Krypton Disinfection Lighting

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October 13, 2020

FAR UV TECHNOLOGIES

Krypton-11™

Far UV 222nm Ceiling Mount Disinfection Lighting

Far UV Krypton-11 disinfection lighting can be used within any budget to increase the safety of occupants of any environment. Since the immune system of any occupant of space is unknown, the goal is to reduce the viral load as much as possible. Krypton-11 disinfection lighting is the only practical, safe and effective air AND surface disinfection method that can be used while space is occupied.

Dimensions

Diameter: 7.6" (193mm)
Height: 1.76" (44.7mm)

Features & Benefits:

- Up to 3 log+ (99.9%) cumulative disinfection per day
- Designed to meet and not exceed IEC/EN 62471 and ACGIH 222nm UV exposure Threshold Limit Values (TLV) for human exposure
- Air and surface disinfection for up to 250 sq. ft. per fixture with 8-11 ft. ceiling
- No degradation in output over the life of the lamp
- Environmentally friendly/Mercury free
- Instant On/Off
- Delivered dosage is not impacted by ambient temperature

Certifications

Company EPA Registration #96253

ISO 9001 Certified

Made in U.S.A.

Krypton-11™

Product Specifications:

Electrical

Operating Voltage: (optional 24VDC available)	12VDC +/-1
Input Power Nominal	10W +/-1
Input Power Max.	15W
Input Current Nominal	.85A +/-.1
Input Current Max.	1.25A

Optical Properties

Lamp Life:	3,000 hrs
Expected Luminaire Life: (depending on operating parameters)	Up to 15 years
200-230nm Output:	38mW (peak @ 222nm)
Beam Dispersion:	0-80° (1/2 angle)

Operation & Storage

Operating Temperature Range:	-20°C to 60°C
Operating Humidity:	10-80%
Altitude:	0-10,000 ft.
Storage Humidity:	<90%
Storage Temperature:	<60°C

Included Accessories:

- 100-277VAC 50/60 Hz to 12VDC 60W transformer
- Drop ceiling clip mount
- Ceiling mounting plate and hardware for ¼ twist lock installation
- 20 ft., 2 conductor shielded cable
- Installation manual

Applications:

- Medical and dental facilities
- Government and defense facilities
- Commercial office, elevators and stairwells
- Public facilities (airports, city halls, museums, theaters, amusement parks, bathrooms)
- Transportation (airplanes, buses, cruise ships, trains, subways and ferries)
- Elderly care facilities
- Daycare centers
- Grocery and convenience stores
- Hotels, resorts and casinos
- Restaurants/Retail
- Universities and schools
- Athletic facilities (stadiums, locker rooms and equipment)
- Residential, Commercial and Industrial facilities
- Sanitation of water or chemical sensitive applications
- Food preparation and delivery
- Extending food shelf life
- Hand hygiene - no water, soap or paper towels
- Shipping and logistics

Krypton-36™

Far UV 222nm Ceiling-Mount Disinfection Lighting

The Krypton-36 disinfection lights are ideal for rooms with high ceilings that range from 11' to 35' foot ceilings. Krypton-36 can be used within any budget to increase the safety of occupants of any environment. Since the imune system of any occupant of spaces unknown, the goal is to reduce the viral load as much as possible. Krypton-36 disinfection lighting is the only practical, safe and effective air AND surface disinfection method that can be used while space is occupied.

Dimensions

Length: 11.0" (279mm)
Width: 7.0" (177mm)
Height: 2.152" (54.6mm)

Features & Benefits:

- Up to 3 log+ (99.9%) cumulative disinfection per day
- Designed to meet and not exceed IEC/EN 62471 and ACGIH 222nm UV exposure Threshold Limit Values (TLV) for human exposure
- Air and surface disinfection for up to 1000 sq. ft. per fixture
- Recommended for 11-35 foot ceiling heights
- No degradation in output over the life of the lamp
- Environmentally friendly/Mercury free
- Instant On/Off
- Delivered dosage is not impacted by ambient temperature

Certifications

Company EPA Registration #96253

ISO 9001 Certified

Made in U.S.A.

FAR UV TECHNOLOGIES

www.faruv.com

Krypton-36™

Product Specifications:

Electrical

Operating Voltage:	24VDC +/-1
Input Power Nominal	12W +/-1
Input Power Max.	15W
Input Current Nominal	.50A +/-.1
Input Current Max.	.63A

Optical Properties

Lamp Life:	3,000 hrs
Expected Luminaire Life: (depending on operating parameters)	Up to 15 years
200-230nm Output:	320mW (peak @ 222nm)
Beam Dispersion:	0-40° (1/2 angle)

Operation & Storage

Operating Temperature Range:	-20°C to 60°C
Operating Humidity:	10-80%
Altitude:	0-10,000 ft.
Storage Humidity:	<90%
Storage Temperature:	<60°C

Included Accessories:

- 100-277VAC 50/60 Hz to 24VDC 60W transformer
- Drop ceiling clip mount
- Ceiling mounting plate and hardware for ¼ twist lock installation
- 20 ft., 2 conductor shielded cable
- Installation manual

Applications:

- Medical and dental facilities
- Government and defense facilities
- Commercial office, elevators and stairwells
- Public facilities (airports, city halls, museums, theaters, amusement parks, bathrooms)
- Transportation (airplanes, buses, cruise ships, trains, subways and ferries)
- Elderly care facilities
- Daycare centers
- Grocery and convenience stores
- Hotels, resorts and casinos
- Restaurants/Retail
- Universities and schools
- Athletic facilities (stadiums, locker rooms and equipment)
- Industrial facilities
- Sanitation of water or chemical sensitive applications
- Food preparation and delivery
- Extending food shelf life
- Hand hygiene - no water, soap or paper towels
- Shipping and logistics

Far UV Technologies never stops innovating. It will introduce additional smart fixtures and an even higher-powered handheld unit before the end of 2020 to augment its Krypton disinfection solution portfolio to address almost any application.

Far UV Technologies has ramped its manufacturing capacity to several thousand units a month and expects to produce over 1 million units in 2021. Krypton disinfection lighting is manufactured in an ISO 9001 production facility and every unit shipped is tested to insure reliability.

Certificate US18/81627512.00

The management system of:

Pivot International

10932 Strang Line Road
Lenexa, KS 66215, United States

has been assessed and certified as meeting the requirements of:

ISO 9001:2015

For the following activities:

Sales, industrial design, prototyping and modelling, global purchasing and coordination of externally provided manufacturing of electronic products.

Further clarifications regarding the scope of this certificate and the applicability of ISO 9001:2015 requirements may be obtained by consulting the organization

This certificate is valid from 9 February 2018 until 9 February 2021 and remains valid subject to satisfactory surveillance audits.
Recertification audit due a minimum of 60 days before the expiration date.
Issue 1: 21 August 2018. Certified since 9 February 2015.

The audit leading to this certificate commenced on 19/09/2018.

This is a multi-site certification.
Additional site details are listed on subsequent pages.

Authorized by:

Ralph McLouth
Vice President of Accreditation, North America
SGS North America Inc.
201 Route 17 North, Rutherford NJ 07070, USA
t (201) 508-3000 f (201) 933-4555 www.us.sgs.com

This certificate remains the property of SGS and shall be returned upon request

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Krypton Far UV Safety White Paper

The safety of Krypton Far UV lighting is well-supported by short wavelength physics, by multiple peer-reviewed animal and human studies, and by the design of the Krypton unit which ensures that it remains within IEC/ACGIH guidelines. Because it is neither considered a cure for diseases (such as COVID-19) nor intended to be used for disinfecting equipment for medical procedures, the EPA rather than the FDA regulates the technology and does not require clinical studies; still, the number of peer-reviewed publications that support the safety of far UV lighting is significant. In this White Paper, we review the physics of Far UV lighting which shows that it is incapable of penetrating the superficial layer of the skin or eyes, the key published literature for safety studies in animals and humans, and the unique design of the Krypton light with its strict adherence to safety regulations and guidelines.

Physics and the Safety of Krypton Far UV Light

The physics of far UV-C light (ultraviolet C, short wavelength at 222 nanometers) is significantly different from conventional germicidal UV-C light (longer wavelength at 254 nm). Even though they are both capable of the same germicidal kill of microorganisms (including viruses), the 222 nm far UV-C light is unable to travel through biomaterials whereas the conventional germicidal 254 nm UV-C light can penetrate into the skin and the eye to cause damage. The reason for this difference lies in the ability for shorter UV-C light to be more quickly absorbed by proteins in the superficial layer of biomaterials; as a result, the light is only able to travel very short distances in the skin or eye. This is the reason why pure far UV-C light cannot penetrate the superficial layer of the skin called the stratum corneum, a layer that contains dead cells along with free proteins. Similarly, pure far UV-C light is unable to penetrate through the tear layer of the eye, a film that is rich in proteins. Therefore, the physics of far UV-C light at 222 nm do not allow for entry or damage to the skin or eyes, regardless of age, sex or ethnicity. It is important to note that devices that emit far UV-C light can also emit other light spectra, so it is necessary to use the appropriate device controls and filters (at high power) to limit the presence of longer wavelength contamination to ensure safety. The design of Krypton Far UV lights and its compliance to guidelines is critical to minimize the presence of longer wavelength emissions. In addition, Krypton Far UV lighting units are designed for ceiling installation to maximize the zone for germicidal kill while ensuring a distance between the light and the occupants within a public space as opposed to wand and portal devices which can easily get close to an occupant.

Regulations and the Safety of Krypton Far UV Light

For decades before the onset of the COVID-19 pandemic, common limits within an existing international regulatory framework had been established for the maximum daily exposure to all artificial UV-C wavelengths. Far UV Technologies designs its Krypton disinfection lighting products to stay within current threshold limit values (TLVs) as defined by the **International Committee on non-Ionizing Radiation Protection** (ICNIRP 14/2007), **American Conference of Governmental Industrial Hygienists** (ACGIH 2008), **European Commission** (2006/25/EC), **American National Standards Institute/Illuminating Engineering Society** (ANSI/IES RP-27.1-15), and **International Electrotechnical Commission** (CEI/IEC 62471:2006). Agreement on a spectral weighting and overall exposure limits allow

for these standards to be summarized in Figure 1, showing the expected daily (8- hour equivalent) safe exposure limit as a function of wavelength across the UV-C spectrum. Figure 1 below indicates that

these exposure limits (Threshold Limit Values or TLVs) are ~22-23 mJ/cm^2 at 222nm for Far UV and about ~6 mJ/cm^2 at around 254nm for conventional germicidal UV-C.

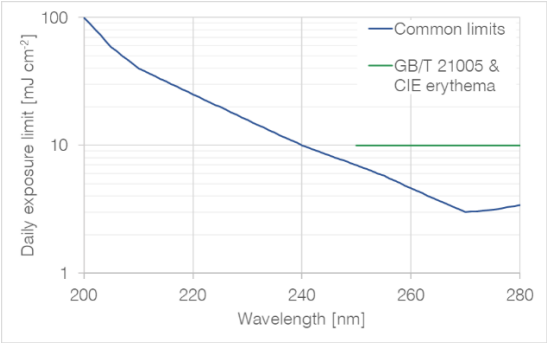

Figure 1: The daily exposure limits as a function of UV wavelength as determined by ACGIH, ICNIRP, 2006/25/EC, ANSI/IES RP 27.1-15, CEI/IEC 62471:2006 (common limits), and as per GB/T 21005 and CIE 187 for human skin erythema.

The most common far UV sources are Krypton Chloride ("KrCl") excimer lamps (tubular or micro-plasma type), in which a voltage applied across a sealed chamber containing the gas mix causes spontaneous generation of far UV photons. Excimer sources are not monochromatic (Figure 2) and the full emission spectrum must be considered when evaluating their safety. Emission spectra from KrCl lamps show a dominant peak at 222 nm with the majority (up to ~95%) of its total emissions +/-4 nm from 222nm. The remaining approximately 5-15% of the total power output of a typical unfiltered KrCl lamp often lies outside of this range including some within the conventional germicidal UV-C range between 230-260nm. The combination of Figures 1 and 2 confirms that a low power Krypton disinfection device, if designed, controlled and used as directed, could be safely used without a bandpass filter (not exceeding the TLVs). For higher-powered products or with bulbs with a higher proportion of off-nominal emissions, Far UV Technologies uses bandpass filters to continue to ensure the TLVs are not exceeded.

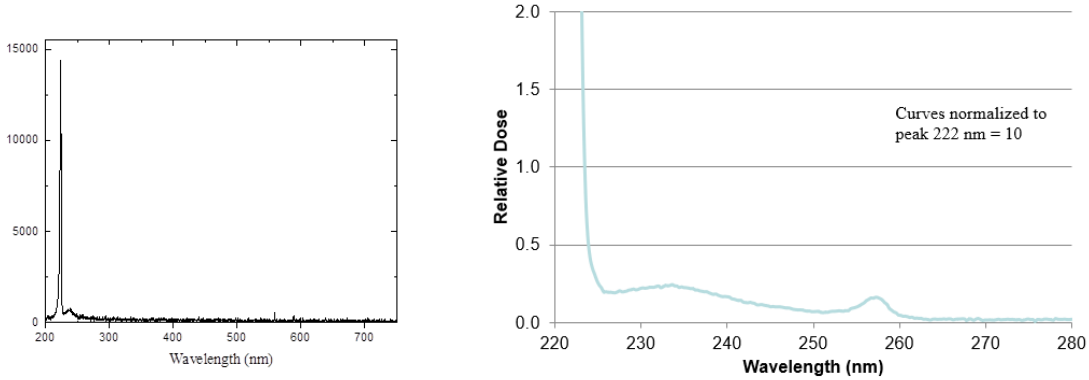

*Figure 2: Left: **overall emission spectra from Krypton KrCl lamp** and Right: increased scale to better illustrate off-nominal emissions*

FAR UV TECHNOLOGIES

Key Safety Studies in the Peer-Review Literature

There have been a number of studies conducted and published in animals at high risk for developing cancer, in 3-D skin models, and most recently a volunteer human study using high doses to demonstrate that the physics of far UV-C light at 222 nm (with minimal high wavelength contaminants) does not allow penetration and therefore does no harm to the skin or eyes.

In a paper published by David Brenner and colleagues at Columbia University in New York City[1], 222 nm excimer lamps with high-wavelength filters were used to administer 157 mJ/cm^2 over 7 hours compared to 254 nm UV-C and sham cohorts. Hairless albino SKH-1 mice are extremely vulnerable to the development of skin cancers and eye damage. The results at 48 hours showed no histological inflammatory changes in the skin compared to the 254 nm UV-C irradiated mice which showed inflammatory and hyperplastic changes. There was an increase in pre-mutagenic photoproducts (CPD dimers and 6-4PP) with 254 nm UV-C whereas the mice irradiated with 222 nm UV-C were no different from the sham arm. In unpublished but publicly presented studies, Dr. Brenner and colleagues have created a chronic exposure model where they give doses of 125 mJ/cm^2, 250 mJ/cm^2 and 500 mJ/cm^2 doses for 8 hours per day, 5 days a week, to the hairless albino SKH-1 mice. These doses are 5-20 times the amount of the regulated TLV dose of 22-23 mJ/cm^2 for the current Krypton Far UV-C light. The animals have undergone monthly exams of their skin and slit-lamp examination of their eyes. At 48 weeks, no eye pathology or abnormality of the skin have been noted even with the stratum corneum layer of the mice being thinner than in human skin. The study is designed to follow a cohort of albino SKH-1 mice out to 60 weeks of chronic exposure.

In a paper published by Yamano and colleagues at Kobe University in Japan[2], filtered far UV light was studied in Xpa-KO mice, a type of knock-out mouse that develops Xeroderma Pigmentosum, a genetic disorder that exhibits exaggerated skin burns and the development of skin cancer in humans. Initially, single high doses up to 10 kJ/m2 (or 100 mJ/cm^2) of 222 nm UV-C light placed 30 cm below the UV source did not produce any redness of the skin or swelling of the ear compared to severe inflammation observed in a group of mice exposed to 254 nm UV-C light. A chronic exposure model was simulated by exposing the Xpa-knockout mice to 0.5 and 1.0 kJ/m^2 (or 50-100 mJ/cm^2) two times a week for 10 weeks and followed for another 15 weeks. No skin tumors or eye pathology were observed in this group compared to 80% of tumors found in mice exposed to UV-B light. Challenges of super high doses of 222 nm UV-C (up to 10 kJ/m^2 or 1,000 mJ/cm^2) developed some pre-cancerous CPD dimers in the

[1] Buonanno, M, Brenner DJ et al. Germicidal Efficacy and Mammalian Skin Safety of 222-nm UV Light. Radiation Res 2017 Apr; 187(4): 483-491.

[2] Yamano N et al. Long-term Effects of 222-nm Ultraviolet Radiation C Sterilizing /m2Lamps on Mice Susceptible to Ultraviolet Radiation. Photochemistry and Photobiology 2020 March. DOI: 10.1111/php.13269.

superficial epidermis rather than the basal layers where skin cancers more commonly form. When an additional filter was used at this high power to filter out the 235-280 nm wavelength, the precancerous CPD dimers were significantly reduced along with inflammatory changes in the superficial epidermal layer. In conclusion, repetitive irradiation with 222 nm-UV-C light did not produce skin cancers even in a highly photosensitive and skin cancer prone Xpa-KO mouse model.

Most recently, Fukui and colleagues at Kobe University[3], published a study in human volunteers in PLOS ONE on August 12, 2020. The study looked at both the bactericidal effect and safety of a specific 222 nm UV-C light-emitting device placed directly on the back of 20 healthy male volunteers to study the potential application for surgical sterilization (figure 3). From a safety standpoint, the device used step-up dosing from 50-100-200-300-400-500 mJ/cm^2 directly on the back with the skin assessed at 24 hours (erythema test), a skin tissue biopsy 1 hour after the last dose, and a skin exam at 3 months. The results demonstrated no redness at 24 hours or abnormality of the irradiated skin at 3 months. The skin biopsies taken after all doses were administered, including the 500 mJ/cm^2 dose, showed some evidence of CPD dimers measured by ELISA assay, although significantly less than the positive control, it was still slightly higher than the negative control. This may have been due to the super high doses of irradiation (25 times that of the TLV for the Krypton 222 nm UV-C light), potential long wavelength contamination, or the direct administration of the light in close proximity to skin.

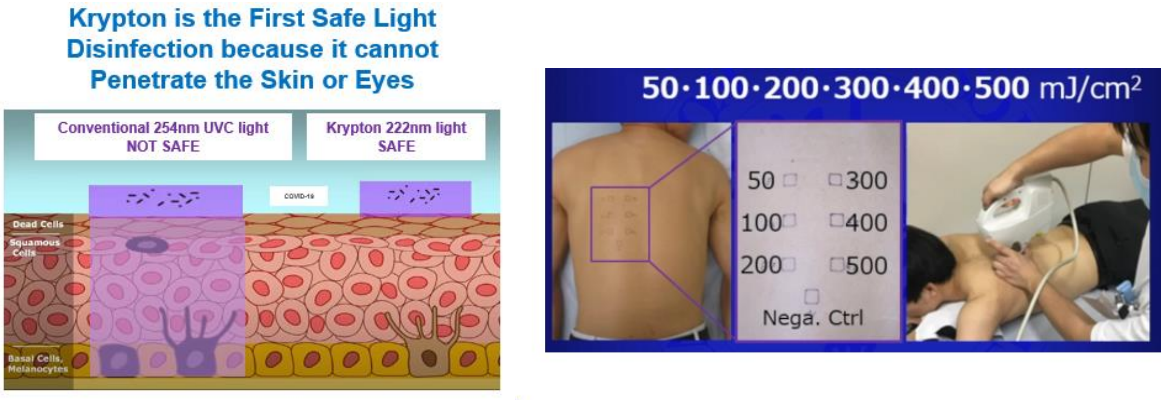

Figure 3: (Left) 222nm wavelengths cannot penetrate human and animal cells but can penetrate and eradicate microorganisms including viruses and bacteria in air or on surfaces [Dr. Brenner, Columbia University Medical Center] and (Right) 222nm in human trials [Kobe University]

[3] Fukui T, Nikura T, Oda T, Kumabe Y, Ohashi H, et al (2020) Exploratory Clinical Trial on the Safety and Bactericidal Effect of 222-nm Ultraviolet C Irradiation in Healthy Humans. PLOS ONE 15(8): e0235948. August 12, 2020.

FAR UV TECHNOLOGIES

New developments: 2016-2020

More recently, Columbia University Medical Center and Kobe University set out to prove a hypothesis that the physics of the absorption of 222nm wavelength UV light into biological materials could not penetrate a single human cell (in cellular level studies). They have since both demonstrated no evidence for any health issues or risk for live cells with doses up to 500 mJ/cm², and it is increasingly anticipated that new and potentially higher TLVs for 222nm exposure may be established in the near term. Far UV Technologies is already preparing future designs to take advantage of the new prospective guidelines to provide even greater levels of safe continuous disinfection of occupied spaces.

Far UV Technologies and its suppliers have not been able to detect ozone from low powered Krypton lamps. Ozone production is seen more commonly for UV light at wavelengths of < 200 nm.

The healthy bacteria in the skin biome is not expected to be significantly impacted by Krypton lighting. Krypton lighting cannot penetrate clothing or hair leaving much of the body unexposed. In addition, the skin biome has proven resilient to restoring itself quickly after conventional daily bathing hygiene habits.

Finally, the protection provided by the superficial layer of the skin (stratum corneum) or the superficial layer of the eye (tear film) should not be age dependent. The tear film layer does become thinner over time but remains robust enough to absorb short wavelength light throughout life. The stratum corneum is approximately 8 microns thick in the neonate, increases in thickness by 4-5 months of age, and then remains constant throughout the aging process.

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About the Author

Dr. Robert Honigberg, MD is the Chief Medical Officer of Far UV Technologies and provides Far UV Technologies with over 25 years of executive management, strategic market knowledge and hands-on experience in pharmaceuticals, devices and diagnostics in both mid-to-large size and start-up companies. Dr. Honigberg was previously Chief Medical Officer of GE Healthcare and Johnson & Johnson, Head of US and NA Medical Affairs and Immunology at Shire and an Adjunct Professor for Health Enterprise Management at Kellogg School of Management, Northwestern University, among others. He provides an invaluable perspective on medical and regulatory requirements for both end users and their customers.

FAR UV TECHNOLOGIES

Krypton Far UV Regulatory Overview

While Krypton disinfection lighting has been proven to be safe for human and animal exposure and does not exceed the IEC/ACGIH guidelines, it is not a cure for COVID-19 or other diseases and is not intended to be used for disinfecting people or equipment to be used in medical procedures on people. Instead it is meant to disinfect the environments (air and surfaces) that people inhabit or come into contact with to prevent the risk of infection between people. As a result, Krypton disinfection lights are not medical devices and thus do not require FDA approval and the FDA has confirmed this. If others are interested in using 222nm lighting in medical devices, those products may require FDA approval. Far UV Technologies is registered with the EPA with an EPA Establishment Number of 96253 and complies with all pesticidal device FIFRA labeling requirements given Krypton Far UV lighting components and devices have been tested for efficacy or safety to use against coronaviruses and harder-to-kill viruses than SARS-CoV-2 as noted above and in the Krypton Far UV Efficacy White Paper dated 8/1/20.

Krypton disinfection lighting devices are low voltage and thus do not require UL or CE approval. For applications utilizing higher voltage AC power, Far UV Technologies uses UL, CSA or CE power supplies to drop the voltage down to 12VDC. We CE certification for Krypton-11 lighting disinfection.

Details of the self-certification are noted below:

EMC Directive 2013/30/EU
EMI testing was conditionally passed at Boeing using the EN55011 standard for conducted and radiated emission. Far UV Technologies is currently implementing recommendations in its designs and will retest again prior to self-certification before the end of October 2020.

The Restriction of Hazardous Substances in Electrical and Electronic Equipment (ROHS) Directive 2011/65/EU
The lamp fixture, power supply or lamp do not contain any chemicals that are on the ROHS list therefore the device is compliant with this Directive.

The ErP Directive 2009/125/EC the implementation measure for "Lamps"
The design of the fixture is very ergonomic. The power draw is very low and the efficiency of the power supply and lamp are above average.

Conclusion: The low voltage directive for CE allows the Krypton device to be self-certified. The incoming voltage to the device is 12VDC which is far below the 60V directive to classify the device as a low voltage device that does not require CE. Far UV Technologies will complete the EN55011 standard testing and self-certification.

Declaration of Conformity

CE

Manufacturer/Importer:

Name: Far UV Technologies, Inc
Address: 7208 Wornall Rd, Suite 210, Kansas City, MO 64114
Phone/Fax no: (816) 392-5736

Declares that the product:

EUT Description: Krypton-11 Far UV Disinfection Light
Model Number: N/A

Conforms to the following technical standard:

EN 55011:2009+A1:2010
EN 55015:2015

Identification of Product:

This device complies with European Union Medical Directive 93/42/EEC.

The following test reports are subject to this declaration:

Test Report Number:	Issue Date:
2010-118E	12/3/2020

Prepared By:

KEYSTONE COMPLIANCE

131 Columbus Inner Belt ▪ New Castle ▪ PA 16101
Ph.: 724-657-9940 ▪ Fax: 724-657-9920
www.keystonecompliance.com

The manufacturer is responsible for this declaration:

Name/Title: Vinay Budhraja

Date: 12/3/2020

Signature: _____

Non CE Marking Directives that Apply

The General Products Safety Directive (GPSD) 2001/95/EC
The Krypton device is a low voltage product and is safe to operate. There is no physical switch on the device or any reason to physically touch the device after installation. The fixture has a front glass or filter that will protect people positioned below the device in case of lamp breakage. No shards of glass will be ejected from the fixture.

The Batteries and Accumulators Directive 2006/66/EC
At this point there are no plans to have the capacity to battery operate the Krypton lighting device.

The WEEE Directive 2012/19/EU
This product should be recycled as an electronic part and should be disposed of as such. The company or end user of this Krypton device will be responsible for cost of physically recycling the unit or sending it back to Far UV Technologies when the products lifetime has been met or the product fails prior to the products end of life.

About the Author

Michael Clark serves as Far UV Technologies' VP of Engineering and Sales. Mr. Clark has deep expertise in the lighting electronics space, having been in the lighting industry for 30 years. As Director of Infection Prevention at Ushio America he managed the sales, product and engineering development for KrCl 222nm Far UV lamps and systems and had P&L responsibility for ultraviolet and infrared products for over 8 years before joining Far UV Technologies in 2020. Prior to joining Ushio, Mr. Clark was a General Manager at PerkinElmer and a Country Manager for PerkinElmer Optoelectronics.

Krypton Far UV Efficacy White Paper

Introduction

For over 100 years, we have known that there is a widely available technology called ultraviolet light available to eradicate any known pathogenic bacteria, virus or mold. Ultraviolet light is unique in that there is no known biological resistance to it as is often the case with antibiotic or chemical based disinfection solutions (leading to continuing hospital acquired infections, even when current best practices are followed). This is because ultraviolet light directly deactivates the DNA/RNA building blocks of microorganisms or the proteins that hold them, disabling their ability to replicate into concentrations beyond which our immune systems can handle. Ultraviolet light also does not require active human input and potential error in application (such as wiping down surfaces), which can profoundly limit disinfection efficacy. The predominant limiting characteristic of conventional 254nm germicidal UV light has been that it is a carcinogenic health hazard to human cells and tissue which has therefore limited its use primarily to water treatment and unoccupied hospital operating rooms.

Conventional UV-C light around 254nm is typically produced with a mercury lamp and more recently LED technologies around 260nm. It had long been believed that the ideal kill mechanism to disable microorganisms was the creation of thymine dimers in the DNA and the absorption of UV to achieve that followed the curve noted below in Figure 1. This, along with minimal hardware alternatives to reliably and economically create other wavelengths of light, is why other wavelengths of light were not extensively pursued or studied for their prospective germicidal efficacy. However, the promise of safe UV disinfection has significantly broadened the interest of 222nm wavelengths (*see Krypton Far UV Safety White Paper*) and a better understanding of how protein absorption may play an even more profound impact on permanent disinfection by avoiding photoreactivation within which pathogens can regenerate after subsequent exposure to UVA or blue light.

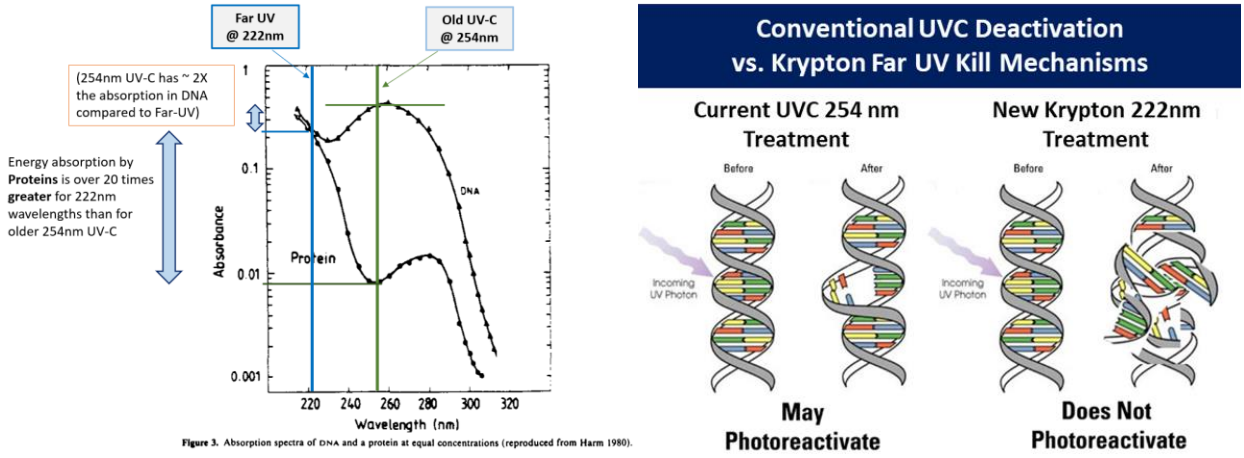


Figure 1: Left: Ultraviolet absorption in DNA and protein. Right: Differing kill mechanisms

Krypton 222nm Far UV disinfection efficacy has been demonstrated by Far UV Technologies alongside our strategic academic and industry partners including Columbia University Medical Center, the University of Missouri – Kansas City, MRI Global, Boeing, Ushio and Eden Park Illumination.

The efficacy of Krypton disinfection lighting is determined by:

1) The reduction of a targeted biological pathogen concentration to an amount of fluence (the amount of UV irradiation) delivered; and
2) A fixture's ability to create and deliver a known amount of fluence over a targeted area.

Microbiological Testing

Far UV Technologies completed extensive microbiological testing of Krypton Far UV 222nm lighting under an SBIR contract with NASA in 2018 titled "Innovative Disinfection Method to Prevent Foodborne Illness in Spaceflight". Far UV Technologies was able to demonstrate 4-log (99.99%) and 5-log (99.999%) kills against E. coli in controlled settings.

Figure 2: Far UV Technologies spiking, rinsing, diluting and plating at UMKC

Far UV Technologies also learned a lot about the complexities and opportunities of treating different kinds of organic and inorganic surfaces throughout the effort that has led to improved applications development that others entering the space now will likely learn through their own trial and error.

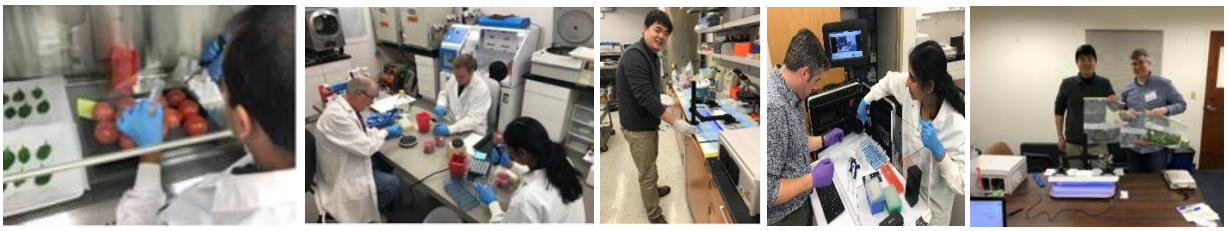


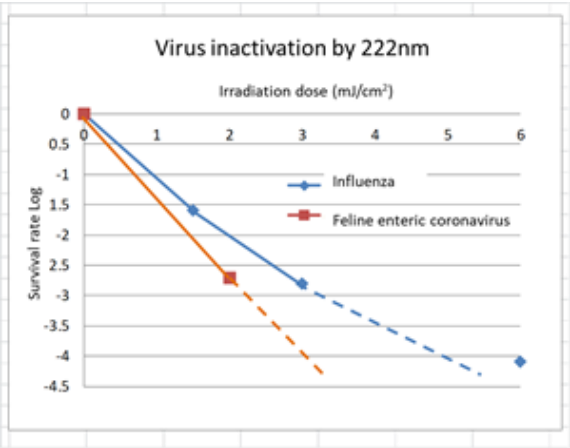
Figure 3: Far UV Technologies biological testing with MVS, UMKC, MRI Global and Eurofins

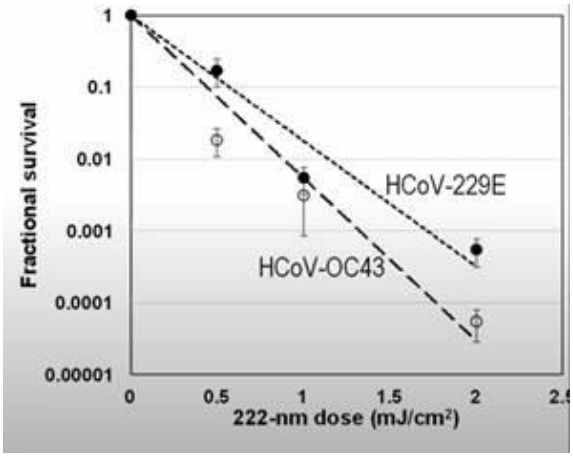
There has been a significant amount of microbiological testing in air and on surfaces at multiple leading academic and institutional research facilities to confirm the efficacy of 222nm Far UV against a variety of different pathogens including coronaviruses and not limited to the other pathogens shown below in Table 1.

Table 1: 222nm Microbiological Disinfection Efficacy

Pathogen	Disinfection (mJ/cm² of 222nm)			Source
	90.0%	99.0%	99.9%	
Bacilus subtilis	2.0	4.0	7.0	Clauss
Bacilus cereus	8.0	11.0	14.0	Clauss, Far UV
Arthrobacter nicotinovorans	10.0	15.0	18.0	Clauss
Staphylococcus aureus	10.0	12.0	15.0	Clauss
Enterococcul faecalis	19.0	24.0	27.0	Clauss
Pseudomonas aeruginosa	3.0	5.0	6.0	Clauss
Escherichia coli	4.0	6.0	7.0	Clauss, Far UV
Clostridium pasteurianum Sporen	2.0	5.0	15.0	Clauss
Streptomyces griseus Sporen	13.0	17.0	21.0	Clauss
Aspergillus niger (A. fumigatus)	85.0	215.0	320.0	Clauss, Far UV
Penicillium expansum	15.0	35.0	50.0	Clauss
MRSA	1.0	2.0	2.5	Buonanno
Influenza A (H1N1)	1.3	2.6	3.8	Welch
Coronavirus - HCoV-229E	0.6	1.1	1.7	Buonanno
Coronavirus - HCoV-OC43	0.4	0.8	1.2	Buonanno

As shown in the unpublished graph on the left below, Krypton 222nm light can provide 3 log (99.9%) surface disinfection for the Feline Enteric coronavirus with a dose of about 2.25 mJ/cm². A 4 log (99.99%) reduction can be achieved with only 3 mJ/cm², which is far less than the 22 mJ/cm² Threshold Limit Value over 8 hours prescribed by IEC and ACGIH for safe human exposure. Another unpublished graph (on the right below) demonstrates of the efficacy of 222nm light against other aerosolized coronavirus surrogates. Because we would also be disinfecting all of the air between the light and the targeted surface, our mJ/cm² at those closer distances would also be higher than 2.25 mJ/cm² which is interesting as the coronaviruses are even easier to kill in air where we can actually achieve a greater than 4 log kill (99.99%) with only 2 mJ/cm².





Obtaining rapid COVID-19 specific testing was more challenging because it required Bio-Safety Level (BSL) 3 labs, which are less common, and most research institutions have been closed due to the pandemic. That said, based on the significant efficacy of 222nm UV light against other coronaviruses such as feline enteric coronavirus, HCoV-229E and HCoV-OC43, there was no reason to believe that 222nm UV light will not be effective in killing COVID-19 and Dr. Brenner at Columbia University Medical

Center has since confirmed that the preliminary test results with SARS-CoV-2 were similar to the surrogates. Coronaviruses are actually among the easiest of pathogens for Krypton disinfection.

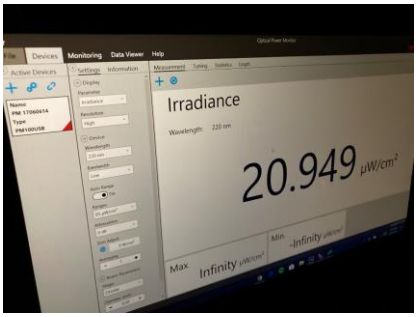
Fluency Testing and Product Development

As Far UV Technologies learned that several of our prospective customers actually preferred to have "independent" test data on the microbiological efficacy, we began to focus more on the applications development and product design which has as much if not more impact on the actual disinfection efficacy in application. As one of the only companies developing end user products utilizing 222nm since 2016, Far UV Technologies has one of the most extensive 222nm testing and product development capabilities in the world. Far UV Technologies' research, development and demonstration labs include:

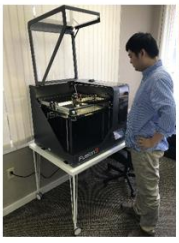
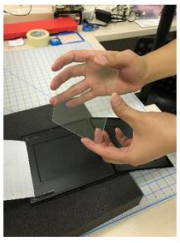
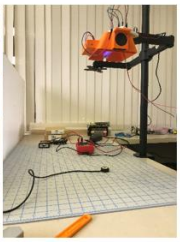
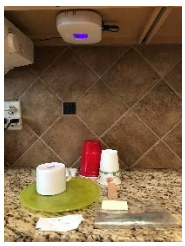
- Optical Power and Energy Meters
    - Thorlabs PM100USB and S120VC Si Photodiode (UV Extended), calibrated under our NASA contract to Ushio's UIT-250 sensor, which was calibrated to the National Institute of Standards (NIST)
    - Multiple International Light Technologies 2400-222nm Handheld Narrow-band UVC Light Meters (NIST calibrated)
    - Hamamatsu C9536 UV Power Meter and H9535-222 UV Power Meter Head (NIST calibrated)
        - Note: Many conventional UV-C dosage strips or meters may indicate they can detect 200-280nm but are calibrated for 254nm and do not accurately measure 222nm. Far UV Technologies is designing new handheld meters that will be commercially available in the fall of 2020.

- Dark rooms for fluence testing





- Applications development, 3D printing and rapid prototyping, optics, power, advanced aging and materials testing labs.


- Real world installations to obtain and optimize around customer feedback.





- Evaluation of Far UV versus competitive offerings and/or multi-hurdle system optimization

Competitive Offering	Disinfection Capability	Waste	Labor to Apply	Hazardous Element	Device Mass /Volume	Temperature-Humidity Sensitive	Material Impact	Whole Room Disinfection	Continuous Air Disinfection	Continuous Surface Disinfection
Wipes/Bleach										
Fogging/Chemicals										
Hydrogen Peroxide										
Ozone										
UV-C 254nm										
Krypton Far UV 222nm										

About the Authors

PJ Piper is the CEO and founded Far UV Technologies in 2016, long before the COVID-19 pandemic, to research, develop and commercialize far UV technologies to eradicate the world of infectious disease. As Principal Investigator on NASA and Air Force contracts, Mr. Piper has proven the efficacy of Krypton disinfection lighting on multiple pathogens, established the most comprehensive global research and development facilities, assembled a world class team with over 50 years of UV disinfection experience and scaled manufacturing to commercialize products in the medical, transportation, defense and multiple other markets. Mr. Piper previously co-founded and exited multiple successful companies including Aspen Aerogels, an advanced aerogel insulation nanotechnology company (NYSE: Ticker "ASPN"), was a former investment banker at JP Morgan Chase and a Board member of Triton Systems, which has created over $3.9 billion in shareholder value through multiple IPOs, mergers and acquisitions.

Dr. Vinay Budhraja is a Senior Electrical Engineer and Materials Scientist and manages Far UV Technologies' power, optical and materials test labs. Dr. Budhraja earned his Master's degree in Materials Science at the Indian Institute of Technology and his PhD in Electrical Engineering from the New Jersey Institute of Technology and leverages his expertise gained from previous roles leading spectroscopy and reflectance projects at the Sandia National Laboratory and the National Renewable Energy Laboratory (NREL).

Installation Guide

Far UV Technologies engineers work with our customers to determine optimal placement of fixtures based on targeted floor plans, ceiling heights, higher traffic – higher risk areas, expected air flows, other already implemented or expected disinfection approaches and targeted budgets.

Note: Installation of Krypton Disinfection Lighting must be performed by a Qualified Person as determined by the National Electrical Code. Do not reverse polarity. Improper installation will void the warranty.

Before You Begin: Carefully unpack your ceiling mount Krypton disinfection lighting system. Ensure that all components, including the lamp assembly, ceiling mount plate, power supply, additional wiring and wire nuts, are present and intact. Included components may vary depending on the specifications of your order and application.

Figure 1
Left – Krypton-11 lighting in packaging with wall adapter and power supply
Right – Components for installation including: Krypton lamp, 20 ft wire, wall adapter, 100-277V power supply, ceiling mount, wire nuts, and screws

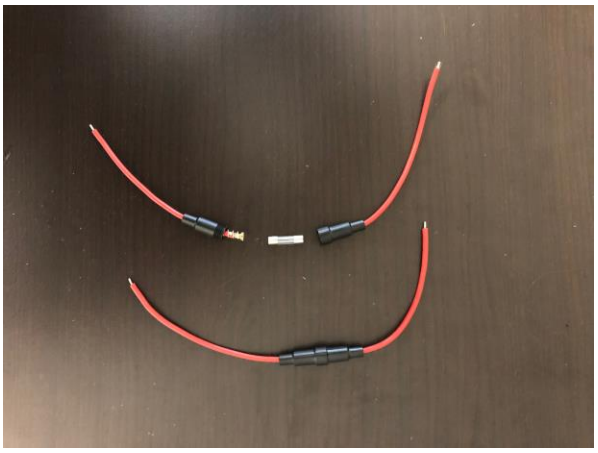


Figure 2
For transportation installations use 2A inline fuse

1. Mount unit at desired location using approved method.

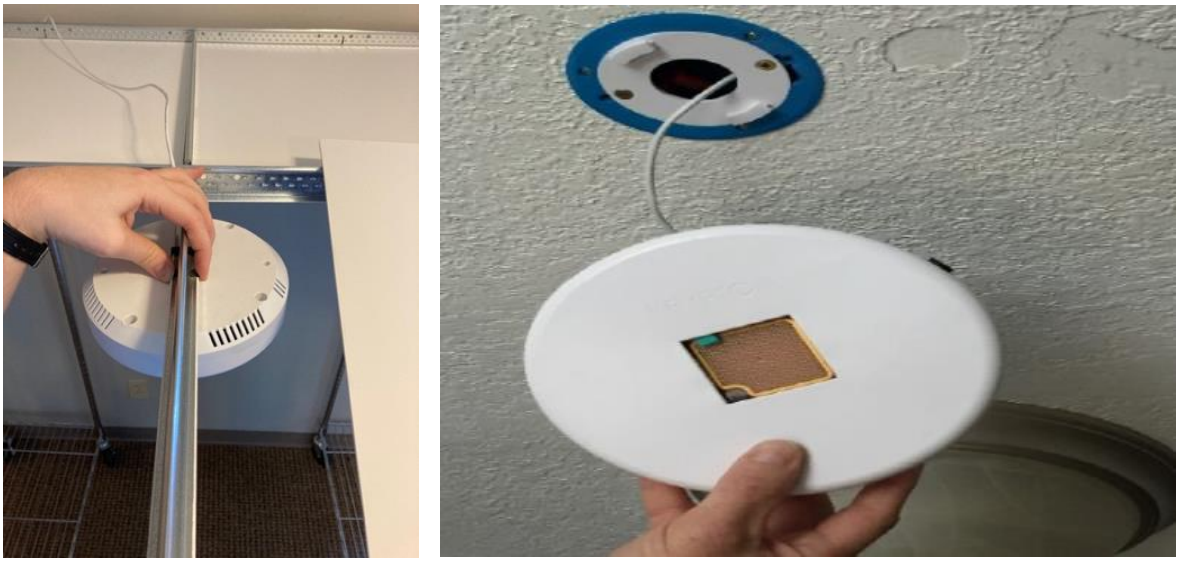


Figure 3
Left – Use T-clamp for conventional drop ceiling
Right – Standard cut-in box installation

2. Route wire to power supply using approved method.

3. Connect unit to 12V power supply using approved method.
Note: Far UV Technologies offers alternative 12VDC sources for the Krypton unit upon request including multi-light junction boxes and adapters for wall outlets (Figure 4). Please consult with Far UV Technologies on the 12VDC source that best fits your application before ordering.

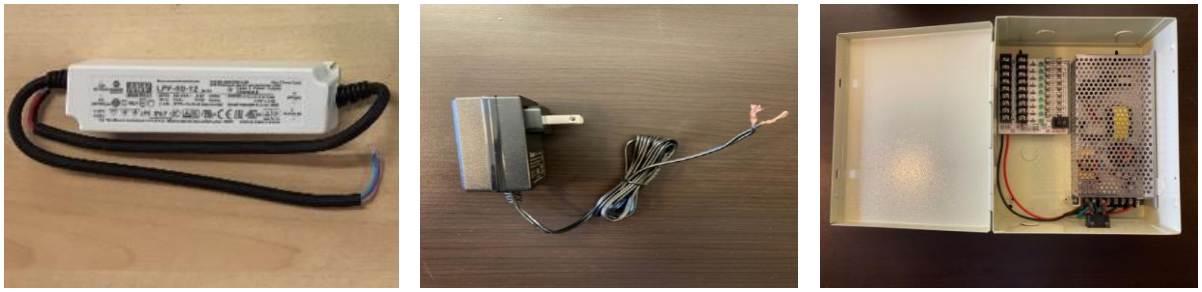


Figure 4
Left – 100-277V power supply that can power up to 3 lights
Center - Wall adapter for samples or temporary use
Right – Junction box that can power up to 9 lights

4. Connect power supply to correct voltage using approved method.

FAR UV TECHNOLOGIES

Operation

The Krypton unit once installed is simple to operate.
This unit will often be connected to a switching source (through your light switch or other switching devices) to either emit Far UV continuously or cycling throughout the day.
Turning your unit and/or lights off in unoccupied rooms can extend the useful life.
The Krypton unit will provide 222nm radiation limited by IEC/EN 62471 or ACGIH exposure limit recommendations for 222nm radiation.

Note: This unit is intended for operation at a minimum height of 8'. If your ceiling height is less than 8', please contact Far UV Technologies for custom cycling options.

Caution

Do not expose the Krypton unit to water
Do not touch the Krypton unit while operating
Do not use the Krypton unit near foggers and misters
Make sure the power source supplied by the manufacturer or user is rated appropriately for the number of Krypton lamps it supplies
The unit emits Far UV Technologies 222nm wavelength light. Studies have shown that 222nm in appropriate daily doses is not harmful to the skin or eyes. This Krypton device meets the maximum exposure guidelines as set by IEC/EN 62471 or ACGIH when used as described in this Installation and operation guide

Warranty

The limited warranty set forth below is given by Far UV Technologies, Inc. and applies to the Far UV Technologies fixture only. The product when delivered to you in new condition in its original container is warranted against defects in materials and workmanship under normal use and service for a period of 6 months from the date of purchase. If the product is found to be defective during this warranty period Far UV Technologies will repair or exchange the unit for a new or refurbished unit as determined by Far UV Technologies.

Tony Stephens is a Master Electrician and manages Far UV Technologies' installation, maintenance and field operations. Mr. Stephens has over 30 years of extensive electrical experience in the commercial, industrial, residential and transportation markets. In addition to working for several electrical contracting companies, including his own, Mr. Stephens has been a Certified Instructor, Certified Safety Engineer and worked at AllCom Global Services, General Motors and Amtrak.