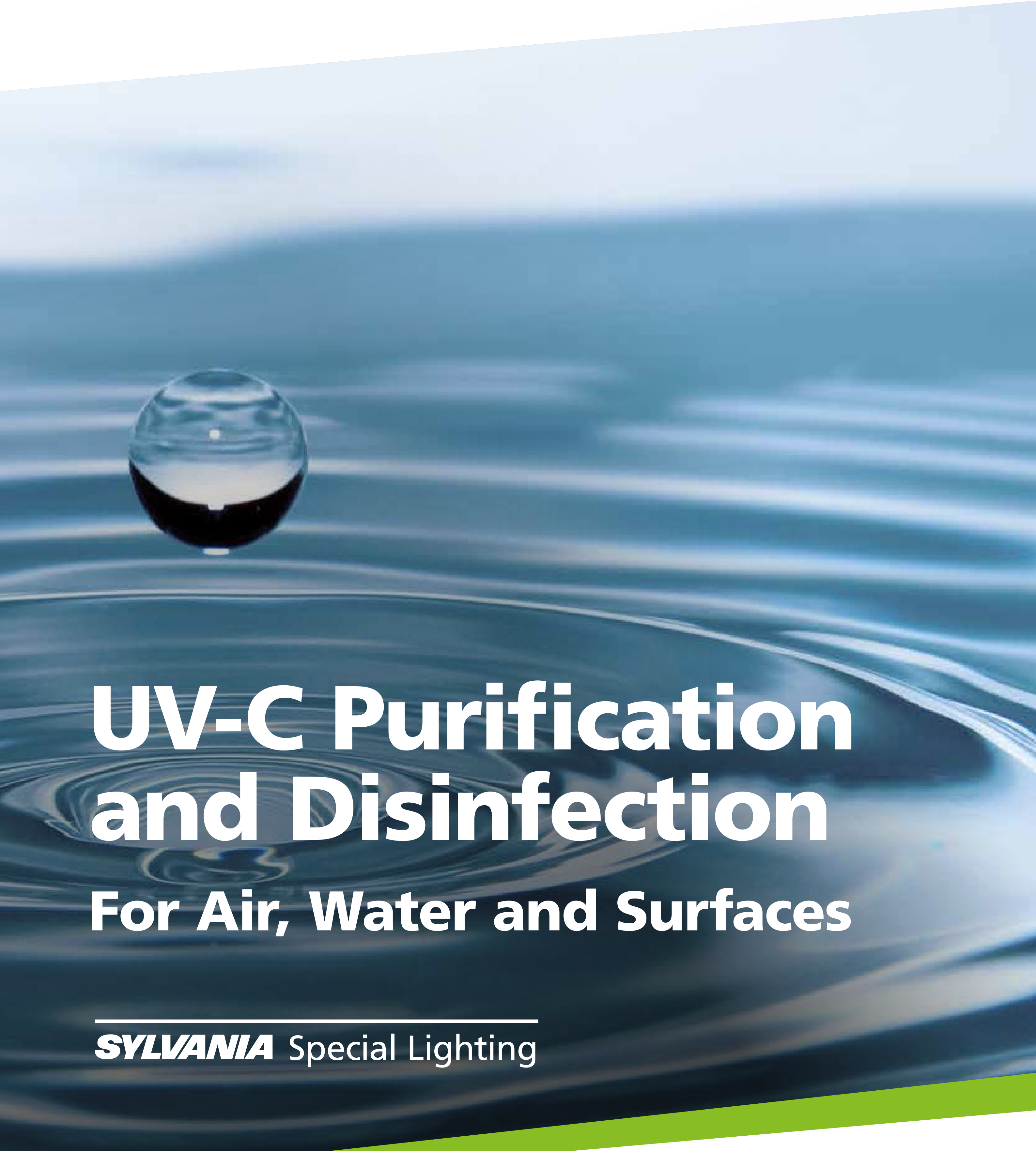
SYLVANIA



UV-C Purification and Disinfection

For Air, Water and Surfaces

SYLVANIA Special Lighting

Light your world

Air and water are two of the most essential things in life. On average, the human body is made up of 60% water and we can't survive more than a few days without it. Without air, it is only a few minutes.

Clean air and pure water support development and a healthy brain and body function. They make us feel happier, healthier and more energetic. Safe recreational water (e.g. for swimming) is also a key element for health, as it enables people to be outdoors and active in the water, directly connecting with their environment.

A better quality of life

Even with all the great benefits, both air and water can cause harm due to their ability to rapidly spread micro-organisms, which can impact our health and our environment. These include viruses (such as Coronavirus), bacteria and mould spores. Crowded conditions with poor air circulation (like public transportation, offices, shops, schools), surfaces and recreational water facilities make it easy for micro-organisms to spread and increase our risk.

UV-C technology has been used for almost 80 years in the purification and disinfection of air, water and surfaces. It is a proven way of destroying the DNA or RNA of micro-organisms, preventing their replication and effectively deactivating them.

Meeting your purification and disinfection needs

Sylvania has a long standing history of expertise in the Germicidal business, having introduced its first lamps in the early 1940's. We have seven decades of experience of producing UV-C products for the purification and disinfection of air, water and surfaces

Our range covers the full spectrum of Germicidal UV-C lamps, from small compacts to long tubes. UV-C Mercury lamps remain unparalleled in their efficiency for the destruction of viruses, bacteria, mould spores and other micro-organisms.

GERMICIDAL LAMP *is studied by (L to R): H. A. Lent, Equipment; P. J. Brown, Production; A. L. Mitchell, Bacteriology; H. H. Chun, Quality.*

GERMICIDAL LAMPS GIVEN TO CAMBRIDGE CITY HOSPITAL

Twenty-one germicidal units have been presented to the maternity section of Cambridge City Hospital by Sylvania. The gift is a part of an effort to aid the hospital in its intensive clean-up program after a recent outbreak of illness. The lamps throw a blanket of ultraviolet irradiation across the upper air to kill virtually all airborne bacteria in the nurseries, formula rooms, pre-natal clinics and lobby.

The fixtures are indirect units designed and installed so as to completely protect the babies from the intense rays which calculations indicate will eliminate more than 90% of any room's airborne bacteria.

SYLVANIA NEWSLETTER 1946

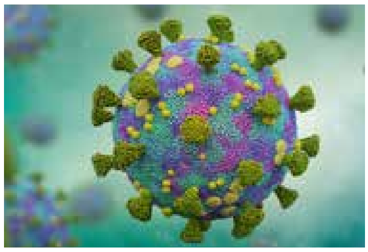
Micro-organisms

Micro-organisms are classified separately from plants and animals because of their tiny dimensions. While some are essential for life, such as in the human digestive system, others can lead to serious diseases and man faces a constant battle against their multiplication.

Traditional techniques for the control of micro-organisms, such as pasteurisation, only lead to a reduction in the total quantity of micro-organisms. Alternative methods involving moist or dry heating, filtration and use of chemical agents can also have some effect, but irradiation by UV-C lamps is considered by far the most effective.

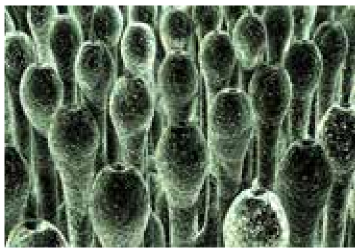
THERE ARE THREE DISTINCT KINDS OF MICRO-ORGANISMS

Viruses Extremely small parasitic organisms which do not multiply themselves, but survive by taking over a host cell. Responsible for some of the most widespread human diseases such as Coronaviruses (e.g. Covid-19), and influenza. In the animal kingdom, foot-and-mouth disease and avian/swine flu have had devastating effects. Plants such as flowers and crops can also be attacked by viruses.

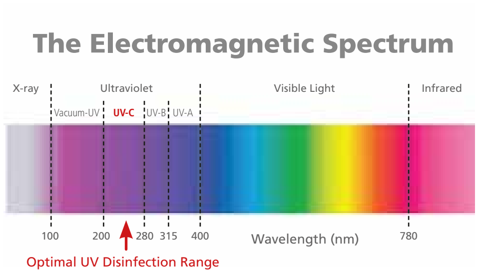


Bacteria / bacterial spores May be single-cell or multi-cellular organisms, which multiply extremely rapidly. Found in air, water, soil, plants/animals and particularly rotting organic matter.

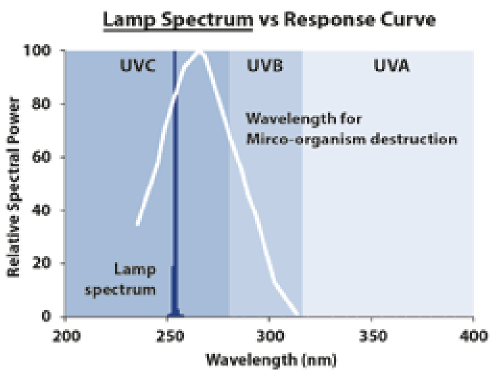
Moulds / Yeasts A broad variety of multi-cellular organisms (moulds) or single-cells (yeasts) which exist almost everywhere. Most moulds are saprophytic (feed on dead organic matter) and are widely used in the production of bread and alcoholic beverages.



Germicidal Action of UV-C Radiation



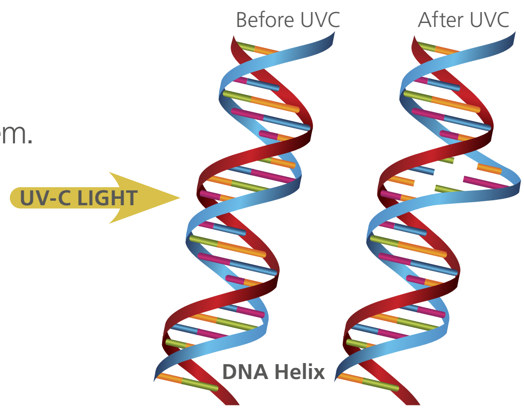
Ultraviolet (UV) radiation is a type of radiant energy located in the wavelength range between 100 and 400nm on the electromagnetic spectrum. As such, it has shorter wavelengths, and higher energy than visible radiation (light). The shorter the wavelength, the more energetic, dangerous and the deeper it can penetrate into living organisms. UV radiation is split into three types: UV-A, UV-B and UV-C. At shorter wavelengths, the radiation takes the form of even more energetic X-Rays.

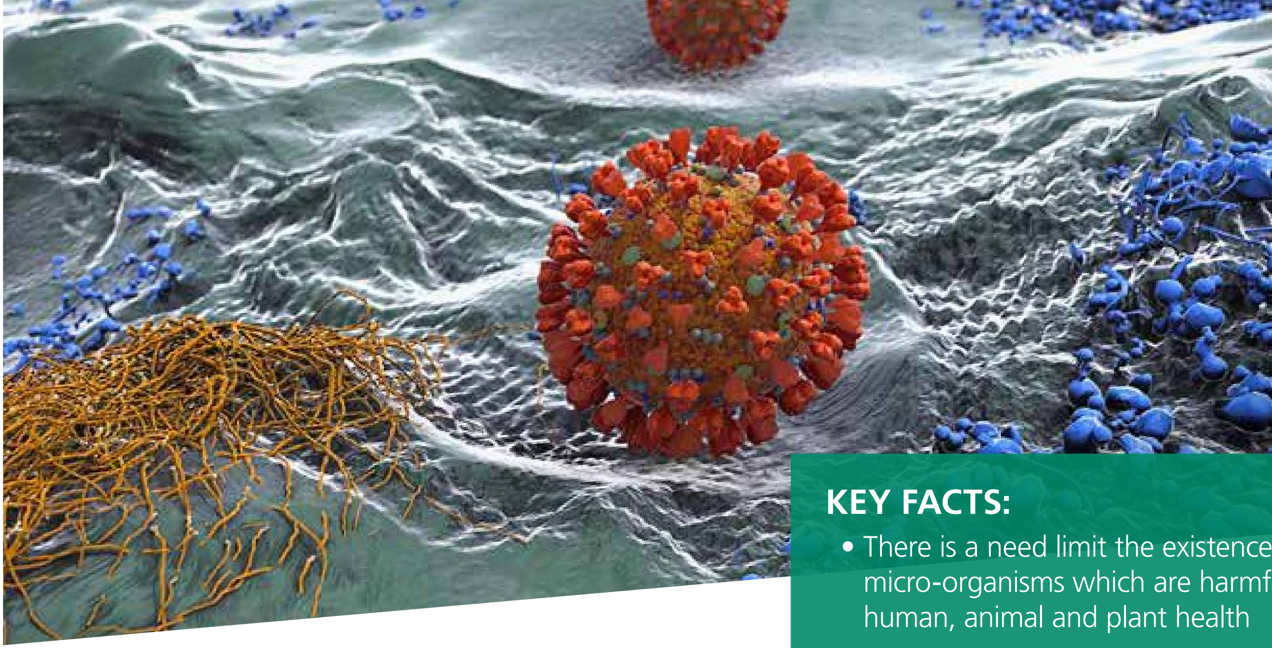


The Germicidal Action Spectrum diagram reveals that the optimal wavelength for the destruction of DNA is 265nm. An electrical discharge through mercury vapour produces intense radiation very near to this peak, at 253.7nm, where the Germicidal efficiency is about 85% of the theoretical maximum. UV-C mercury lamps are thus extremely effective in destroying all living organisms.

The rays destroy the DNA of the micro-organisms thereby preventing cells from dividing and effectively deactivating them.

Although certain safety measures need to be taken when applying UV-C and UV-B radiation, properly designed luminaires that comply with the IEC Safety Standard on Photobiological Radiation are entirely safe for use around humans and animals.





Germicidal UV-C lamps

Low pressure mercury lamps are the most efficient known converters of electrical energy into UV-C radiation. Peak performance is attained when the bulb temperature is around 40°C, which corresponds to an ambient temperature of 25°C. Lower or higher temperatures will both result in falling UV-C levels. In case the lamp is exposed to an air flow which may have a cooling effect, it is desirable to use HO (High Output) types which are loaded at higher wattage than normal, to maintain optimal bulb temperatures even in colder environments.

KEY FACTS:

- There is a need limit the existence of micro-organisms which are harmful to human, animal and plant health
- There are 3 types of micro-organims:viruses, bacteria and moulds/yeasts
- UV-C light is the most efficient and effective technology in the destruction of micro-organisms
- The optimal wavelength for the destruction of a micro-organisms' DNA is 265nm
- UV-C Mercury lamps produce radiation at 253.7nm and are therefore extremely effective at killing micro-organisms
- UV-C lamps are available in compact or linear forms
- The primary application of UV-C radiation is for the purification of air and disinfection of water and surfaces

Application areas

Air Purification

‘Fresh air’ has always been considered beneficial. Indoors, however, air can be relatively stagnant or have poor circulation, particularly in cold weather, where windows are often kept closed. Air can also be contaminated with germs from human beings. Under such conditions, air can be a means of carrying infectious organisms into the body.

Bacteria and mould spores in the air can also cause considerable damage to products in a wide variety of industries. This damage takes the form of spoilage and contamination. In addition to the costs resulting from such damage, there are additional costs, such as added maintenance and refrigeration, plus the ever present threat to the health of consumers from the affected products. Therefore it is widely acknowledged that product sanitisation is of vital importance.

Air is easy to purify because it is quite transparent to UV-C down to 200nm, allowing it to penetrate and kill floating micro-organisms which are responsible for many airborne infections. Direct irradiation methods can be based on ceiling mounted lamps which are energised whilst the room is unoccupied, upward radiation mounted safely above eye level, or concealed downward radiation to sterilise floors. Alternatively, Germicidal lamps may be mounted within air ducts of a ventilation system which has the advantage that higher UV-C doses can be given, because the lamps are out of view. Portable standalone units which draw in air, purify it and then expel clean air into the room are becoming increasingly popular.

Application areas

Water / Liquid Disinfection

Water is essential to the life of most living organisms. The human body is made up of 60% water and we can't survive for more than 3-4 days with out it. Water allows blood to transport oxygen and nutrients to every cell of the body. However consumption of contaminated water can lead to fatal medical conditions such as cholera and typhoid.

Clean water is not just needed for drinking but for sanitation and recreational purposes as well. If clothes or the body are washed with contaminated water this will also result in the risk of infection.

Therefore clean water is essential to remain safe from sickness and to maintain good health.

Liquids are more challenging to purify because they tend to absorb some of the UV-C themselves. To design suitable equipment the absorption coefficient needs to be known, as well as the flow rate and dose. Some examples of absorption coefficient for various liquids are provided in the table.

Drinking Water: Germicidal sterilisation is increasingly being used in municipal water installations to circumvent the ecological impact of chlorine, and because filters cannot catch all micro-organisms. It is also employed in smaller scale residential installations, and in many water cooler-dispensers.

Swimming Pools: The use of a UV-C purification unit can realise significant cost savings, by reducing the use of chlorine by up to 50%.

Ponds & Aquaria: A closed-loop system which circulates the water over a germicidal lamp a few times per day not only reduces parasites, but substantially reduces the build-up of algae.

Examples of absorption coefficients

Liquid	Absorption Coefficient cm^{1}
Drinking Water	0,02 - 0,1
Distilled Water	0,007 - 0,01
Clear Syrup	2 - 5
Beer	10 - 20
White wine	10
Red wine	30
Milk	300

Application areas

Surface Disinfection

Micro-organisms can survive on surfaces for anything from a number of hours to a number of days, depending on the material the surface is made from, and its roughness. These micro-organisms can then transfer to a healthy person when the surface is touched and then they touch their mouth, nose or eyes.

Cleaning physically removes dirt, organic matter and most micro-organisms from surfaces but it does not always destroy them and some harmful germs may remain. Therefore, in some locations, such as hospitals, doctors surgeries and offices, it may be important to use a method of surface disinfection such as UV-C light.

The significant factor that it is impossible to prevent shadows in the case of treating an entire room, such as those cast from furniture and equipment, should always be considered. Surface irradiation is only effective in the case of treating relatively small and well-defined areas, therefore air purification systems should also be considered for full room disinfection.

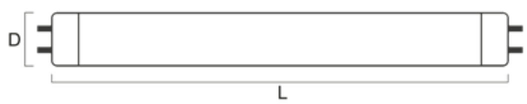
Product portfolio and UV-C dosage needs

For use in professional air, water and surface purification and disinfection units, Sylvania T5 & T8 linear lamps are an effective solution to your Germicidal needs.

UV-C GERMICIDAL
T5 & T8 LINEAR

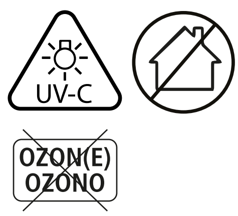
Features
- For use in professional and residential air, water and surface purification and disinfection units
- These lamps consist of a tubular glass or quartz envelope and emit more than 85% of their energy in UV-C ultraviolet radiation with a peak at 253.7nm for germicidal action
- Shape, electrical characteristics and lighting circuits are similar to general fluorescent lamps
- The HO (High output) lamps are most efficient in air purification installations as they are wind corrected
- A protective coating on the inside of the lamp limits the depreciation of the UV-C output
- Ozone-free due to special lamp glass

Applications
- Residential drinking water units
- Standalone air purifiers
- Wall mounted air purification units
- Ponds & Aquaria



Code	Item description	Power (W)	Voltage (V)	Current (A)	UV-C Irradiance (uW/cm^3 at 1m	Cap	Diameter (mm) D	Length (mm) L	Life (h)	Packaging Quantity
T5										
0002329	G4W T5 UV-C	4	29	0.170	11	G5	16	136	8000	30
0002330	G6W T5 UV-C	6	42	0.160	18	G5	16	212	8000	30
0002331	G8W T5 UV-C	8	56	0.145	22	G5	16	288	8000	30
T8										
0000517	G15W T8 UV-C	15	55	0.310	50.5	G13	26	437	9000	25
9000526	G25W HO T8 UV-C	25	46	0.600	71.8	G13	26	437	8000	24
0000518	G30W T8 UV-C	30	96	0.365	135	G13	26	894	9000	25
0002208	G55W HO T8 UV-C	55	83	0.770	194	G13	26	894	8000	24
0002217	G58W T8 UV-C	58	100	0.670	202	G13	26	1,500	8000	12

Warning
- The radiation from these lamps is very harmful to eyes and skin. Always protect your eyes and skin against radiation
- Germicidal lamps must only be used in appropriate equipment and applications



Compact and effective UV-C lamps that easily fit into small fixtures designed for residential water and air disinfection units, as well as specialist surface treatment applications.

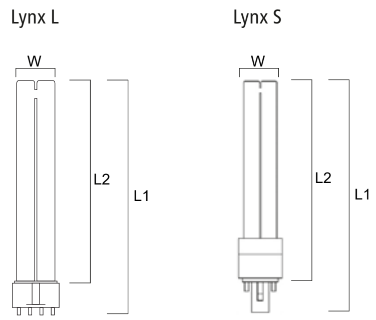
UV-C GERMICIDAL
COMPACT

Features

- For use in residential air, water and surface purification and disinfection units
- Very compact shape allowing for a small fixture design
- Intense radiation at 253.7nm (UV-C) for effective purification and disinfection
- Single-ended lamps enabling easy replacement
- Shape, electrical characteristics and lighting circuits are similar to general lighting compact fluorescent lamps
- The HO (High output) lamps are most efficient in air purification installations as they are wind corrected
- A protective coating on the inside of the lamp limits the depreciation of the UV-C output
- Ozone-free due to special lamp glass

Applications

- Residential drinking water units
- Ponds
- Induct air treatment units
- Standalone air purifiers



Code	Item description	Power (W)	Voltage (V)	Current (A)	UV intensity (µW/cm²) (Distance =1m)	Cap	Width (mm) W	Total Lamp Length (mm) L1	Length to pins (mm) L2	Life (h)	Packaging Quantity
0025037	G9W LYNX-S G23 UV-C	9	60	0.170	25	G23	33	167	145	9000	10
0025038	G11W LYNX-S G23 UV-C	11	91	0.155	39	G23	33	237	215	9000	10
0025039	G13W LYNX-S GX23 (110V) UV-C	13	59	0.285	38	GX23	33	186	164	9000	10
0025020	G18W LYNX-L 2G11 UV-C	18	58	0.375	57	2G11	40	217	195	9000	10
0025057	G36W LYNX-L 2G11 UV-C	36	106	0.435	147	2G11	40	411	379	9000	10
0025058	G55W LYNX-L 2G11 UV-C	55	101	0.550	170	2G11	40	533	503	9000	10
0025059	G90W HO LYNX-L 2G11 UV-C	90	110	0.800	300	2G11	40	533	503	9000	10

Warning

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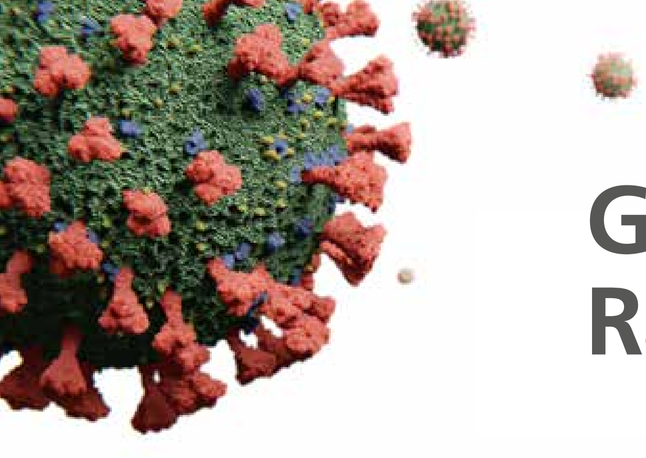
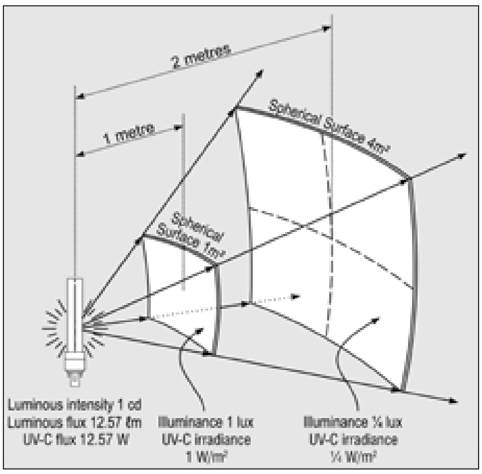
- Germicidal lamps must only be used in appropriate equipment and applications



Germicidal Radiation Terms

For those familiar with general lighting terms, the *UV-C radiant flux* of a germicidal lamp (measured in radiated Watts, W) can be likened to the *luminous flux* of a standard lamp (measured in lumens, ℓm). This is a purely lamp-related parameter which represents the total amount of radiation in all directions. Whereas the more powerful standard lamps deliver greater *luminous flux*, the more powerful germicidal lamps produce greater *UV-C radiant flux*.

When designing a general lighting installation the most important parameter is the *illuminance*, which links the *luminous flux* produced by the lamp to the *surface area* being lighted. The units of *illuminance* are lumens per square metre (ℓm/m²), more commonly known as lux (ℓx). The basic unit of light is still a standardised candle, which has a *luminous intensity* of 1 candela (cd) and radiates 4π lumens (4x 3.142 = 12.57 ℓm). If that is placed at the centre of a sphere having radius 1m, then a surface area of 1m² on that sphere will geometrically intercept 1 ℓm of light. It is therefore lit with an illuminance of 1 ℓm/m² or 1 ℓx. At double the distance, i.e. a sphere of 2m radius, the same quantity of light falls on an area of 2x2 = 4 m², so the illuminance is $^1/_4$ ℓx. At 3m distance it would be 3x3 = 9m² so $^1/_9$ ℓx, and so on.



Precisely the same is true in the germicidal world. For instance, if the entire spherical radiation from a lamp having a *UV-C radiant flux* of 5 W is directed uniformly over a surface area of 1 m², then the installation has a *UV-C irradiance* of 5 W/m².

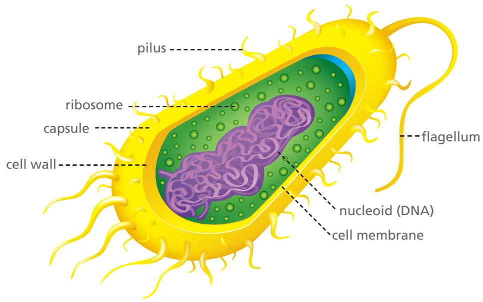
Sylvania defines the UV-C Irradiance of our lamps at the standardised distance of 1m in an infinitely black space. It is not true that a lamp having higher UV-C flux will automatically have a proportionally higher UV-C irradiance, because the more powerful lamps tend to be longer. Their radiation is spread over a larger area, thus the increase in UV-C irradiance is somewhat less. A convenient way to obtain the desired UV-C irradiance in an installation is to adjust the distance between the lamp and the area being treated, as illustrated in the diagram. It is standard practice to employ germicidal lamps with reflectors, which capture their 360° radiation and focus this onto the area being treated. Well-designed reflectors made from suitable materials can greatly amplify the UV-C irradiance.

Germicidal Radiation Dosage

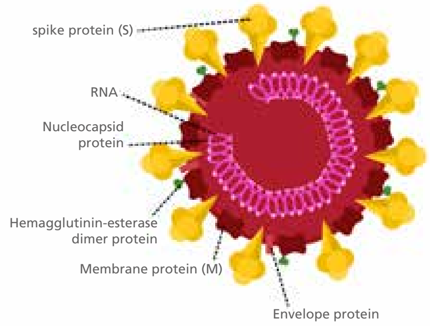
When working out what radiation dose is necessary to destroy a particular micro-organism, it is important to know the actual UV-C irradiance of the installation, bearing in mind the distance and reflector design. **Sylvania Special Products Group** can provide assistance with these calculations, and deliver optical files enabling modelling of UV-C irradiance in standard lighting design software.

Different micro-organisms have varying levels of susceptibility to Germicidal radiation, just as in nature certain plants or animals are tougher than others. Some have an outer protective layer of proteins or fats, or stronger healing capability, and greater doses of UV-C radiation may be required to destroy their nucleic acids.

Bacteria Cell Anatomy



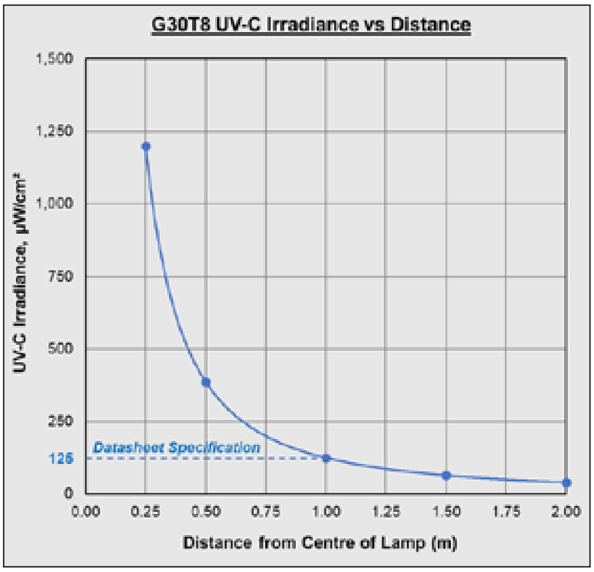
Virus Cell Anatomy



The quantity of energy required to eliminate a particular micro-organism can be expressed as a *UV-C dose*. This a time-dependent measure, which is a combination of three parameters:

a) *UV-C Flux* (or UV-C Power), measured in Watts of UV-C radiation (W)
b) *Irradiated Area*, measured in square metres (m^2)
c) *Irradiation Time*, measured in seconds (s)

The first two parameters can be combined to represent the *UV-C irradiance* (W/m^2). Then the only other variable is exposure time. The resulting measure of *UV-C dose* is in Watt-seconds per square metre (Ws/m^2). Since the unit of energy, the Joule, is equal 1 Watt per second, germicidal doses are frequently stated in Joules per square metre (J/m^2) or other derivatives – for instance millijoules per square centimetre (mJ/cm^2).



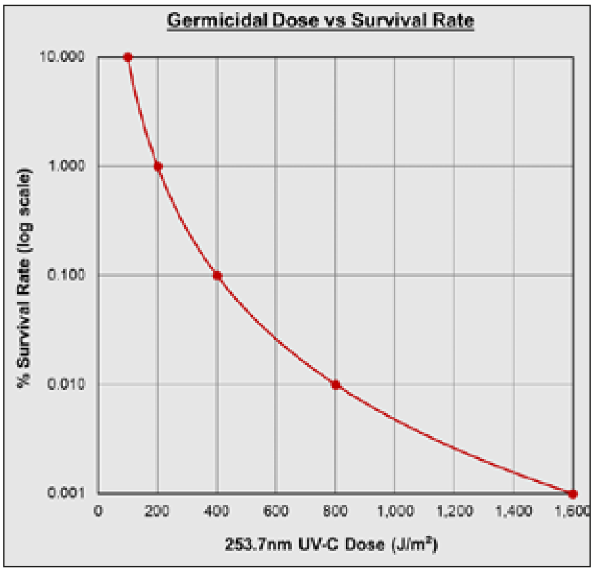
For deactivating different organisms, it makes little difference if the UV-C dose consists of a powerful irradiance for a short time, or a weaker irradiance for a longer duration. If a dose of 100 J/m^2 is required, this can be achieved in multiple ways, e.g.

100 W/m^2 x 1s = 100 J/m^2
10 W/m^2 x 10s = 100 J/m^2
2 W/m^2 x 50s = 100 J/m^2

Radiation Doses for Inactivating Micro-organisms

The table below details the required doses for inactivation of a variety of common pathogens. All figures represent what is known as the *log reduction* value, i.e. a ten-fold reduction. That corresponds to a 90% destruction (or 10% survival) rate. There is an approximately logarithmic relationship between UV-C Dose and destruction rate. So doubling the dose will kill another 90% of the survivors (for total 99% or *two-log* destruction rate). Doubling the dose yet again to four times the reference value will achieve a three-log or 99.9% destruction rate, and still another doubling to eight times the reference value delivers a four-log or 99.99% destruction rate. To be effective a three or four log destruction rate should be targeted, however in many cases a two-log or 99% destruction is considered satisfactory.

In case of surface disinfection, these figures assume a perfectly smooth surface. In reality, microscopic crevices are always present and these create shadows that the UV-C radiation cannot reach so easily. Textured surfaces such as clothing or soft furnishings typically require very much higher doses.
All values are based on the assumption that the radiation is produced at 253.7nm, the wavelength generated by a Germicidal mercury vapour lamp. Note that for instance,



UV-C LEDs tend to radiate at 275-285nm, and at these longer wavelengths the Germicidal efficiency is reduced (see chart on Page 6). Proportionally greater doses may therefore be required in case of UV-C LED irradiation.

RNA-Viruses	J/m^2
Coronavirus	**50**
SARS-CoV-2	50
Picornavirus	**72 (36-186)**
Poliovirus	110
Poliov type 1 Mahoney	67
Poliov	133
Poliov type 1	36
Poliov Mahoney	45
Reovirus	**102 (18-159)**
Reovirus type 1	48
Rotav	159
Rotav SA11	65
Paramyxovirus	**35 (15-55)**
Sindbis virus	55
Newcastle Disease	15
Ortomyxovirus	**35**
Influenza	35

HIV (Lentiv)	**1438 (600-2400)**
HIV (HTLVIII)	600
HIV (Sup T1)	1450
HIV (H9)	2400
HIV (PHA-stim. PBL)	1300

DNA-Viruses	
Parvovirus	**35 (30-40)**
Bov. Parvovirus	40
Kilham rat virus	30
HCC (Dog hepat. Adenov)	**265**
Herpes virus	**57 (15-165)**
Pseudorable virus	70
Herpes simplex MP str.	67
Herpes simplex MP str.	15
Herpes simplex, type 1	165
Vaccinia	**18**

Bacteria

Bacillus (vegetative)	**32 (13-58)**
Bac. anthracis	45
Bac. Megatherium	13
Bac. paratyphosus	32
Bac. subtilis	58
Bacillus (spore)	**118 (11-365)**
Bac. Megatherium	27
Bac. subtilis	120
Bac. anthracis	45
Bac. Subtilis (ATCC6633)	365
Bacillius subtilis	11
Bac. subt. spore ATCC6633	152
Campylobacter jejuni	**29**
Clostridium tetani	**130**
Coryneb. diphteria	**34**
Escherichia coli	**45 (7-54)**
Escherichia coli	30
Escherichia coli (in air)	7
Escherichia coli (in water)	54
Escherichia coli B/ r ATCC12407	53
Klebsi. Pneumon. ATCC 4352	**42**
Legionella	**25**
Legionella pneumophila	25
Micrococcus	**80 (61-100)**
Micrococcus candidus 61	61
Microc. Sphaeroides 100	100
Neisseria catarrhalis	**44**
Pseudomonas aerug.	**35 (15-55)**
Pseudomonas aeruginosa	55
Salmonella	**43 (21-80)**
Salm. Typhimurium	80
Salm. Enteritidis	40
Salmonella Paraty phi	32
Serratia marcescens	**32 (7-85)**
Shigella paradysenteriae	**17**
Staph	**44 (18-110)**
Staph. albus	18
Staph. aureus	26
Staph. epidermis	110
Streptococcus	**36 (18-65)**
Strep. haemolyticus	22
Strep. lactis	62
Strep. viridans	20
Strep. faecalis (ATCC29212)	65
Strep. faecalis	55
Strep. pyogenes	22
Strep. salivarius	20
Strep. albus	18
Strep. faecalis (ATCC29212)	65
Strep. faecalis	55
Strep. pyogenes	22
Strep. salivarius	20
Strep. albus	18
Vibrio	**24 (8-39)**
Yersinia enterecolitica	**15**

Protozoa	**600-1000**

Algae	**3000-6000**
Green algae, blue algae, diatoms	

Yeasts	**59 (23-100)**
Oospora lactis	**50**
Saccharomyces cerevisiae (baking yeast, brewing yeast)	33-100
Saccharomyces ellipsoideus	60
Saccharomyces sp.	80
Torula sphaerica (in milk and cream)	23

Fungi	**713 (130-3000)**
Aspergillus glaucus	440
Aspergillus flavus	600
Aspergillus niger	1320
Aspergillus niger (pasta)	1500
Aspergillus amstelodami (meat)	700
Mucor racemosus	170
Mucor mucedo (meat, bread, fat)	600
Oospora lactis	50
Pencilium chrysogenum (fruit)	500
Pencilium roquefortii	130
Pencilium expansum	130
Pencilium digitatum	440
Rhisopus nigricans	1100
Scopularipsis brevicaulis (cheese)	800

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