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Possible ban on some types of UV lamps in the European Union from 2027

Fraunhofer Institute of Optronics, System Technologies and Image Exploitation

Innovation hub "Smart UV systems"

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Health hazard mercury

Mercury is a highly toxic element that poses considerable health risks. As a neurotoxin, it causes permanent brain and kidney damage. It also has a negative effect on fetal and early childhood development.
It has therefore been classified by the EU, based on the United Nations Minamata Convention, as life-threatening if inhaled and harmful to organs and the environment. Researchers predict that mercury levels in the world's oceans could rise to five times the levels of the 16th century by 2050 if no effective measures are taken to reduce mercury emissions. Marine fish, especially eels and tuna, are already so heavily contaminated with mercury that pregnant women in particular are advised to avoid eating them.

In view of the dangers posed by mercury to humans and the environment and the increasing concentrations in the environment, the EU drew up a mercury strategy back in 2005, which was revised in 2010. Its aim is to gradually replace mercury-containing lamps that are harmful to health with more energy-efficient lighting alternatives. The Minamata Convention has been implemented by the European Union's Mercury Regulation 2017/852 since January 1, 2018. The regulation has now been updated. The adapted Mercury Regulation 2024/1849 has been implemented since June 13, 2024. To date, 151 countries have acceded to the Convention; the current accession status of the contracting states can be on the UN website.

Background: EU Regulation 2017/852 stipulates that many products containing mercury may no longer be manufactured, imported or exported. Directive 2011/65/EU of the European Parliament also serves to restrict certain harmful raw materials used in electronic and electrical devices.

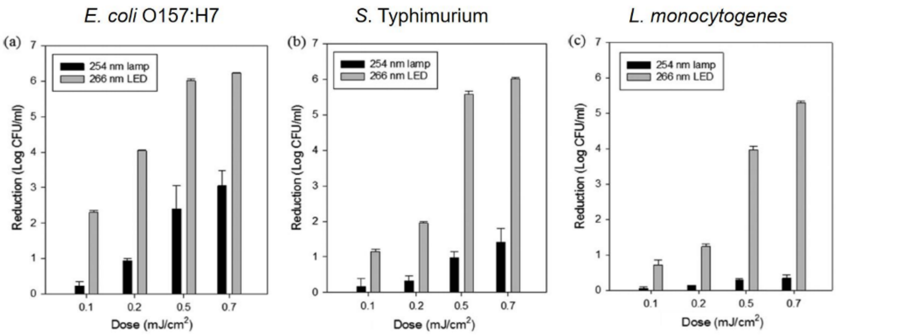
Status at the beginning of 2025

While many mercury-containing light sources such as energy-saving lamps and fluorescent lamps for room lighting have already been withdrawn from the market in recent years or only existing stocks may be sold, there is currently still an exemption for mercury-containing vapor discharge lamps for disinfection purposes in the UV range until February 24, 2027. It is currently not certain whether and in what form this exemption will be extended again. However, UVC LEDs are becoming increasingly popular for disinfection applications in particular, which means that an alternative technology is already available for certain applications. Although currently supposedly more expensive than mercury-containing light sources, they can certainly keep up with them in terms of radiation output and even significantly outperform them in terms of their disinfection effect thanks to other possible emission wavelengths. In the following, various narratives will be examined more closely.

Advantages of UVC LEDs

UVC LEDs already offer several decisive advantages over classic mercury radiation sources.

The wavelength of UVC LEDs can be varied during the manufacturing process. This is not possible with classic gas discharge lamps. However, by shifting the emission wavelength and broadening the spectrum, the disinfection efficiency increases significantly. For some microorganisms, one to two log levels (factor 10-100) higher inactivation can be achieved with the same irradiation dose. Different wavelengths can also be combined in an LED array, thus extending the efficiency of pure DNA damage to microorganisms to other mechanisms of action (e.g. protein damage).



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Classic UV lamps usually take the form of long cylindrical tubes. This significantly restricts the freedom of efficient reactor design. UVC LEDs, on the other hand, are small spotlights that can be placed not only on planar arrays but also three-dimensionally on curved surfaces. This means that the radiation characteristics can be optimally adapted to the disinfection problem. The radiation can be further varied and optimized for each individual LED using small, cost-effective lenses. With conventional lamps, large reflectors can only be used to a limited extent.

UVC LEDs can be switched quickly and, unlike conventional lamps, do not age as a result of these switching cycles. This offers enormous energy-saving potential, particularly in point-of-use disinfection (e.g. directly at the tap), as UVC LEDs are only switched on when water is drawn. Conventional lamps usually run 24/7 and consume vast amounts of electrical energy in the process.

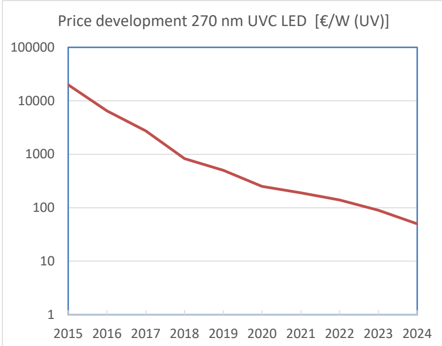
UVC LEDs achieve very high intensities of up to 10 W/cm² on their surface. This can significantly reduce the size of reactors with a good design.

UVC LEDs operate in the low-voltage range, which increases the electrical safety of a UV system. This is particularly important for medical applications, as a limit of 48V must often be observed here.

The use of LEDs directly in water is also possible with appropriate highly insulating coatings, whereby the water or another medium to be disinfected can be used effectively for cooling. The use of expensive cladding tubes is no longer necessary here.

Are LEDs really too expensive?

It is often argued that UVC LEDs are still too expensive and that LED-based systems are therefore difficult to sell. However, this is only true to a limited extent. The advantages of UVC LEDs already outweigh the disadvantages of the price. Only the current low availability is problematic. However, both will disappear as soon as demand increases. The price will fall significantly when higher quantities are required and production lines are better utilized.
In recent years, the price per watt of UV radiation from UVC LEDs has fallen dramatically. Whereas 10 years ago, one watt of UV radiation (at 265 nm) from a UVC LED cost a good €20,000, today it is just under €50. The purchase quantity (graduated prices) from the supplier also plays a decisive role for manufacturers. Since October 2024, UVC LEDs with an optical output of 150 mW at a wavelength of 265 nm have been available for around € 7/unit for a purchase quantity of 10,000 units.



However, due to the significantly higher microbiological disinfection efficiency described above, UVC LED systems require a lower irradiation dose and therefore less optical power than classic mercury lamps, which again significantly reduces the price in relation to the disinfection efficiency. It should also be noted that the power of mercury lamps is always stated as electrical power. With UVC LEDs, on the other hand, the optical output is always stated. This often leads to confusion when comparing the prices of different technologies.
If the overall system price is already high, for example in the case of medical devices, a higher price for the radiation source is irrelevant anyway. In many areas of clinical disinfection, UV radiation can be used for disinfection much more efficiently and, above all, more cost-effectively than disinfection with chemical agents. The latter involves high consumable costs. In addition, disinfectants often end up in wastewater and the environment, where they cause consequential damage.
Further increases in performance are possible thanks to the optimized reactor design described above. UVC LEDs offer much greater flexibility here than conventional systems.



The situation can be compared with the discussion about combustion and electric cars. Here, too, a new technology is competing with an old, established one. The technology of combustion engines is mature and can hardly be made any more efficient. Electric vehicles, on the other hand, are significantly better than combustion engines in many parameters. Only in terms of range, weight and price do they still lag behind the old technology. Nevertheless, many people are already opting for electric cars, even though they are expensive to buy. However, these costs are offset by lower operating costs over the life cycle. The purchase price is not the decisive criterion. Electric vehicles are taxed more favorably and fuel for combustion engines is gradually becoming more expensive due to the CO_2 tax.
The EU could also use this method of increasing the price of old technology through a special levy for classic mercury lamps. In this way, pressure can be exerted on the market for a faster transformation.

How could the EU decide?

It is undisputed that LEDs are the radiation medium of the future. As they are already being used successfully in smaller disinfection systems, particularly in point-of-use water disinfection and portable surface disinfection systems, it can be assumed that the exemption will not be extended for such systems and that they may only be operated with LEDs from February 24, 2027. For larger systems, such as those found in systems with medium-pressure lamps in municipal water treatment, the use of LEDs is not yet sensible for economic reasons. The exemption for such lamps is likely to be extended again on application, which will give a few more years for new developments. But postponed is not canceled. Applications for an extension of the exemption can be submitted to the responsible EU authority by 23.08.2025 together with a conclusive justification.

What does it mean for lamp manufacturers?

The manufacturers of the potentially affected lamp types face the problem, which should not be underestimated, that their business model will be completely destroyed. An expiry of the exemption would mean that they would no longer be allowed to manufacture these lamps. It is to be expected that these manufacturers will try by all means and arguments to extend the exemption again. However, pure lamp manufacturers should develop a transfer or exit strategy.

Retrofit or new systems?

UVC LEDs only show their full potential in new, adapted systems. There is no general answer as to whether a retrofit solution makes sense for existing systems. Retrofitting means that LED spotlights would have to be developed that have a tubular shape with the same electrical connection conditions. However, the biggest problem here is cooling the LEDs. In contrast to mercury lamps, which require a higher temperature to run efficiently, low temperatures are more advantageous for LEDs. High temperatures accelerate ageing.
As a system manufacturer, however, you will have to decide against the background of the quantity of your systems in daily use whether the previous radiation sources can be replaced by UVC LEDs in a comparable form factor (retrofit) as soon as their lamps have reached the end of their life. It is unlikely that all customers will purchase new LED-based systems in the near future. One possible scenario would be that the EU decides to continue to supply existing systems for a certain period of time with classic lamps that have already been produced (already produced stock), but pushes for the use of LEDs in new systems.

What should appliance manufacturers do?

As a device manufacturer of classic disinfection systems, a possible expiry of the exemption means an urgent need for action. It is not a question of whether the ban will come, but when. Any company that acts in good time (first mover) and develops new products has a decisive market advantage. In many cases, previous know-how acquired over many years has to be thrown overboard, as the design of a UVC LED disinfection system differs fundamentally from that of classic systems with mercury lamps. As early as the ray tracing stage during reactor design, it is necessary to rethink the design from surface emitters to spot emitters, which have different radiation characteristics depending on the type of LED used. Simple calculation concepts using Excel, which may have been practicable in the past, are no longer applicable here. More complex simulation methods are required, in which not only ray tracing but also, for example, fluid dynamics coupled to the radiation field must be simulated for air and liquid disinfection. In contrast to classic lamps, LEDs should be cooled as well as possible. Thermal simulations of the system are therefore also essential in the development process. However, the effort is rewarded with more compact, well-optimized and durable systems that offer completely new possibilities thanks to more flexible reactor geometry.

UV-LED research at Fraunhofer?

The "Smart UV Systems" research group at the Fraunhofer Institute of Optronics, System Technologies and Image Exploitation has been researching the practical use of UV LEDs in a wide range of applications for more than 10 years. We have a well-equipped UV laboratory that is specially designed for UV LED applications. We are also able to simulate and optimize complex system geometries under all aspects (radiation field, fluid mechanics, thermodynamics) by means of multiphysics simulation. We use our knowledge of the microbiological disinfection efficiency of different emission wavelengths as well as material compatibility and ageing effects for efficient and durable system design. We also offer measurement services such

as spectral and goniometric measurement of radiation sources, transmission and reflection measurements in the UV-VIS range between 200 nm and 830 nm as well as FTIR analyses. The development and design of UVC LED drivers and other electronics are part of our repertoire.

We are happy to support you in successfully making the transition from mercury-containing radiation sources to environmentally friendly LED technology in your products.

Sources

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