TEG TECHNOLOGIES

Riu Güell,34 17180 Vilablareix-Girona · Tel +34 972 244 606

UV-C LIGHT

gilua-Tex®

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INTRODUCTION

Ultraviolet light is a proven technology for eliminating viruses, bacteria and other microorganisms that may pose a risk to humans. UV-C light eliminates or inactivates microorganisms, destroying and affecting their DNA and leaving them unable to perform their vital cellular functions.

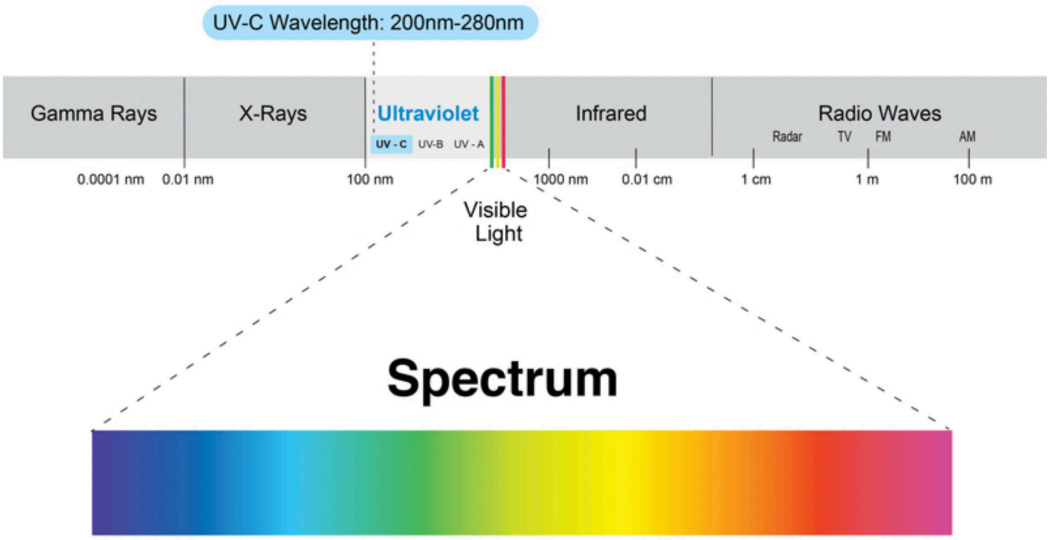
The purpose of the marketing of machinery with ultraviolet technology is to reduce the microbial load of the surface or element to be disinfected so as to achieve a degree of reduction that ensures our safety, as the applied dosage breaks the disinfection chain.

In this regard, the gilua-Tex disinfection cubicle seeks to guarantee the removal of microorganisms that may be present on pieces of clothing within a reduced cycle time (<1min) by uniformly applying the required dosage over the entire surface of the garment.

GERMICIDAL UV-C LIGHT

WHAT IS ULTRAVIOLET LIGHT?

Ultraviolet light is a kind of electromagnetic radiation. It is a light that can't be seen by human beings because its wavelength is below the visible spectrum (the range is between 100 nm and 400 nm).



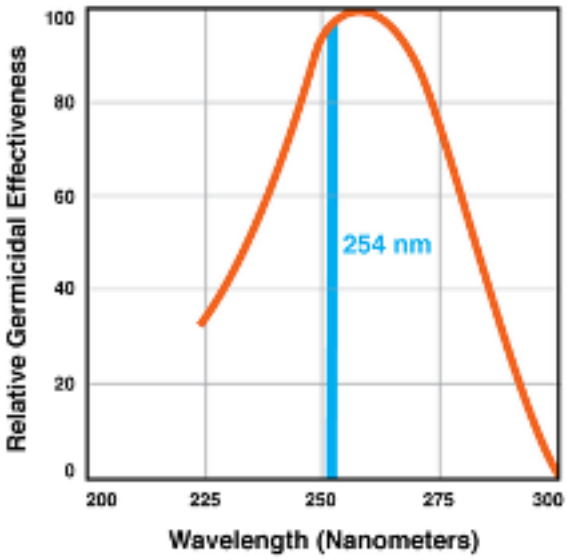
WHAT IS UV-C LIGHT?

We can distinguish the following bands within the spectrum of ultraviolet lights [1]:
UV-A (long-wave; 400 nm - 315 nm): used to tan skin and for ink and resin treatments.
UV-B (medium-wave; 315 mm - 280 nm): used for psoriasis therapies, may cause burns and contribute to the appearance of skin cancer, etc.
UV-C (short-wave; 280 nm - 200 nm): the most effective kind for germicidal purposes.
UV-V (vacuum UV, below 200 nm): may produce ozone in the air.
All the wavelengths listed above are emitted by the sun, but only the longest (UV-A and UV-B) reach Earth. UV-C rays, those with the shortest wave but, in turn, the highest energy, are blocked by the ozone layer.

WHAT LIGHT IS REGARDED AS GERMICIDAL (GUV)?

Given that UV-C rays are blocked by the ozone layer, microorganisms have not developed a natural defence mechanism against the energy of this light. The energy radiated by ultraviolet light causes instabilities in the nucleic acids (DNA and RNA) of microorganisms, interrupting their sequence and causing mutations preventing their reproduction and causing the death of the bacteria and the inactivation of the virus.

Low-pressure mercury lamps such as those installed in the gilua-Tex cubicle emit at a wavelength of 253.7 nm, very close to the peak of the germicidal curve (situated at around 265 nm). This is why their use is widespread in equipment for the sterilisation, disinfection and/or removal of microorganisms.



UV-C. COVID-19

Germicidal UV-C light kills live bacteria but, in the case of viruses (such as SARS-CoV-2, which causes the COVID-19 disease) [2], they aren't living microorganisms and, therefore, the proper term to use when referring to them is "inactivated viruses".

Due to the fact that SARS-CoV-2 has only recently been identified, there is a lack of scientific information concerning the survival of the virus under different conditions and the effectiveness of disinfection with different methods.

The first studies published on the survival of SARS-CoV-2 on surfaces [3] show survival for 4 days on plastic and stainless steel, 2 days on cardboard and 10 hours on copper. It is therefore logical and consistent to assume that the virus survives on the different commonly-used textiles and that disinfection of clothing is necessary to prevent the spread of the virus.

With regard to the susceptibility of the SARS-CoV-2 virus to radiation, its behaviour is expected to be similar to that of any other encapsulated coronavirus. The SARS-CoV-2 virus is currently undergoing scientific analysis to determine its inactivation under the effects of germicidal light. For years the scientific community has conducted different studies on the family of coronaviruses, during which it has been observed that UV-C light can completely inactivate them.

The following table summarises different studies carried out on coronaviruses exposed to ultraviolet light and the necessary D_{90} dosages (indicates the dosage required for an inactivation of 90% of the initial sample) [4]:

Table 1: Summary of Ultraviolet Studies on Coronaviruses

Microbe	D_{90} Dose J/m^2	UV k m^2/J	Base Pairs kb	Source
Coronavirus	7	0.35120	30741	Walker 2007[a]
Berne virus (Coronaviridae)	7	0.32100	28480	Weiss 1986
Murine Coronavirus (MHV)	15	0.15351	31335	Hirano 1978
Canine Coronavirus (CCV)	29	0.08079	29278	Saknimit 1988[b]
Murine Coronavirus (MHV)	29	0.08079	31335	Saknimit 1988[b]
SARS Coronavirus CoV-P9	40	0.05750	29829	Duan 2003[c]
Murine Coronavirus (MHV)	103	0.02240	31335	Liu 2003
SARS Coronavirus (Hanoi)	134	0.01720	29751	Kariwa 2004[d]
SARS Coronavirus (Urbani)	241	0.00955	29751	Darnell 2004
Average	**67**	**0.03433**		

[a] *(Jingwen 2020)* [b] *(estimated)* [c] *(mean estimate)* [d] *(at 3 logs)*

Without any conclusive scientific studies on SARS-CoV-2 or specific legislation to determine a target dosage, scientific consistency is required for the scaling of disinfection machinery such as the gilua-Tex cubicle. For this reason, despite the suggested average value of 67 J/m^2, the cubicle is sized much more conservatively, assuming the highest dosage that appears in the scientific literature on viruses in the coronavirus family (241 J/m^2). In addition, based on the indications of the Illuminating Engineering Society [5], which suggests a D_{99} dosage for disinfection machinery, this value has been doubled and a target dosage **of 482 J/m^2 is certified for the entire volume of the gilua-Tex cubicle**.

TARGET DOSAGE. LOGARITHMIC REDUCTION

The germicidal effect of ultraviolet light is proportional to the exposure dosage (typically expressed in millijoules per square centimetre, mJ/cm^2, or joules per square metre, J/m^2), which is the product of the irradiance (typically in mW/cm^2 or W/m^2) and the exposure time (s).

How is the target dosage of the gilua-Tex cubicle (**D_{99}=482 J/m^2**) determinated?

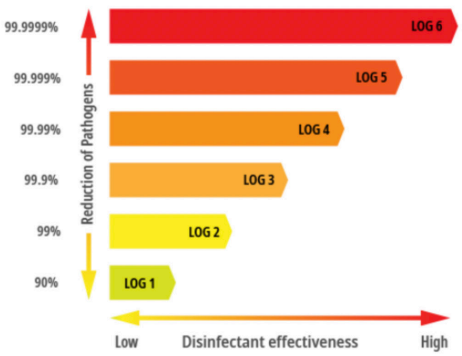
We first need to familiarise ourselves with the concept of **logarithmic reduction**, which measures how a decontamination process reduces the concentration of a contaminant.

A colony-forming unit (CFU) of the microorganism to be analysed is used as a measurement to characterise the disinfection systems. When its disinfection is analysed in a laboratory, the relative number of microorganisms that have been eliminated at each moment is expressed by means of a reduction factor that is typically presented in factors of 10 on a logarithmic scale.

$$Logarithmic\ reduction = log_{10}\left(\frac{N_0}{N}\right)$$

Where:
N_0 = colony-forming unit (CFU) of the microorganism before exposure to UV light
N = colony-forming unit (CFU) of the microorganism after exposure to UV light

For example, a 1-log reduction corresponds to a 90% inactivation of the microorganism (with respect to the initial CFU), when this has been reduced by a factor of 10. Therefore, a 2-log reduction corresponds to a reduction of 99% or a factor of 100 and so on.



It is clear that the effectiveness as a disinfectant and the reduction of the microbial load of a surface (in the case of the cubicle, the garment's textile) will depend on the desired target dosage. Without any specific legislation and taking a conservative approach, we position ourselves at disinfection target values of 2 logarithmic reductions (D_{99} - 99% inactivation), the dosage for disinfection machinery recommended by the Illuminating Engineering Society [5].

How is one logarithmic reduction related to another? Based on its biological mark, every pathogen has a different sensitivity to UV-C light. As has been mentioned above, there is no scientific literature on SARS-CoV-2, so it is based on the highest D_{90} dosage documented in the scientific literature for organisms of the same coronavirus family (D_{90}= 241 J/m^2).

In order to identify the dosage required for different logarithmic reductions, it is necessary to experimentally characterise them by means of laboratory tests. In most viruses and bacteria the increase required to move from one reduction to another is less than the double of the dosage to be applied [6]:

	UV Dose*				
	2 LRV	3 LRV	4 LRV	5 LRV	6 LRV
E. Coli	6.5	7	8	9	10
Pseudomonas aeruginosa	11	16.5	22	--	--
Salmonella typ	4.1	5.5	7.1	8.5	--
Staphylococcus aureus	5.4	6.5	10.4	--	--

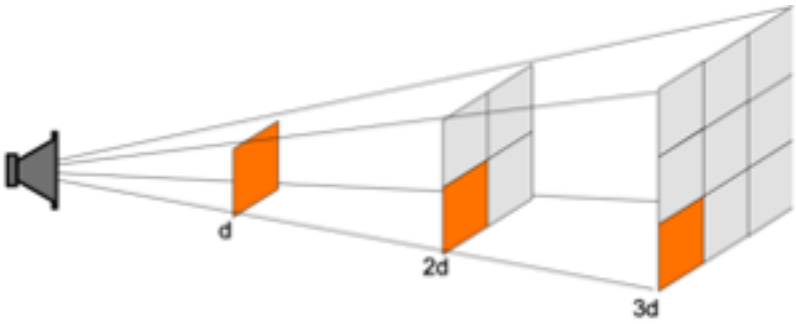
Consequently, it is conservative to assume that by doubling the initial dosage of D_{90}= 241 J/m^2 to a target dosage of **D_{99}= 482 J/m^2** we are applying a dosage with a safety margin to achieve a high degree of disinfection (D_{99}) over the entire surface of the clothing to be disinfected.

The importance of this value (**D_{99}= 482 J/m^2**)must be underlined, as no manufacturer of disinfection equipment can guarantee a dosage to inactivate SARS-CoV-2, as there is no related scientific literature. When we procure disinfection equipment we should know what dosage it provides and upon what basis it has been defined. The gilua-Tex disinfection cubicle guarantees a 482 J/m^2 dosage, which, as has been explained above, can be conservatively assumed to be higher than the D_{99} dose for SARS-CoV-2.

Note: the cubicle can readjust the cleaning time to ensure higher dosages in the event of the emergence of scientific studies suggesting higher values for SARS-CoV-2.

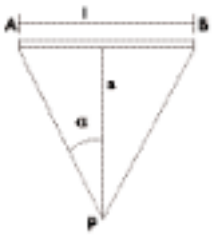
INVERSE-SQUARE LAW FOR LIGHT PROPAGATION

The irradiation emitted by UV-C light obeys the inverse-square law, whereby the intensity at any given point is inversely proportional to the square of the distance from this point to the light emitter.



In the case of the gilua-Tex cubicle, its design allows the entire surface of the clothing to be kept at a minimum distance from the light emitters, thus maximising the irradiance on the surface and minimising the cleaning cycle for each garment.

With regard to fluorescence, the specific formulation was presented 50 years ago by Philips [7] and provides the length of the fluorescent tube and its nominal power (W) to determine the irradiance at a perpendicular point with the following formula:



$$E = \frac{\varphi}{2\pi^2 la}(2\alpha + \sin 2\alpha)$$

Where φ indicates the radiated power (in W) and E (W/m^2) the irradiance at the P measurement point.

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Riu Güell,34 17180 Vilablareix-Girona · Tel +34 972 244 606