



UV-C disinfection devices for home use

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This fact sheet covers UV-C disinfection devices for home use, but not professional systems and devices.

Ultraviolet (UV) rays can destroy pathogens such as bacteria, viruses or fungi on surfaces, in air flows or in liquids. In drinking water treatment, for example, UV radiation destroys dangerous pathogens in the water. These professional UV disinfection devices are also suitable for disinfecting objects, surfaces or air in the healthcare sector or in industry. Thanks to their high-energy UV-C radiation, these professional systems eliminate more than 90% of germs, depending on the intensity, duration of irradiation and wavelength. These systems are reserved for trained personnel who protect themselves with clothing, goggles or protective screens when exposed to UV radiation.



UV-C products for home use have been available for some time. These are often portable devices that emit UV-C rays. According to the product descriptions, these devices are supposed to eliminate germs such as bacteria, viruses, mites, fungi, yeasts, moulds, allergens and organic and inorganic odorous substances.

To destroy germs on surfaces and objects, sufficiently powerful UV-C radiation is required. It must act for a sufficient length of time and in a targeted manner on the surfaces or objects to be disinfected. This means, on the one hand, that the radiation must be emitted by the UV-C device. On the other hand, the UV-C radiation from a UV-C device that is used slightly incorrectly

- disinfect surfaces and objects incompletely or not at all,
- endanger the health of the skin and eyes of persons carrying out the disinfection or who are present on site.

In order to avoid such health risks, the UV-C radiation from the devices must not exceed the applicable UV limit values. These limit values apply primarily to people in their workplace. They can only be applied to a limited extent to the general population, which also includes people who are sensitive to UV radiation, such as children or other people with sensitive eyes and skin.

Overall, this means that people should not use UV-C devices that emit UV-C radiation in their private lives.

Devices with a closed disinfection chamber are also commercially available. These are recommended for disinfecting small devices. High-quality devices that do not emit any UV-C radiation into the environment are safe to use.



Measurements carried out on behalf of the FOPH show that UV-C disinfection devices for home use either exceed the UV-C limit values and therefore pose a health risk or produce only low or no UV-C radiation, meaning that their disinfecting properties are unrealistic.

The following recommendations will help you protect yourself from these dangers:

- Do not use devices that emit UV rays from their casing to disinfect surfaces, objects or rooms in your home and in everyday life. These devices can be harmful to your health, both through direct irradiation of your body and through radiation reflected from surfaces. This also applies to far-UV-C lamps, which are advertised as harmless or safe for the skin and eyes. Do not import such devices from abroad.
- Do not use devices with a closed disinfection chamber whose quality you cannot assess. It is best to purchase these devices from specialist shops.
- Do not follow instructions and recommendations that people should expose themselves to UV radiation to protect themselves against infectious germs.
- Follow the rules of the Federal Office of Public Health to protect yourself against dangerous germs.



1 Technical principles of UV disinfection devices

1.1 Classification of UV rays

Ultraviolet radiation is short-wave radiation. It is classified into the following categories:

- UV-C radiation, with a wavelength between 100 and 280 nanometres (nm), is the most energetic form of UV radiation. It comes from the sun or is generated artificially. UV-C radiation is not naturally present on the Earth's surface, as it is completely filtered out by the upper layers of the atmosphere.
- Far UV radiation refers to UV radiation in the wavelength range between 200 and 240 nm. Typical wavelengths of technically produced far UV radiation are 222 nm or 233 nm.
- UV-B radiation, with a wavelength between 280 and 315 nm, comes mainly from the sun. As the Earth's atmosphere filters out much of the UV-B radiation depending on the thickness of the ozone layer, only a fraction of it reaches the Earth's surface. UV-B radiation can also be produced artificially, for example in solariums or portable skin irradiation devices.
- UV-A radiation, with a wavelength between 315 and 400 nm, comes mainly from the sun. As it is not filtered by the Earth's atmosphere, it is the main component of UV radiation present on the Earth's surface. UV-A radiation can also be produced artificially, for example in solariums.

1.2 Sources of UV radiation for disinfection devices

Disinfection devices operate with UV-C radiation, which can be generated using various techniques.

1.2.1 UV-C LEDs

UV-C LEDs can emit UV light in different wavelength ranges depending on the alloy of the semiconductor materials. They can eliminate viruses and bacteria. There are

- UV-C LED lamps with a wavelength range of 265 to 280 nm. They are considered a replacement for UV-C discharge lamps (see 1.2.2).
- Far-UV-C LED lamps with a wavelength range of 200 to 240 nm.

UV-C LEDs do not emit visible light unless they are combined with LEDs that emit visible light. UV-C LEDs do not contain mercury.

1.2.2 UV-C discharge lamps

UV-C discharge lamps contain mercury vapour and two electrodes. During operation, a conductive plasma forms between the electrodes, whose electrons raise the mercury atoms to higher, unstable energy levels by consuming energy. When the mercury atoms fall back to their original energy level, energy is released in the form of, among other things, UV-C radiation of various wavelengths. The mercury gas in UV-C lamps is enclosed in a quartz glass or sodium-barium glass bulb, both of which are permeable to UV-C radiation.



1.2.2.1 Low-pressure mercury lamps

Conventional UV-C lamps with limited power are low-pressure mercury lamps, also known as quartz lamps. They emit UV-C radiation with a wavelength of 254 nm and, depending on the material properties of the bulb, several additional wavelengths. These lamps can be recognised by their clear, transparent glass bulb. If the glass breaks, the mercury in the lamp poses no proven health risk. It is therefore sufficient to ventilate the room thoroughly after removing the debris.

1.2.2.2 Medium-pressure mercury lamps

Medium-pressure mercury lamps are characterised by higher pressure, higher power and hotter plasma. They are used for industrial processes and water disinfection. They are not covered in this information sheet.

1.2.2.3 UV-C excimer lamps

UV-C excimer lamps are low-pressure discharge lamps filled with mixtures of rare gases or a mixture of halogens and rare gases, but do not contain mercury. They generate a high-frequency, high-voltage plasma inside, in which the mixtures combine to form what are known as dimers. These disintegrate very quickly, producing UV-C radiation. The typical wavelengths of krypton chloride lamps are 222 nm in the far UV-C range. However, the lamps also emit in the rest of the UV-C spectrum, as well as in the UV-B and UV-A spectra. They can be combined with optical filters that only allow the desired wavelength to pass through.

1.2.3 Reflection of UV-C

Surfaces can reflect both far-UV-C and UV-C rays. Metallic surfaces reflect rays more than organic surfaces such as wood, paper or plastics, or inorganic surfaces such as stone, brick or mirrors [1].

1.3 Professional UV-C disinfection systems

Professional UV-C disinfection devices and installations are designed so that closed or locked housings protect the UV lamps (water purification systems and air treatment). Air treatment systems can also be arranged so that they only irradiate the upper volume of tall rooms, where no people are present. In premises where the entire volume must be irradiated, organisational measures can be taken to prevent people from being exposed to radiation by prohibiting them from entering irradiated rooms. If the presence of properly trained personnel is essential in irradiated rooms, they must protect themselves from UV radiation by wearing protective clothing.

1.4 UV-C disinfection devices intended for use by consumers (home use)

For some time now, UV-C disinfection devices intended for consumers have been available on the market which, according to the manufacturers' claims, can be used to disinfect ambient air, water in swimming pools or garden ponds, objects, clothing, sanitary facilities or other surfaces. There are also devices that, according to the manufacturers, destroy unpleasant odour molecules using UV-C rays.



Some of the products are devices in which the UV lamp is enclosed in a sealed housing. In these devices, UV-C rays can only escape during maintenance work, unless competent persons replace defective UV lamps. This maintenance work must therefore always be carried out in strict accordance with the instructions for use and when the device is switched off. A device whose housing leaks UV-C radiation due to maintenance must be disposed of.

Commercially available devices with open UV radiation sources must be manually moved over surfaces and objects by users, or they are devices that are placed in rooms to disinfect the ambient air. Uncapsulated UV-C lamps can expose users and bystanders to the device's UV-C radiation. Open UV-C radiation can also harden and weaken materials such as plastics and damage plants and animals.

2 Effects of ultraviolet radiation

2.1 Health effects of UV radiation

2.1.1 Principles

The wavelength range of ultraviolet radiation lies between visible radiation and ionising radiation. Due to its limited energy, visible radiation, with a wavelength between 400 and 700 nanometres (nm), cannot ionise molecules and therefore does not directly damage biological tissue, but only through secondary biological processes. In contrast, ionising radiation, which is more energetic and has a wavelength of less than 100 nm, can directly damage molecules such as genetic material. Ultraviolet radiation is the transition zone. Depending on the wavelength, direct or indirect damage is possible:

- UV-C radiation can damage biological molecules. It has the most powerful germicidal effect.
- UV-B radiation can damage biological molecules.
- UV-A radiation cannot damage molecules directly, but only through secondary biological processes.

In humans, excessive UV radiation can damage the skin and eyes.

2.1.2 Risks to the skin

UV-C rays penetrate the outermost layers of the skin, the epidermis, with their penetration depth decreasing as the wavelength decreases. They only reach the tissues beneath the epidermis when the epidermis is thin. Like UV-B rays, UV-C rays can cause skin redness and sunburn. However, at comparable doses, the skin reacts more sensitively to UV-C rays than to UV-B rays [2]. These symptoms disappear after a certain amount of time.

Laboratory and human studies show that UV-C rays, like UV-B rays, can damage genetic material (deoxyribonucleic acid, DNA) if they penetrate the deeper layers of the skin. This leads to the formation of cyclobutane pyrimidine dimers in the DNA, which have carcinogenic properties and can cause skin cancer. Due to a lack of data, the cancer risk associated with UV-C rays cannot be assessed [2]. UV-B rays and, above all, UV-A rays can penetrate the deeper layers of the skin. They are recognised as



carcinogenic and, in the case of chronic exposure, cause skin cancer and, in the case of UV-A rays, premature ageing of the skin [3]. UV rays also pose a significant risk to people for whom even low doses of ultraviolet rays can cause serious skin and whole-body diseases.

Far-UV-C

For some time now, the question has been raised as to whether open far-UV-C devices can be used to safely disinfect objects or surfaces in rooms where people are present at the same time. Studies show that UV-C lamps with wavelengths of 222 nm or 233 nm only cause genetic mutations in the upper layer of the epidermis. As there is no longer any cell division in this layer, these lamps are considered safe. However, it has been shown that repeated exposure can lead to an accumulation of genetic damage [4].

The potential long-term effects of UV-C, as well as other effects on the skin or the skin's natural microbiome (skin flora), which protects the skin and body from pathogens, have not been studied [5].

2.1.3 Risks to the eyes

UV-C and UV-B rays can burn the surface tissue of the eyes and cause acute, temporary inflammatory reactions. Photokeratitis is an inflammation of the cornea, which is the foremost optical surface of the eye. Inflammation of the cornea is caused by UV rays with wavelengths between 200 nm and 400 nm, with wavelengths between 220 nm and 320 nm being the most dangerous. The maximum danger occurs at wavelengths of around 270 nm. The cornea of the eye is particularly sensitive to UV rays because it is not protected by a layer of keratinised, dead cells like the skin. Photoconjunctivitis causes inflammation of the conjunctiva, which covers the white sclera of the eye. These two inflammatory reactions usually occur together following exposure to UV rays. They are commonly known as "snow blindness" and "arc eye". Symptoms include intense pain and a foreign body sensation in the eye ("gritty feeling in the eye"), violent and involuntary contractions of the eyelid muscles, and blurred vision. These symptoms usually disappear within a week but may persist longer in cases of intense exposure. UV-A rays can, especially in children and adolescents, partially penetrate the outer layers of the eye, reach the retina and damage it. In the long term, chronic exposure to UV-C or UV-B rays can lead to the development of cataracts. It is not known whether short-term exposure to UV-C rays also contributes to the development of cataracts.

Far UV-C

A study [6] shows that

- Far-UV-C rays with a wavelength of 222 nm penetrate less deeply into the outer layer of the cornea (epithelium) and cause less damage than far-UV-C rays with a wavelength of 233 nm.
- Far-UV-C light with a wavelength of 233 nm causes more genetic damage to the epithelium with multiple exposures than with a single exposure.
- UV-C rays with a wavelength of 254 nm cause damage to the innermost layer of the cornea (endothelium), unlike far UV-C and UV-B rays.

Current knowledge, which indicates a reduced potential for damage from far-UV-C, does not allow, due to uncertainties, for a reduction in safety measures for far-UV-C and for the eyes to be exposed to this radiation without protection. The possible long-term effects of UV-C and other effects on the eye,



for example on the tear fluid, have not been studied.

2.2 Germicidal effects of UV radiation

UV-C radiation acts primarily on the genetic material of germs (deoxyribonucleic acid DNA; ribonucleic acid RNA), which strongly absorbs UV-C radiation. At a sufficient dose, it inserts cyclobutane-pyrimidine dimers into the genetic material of the germ, thereby preventing the germ's DNA from replicating or the germ from copying itself. In addition, far-UV-C rays in particular can denature and damage the germ's proteins. However, if the UV-C doses are too low, the biological repair systems of the germs may repair the damage to their genetic material. The amount required for disinfection depends on the type of germs, the nature of the contaminated surfaces and other parameters such as air humidity [7].

2.3 Health effects of UV-C devices for home use

There are few studies on the health risks associated with UV-C disinfection devices for home use. A recent study shows that commercially available UV-C disinfection devices for private use may pose a health hazard [8]. A family used such a disinfection device to try to eliminate any COVID-19 viruses that might be present in their flat. The family members suffered from skin redness on their faces and necks, a decrease in visual acuity of up to 50%, and symptoms attributable to photokeratitis and photoconjunctivitis. Other case studies describe situations in which individuals or groups of people were exposed to radiation from professional UV-C disinfection devices and installations [2] or portable devices at home or in the workplace [9]. These accidental exposures to radiation were due to improper handling of the devices, failure to follow the instructions for use, or defective disinfection installations. Those affected suffered burns and inflammation of the skin, cornea or conjunctiva. In most cases, the symptoms disappeared within a week. However, one study has shown that these symptoms can persist for more than two years in cases of intense radiation.

2.4 Limit values and standards

The International Commission on Non-Ionising Radiation Protection (ICNIRP) has recommended limit values for ultraviolet radiation to protect the skin and eyes [10, 5]. The ICNIRP limit values are expressed in units of radiant energy per irradiated surface area (J/m^2). Radiant energy is calculated from the intensity (power per irradiated surface) of the radiation multiplied by the duration of irradiation during which the radiation acts on a person. The limit values depend on the wavelength of the radiation. For the most biologically effective wavelength, 270 nm, the limit value is $30 J/m^2$. Conventional UV-C mercury vapour lamps emit at a wavelength of 254 nm, for which the limit value is $60 J/m^2$. For far UV-C lamps with a wavelength of 222 nm, the limit value is $227 J/m^2$, and $136 J/m^2$ at 233 nm. In order to determine the exact limit value for a specific UV lamp or UV LED, it is essential to know the wavelength of the UV-C radiation it emits. The ICNIRP limit values apply to the working population and, according to the ICNIRP, can also be extended to the general population with certain precautions. Particular caution is advised for vulnerable individuals [5].

- Children: eyes and skin.
- People with congenital, acquired or temporary corneal damage or a thinner epidermal corneal layer.



- People with a medical history of corneal or epidermal layer impairment.
- People with a medical history and/or eye and skin lesions.
- People who have previously had skin cancer.
- People unable to regenerate skin lesions caused by UV rays (e.g. patients with xeroderma pigmentosum).
- People whose skin is generally more photosensitive than average.
- People taking medicines or herbal preparations that increase photosensitivity.
- People who come into contact with photosensitising substances, for example by touching certain plants.

The ICNIRP limit values form the basis for Swiss and European standards according to which manufacturers must assess the safety of their devices. Since UV disinfection devices consist of UV-C lamps and the wavelengths of the UV lamps used are generally above 200 nm, the Swiss-European standard SN EN 62471 [11] applies. The lamp standard requires manufacturers to classify each of their lamps into a risk group. These risk groups are based on the ICNIRP limit values or on the exposure time during which a lamp reaches the ICNIRP limit value. The standard distinguishes between lamps which, due to their low radiation levels, pose no risk even when used for unlimited periods of time, and lamps which, due to their more intense or strong radiation, are only safe for limited or very short periods of use. These groups are defined as follows for ultraviolet radiation:

- Unrestricted group: safe to use even with very long exposure of the skin and eyes, exceeding 30,000 seconds.
- Risk group 1: safe to use for irradiation times of at least 10,000 seconds ("low risk"). The limit value is reached for irradiation times between 10,000 and 30,000 seconds. The maximum safe irradiation time is specific to each lamp.
- Risk group 2: safe use for irradiation times of at least 1,000 seconds ("medium risk"). The limit value is reached for irradiation times between 1,000 and 10,000 seconds. The maximum irradiation time for safe use is specific to each lamp.
- Risk group 3: the limit value is reached for irradiation times of less than 1,000 seconds ("high risk"). The irradiation time is specific to each lamp.

In accordance with technical report IEC TR 62471-2, UV lamps in risk groups 1, 2 and 3 must also be accompanied by a warning, precaution or caution on the packaging or in an accompanying leaflet [12]. For UV-C sources in risk group 3, appropriate UV protection measures must be taken [11, 13]. The maximum permissible exposure for humans is defined in standard SN EN ISO 15858 [13]. This standard does not define the permissible UV-C radiation of a given product, but rather the permissible and safe exposure of persons who are exposed without protection to the radiation of UV-C lamps for a specified period of time. The corresponding limit values in this standard are based on the ICNIRP recommendations in the UV-C range.



3 Intensity of ultraviolet radiation from UV-C disinfection devices for home use

3.1 Measurements

In 2020, at the request of the FOPH, METAS measured the ultraviolet radiation generated by UV-C disinfection devices for home use and classified them into different risk groups [14]. The results shown in Table 1 indicate that most devices belong to risk group 3. A few isolated devices that do not emit in the UV-C range belong to the free group. The time required to reach the limit value for damage to health depends on the distance between the device and the irradiated body. Device 11 is a device with a closed disinfection chamber whose safety mechanism can be easily bypassed, so that open operation, not intended by the manufacturer, is also possible.

De-vice	Handling	Radiation source	Time in seconds during which the limit value for health risks is reached at a distance of 0 cm, 20 cm or 100 cm			UV range	Risk group
			0 cm	20 cm	100 cm		
1	manually guided	open	0.7	112	2358	UV-C	3
2	portable	open	2.7	640	11,733	UV-C	3
3	manually guided	open	2.1	354	8411	UV-C	3
4	manually guided	open	>30,000	>30,000	>30,000	UV-A	Free group
5	manually guided	open	0.7	738	14,761	UV-C	3
			88.7			UV-A	
6	Table model	open	1.2	59	1621	UV-C	3
7	manually guided	open	0.3	13	257	UV-C	3
8	manually guided	open	0.8	18	351	UV-C	3
9	Lamp with screw socket	open	0.1	5	83	UV-C	3
10	Table model	open	0.8	18	351	UV-C	3
11	Closed sterilisation chamber	closed when used correctly	When used incorrectly in the open air			UV-C	3
			0.9	303	8346		
12	manually guided	open	>30,000	>30,000	>30,000	UV-A	Free group



13	manually guided	open	>30,000	>30,000	>30,000	UV-A	Free group
14	Table model	open	>30,000	>30,000	>30,000	UV-A	Free group

Table 1 Radiation properties of UV-C disinfection devices

3.2 Health assessment

The measurements carried out by METAS allow the following conclusions to be drawn regarding the health effects of UV-C disinfection devices intended for home use :

- UV-C disinfection devices that, as advertised by manufacturers, generate UV-C radiation belong to the highest risk group. When used close to the body, damage to health is possible even after very brief exposure, in the order of a few seconds. At greater distances, the radiation exceeds the limit values within a few minutes or hours.
- UV-C disinfection devices with a closed disinfection chamber must not be used when open under any circumstances, even if a faulty safety mechanism allows it.
- UV-C disinfection devices that, contrary to manufacturers' claims, do not produce UV-C radiation pose no health risk. However, due to these misrepresented devices, users are unclear as to whether a product marketed as a UV-C disinfection device actually generates germicidal UV-C radiation. Users cannot be sure that UV-C disinfection devices are actually capable of disinfecting.

Furthermore, there is currently only unverified information on the doses of UV-C radiation required to eliminate germs with sufficient safety using home disinfection devices. Furthermore, these devices do not allow users to check whether the surfaces to be disinfected are sufficiently exposed to UV-C radiation. There is a risk that sterility may be pretended due to shadows, multiple layers of material, insufficient device power or excessive distance during the irradiation process.

The Federal Office of Public Health therefore advises against the use of UV-C disinfection devices marketed to consumers.

4 Legal regulations

As low-voltage products, UV-C disinfection devices must meet the essential requirements of the Low Voltage Directive (LVD) [15]. Low-voltage products must not pose any danger to persons or property and may only be placed on the market if they meet the essential health and safety requirements of the European Low Voltage Directive 2014/35/EU [16]. The essential requirements are specified in European standards. The permissible optical radiation of UV-C disinfection lamps is defined in standard SN EN 62471 [11]. Manufacturers are responsible for ensuring that their devices comply with these criteria. In Switzerland, no authority checks whether UV-V devices comply with this standard [17].



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17. [23.4244 | Handys strahlen stärker, als erlaubt. Endlich auch in der Schweiz die NIS-Grenzwerte prüfen! | Geschäft | Das Schweizer Parlament](#)

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