LIGHTINGEUROPE
THE VOICE OF THE LIGHTING INDUSTRY

Frequently Asked Questions

On UV-C Disinfection Technologies

13 November 2020

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Foreword

This Frequently Asked Questions complements the LightingEurope statement on the benefits of UV-C disinfection technology of 14 September 2020 (link) and the Global Lighting Association publications: Position Statement on Germicidal UV-C Irradiation UV-C Safety Guidelines (May 2020); and Germicidal UV-C Irradiation Sources, Products and Applications (September 2020).

It summarises the understanding of LightingEurope about the state of technology and applicable norms at the time of publication and may be subject to review.

The information provided in this FAQ is based on the latest research, studies and applicable regulations and standards. While we have made every attempt to ensure that the information has been obtained from reliable sources, LightingEurope is not responsible for any errors or omissions, or for the results obtained from the use of this information.

LightingEurope is the association representing the lighting industry in Europe. We are the voice of more than 1,000 lighting companies that employ more than 100,000 Europeans and create an annual European turnover of over € 20 billion. Our daily mission is to advocate and defend the lighting industry in Brussels, while reconciling it with ongoing EU policy aims. LightingEurope is committed to innovation, sustainability, quality and leadership, and we help shape policy and establish industry standards and guidelines. In doing so, we are dedicated to promoting efficient lighting practices for the benefit of the global environment, human comfort, and the health and safety of consumers. More information is available at: www.lightingeurope.org

General

1. **What is UV radiation?**

Ultraviolet radiation is a form of electromagnetic radiation with a wavelength from 100 nm to 400 nm. UV-C radiation is a part of the optical radiation that is not visible. UV radiation is present in solar radiation and constitutes about 10% of the received solar electromagnetic radiation.

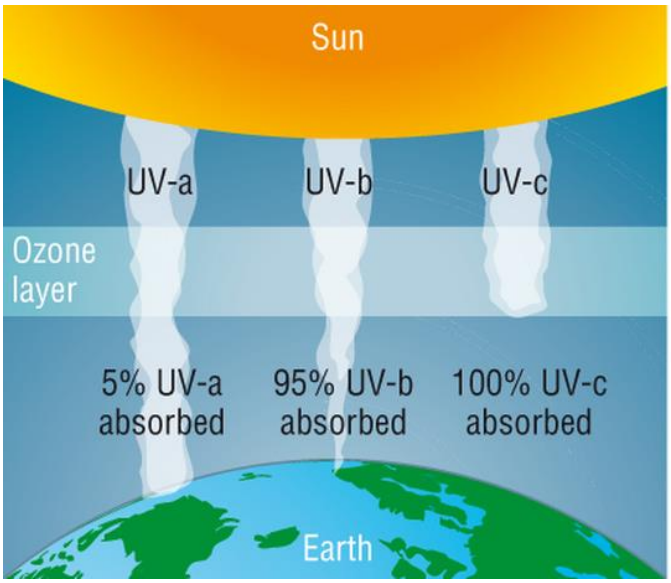

Image source: https://ozonedepletiontheory.info/Papers/Ward2017GJHSlidesLinear.pdf

2. **What is the difference between UV-A, UV-B and UV-C?**

The spectrum of UV radiation is split in 3 ranges, namely: UV-A, -B and -C, in the same way visible light is split in different colours. UV-A light ranges between 315-400 nm, UV-B from 280-315 nm, UV-C from 100-280 nm[1].

UV-A and -B are found naturally on earth in the atmosphere. UV-C does not go through the atmosphere, so there is hardly any UV-C naturally, because it is filtered by the ozone layer.

UV-C is much more efficient as a germicide than UV-A and -B. UV-C radiation is less harmful to our skin and eyes than UV-B.

[1] See CIE Lighting Vocabulary: http://eilv.cie.co.at/term/1367. Please note that the wavelength below 200 nm Is called UV-V (ultraviolet vacuum).

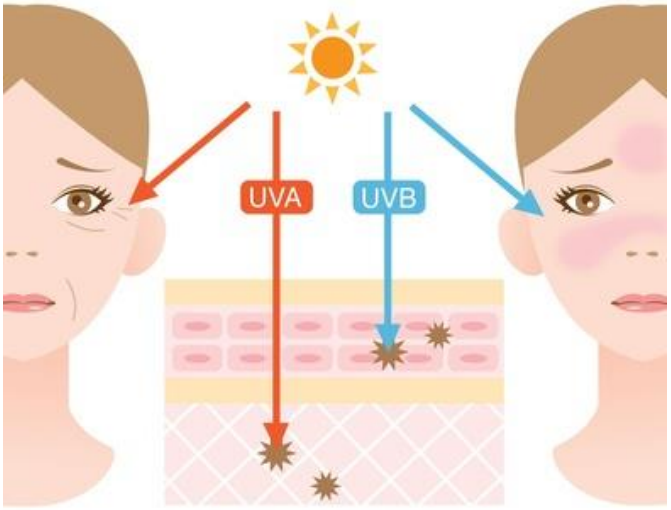

Image source: https://solarfive.com/summer-skincare-tips/

3. Is UV-C radiation visible?

UV-C radiation is not visible to the human eye. There are some UV-C sources that also emit part of their radiation inside the visual spectra, so we can see only that part.

4. Where is UV-C used?

UV-C is used in air, water and surface disinfection, below are a few key examples[2]:

a) **Air:** Trapped or recirculated indoor air may contain microorganisms and viruses that can infect building occupants. Applying UV-C germicidal irradiation can considerably reduce these contaminants and the associated airborne infections. Products used for air disinfection are typically found in commercial and public environments - for example in offices buildings, cruise ships, hotels and apartment buildings. ISO standard 15858 applies.

b) **Water**: disinfecting drinking water (tap water, water coolers, dispensers, coffee machines), disinfecting water from industrial processes, swimming pools, fishponds and aquariums, wastewater etc.

c) **Surface disinfection**: in industrial and public environments, for example to disinfect trains, aircrafts, buses, food manufacturing sites, hotels, hospitals, offices, schools, laboratories, etc.

[2] The Global Lighting Association has published an overview of the applications of UV-C disinfection technologies in its document on Germicidal UV-C Irradiation: Sources, Products and Applications. (link)

Is UV-C Effective?

5. **Why is UV-C used for disinfection?**

UV-C is a very effective radiation technology for germicidal inactivation of known viruses and bacteria, as it is easy to apply in a defined area. Germicidal inactivation refers to the damaging of the reproductive capability of DNA/RNA.

UV-C does not use any chemicals, making it a sustainable choice.

With an adequate amount of UV-C radiation, it is a fast disinfection system. It is a very well-known technology, broadly used in hospital disinfection during the first half of the last century, until the advent of penicillin and vaccines.

6. **Is UV-C effective against SARS-CoV-2?**

Yes, it is. Studies have demonstrated that UV-C is effective in inactivating known viruses and pathogens, including SARS-CoV-2[3] and the common flu.

To be effective, the virus must be exposed to the UV-C radiation. The areas that fall in the shadow of the radiation are not disinfected, which is why UV-C should be used in conjunction with cleaning.

7. **Which effectiveness guidelines apply for UV-C?**

To measure UV-C radiation, specially calibrated equipment must be used, as general photometers are only calibrated to the visual spectrum. UV-C radiation does not reflect on surfaces as light. The standard software calculation tools for lighting do not take it in consideration, resulting in incorrect germicidal calculations.

Use of both direct and indirect hybrid systems are more efficient than just using each on their own. Indirect radiation can be used to disinfect the upper air when people are present and direct radiation can be used when people are not present to disinfect the radiated surfaces and the lower portion of the air in a room.

For additional information please access CIE 187:2010 UV-C Photocarcinogenesis Risks from Germicidal Lamps and CIE 155:2003 Ultraviolet Air Disinfection

[3] Recent studies performed at Boston University show that with an appropriate UV-C dose, the SARS-CoV-2 virus can be completely inactivated (link). Studies performed by Bianco et al in Italy confirm that UV-C light is effective at inactivation and inhibition of the SARS-CoV-2 virus (page 6, link).

Is UV-C Safe?

8. How can UV-C be installed and used safely?

There are a number of requirements in place to ensure UV-C is installed and used safely. Below is a summary of requirements that are listed in a number of sources, e.g. standard series EN 61508 or equivalent ones, the Low Voltage Directive 2014/35/EU, risk assessments, etc. Further details are available In the GLA Safety Guidelines.

- The apparatus that are incorporated into installations that emit UV-C must include visible mandatory markings on their packaging and on the product itself, clearly and unmistakably indicating that it emits UV-C radiation.

- The accompanying documentation must include the possible harm it may cause to human health.

- Only products that actually and mainly emit this radiation may be marked with the UV-C label, and those that emit more than 10% in wavelengths between 280 - 400 nm must be marked as UV because these product have to fulfil both the requirements for UV-C and the requirements for UV-A.

- The products must be differentiated according to whether they are designed for direct, indirect or mixed radiation. It must be ensured that the installations meet the safety requirements that are applicable when the radiation is direct and indirect.

- The apparatus for direct radiation must not be in operation if there are persons within the radiation field where the exposure will be higher than the allowed limits. The apparatus and/or installations must be equipped with safety and warning elements if they are installed in spaces where persons could be present (e.g. movement or presence sensors, visual and sound signals etc.), as well as a backup mechanism which, if any of the systems fails, ensures that the system remains safe. To do this, the installer must perform a risk analysis of the installation and use of the system. The presence sensor used must be catalogued as a functional safety sensor and be in accordance with the relevant standards (for example standard series EN 61508 or equivalent ones).

- Clear and concise instructions must be provided to place at the entrances to rooms equipped with installations of UV-C apparatus. Once the system is installed, it must be verified that it meets the specification relating to the system's safety.

- A verification must be carried out in the case of indirect radiation installations, to ensure that established UV radiation levels are not exceeded in the space occupied by humans.

- Regular measurements must be made (at least every six months) of the installations containing UV-C apparatus.

- Portable type or apparatus that may have different application locations must also meet the following requirements:

    a) they must have an "on" and "off" timer, in order to program a time for the start-up that allows the user to leave the radiation area and to ensure the apparatus operates during the required time without the need to manipulate the machine to turn it off while it is in operation;

    b) they must have a presence detector incorporated in the apparatus itself, which ensures the apparatus does not start operating when the presence of humans is detected in the radiation area.

- UV-C radiation is intended for specific applications: disinfecting air and surfaces, as well as disinfecting water. UV lamps should not be used to disinfect the hands or any other area of the skin, as is advised by the International Classification of Diseases (ICD) and World Health Organization (WHO).

- For an adequate assessment of the UV radiation of the disinfection equipment and its risk management, the on-site measures must be performed with calibrated and traceable equipment using them adequately in the installation and in its maintenance.

9. Which safety standards and regulations apply for UV-C products?

All available standards for surface disinfection are listed in the GLA UV-C Safety Guidelines (link). There are different standards for products for the treatment of water (IEC 60335-2-109) and air (IEC 60335-2-65).
Depending on the applications these products are used in, they have to meet specific requirements, e.g. workplace safety (Directive 2006/25/EC).[4]

10. Does UV-C radiation cause risk to human health?

There are two types of hazards - irradiance and ozone (O_3).

The irradiance hazard can damage the human eye (photokeratitis) and cause a severe sunburn-like reaction to the human skin. In the worst case, the genetic information (the genes) is affected, so that the cells can either no longer replicate or they begin to replicate uncontrollably. People must be protected against direct radiation of these wave lengths.

The ozone (O_3) hazard occurs at wavelengths below 242 nm and can cause a toxic reaction in the human body.[5] The long-term exposure limit for an eight hours' period has been generally limited to 200 µg/m.[6]

To address and manage these risks, there are product and application guidelines in

[4] See also ANSI/ASHRAE Standard 185.1-2015.
[5] GLA: Position Statement on Germicidal UV-C Irradiation UV-C Safety Guidelines (link)
[6] IEC 62368-1:2018 "Audio/video, information and communication technology equipment – Part 1: Safety requirements"

place to ensure UV-C disinfection technologies are sourced, installed and used correctly - see question 8 above.

11. Does UV-C impact materials?

UV-C radiation may cause the photodegradation of materials and this should be taken into account when installing and using UV-C where susceptible materials, such as plastics, textiles, paints etc. are in the exposed environment or when disinfecting surfaces made of these materials.

12. Can UV-C be reflected from ceilings and walls?

Not all white paint on the walls and ceiling reflect radiation of 254 nm in the same way. Some have a reflectance of 8%, whilst others with metallic components can reach 47%. By way of comparison, white paint normally reflects between 70-90% of the light.

Indirect radiation installations should use paint with lower UV reflectance. It Is recommended to measure the Installation prior to use to confirm It Is safe for use for humans.

Technical

13. What is "far UV-C"?

Far UV-C is terminology that describes UV-C radiation in the range between 207-222 nm. The 222nm range is the one that is most investigated at present.

14. What is the difference between UV-C at 254nm and far UV-C?

The main difference is the wavelength.

254nm is a mature and effective conventional technology that has been used for decades.

222nm is an emerging and promising technology. Current research is looking into whether it is less harmful to people (because it is less capable of entering the body and the skin) while still successfully inactivating viruses.

15. Does UV-C create ozone?

UV-C at 254 nm will not create ozone. There are alternative technologies at 185 nm that do, but these are limited to highly specified industrial uses. Ozone will be formed when O_2 is split in 2 oxygen atoms (O) which will react with an oxygen molecule(O_2). The result is then O_3. To split an oxygen molecule (O_2) in 2 oxygen atoms (O) energy is required which is present in electromagnetic radiation with a wavelength below 242nm.

16. Does UV-C emit ionizing radiation?

No, UV-C is defined as non-ionizing radiation according to the International Commission on Non-Ionizing Radiation Protection (ICNRP).[7]

17. Does a UV-C lamp contain mercury?

Conventional lamps with a wavelength of 254nm contain mercury and are subject to the strict limits and requirements of the EU Restriction of Hazardous Substances (RoHS) Directive (2011/65/EU) and the end of life obligations of the EU Waste Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU).

UV-C LEDs do not contain mercury.

[7] Opening paragraph, at link here: https://www.icnirp.org/en/frequencies/uv/index.html

Market

18. What type of UV-C products are there on the market?

UV-C lamps have been in use for decades in air, water and surface disinfection and have many applications. For further information on applications for UV-C disinfection technologies, please see the Global Lighting Association publication Germicidal UV-C Irradiation: Sources, Products and Applications.

19. Are all UV-C products available on the market safe?

In case of high UV-C irradiance levels, direct exposure to UV-C is harmful to humans or animals. Standards and industry guidelines outline the information and safeguards manufacturers must provide to ensure people's safety and address foreseeable misuse.

The Global Lighting Association has published and widely disseminated UVC Safety Guidelines providing guidance on the safe use of UV-C products, by means of technical safeguards (e.g. presence detection or access controls) and/or instructions and warning labels as needed and applicable. Standards also exist to avoid chemical decomposition product, e.g. ozone; these are outlined in the GLA Safety Guidelines.

These existing requirements need to be enforced by authorities to ensure only compliant products are placed and made available on the market.

20. Who is monitoring and enforcing product safety for UV-C?

Within the EU, it is the role of national market surveillance authorities to monitor and enforce safety and other requirements for UV-C. These authorities however often have limited capacity and resources.

Enforcement in the case of products sold online is particularly challenging as there is often no economic actor within the EU jurisdiction who can be held responsible and be made to take reparatory action.

LightingEurope advocates for sufficient resources, tools and support to be provided to market surveillance and customs authorities across Europe. We support authorities by sharing our industry's technical expertise and publishing guidelines on how existing requirements should be understood, applied and enforced.[8]

[8] LightingEurope Press Release on The Impact of EU rules depends on their Better Enforcement, 2 July 2019, link.