UVGI (UV-C) SURFACE STERILIZATION AND MATTERS TO CONSIDER IN APPLICATION

When we mention about ultraviolet light or UV, we mean the light that is outside the visible light band between 400 nm and 10 nm wavelength (We sometimes define it as Ultraviolet Radiation). We seperate this into 4 areas.

Distribution and basic properties of UV light according to wavelength		
UV Band	***Wavelength (Nanometer)***	***Description***
UV-A	*315-400*	*It passes through the skin and reaches the tissues. Causes early skin aging and wrinkles (Photoaging). It is also effective in cataract and cancer formation. It is 500 times more than UV-B in daylight. Sunscreens on the market provide more protection in the UV-B band. It is generally insufficient in UV-A protection.*
UV-B	*280-315*	*It can cross the skin, but not too deep. It is the main cause of sunburn and skin cancer (malignant melanoma).*
UV-C	*200-280*	*Unlike UV-A or UV-B, most of the light coming to the skin is reflected. A portion of 4% to 7% is held in the first 2 µm of the stratum corneum, the top layer of the epidermis. The most affected organ is the eye. 1 to 12 hours after exposure to overdose, the sensation of sand in the eye begins to age and pain begins. Although uncomfortable and frightening, the level of risk is low, usually passes completely without leaving permanent damage within 1-2 days. It is called Photokeratoconjunctivitis.*
UVGI	*253.7(254)*	*This wavelength of UV-C is known as germicidial, germicidal. Light in this wavelength is absorbed by nucleic acid in DNA / RNA structures, causing dimerization of Pyrimidine molecules. Dimerisation of Thymine molecules found only in DNA / RNA structures first destroys DNA / RNA, and in the continuation of the effect,* *Even if damage occurs in mammalian cells, DNA repair enzymes provides repairs quickly. Research is ongoing in UVGI treatment of wounds caused by resistant bacteria, which no antibiotic is beneficial, and very successful results are obtained.*
Vacuum UV	*10-200*	*The most important feature of vacuum UV is that it does not advance much in the air and converts the oxygen molecules it hits into Ozone. Where it is used, the amount of ozone should be kept under control.*

We focus on two main issues in applications.

1-Security

2-Effectiveness

UV is not visible. The blue light we see is not UV but scattering at the extremes of the light spectrum.

Initially, ELVs (Exposure limitvalues) values should not be exceeded. These values are for unprotected naked eyes and skin. Although there are different values in different countries. The Control of Artificial Optical Radiation at Work Regulations 2010 are taken as basis.

- *Max range in the range of 180 nm-400 nm for 8 hours day. 30 J / m2 eff*
- *10,000 J / m2 in the range of 315nm-400nm for 8 hours day*

These values are for human, not light source.

- *Determined by the effects of staff with the same exposure continuously.*
- *It is determined according to a light and sensitive person. However, some people may be even more sensitive.*
- *Time limitation and reduction of acute effects reduce the risk.*
- *These values are determined by a large margin of safety. So much so that in England, these limits fill in 6 minutes in summer and 21.6 minutes in winter.*
- *Especially for UV-A, it is much tighter than American standards.*
- *It can be overcome in a short time even with natural UV sources.*
- *Values for UV_C only are not defined in Europe or America.*
- *Areas where UV is used should be marked and, if necessary, UV glasses should be provided for personnel.*
- *Light trays should be used wherever possible.*
- *It passes through UV-C quartz glass, not through normal glass.*

2-Effectiveness

In the design of the system to be used, it is important to which microorganisms we want to disinfect. When we double the dose that we calculate according to 90% effectiveness, we reach 99%, when we triple, 99.9%, and when we quadruple, we reach 99.99%. Necessary doses according to targeted microorganism and efficacy rates are given below.

Bacteria

Micro-organism (microbe)	***UV light exposure (dose) in J/m² required to achieve 90% – 99.99% reduction of the specified micro-organism types***			
	90% (1 log)	*99% (2 log)*	*99.9% (3 log)*	*99.99% (4 log)*
Bacillus anthracis – Anthrax	*45.2*	*90.40*	*135.60*	*180.80*
Bacillus anthracis spores – Anthrax spores	*243.2*	*486.40*	*729.60*	*972.80*
Bacillus magaterium sp. (spores)	*27.3*	*54.60*	*81.90*	*109.20*
Bacillus magaterium sp. (veg.)	*13.0*	*26.0*	*39.0*	*52.0*
Bacillus paratyphusus	*32.0*	*64.0*	*96.0*	*128.0*
Bacillus subtilis spores	*116.0*	*232.0*	*348.0*	*464.0*
Bacillus subtilis	*58.0*	*116.0*	*174.0*	*232.0*
Clostridium difficile (C. difficile or C. diff)	*60.0*	*120.0*	*180.0*	*240.0*
Clostridium tetani	*130.0*	*260.0*	*390.0*	*520.0*
Corynebacterium diphtheriae	*33.7*	*67.4*	*101.1*	*134.80*

Ebertelia typhosa	*21.4*	*42.80*	*64.2*	*85.60*
Escherichia coli	*30.0*	*60.0*	*90.0*	*120.0*
Leptospiracanicola – infectious Jaundice	*31.5*	*63.0*	*94.5*	*126.0*
Micrococcus candidus	*60.5*	*121.0*	*181.5*	*242.0*
Micrococcus sphaeroides	*10.0*	*20.0*	*30.0*	*40.0*
MRSA	*32.0*	*64.0*	*96.0*	*128.0*
Mycobacterium tuberculosis	*62.0*	*124.0*	*186.0*	*248.0*
Neisseria catarrhalis	*44.0*	*88.0*	*132.0*	*176.0*
Phytomonas tumefaciens	*44.0*	*88.0*	*132.0*	*176.0*
Proteus vulgaris	*30.0*	*60.0*	*90.0*	*120.0*
Pseudomonas aeruginosa	*55.0*	*110.0*	*165.0*	*220.0*
Pseudomonas fluorescens	*35.0*	*70.0*	*105.0*	*140.0*

Salmonella enteritidis	*40.0*	*80.0*	*120.0*	*160.0*
Salmonela paratyphi – Enteric fever	*32.0*	*64.0*	*96.0*	*128.0*
Salmonella typhosa – Typhoid fever	*21.5*	*43.0*	*64.5*	*86.0*
Salmonella typhimurium	*80.0*	*160.0*	*240.0*	*320.0*
Sarcina lutea	*197.0*	*394.0*	*591.0*	*788.0*
Serratia marcescens	*24.2*	*48.4*	*72.6*	*96.8*
Shigella dyseteriae – Dysentery	*22.0*	*44.0*	*66.0*	*88.0*
Shigella flexneri – Dysentery	*17.0*	*34.0*	*51.0*	*68.0*
Shigella paradysenteriae	*16.8*	*33.6*	*50.4*	*67.2*
Spirillum rubrum	*44.0*	*88.0*	*132.0*	*176.0*
Staphylococcus albus	*18.4*	*36.8*	*55.2*	*73.6*
Staphylococcus aureus	*26.0*	*52.0*	*78.0*	*104.0*
Staphylococcus hemolyticus	*21.6*	*43.2*	*64.8*	*86.4*

Staphylococcus lactis	*61.5*	*123.0*	*184.5*	*246.0*
Streptococcus viridans	*20.0*	*40.0*	*60.0*	*80.0*
Vibrio comma – Cholera	*33.75*	*67.5*	*101.25*	*135.0*

Moulds

Microorganism (microbe)	***UV light exposure (dose) in J/m² required to achieve 90% – 99.99% reduction of the specified micro-organism types***			
	90% 1 log	*99% 2 log*	*99.9% 3 log*	*99.99% 4 log*
Aspergillius flavus	*600.0*	*1,200.0*	*1,800.0*	*2,400.0*
Aspergillius glaucus	*440.0*	*880.0*	*1,320.0*	*1,760.0*
Aspergillius niger	*1,320.0*	*2,640.0*	*3,960.0*	*5,280.0*
Mucor racemosus A	*170.0*	*340.0*	*510.0*	*680.0*
Mucor racemosus B	*170.0*	*340.0*	*510.0*	*680.0*
Oospora lactis	*50.0*	*100.0*	*150.0*	*200.0*
Penicillium expansum	*130.0*	*260.0*	*390.0*	*520.0*

Penicillium roqueforti	*130.0*	*260.0*	*390.0*	*520.0*
Penicillium digitatum	*440.0*	*880.0*	*1,320.0*	*1,760.0*
Rhisopus nigricans	*1,110.0*	*2,220.0*	*3,330.0*	*4,440.0*

Protozoa

Microorganism (microbe)	***UV light exposure (dose) in J/m² required to achieve 90% – 99.99% reduction of the specified micro-organism types***			
	90% 1 log	*99% 2 log*	*99.9% 3 log*	*99.99% 4 log*
Chlorella Vulgaris	*130.0*	*260.0*	*390.0*	*520.0*
Nematode Eggs	*450.0*	*900.0*	*1,350.0*	*1,800.0*
Paramecium	*110.0*	*220.0*	*330.0*	*440.0*

Virus

Micro-organism (microbe)	***UV light exposure (dose) in J/m² required to achieve 90% – 99.99% reduction of the specified micro-organism types***			
	90% 1 log	*99% 2 log*	*99.9% 3 log*	*99.99% 4 log*
Bacteriophage – E. Coli	*26.0*	*52.0*	*78.0*	*104.0*

Infectious Hepatitis	*58.0*	*116.0*	*174.0*	*232.0*
Influenza	*34.0*	*68.0*	*102.0*	*136.0*
Poliovirus – Poliomyelitis	*31.5*	*63.0*	*94.5*	*126.0*
Tobacco mosaic	*2,400.0*	*4,800.0*	*7,200.0*	*9,600.0*

Yeast

Micro-organism (microbe)	***UV light exposure (dose) in J/m² required to achieve 90% – 99.99% reduction of the specified micro-organism types***			
	90% 1 log	*99% 2 log*	*99.9% 3 log*	*99.99% 4 log*
Brewers yeast	*33.0*	*66.0*	*99.0*	*132.0*
Common yeast cake	*60.0*	*120.0*	*180.0*	*240.0*
Saccharomyces carevisiae	*60.0*	*120.0*	*180.0*	*240.0*
Saccharomyces ellipsoideus	*60.0*	*120.0*	*180.0*	*240.0*
Saccharomyces spores	*80.0*	*160.0*	*240.0*	*320.0*

The distance of the target from the light source is important. The effect decreases in proportion to the square of the distance. For example, increasing the distance between the target and the light from 10 cm to 100 cm reduces the effect to one percent. It should be ensured that light does not come directly into the eyes.

- *A small amount of mercury is used in the production of UVGI lamps. Measures should be taken against breakage. The protective case allows transparent UV. Transparent PTFE, etc. can.*

- *UV working hours should be monitored. When the efficiency reaches 90% point, change should be provided. This point is around 9000 hours for main producers. This means approximately 1 year of working 24 hours a day, 7 days a week. However, as with pass-box applications (about 20 seconds), life will be shorter in very short-term and frequent work.*

- *The design should be easy to access for maintenance / lamp replacement, a shutdown button should be available near the device prior to maintenance.*

- *In air duct applications, the air velocity should not exceed 5-6 m / s, if exceeded, the amount of radiation should be increased proportionally.*