
L	>99.9 %	2.2 hr	6.5 hr

[3] See pathogen inactivation dose reference list - 222nm, 254nm, & Pulsed Xenon UV Light Sources

Care222® Projected Pathogen Inactivation on Surfaces

Feline Calicivirus (FCV)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	7.0 hr	20.9 hr
B	>99.9 %	7.2 hr	21.6 hr
C	>99.9 %	6.5 hr	19.6 hr
D	83.5 %	30.7 hr	92.0 hr
E	99.6 %	10.0 hr	30.1 hr
F	82.9 %	31.3 hr	93.9 hr
G	>99.9 %	7.9 hr	23.7 hr
H	86.9 %	27.2 hr	81.5 hr
I	>99.9 %	7.0 hr	21.1 hr
J	>99.9 %	7.2 hr	21.6 hr
K	>99.9 %	6.6 hr	19.7 hr
L	>99.9 %	6.9 hr	20.7 hr

Staphylococcus Aureus (MRSA)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	4.8 hr	14.4 hr
B	>99.9 %	5.0 hr	14.9 hr
C	>99.9 %	4.5 hr	13.5 hr
D	92.7 %	21.1 hr	63.4 hr
E	>99.9 %	6.9 hr	20.8 hr
F	92.3 %	21.6 hr	64.7 hr
G	>99.9 %	5.4 hr	16.3 hr
H	94.8 %	18.7 hr	56.2 hr
I	>99.9 %	4.9 hr	14.6 hr
J	>99.9 %	5.0 hr	14.9 hr
K	>99.9 %	4.5 hr	13.6 hr
L	>99.9 %	4.8 hr	14.3 hr

[3] See pathogen inactivation dose reference list - 222nm, 254nm, & Pulsed Xenon UV Light Sources

Care222® Projected Pathogen Inactivation on Surfaces

Salmonella Enterica (Salmonella)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	3.1 hr	9.4hr
B	>99.9 %	3.2 hr	9.7 hr
C	>99.9 %	2.9 hr	8.8 hr
D	98.2 %	13.7 hr	41.2 hr
E	>99.9 %	4.5 hr	13.5 hr
F	98.1 %	14.0 hr	42.1 hr
G	>99.9 %	3.5 hr	10.6 hr
H	98.9 %	12.2 hr	36.6 hr
I	>99.9 %	3.2 hr	9.5 hr
J	>99.9 %	3.2 hr	9.7 hr
K	>99.9 %	2.9 hr	8.8 hr
L	>99.9 %	3.1 hr	9.3 hr

Escherichia Coli (E. coli)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	2.2 hr	6.6 hr
B	>99.9 %	2.3 hr	6.8 hr
C	>99.9 %	2.0 hr	6.1 hr
D	99.7 %	9.6 hr	28.8 hr
E	>99.9 %	3.1 hr	9.4 hr
F	99.6 %	9.8 hr	29.4 hr
G	>99.9 %	2.5 hr	7.4 hr
H	99.8 %	8.5 hr	25.6 hr
I	>99.9 %	2.2 hr	6.6 hr
J	>99.9 %	2.3 hr	6.8 hr
K	>99.9 %	2.1 hr	6.2 hr
L	>99.9 %	2.2 hr	6.5 hr

[3] See pathogen inactivation dose reference list - 222nm, 254nm, & Pulsed Xenon UV Light Sources

Care222® Technology Projected Pathogen Inactivation in Air

Use the chart below to estimate the effectiveness of the design shown in the Reflected Ceiling Plan on page 6 using BLT with Care222 technology products in inactivating the listed pathogens in the air. The calculated average dose for each location within the room is determined from Visual® Lighting Software radiometric modeling** and is then correlated with laboratory research[3] to derive projected inactivation effectiveness for specific pathogens.

Care222 Air Pathogen Reduction Performance

Type	Microbe	Dose over 24 hr period (mJ/cm²)	eACH	Hours to 90.0% Pathogen reduction	Hours to 99.9% Pathogen reduction
VIRUSES	SARS-CoV-2	22.8	1.83	1.3	3.8
	Influenza A (H1N1)		1.73	1.3	4.0
	Feline Calcivirus (FCV)		0.34	6.7	20.1
BACTERIA	Staphylococcus aureus (MSRA)		0.50	4.6	13.9
	Salmonella enterica		0.77	3.0	9.0
	Escherichia coli		1.09	2.1	6.3
	Pseudomonas aeruginosa		1.11	2.1	6.3
	Clostridium difficile (endospores)		0.19	12.1	36.2
FUNGUS	Candida albicans		0.16	14.6	43.7

**As a result of the computational limitations and simplifying modeling assumptions in Visual Lighting software, variations in actual product performance from tested product samples and/or variation in field conditions from laboratory testing conditions, the accuracy of calculated output values identifying radiometric quantities and any resulting derived radiation dose predictions may be adversely affected. See Complete Disclaimer.

[2] See pathogen inactivation dose reference list – 222nm, 254nm, & Pulsed Xenon UV Light Sources

Unoccupied Spaces with White Light and Pulsed Xenon UV Disinfection Technology for Surface Air Treatment

PulseX™ Dual Unit

2'x4' BLT

PulseX™ Dual Unit with Violet Defense® Technology and 2'x4' BLT Luminaire

Design Intent	Design Approach by Technology
Achieve high quality volumetric light distribution	BLT has high performance extruded acrylic diffusers to conceal LEDs and efficiently deliver light in a volumetric distribution
Controls for dimming and ability to utilize natural light when possible	Wired and wireless control through our nLight® platform offers occupancy sensing, daylight harvesting and more
Rapid treatment of desks, chairs and other high touch surfaces in the space by using a high intensity, broad spectrum of UV wavelengths	Dual PulseX unit delivers a short duration UV air and surface treatment* while the space is unoccupied.

EXPLORE PulseX >

EXPLORE 2'x4' BLT >

Reflected Ceiling Plan*

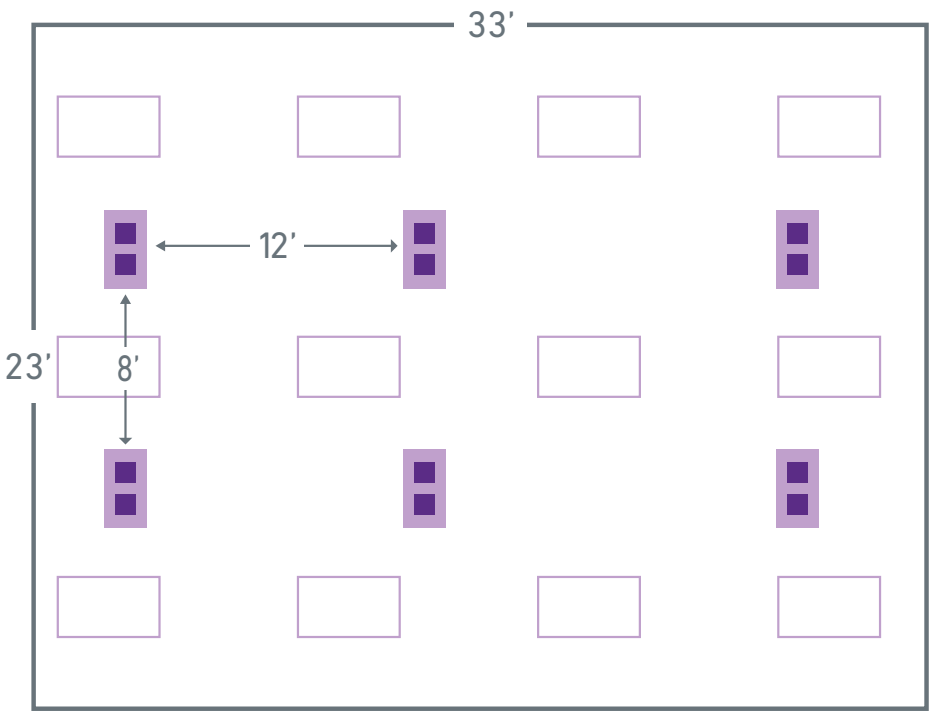
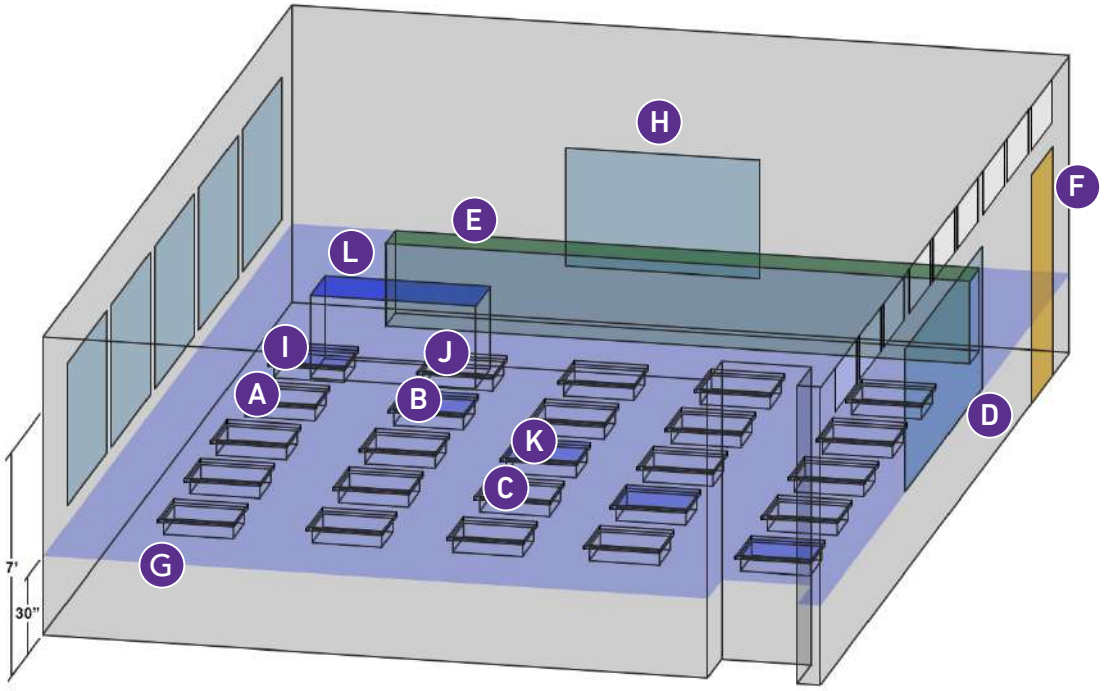


*Illustration may not be drawn to scale

PulseX™ and BLT Luminaire		
EXAMPLE ROOM SPECS	Ceiling Height	11'
	Room Reflectance for Illumination	80% ceiling, 50% walls, 20% floor, 30% other surfaces
	Room Reflectance for PulseX	0% ceiling, walls, floors and other surfaces
	Fixture type and quantities	(12) 2BLT4 40L ADP LP840 (6) HXMD UVX 120
BLT WHITE LIGHT ILLUMINATION METRICS	Average Illumination at 2.5' AFF	41 FC
	Uniformity	2.5:1 Max:Min
	Lighting Power Density	0.49 W/sq. ft.
	Annual Energy Use 10hrs/day 5 days/week	967 kWh
	Annual Energy Cost at $0.1062 per kWh[4] (national commercial average)	$102.72
PULSEX™ DUAL UNIT UV METRICS	UV power density	0.99 W/ sq. ft.
	Annual energy Cost for one 30-minute treatment cycle per day	45.6 kWh
	Annual energy cost at $0.1062 per kWh[4] (national commercial average)	$4.85

PulseX™ Projected Pathogen Inactivation on Surfaces

Use the chart below to estimate the effectiveness of the design shown in the Reflected Ceiling Plan on page 13 in inactivating the listed pathogens on surfaces. The calculated average dose for each location within the room is determined from Visual® Lighting Software radiometric modeling** and is then correlated with laboratory research[3] to derive projected inactivation effectiveness for specific pathogens. For illustration purposes the calculations include illustrated objects combined with surfaces highlighted as a calculation zone.



Calculation Zones[3]		
ZONE	**TARGET OBJECTS**	**DOSE**
A	CHAIR 1	18.1 mJ/cm^2 over 30 min.
B	CHAIR 2	30.6 mJ/cm^2 over 30 min.
C	CHAIR 3	33.8 mJ/cm^2 over 30 min.
D	CORK BOARD	15.9 mJ/cm^2 over 30 min.
E	CREDENZA	19.0 mJ/cm^2 over 30 min.
F	DOOR VERTICAL	11.8 mJ/cm^2 over 30 min.
G	LEVEL 2.5' AFF	24.2 mJ/cm^2 over 30 min.
H	SMART BOARD	20.6 mJ/cm^2 over 30 min.
I	STUDENT DESK 1	17.7 mJ/cm^2 over 30 min.
J	STUDENT DESK 2	29.7 mJ/cm^2 over 30 min.
K	STUDENT DESK 3	36.1 mJ/cm^2 over 30 min.
L	TEACHER DESK	22.0 mJ/cm^2 over 30 min.

**As a result of the computational limitations and simplifying modeling assumptions in Visual Lighting Software, variations in actual product performance from tested product samples and/or variation in field conditions from laboratory testing conditions, the accuracy of calculated output values identifying radiometric quantities and any resulting derived radiation dose predictions may be adversely affected.
See Complete Disclaimer.

[3] See pathogen inactivation dose reference list – 222nm, 254nm, & Pulsed Xenon UV Light Sources

PulseX™ Projected Pathogen Inactivation on Surfaces

SARS-CoV-2[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	0.2 hr	0.5 hr
B	>99.9 %	0.1 hr	0.3 hr
C	>99.9 %	0.1 hr	0.3 hr
D	99.8 %	0.2 hr	0.5 hr
E	>99.9 %	0.2 hr	0.5 hr
F	99.1 %	0.2 hr	0.7 hr
G	>99.9 %	5.7 hr	17.1 hr
H	>99.9 %	0.1 hr	0.4 hr
I	>99.9 %	0.2 hr	0.5 hr
J	>99.9 %	0.1 hr	0.3 hr
K	>99.9 %	0.1 hr	0.2 hr
L	>99.9 %	0.1 hr	0.4 hr

Influenza A (H1N1)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	99.0 %	0.3 hr	0.8 hr
B	>99.9 %	0.1 hr	0.4 hr
C	>99.9 %	0.1 hr	0.4 hr
D	98.2 %	0.3 hr	0.9 hr
E	99.2 %	0.2 hr	0.7 hr
F	94.8 %	0.4 hr	1.2 hr
G	99.8 %	9.1 hr	27.3 hr
H	99.4 %	0.2 hr	0.7 hr
I	98.8 %	0.3 hr	0.8 hr
J	>99.9 %	0.2 hr	0.5 hr
K	>99.9 %	0.1 hr	0.4 hr
L	99.6 %	0.2 hr	0.6 hr

[3] See pathogen inactivation dose reference list - 222nm, 254nm, & Pulsed Xenon UV Light Sources

PulseX™ Projected Pathogen Inactivation on Surfaces

Feline Calicivirus (FCV)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	81.4 %	0.7 hr	2.1 hr
B	94.1 %	0.4 hr	1.2 hr
C	95.7 %	0.4 hr	1.1 hr
D	77.1 %	0.8 hr	2.3 hr
E	82.9 %	0.7 hr	2.0 hr
F	66.6 %	1.1 hr	3.2 hr
G	89.4 %	24.6 hr	73.8 hr
H	85.3 %	0.6 hr	1.8 hr
I	80.6 %	0.7 hr	2.1 hr
J	93.7 %	0.4 hr	1.3 hr
K	96.5 %	0.3 hr	1.0 hr
L	87.1 %	0.6 hr	1.7 hr

Staphylococcus Aureus (MRSA)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	0.1 hr	0.2 hr
B	>99.9 %	0.0 hr	0.1 hr
C	>99.9 %	0.0 hr	0.1 hr
D	>99.9 %	0.1 hr	0.2 hr
E	>99.9 %	0.1 hr	0.2 hr
F	>99.9 %	0.1 hr	0.3 hr
G	>99.9 %	2.2 hr	6.7 hr
H	>99.9 %	0.1 hr	0.2 hr
I	>99.9 %	0.1 hr	0.2 hr
J	>99.9 %	0.0 hr	0.1 hr
K	>99.9 %	0.0 hr	0.1 hr
L	>99.9 %	0.1 hr	0.2 hr

[3] See pathogen inactivation dose reference list - 222nm, 254nm, & Pulsed Xenon UV Light Sources

PulseX™ Projected Pathogen Inactivation on Surfaces

Salmonella Enterica (Salmonella)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	0.1 hr	0.2 hr
B	>99.9 %	0.0 hr	0.1 hr
C	>99.9 %	0.0 hr	0.1 hr
D	>99.9 %	0.1 hr	0.3 hr
E	>99.9 %	0.1 hr	0.2 hr
F	>99.9 %	0.1 hr	0.4 hr
G	>99.9 %	3.0 hr	8.9 hr
H	>99.9 %	0.1 hr	0.2 hr
I	>99.9 %	0.1 hr	0.3 hr
J	>99.9 %	0.1 hr	0.2 hr
K	>99.9 %	0.0 hr	0.1 hr
L	>99.9 %	0.1 hr	0.2 hr

Escherichia Coli (E. Coli)[3]			
ZONE	PATHOGEN LOAD REDUCTION	HRS to 90.0%	HRS to 99.9%
A	>99.9 %	0.1 hr	0.3 hr
B	>99.9 %	0.1 hr	0.2 hr
C	>99.9 %	0.1 hr	0.2 hr
D	>99.9 %	0.1 hr	0.3 hr
E	>99.9 %	0.1 hr	0.3 hr
F	>99.9 %	0.1 hr	0.4 hr
G	>99.9 %	3.4 hr	10.2 hr
H	>99.9 %	0.1 hr	0.2 hr
I	>99.9 %	0.1 hr	0.3 hr
J	>99.9 %	0.1 hr	0.2 hr
K	>99.9 %	0.0 hr	0.1 hr
L	>99.9 %	0.1 hr	0.2 hr

[3] See pathogen inactivation dose reference list - 222nm, 254nm, & Pulsed Xenon UV Light Sources

PulseX™ Projected Pathogen Inactivation in Air

Use the chart below to estimate the effectiveness of the design shown in the Reflected Ceiling Plan on page 13 in inactivating the listed pathogens in the air. The calculated average dose for each location within the room is determined from Visual® Lighting Software radiometric modeling** and is then correlated with laboratory research[3] to derive projected inactivation effectiveness for specific pathogens.

PulseX Air Pathogen Reduction Performance

Type	Pathogen	30-min treatment cycle	Pathogen reduction after 30-minute treatment cycle
VIRUSES	SARS-CoV-2	47.1mJ/cm^2 average dose in volume of air	>99.9 %
	Influenza A (H1N1)		>99.9 %
	Feline Calcivirus (FCV)		98.7 %
BACTERIA	Staphylococcus aureus		>99.9 %
	Salmonella enterica		>99.9 %
	Escherichia coli		>99.9 %

**As a result of the computational limitations and simplifying modeling assumptions in Visual Lighting Software, variations in actual product performance from tested product samples and/or variation in field conditions from laboratory testing conditions, the accuracy of calculated output values identifying radiometric quantities and any resulting derived radiation dose predictions may be adversely affected. See Complete Disclaimer.

[3] See pathogen inactivation dose reference list – 222nm, 254nm, & Pulsed Xenon UV Light Sources

Occupied Spaces with Onboard Air UV Disinfection* Technology for Air Treatment

EvolAIR UV™

2'x4' BLT

EvolAIR UV™ and 2'x4' BLT Luminaire

Design Intent	Design Approach by Technology
Achieve high quality volumetric light distribution	BLT has high performance extruded acrylic diffusers to conceal LEDs and efficiently deliver light in a volumetric distribution
Controls for dimming and ability to utilize natural light when possible	Wired and wireless control through our nLight platform offers occupancy sensing, daylight harvesting and more
Discreet, continuous UV-C air pathogen reduction for moderately populated, occupied spaces	Standalone 2x4 EvolAIR UV continuously treats the air 24/7 reducing pathogens by drawing up air through a filter, passing it through a concealed chamber of 254nm UV and then returning treated air back into the space

EXPLORE EvolAIR UV >

EXPLORE 2'x4' BLT >

Reflected Ceiling Plan*

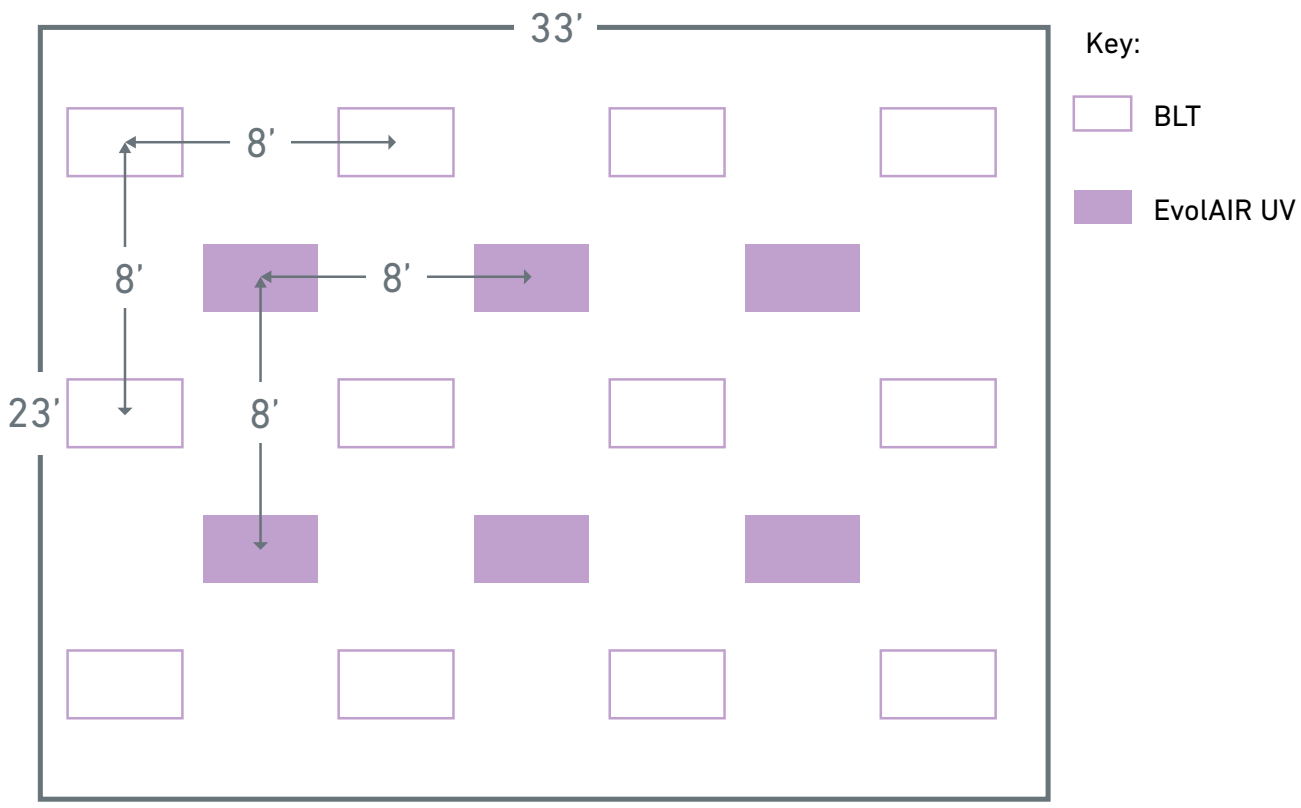
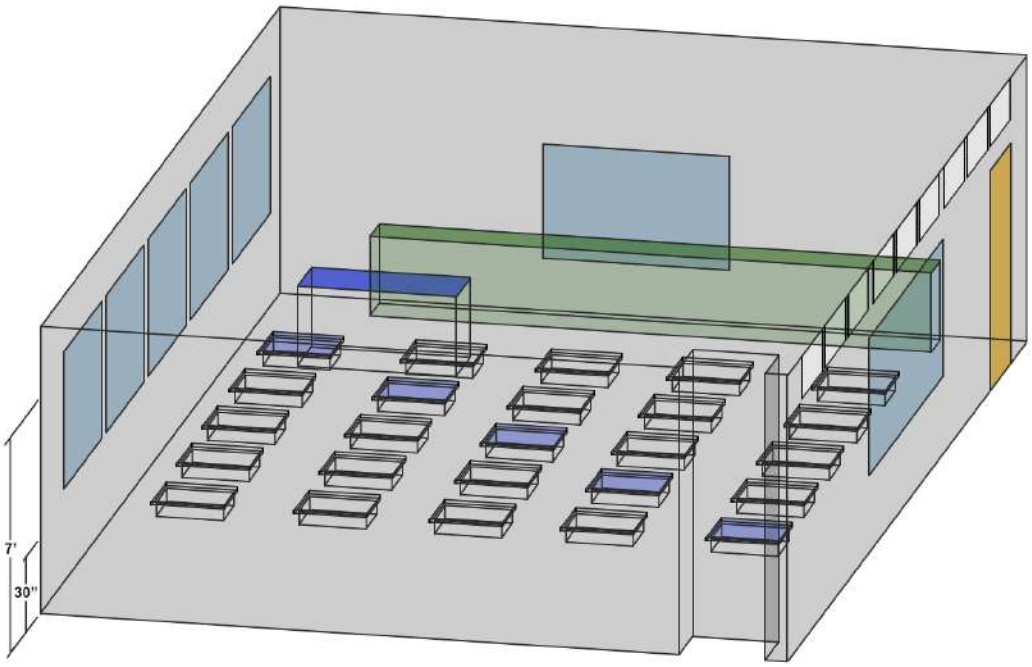


Illustration may not be drawn to scale

EvoLAIR UV™ and BLT Luminaire		
EXAMPLE ROOM SPECS	Ceiling height	11'
	Room reflectance for illumination	80% ceiling, 50% walls, 20% floor, 30% other surfaces
	Fixture type and quantities	(12) 2BLT4 40L ADP LP840 (6) HFLV NDN UV254 MVOLT
BLT WHITE LIGHT ILLUMINATION METRICS	Average illumination at 2.5' AFF	41 FC
	Uniformity	2.5:1 Max:Min
	Lighting power density	0.49 W/sq. ft.
	Annual energy Use 10hrs/day 5 days/week	967 kWh
	Annual energy cost at $0.1062 per kWh[4] (national commercial average)	$102.72
EVOLAIR UV METRICS	EvolAIR UV power density	0.91 W/sq. ft.
	Annual Energy Cost for 24 hr/day operation	6044 kWh
	Annual energy cost at $0.1062 per kWh[4] (national commercial average)	$641.92

EvolAIR UV™ Effectiveness Against Pathogens in Air

EvolAIR UV combines two treatments in its approach to reducing airborne pathogens. First the contaminated air is drawn through the EvolAIR UV Rigid Pad to provide preliminary removal of microbes and particulate matter exhibiting variable removal rates within specific size ranges. The air is then drawn through a chamber and treated by 254nm UV. This dual function treatment system results in a specific Clean Air Delivery Rate (CADR) for different pathogens. Using the CADR calculation, equivalent air changes per hour (eACH) and the hourly percent pathogen reduction projections are derived based on the average volume of air being treated per EvolAIR fixture.



Type	Pathogen	CADR* (cfm)	eACH*	Reduction @ 1hr*	$t_{99.9}$ (hr) *
VIRUSES	SARS-CoV-2	50	2.16	88.4%	3.20
	Influenza A (H1N1)	50	2.16	88.4%	3.20
	Feline Calcivirus (FCV)	50	2.15	88.4%	3.21
BACTERIA	Staphylococcus aureus	50	2.16	88.4%	3.20
	Salmonella enterica	48	2.08	87.5%	3.33
	Escherichia coli	50	2.16	88.4%	3.20
	Mycobacterium tuberculosis	50	2.16	88.4%	3.20
	Pseudomonas aeruginosa	50	2.16	88.4%	3.20
	Clostridium difficile (endospores)	49	2.12	88.0%	3.25
FUNGUS	Candida albicans	50	2.15	88.4%	3.21

*For a complete explanation of the calculation method used to derive these quantities and project pathogen reduction levels, refer to EvolAir Application Methodology for Determining Projected Levels of Pathogen Inactivation.

Additional Resources

For more information on our UV technologies, click here or visit www.acuitybrands.com/UV

For an extensive list of FAQs covering everything from the science behind UV technology to specific product information, click here or visit www.acuitybrands.com/UVFAQ

For a list of published research on the topic of UV, click here or visit www.acuitybrands.com/UVresearch

Application design layout and associated projected reduction of pathogenic bioburden available by requesting a consultation with an Acuity Brands UV lighting specialist. www.acuitybrands.com/UV-Consultation

*UV Light Disinfection Technology Disclaimer

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 pathogenic bioburden is a function of fixture run time and the distance to the UV light source, airflow, room size, shadow areas and/or other factors, and the level of reduction will vary within a specific space. The fixtures shown in this guide are not intended for use in the cure, mitigation or prevention of disease and are not certified or approved for use as a medical device by the FDA. It is the obligation of the end-user to consult with appropriately qualified Professional Engineer(s), a Certified Infection Control Professional and a Certified Industrial Hygienist, as applicable, to determine whether these fixtures meet the applicable requirements for system performance, code compliance, safety (including safety and hazard alerting signs), suitability and effectiveness for use in a particular application design. In no event will Acuity Brands Lighting be responsible for any loss resulting from any use of these fixtures meet in an application design.

**Visual® Lighting Application Design Disclaimer

An application design that is generated by an application designer using Visual® Lighting application software is not a professional engineering drawing, and the design, including reported data and calculated results, is for informational purposes only, without any warranty as to accuracy, completeness, safety or otherwise. Such design is the result of calculations made using the Visual software, photometric/radiometric data measured in a laboratory, and certain computational and modeling assumptions.

Far-field photometric/radiometric data may have been used to perform one or more calculations. Photometric/radiometric data is typically collected under far-field measurement conditions; far-field data is not generally representative of near-field geometric conditions. When using far-field photometric/ radiometric data, the Visual software applies certain generalizing assumptions to approximate near-field performance. These approximations may result in significant inaccuracies in individual calculated luminous and/or radiant power quantities in areas where a source is in close proximity to a particular surface or point.

The modeling of radiant flux exchange used in the Visual software requires a uniform exitance across each reflecting surface. The Visual software approximates the uniform surface exitance condition by adaptively subdividing surfaces with non-uniform exitances into subsurfaces with sufficiently uniform exitance gradients. Practical restrictions, due to computer hardware limitations, may prevent the subdivision procedure from subdividing surfaces with high exitance gradients into subsurfaces with sufficiently uniform exitance gradients, introducing potential discretization error into calculated values.

Calculations performed by the Visual software assume that all reflected flux is reflected in a perfectly diffuse (Lambertian) and spectrally uniform manner across the spectral range being analyzed. If actual reflectance characteristics differ from these assumptions, observed luminous and/or radiant power quantities may differ from predicted quantities.

Volumetric calculations to determine projected levels of pathogen inactivation assume perfect air mixing throughout the specified air volume in order to use the average fluence of the air volume as a simplifying modeling assumption. If actual air mixing conditions differ from the assumption of perfect air mixing, observed levels of pathogen inactivation may differ from projected results.

As a result of the computational limitations and simplifying modeling assumptions described above and/or variations in actual product performance from tested product samples, the accuracy of calculated output values identifying expected radiometric quantities and any resulting derived radiation dose calculations may be adversely affected.

In addition, the accuracy of the application design may be adversely affected if information about the physical space provided to the application designer is incomplete, inaccurate, outdated or not in the required format (including but not limited to floor plans, space layout, reflected ceiling plans, physical structures, electrical design or specifications), if incorrect assumptions are made because of such deficiencies in the information provided, or if typical assumptions made about the depicted physical space are not appropriate for the space. Furthermore, actual field performance may differ from performance calculated using laboratory measurements as the result of miscalculations related to deficiencies in the information provided about the physical space, degradation factors in the end- user environment (including, but not limited to, voltage variation and dirt accumulation), or other possible variations in field conditions. Finally, lamp lumen depreciation and/or depreciation in lamp radiant intensity may result in performance over time that differs from performance calculated using a new lamp. Light loss factors may have been used in the application design to estimate such depreciation, but flaws in these estimates may also result in performance over time that differs from calculated performance.

If the application design is based on germicidal ultraviolet radiometric performance analysis, and there is any adverse effect on the derived irradiation dose predictions resulting from any of the factors described above, projected levels of pathogen inactivation provided in connection with this application design may be understated or overstated because the calculated dose of irradiation is used to determine these projected levels of inactivation. Similarly, if the calculated values are used to confirm expected operation within published guidelines for acceptable levels of exposure to UV radiation, such values may also be understated or overstated because the calculated dose of irradiation is used to determine these projected levels of inactivation. Projected levels of pathogen inactivation and calculated levels of exposure, at particular doses of irradiation, have been determined based on references in the Pathogen Inactivation Dose Reference List, published ACGIH® Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices (unless a custom inactivation dose and/or exposure limit has been requested), and lab testing results available from Acuity Brands Lighting. All projections are subject to the limitations stated in the lab testing results and published references.

It is the obligation of the end-user to consult with appropriately qualified Professional Engineer(s), a Certified Infection Control professional and/or a Certified Industrial Hygienist, as applicable, to evaluate, interpret and apply the information available in the referenced resources and to determine whether the application design meets the applicable requirements for performance, code compliance, safety, suitability and effectiveness for use in a particular application. In no event will Acuity Brands Lighting be responsible for any loss resulting from any use of an application design.

Footnotes

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

[2] ACGIH® 2021 TLVs® and BEIs® - Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices. The levels of exposure in the ACGIH guidelines are quantified as Threshold Limit Values (TLVs®) and are expressed as Time-Weighted Averages (TWAs). The TLVs for incoherent ultraviolet (UV) radiation are established for wavelengths between 180 and 400 nm and represent conditions under which it is believed that nearly all healthy workers may be repeatedly exposed without acute adverse health effects such as erythema and photokeratitis. ACGIH guidelines are designed for use by industrial hygienists in making decisions regarding safe levels of exposure to hazards in the workplace.

[3] Pathogen Inactivation Dose Reference List - 222nm, 254nm & Pulsed Xenon UV Light Source.

[4] Kalinoski, G. (2019), What You'll Pay for Electricity in 2020.

[5] This value is checked against exposure guidelines established and published by the American Conference of Governmental Industrial Hygienists (ACGIH®). For the UV exposure dose to remain within the ACGIH guidelines for the level of UV exposure a typical worker can be exposed to without adverse health effects, the maximum exposure dose must not exceed 23 mJ/cm2 (millijoules per square centimeter) for an 8-hour period of time. Per the UL 8802 standard, the upper limit of occupied space is defined to be a test plane 7' Above Finished Floor (AFF). This calculated maximum exposure dose represents the dose an individual would receive over an 8-hour period at 7' Above Finished Floor (AFF) even if stationary in the location of maximum dose. The levels of exposure in the ACGIH guidelines are quantified as Threshold Limit Values (TLVs®) and are expressed as Time-Weighted Averages (TWAs). The TLVs for incoherent ultraviolet (UV) radiation are established for wavelengths between 180 and 400 nm and represent conditions under which it is believed that nearly all healthy workers may be repeatedly exposed without acute adverse health effects such as erythema and photokeratitis. ACGIH guidelines are designed for use by industrial hygienists in making decisions regarding safe levels of exposure to hazards in the workplace.

[6] Kowalski, W. (2009), Ultraviolet Germicidal Handbook, Chapter 8, Springer-Verlag.