Exemption Request Form

Date of submission: 22 August 2025

1. Name and contact details

1) Name and contact details of applicant:

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The VDMA is acting as an authorized representative for the companies listed in Annex V. The submitted application is an elaboration of information of the named companies.

2) Name and contact details of responsible person for this application (if different from above):

Company:		Tel.:	
Name:		E-Mail:	
Function:		Address:	

2. Reason for application:

Please indicate where relevant:

☐ Request for new exemption in:

☐ Request for amendment of existing exemption in

☒ Request for extension of existing exemption in

☐ Request for deletion of existing exemption in:

☐ Provision of information referring to an existing specific exemption in:

☒ Annex III ☐ Annex IV

No. of exemption in Annex III or IV where applicable: 4(f)-IV

Proposed or existing wording: Mercury in lamps emitting light in the ultraviolet spectrum

Duration where applicable: maximum period of validity of five years / 24.02.2032

We request the prolongation of exemption 4(f)-IV, as mercury-containing UV gas discharge lamps are still necessary in a large number of industrial application because the radiation doses required for these processes in the specific spectral ranges cannot yet be achieved in all applications by using UV LED technologies. We propose to retain the existing wording.

☐ Other:

3. Summary of the exemption request / revocation request

The application for prolongation of the existing exemption refers to mercury-containing UV discharge lamps (UV Hg lamps) which are used for curing (e.g. of layers of inks and coatings, adhesives and sealants), for disinfection (e.g. of water, surfaces and air) and for other industrial applications (surface modification, surface activation, photochemical reactions)

The application includes the following lamp types:

— **UV medium-pressure discharge lamps** (MPL) **for curing, disinfection and other industrial applications** (internal operating pressure > 100 mbar)

	
Example of UV-MPL for Curing	Example of UV-MPL for Disinfection
These lamps are used in particular where fast and reliable curing of coatings, inks and adhesives is required and where a durable, scratch-resistant, abrasion-resistant and/or chemical-resistant surface is required.	These lamp types do not differ in design significantly from the lamps used in UV curing. They are used to disinfect water, surfaces and air.

The medium-pressure UV lamps can be doped for example with iron, gallium or indium in addition to the mercury they contain. This changes the spectrum and adapts it to specific process requirements.

The term UV curing (hardening) is to be understood with reference to this application as follows:

Chemical process in which printing inks, varnishes, adhesives or other coatings are cross-linked by the effect of UV radiation (polymerisation). During UV curing, the photons of the UV light stimulate the photoinitiators (catalysts) contained in the materials. The photoinitiators form reactive groups which react with the monomers, oligomers and prepolymers contained in the materials to form a solid crosslinking matrix.

Disinfection is to be understood with reference to this application as follows:

Physical disinfection process for destruction of microorganisms to a level defined for a specific application, which is neither harmful to health nor impairs the quality of products (e.g. food, beverages). The harmful microorganisms are deactivated by UV radiation (destruction of cell structures: DNAs, cell membranes). The defined levels of germ killing are also called log classes (Log4 is a germ killing of 99.99%). The advantage compared to chemical processes (e.g. chlorination) is the extremely fast effect and the fact that no chemical residues remain.

Typical applications to be covered by this application include:

1 Curing

1.1 Curing of inks and coatings in printing processes (sheetfed offset, web offset, flexo, inkjet, screen printing, narrow web) on different substrates (paper, board, paperboard, foils, metal sheets, rigid and flexible materials, even and shaped surfaces) for the printing and finishing of a very large variety of products

1.1.1 Curing of ink and coating layers in commercial and publication printing (e.g. books, brochures, advertising prints, posters...)

1.1.2 Curing of ink and coating layers in packaging printing (folding boxes, food packaging, pharma packaging, cosmetic packaging, electronics packaging, closing caps for beverages, flexible packaging ....)

1.1.3. Printing of labels (self-adhesive labels, Inmoulds, Wrap Arounds, Shrink sleeves …)

1.1.4 Printing on other packaging and objects (e.g. metal, corrugated board, glass, plastic bodies ....)

1.1.5 Security printing (printing of identification documents, credit cards, security features and imprints in banknotes)

1.1.6 Exposure of printing formes; manufacturing of screen printing stencils, printing plates and lightroom films; digital masking processes (inkjet), exposure of printing plates with Digital Micromirror Devices (DMDs)

1.2 Curing of coatings in the decorative sector (e.g. floor coverings, laminate board, coating of wood/MDF, furniture, ceramics, decorative foils and papers)

1.3 Curing of coatings in electronics / microelectronics (e.g. curing of encapsulating compounds for electronic components, bonding of displays, production of printed circuit boards)

1.4 UV curing in 3D printing (Polyjet)

1.5 UV curing of coating layers on optical discs, CDs, DVDs and BluRays

1.6 UV curing of layers on three-dimensional plastic components, e.g. switches and decorative elements in car interiors.

1.7 Other curing and bonding applications; bonding of medical devices (e.g. syringes) and displays, post-crosslinking of plastics, (functional) coatings on surfaces (eyeglasses, contact lenses, automotive industry)

2 Disinfection and water/fluid treatment

2.1 Water disinfection and treatment

2.1.1 Water disinfection in drinking water supply

2.1.2 Disinfection of process water, e.g. in the food industry

2.1.3 Disinfection of wastewater (e.g. ballast water on ships)

2.1.4 Water treatment in public swimming pools, water parks and spas (chloramine reduction)

2.1.5 Control of microbiological growth (fish farming /aquaculture, cooling towers, industrial process systems)

2.2 Disinfection of surfaces

2.2.1 Packaging (aluminium foils, lidding foils, thermoformed plastic packaging, beverage packaging, bottles, bottle caps, cans ...)

2.2.2 Parts of machines or equipment (e.g. transport containers, belts) before they come in contact with the product or packaging material.

2.3 Disinfection of air (e. g. food industry, highly frequented public areas)

2.4 Treatment of other fluids (e.g. water-mixed cooling lubricants)

3 Other industrial applications

3.1 Surface activation and cleaning

3.2 Decomposition of oxidizing agents in the food, pharmaceutical and cosmetics industries

3.3 Exhaust air cleaning in gastronomy (degreasing, odour neutralisation)

3.4 Applications in microelectronics (microlithography, debonding=removing wafer structures from carriers)

3.5 Production of vitamins and pharmaceutical precursors using photochemical processes (e.g. vitamin D3; Dydrogesteron)

The industry is making efforts to reduce the use of UV lamps containing mercury. However, it is technically not possible to replace mercury in special UV lamps with other materials/chemicals to achieve the same widespread radiation distribution.

As an alternative, LED-based technologies are increasingly being used, which in certain applications also offer advantages over mercury-containing UV lamps (e.g. lower heat generation, faster switching).

Nevertheless, UV LED technologies cannot be used as an equivalent replacement in many applications. This has the following reasons:

- UV LEDs provide a limited emission spectrum, narrow band emission; the emitted wavelengths do not exactly match the absorption spectrum of UV-reactive chemistry; a broad spectrum is necessary for many use cases which is only provided by mercury containing UV lamps

- Development and commercialisation of UV-reactive chemistry takes a long time and is partly hampered by other regulations (REACH)
- Achievable surface qualities with UV-LED in curing are to be evaluated as worse than with the use of UV lamps, partly these are accompanied by yellowing effects.
- low performance, short service life and high costs for UV LEDs in the UVB and UVC range (technology still in development)
- in some applications the use of UV LEDs is still uneconomical, especially for large working widths and large installations, depending on the number of required units
- the wall plug efficiency (WPE) of UVC LEDs remains low—typically between 4% and 7.5%—and is highly dependent on the specific wavelength, with shorter wavelengths generally having lower efficiencies
- the limited radiation of UVC LEDs does not meet the requirements for safe, effective, and legally compliant operation of water and wastewater treatment systems
- UVC LEDs undergo significant power loss during operation due to both thermal and current-induced degradation mechanisms. These include gradual degradation of the active AlGaN semiconductor layers, package degradation, and increasing spectral shift and parasitic luminescence that reduce germicidal efficacy.

Mercury containing UV lamps that are used in existing equipment are needed as spare parts for many years to come, as they cannot be replaced immediately by UV LED systems for reasons of economy (high investment costs, long depreciation, long service life for existing equipment) and environmental impacts (those arising from the manufacture of new equipment and from the premature scrapping of functioning equipment).

For printing machines UV LED dryers operating in the UVA range have been developed in recent years. However, the available range of UV-LED-curing consumables is still limited due to the specific chemistry.

In the disinfection sector, the development of LED alternatives is only at an early stage, and the development of commercially viable systems will take some years.

Medium-pressure UV lamps contribute significantly to environmental protection and public health through their use in essential disinfection and treatment processes. While these lamps contain small quantities of mercury, their benefits in terms of microbial control, pollution prevention, and chemical-free treatment outweigh potential environmental risks - especially given strict handling, disposal, and recycling regulations already in place in the EU.

Medium-pressure UV lamps are instrumental in safeguarding drinking water, disinfecting wastewater, controlling air quality, and maintaining hygiene in sensitive industries. Without them, many treatment processes would require the use of hazardous chemicals such as chlorine, peracetic acid, or ozone in higher concentrations, which carry risks of harmful byproducts (e.g., trihalomethanes, bromates) and occupational exposure. By enabling non-chemical disinfection, medium-pressure UV lamps support the EU's goals of reducing environmental pollutants and protecting water bodies under the Water Framework Directive.

Although the radiation output of UV LEDs in the shorter wavelength range (UVC, UVB) has improved in recent years, it is still not sufficient in many applications to guarantee safe processes and to interact ideally with suitable UV-reactive materials. In addition to technical challenges, market economy aspects must also be considered.

The VDMA applies for the prolongation of exemption 4(f)-IV on behalf of the companies listed in Annex V.

The VDMA has many member companies that either manufacture special UV lamps and UV built-in components as well as machine manufacturers who integrate these components into their machinery. The VDMA is the largest European association of the capital goods industry with approx. 3600 mainly medium-sized German and European member companies.

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4. Technical description of the exemption request / revocation request

(A) Description of the concerned application:

1. To which EEE is the exemption request/information relevant?

   Name of applications or products: UV equipment for curing, disinfection, surface treatment and exposure

   a. List of relevant categories: (mark more than one where applicable)

   ☐ 1 ☐ 7
   ☐ 2 ☐ 8
   ☒ 3 ☐ 9
   ☐ 4 ☐ 10
   ☒ 5 ☐ 11
   ☒ 6

   b. Please specify if application is in use in other categories to which the exemption request does not refer: No

   c. Please specify for equipment of category 8 and 9:

The requested exemption will be applied in

☐ monitoring and control instruments in industry

☐ in-vitro diagnostics

☐ other medical devices or other monitoring and control instruments than those in industry

2. Which of the six substances is in use in the application/product?

   (Indicate more than one where applicable)

   ☐ Pb ☐ Cd ☒ Hg ☐ Cr-VI ☐ PBB ☐ PBDE

3. Function of the substance: Mercury is responsible for creating typical spectral lines and therefore the wide UV spectrum, which can't be achieved by other technologies.

4. Content of substance in homogeneous material (%weight): In case of medium-pressure UV lamps, pure mercury (=100%) in liquid form is contained in sealed lamps.

5. Amount of substance entering the EU market annually through application for which the exemption is requested:

   No market data specific to UV lamps for industrial applications is available, that allow a reliable estimation of the total quantities of mercury placed on the EU market annually in UV lamps for curing and disinfection.

   Nevertheless, for the UV curing sector, we have estimated the number of UV special lamps placed on the EU market annually on the basis of publicly available market figures (Yole Développement[1])

Year	Number of lamps	average HG content per lamp [g]	Total EU [kg]
2015	132000	0,5	75
2018	164000	0,66	108
2021	240000	0,66	158

[1] UV LEDs - Technology, Manufacturing And Application Trends 2018 report, Yole Développement, May 2018 (no more available)

This estimate is based on the following assumptions:

Forecast market volume mercury-containing UV Hg lamps 2021:	915.3 million US$
Market share curing:	35%
Share of UV Hg medium-pressure*) lamps in curing:	100%.
Market share Europe:	21%

Further assumptions:

Estimated average price of a UV Hg medium-pressure lamp 2019	275 US$
average content of mercury in UV Hg medium-pressure lamps:	
- 2015	0.5 g
- 2018	0.66 g **)

*) only UV Hg medium-pressure lamps are used for curing

**) there is a trend towards longer lamps, which in turn has led to a higher average amount of mercury per lamp.

In our view, the future demand for mercury for UV special lamps in the curing sector will increase as more UV machines are installed than are withdrawn from the market. UV mercury discharge lamps have a limited service life and must be replaced frequently during the service life of a system (e.g. at printing machines).

For the estimation of mercury quantity for disinfection purposes we have taken basic data from the market study "UV LEDs - Technology, Manufacturing and Application Trends 2016 Report by Yole Developpement":

Forecast market volume mercury-containing UV Hg lamps 2021:	915.3 million US$
Market share disinfection:	27%
Share of UV Hg medium-pressure*) lamps in disinfection:	63.5%.
Market share Europe:	21%

Further assumptions:

Estimated average price of a UV Hg medium-pressure lamp 2019	275 US$
average content of mercury in UV Hg medium-pressure lamps:	0.5 g

*) Share of total UV Hg lamps used for disinfection (low pressure and medium-pressure UV Hg lamps

This results in a calculated market volume of approx. US$ 33 million for UV Hg medium-pressure lamps in the disinfection sector in Europe. Based on the average price, one can infer an approximate quantity of 120,000 UV Hg medium-pressure lamps that are marketed annually for disinfection applications in Europe. With an average of 0.5 g per lamp, this results in a total of 60 kg of mercury for UV Hg medium-pressure lamps in the disinfection sector.

This results in an estimated total amount of mercury of around 200 kg which is placed on the EU market annually in UV special lamps for curing and disinfection purposes.

Please supply information and calculations to support stated figure.

UV LEDs - Technology, Manufacturing And Application Trends 2018 report, Yole Développement, May 2018 (no more available)

New study: https://www.yolegroup.com/product/report/uv-leds-and-uv-lamps--market-and-technology-trends-2021/)

6. Name of material/component: Mercury in discharge lamps

7. Environmental Assessment: not available for these applications

   LCA: ☐ Yes

   No

(B) In which material and/or component is the RoHS-regulated substance used, for which you request the exemption or its revocation? What is the function of this material or component?

Mercury is used in gas discharge lamps in liquid form or in form of solid amalgam. During the starting phase of these lamps, the mercury is vaporised and, therefore, raised to higher energy levels (made unstable). The drop from these higher energy levels (return of the electrons from the higher energy level) causes the emission of UV light with the characteristic spectral lines. The corresponding spectral lines result from the atomic structure of mercury. These spectral lines supply the necessary photons for UV curing and disinfection. See Annex I.

(C) What are the particular characteristics and functions of the RoHS-regulated substance that require its use in this material or component?

The mercury (Hg) within the lamps is able to provide the radiation spectrums needed for industrial UV processes.

1. Curing:

In the polymerisation of layers, so-called photo-initiators (PIs) are needed. The photo-initiator is a component of the UV printing ink or the emulsion and is used as a curing agent. The PIs react to the UV light created by means of mercury especially in the UVC and UVB range. The UVC and UVB light can act as a catalyst and initiates the polymerisation process.

2. Disinfection

An efficient way to destroy harmful microorganisms/ germs (viruses, bacteria, fungi) without the use of chemicals or high temperatures (inactivation) is irradiation with UV light in the UVC range. The UV light of certain wavelengths destroys cell structures (DNA, cell walls) and thus prevents the cell multiplication. The effective wavelengths depend on the microorganisms that are to be inactivated. One focus of DNA binding is at 260 nm.

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5. Information on Possible preparation for reuse or recycling of waste from EEE and on provisions for appropriate treatment of waste

1) Please indicate if a closed loop system for EEE waste of application exists and provide information of its characteristics (method of collection to ensure closed loop, method of treatment, etc.)

UV lamp manufacturers offer users the redemption of their mercury discharge lamps for recycling purposes. Worn-out lamps are handed over to a certified waste management company which takes over the responsibility for the recycling of the mercury lamps.
Users who do not return their used lamps to the manufacturer are instructed (mandatory part of the instruction handbook, duty for marking with symbol for separate collection, see Annex III) to have the used mercury lamps disposed of by a certified waste management company. ISO 14001 and EMAS (Eco-Management and Audit Scheme) certified users will ensure this recycling process.

Because mercury is a hazardous substance, there is a clear political will to reduce the available amount. Therefore, the proper disposal of mercury containing fractions after collection of lamps and recycling of the other lamp materials is one way of collection and treatment. Another way of some recyclers is to distil mercury from waste fractions, usually fractions of different nature, not only lamps. In this case mercury is made available again for other uses as far as allowed in the EU.

UV Hg lamps falling under exemption 4(f)-IV are used by commercial or public legal entities but not by private households. They are legally obliged to dispose of the lamps separately from household waste. Due to the WEEE legislation, the take back and recycling of lamps is free of charge in the EU for the users, illegal disposal by them would lead to high financial and non-financial risks for the user but not create any benefit. This is the basis of our assumption that UV Hg gas discharge lamps from the industrial and public sectors are collected and transferred to recycling companies to a very large extent.

Joint collection systems have been set up in European countries for end-of-life lamps e.g. in Germany organized by Lightcycle (www.lightcycle.de). Many of these systems are organized in Eucolight (https://www.eucolight.org/our-members), the European association of collection and recycling organisations for WEEE lamps and lighting. These systems established in all EU Member States ensure that UV Hg lamps like other discharge lamps are taken back and collected correctly and afterwards treated and recycled by qualified and certified recycling companies.

In practice, it is possible to extract almost 100% of the mercury from UV Hg lamps by using established treatment processes and to make it available again for new products with a high degree of purity or to dispose of it in a long-term and secure way.

2) Please indicate where relevant:

☒ Article is collected and sent without dismantling for recycling

☐ Article is collected and completely refurbished for reuse

☐ Article is collected and dismantled:

- ☐ The following parts are refurbished for use as spare parts:
- ☐ The following parts are subsequently recycled:

☐ Article cannot be recycled and is therefore:

- ☐ Sent for energy return
- ☐ Landfilled

3) Please provide information concerning the amount (weight) of RoHS substance present in EEE waste accumulates per annum:

☐ In articles which are refurbished

☒ In articles which are recycled Worst case will be that all annually delivered lamps will be replaced within one year.

☐ In articles which are sent for energy return

☐ In articles which are landfilled

6. Analysis of possible alternative substances

(A) Please provide information if possible alternative applications or alternatives for use of RoHS substances in application exist. Please elaborate analysis on a life-cycle basis, including where available information about independent research, peer-review studies development activities undertaken

(B) There is no alternative to mercury for producing a typical UV spectrum with UV gas discharge lamps, particularly in the UVC range. UV LED technology is therefore described below as an alternative technology. Excimer, electron beam curing, and flash lamps can also be used for few applications.

(C) Please provide information and data to establish reliability of possible substitutes of application and of RoHS materials in application

6 (B) 1 Applicability of alternatives in the printing and coating sector

UV LED lamps, which are made up of a large number of LED chips, are an alternative to UV medium-pressure mercury discharge lamps. The state of development of UV LEDs, associated UV reactive materials and process designs allows the use of UV LEDs only in certain applications

The commercially available UV LED technology is mainly effective in the UVA range.

The absorption spectra of photo-initiators in the LED printing inks/coatings which initiate the polymerisation process must be matched with the emission spectra of the UV LED lamps.

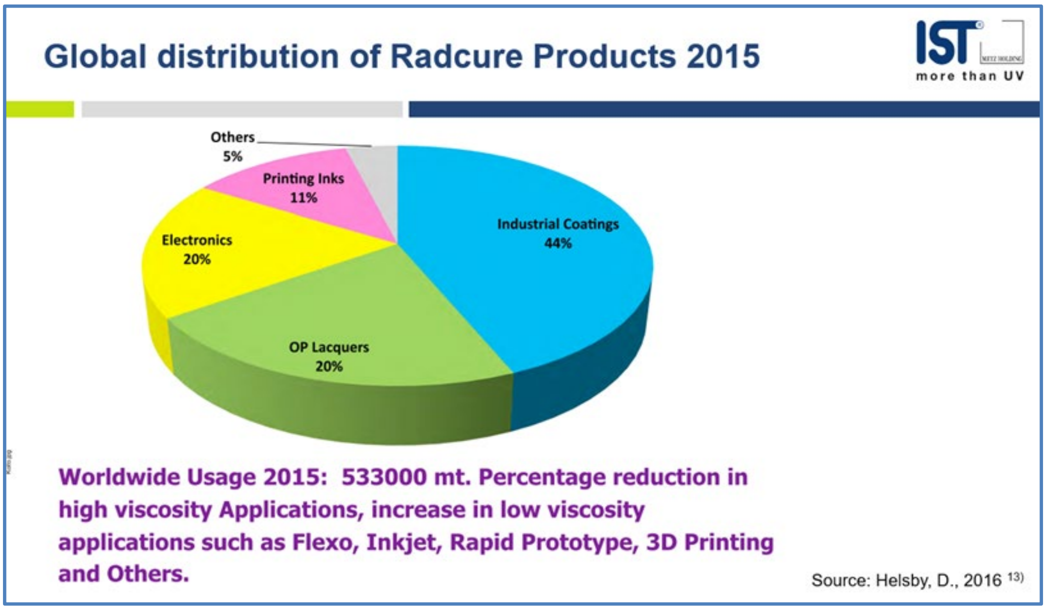
The absorption curves of the photo-initiators show that most of those that can be used have their main absorption bands in the UVB and UVC range.

Furthermore, UV-LEDs emit only in a very narrow-band range.

The problem with all printing applications is that there are currently no high-performance UVC LEDs with a long service life available that are necessary, among other things, for sufficient surface curing (scratch resistance, chemical resistance).

There are a whole range of advantages that make the use of UVC indispensable in the curing of ink and coating (varnish) layers. These include the high energy density, which enables fast and reliable curing of the layers.

The drying of (non-pigmented) varnishes is a widespread and, in terms of quantity, the most important application. Market data describe a share of 84% for UV coatings from the industrial coatings, overprint lacquers and electronics sectors. The actual ink segment, and thus the potential for UV LED, accounts for only approx. 11%.



Especially with industrial coatings and overprint lacquers UV Hg mercury discharge lamps, due to the UVC radiation, show clear advantages for cross-linking and the associated quality. These are.

- No to minimal yellowing of the coating layer.
- Best curing of the surface due to UVC Hg.
- Highest mechanical and chemical resistance (e.g. in industrial print applications in the field of wood and floor decoration, protective films...);
- High safety for food contact materials (FCM), by reducing migration (food and cosmetic packaging);
- Possibility of UVC Hg direct cross-linking with elimination/reduction of photoinitiators.

UVA LED applications are especially found in commercial printing with the process colours Black, Cyan, Magenta and Yellow. In contrast, in packaging printing the use of varnishes and special inks is prevailing. The comprehensive requirements (see list above) for packaging production are today met by classic UV Hg inks in connection with UV Hg drying technology.

Due to the specialisation on only one LED wavelength range (UVA), not many photoinitiators can be used. The LED photoinitiators are very special. The UV Hg inks are established on the market and the ink formulations are stable. There is a much wider choice of special inks and varnishes with UV Hg curing with UV Hg discharge lamps. For this reason, UV Hg lamp technology offers the highest process variability and safety.

In the UVA area, there were and are presumably further restrictions on photoinitiators, some of which are disappearing from the market as a result of

regulation (reclassification). In addition, there is a shortage of alternative UV LED curing photoinitiators.
The application of UVA LED inks also requires more technical effort, as sunlight can already cause the ink to harden (sunlight contains mainly UVA, hardly any UVB - approx. 10%, no UVC share).

6 (B) 1.1 Digital printing

UV inks are used in digital printing because of the desired properties (mechanical, chemical) and to secure inline processes. UV inks can be printed on a wider variety of surfaces/substrates, whereas water-based inks always require appropriate pretreatment (primer). Inkjet is not only used for classic print media but is also increasingly used on manufacturing lines for marking and decoration. Whether UV Hg lamps are still necessary depends on the printing speed, substrates, layers thickness, ink/varnish types and the technology. A basic distinction is made between multi-pass and single-pass systems. Single-pass systems enable very high speeds and still require UV Hg systems for reliable curing at the outfeed. Multi-pass systems can only be used for individual products and small quantities, and the production speed and volume (in terms of printed area) is very low compared to products printed in the multi-pass range.

In digital printing, e.g., for large-format inkjet printing systems, UV LED units have been used successfully for the so-called pinning[2)] for some years already. The UV LED units are mainly integrated in the printing heads. The radiation dose of UV LED modules is lower compared to the conventional medium-pressure mercury lamps.

a) Multi-pass technology

If printing is done in several passes (multi-pass technology), polymerisation is ensured by moving the UV-LED modules over the same spot several times.
Multi-pass technology uses a traversing print head in which the UV LED dryer module is integrated. The feed of the substrate is slow (typically < 1 m/min) and discontinuous. While the print module moves sideways, several lines are printed. The print head prints all colours simultaneously. However, the UV LED lamp irradiates a larger area than the current printed area in the feed direction. This means that the area printed in the previous step is irradiated again when the following area are printed. The UV LED lamp therefore irradiates the same area several times. This increases the radiation dose, which is crucial for curing. That's

2) A process in which the ink is partially cured immediately after being jetted to reduce dot gain and provide a sharper, more vibrant image on an inkjet printer. Through-curing is then carried out in a final dryer, usually with conventional Hg UV dryers based on medium-pressure mercury discharge lamps..

why UVA LED dryer modules are sufficient. However, due to the low printing speed caused by the technology, only individual copies or small quantities can be printed with this technology. This is used, for example, in outdoor advertising or for printing single posters and small print runs. The advantage of multi-pass technology is the possibility of very large print widths, printing on rigid materials and fabrics and the technical effort (use of small print heads) is not so high.

b) single-pass technology
In single-pass digital printing systems, in addition UV mercury discharge lamps are often used in end-of-press drying to guarantee sufficient curing of the layers. The single-pass process works at higher speeds (typically 15 – 270 m/min, depending on the quality). The print heads are fixed, extend across the entire substrate width or they are cascaded. The individual inks are applied via print modules arranged separately one behind the other. By means of an intermediate drying process called pinning, UVA LED dryers fix the individual colours but do not dry them through. This influences also the flow behaviour of the ink droplets. Due to the high feeding speed and the amount of ink on the substrate, a high radiation dose and UVC-light is required for final curing. Since the irradiation time is very short, only conventional UV dryers based on Hg medium-pressure discharge lamps can be used here.

6 (B) 1.2 Conventional Printing

The situation for UV LED application is different in conventional printing methods (offset printing, flexographic printing, gravure printing, screen printing) which account for approx. 90% of the total printing volume in Europe. For these processes, a higher amount and wider spread of energy, which are at present only achieved by UV medium-pressure mercury discharge lamps, are required for UV drying for the following reasons:

- High printing speeds in sheetfed offset and web offset printing machines
- the required distance and the process-related distance between the substrate and the light source
- reliable through-curing of ink and coating layers to ensure low migration (of low-molecular components), especially in food packaging printing

UV drying is mostly used in sheetfed offset printing presses and narrow web presses. It is estimated that 25 to 30% of new sheetfed presses and 90% of narrow web presses are equipped with UV modules based on UV Hg lamps.

The replacement of dryers based on UV medium-pressure mercury discharge lamps by UV LED lamps in sheet-fed offset and flexo printing is not yet possible for all applications and all printing products. It is therefore necessary to take a more differentiated look at the application areas(a to c):

a) Commercial printing:
This sector of the printing industry deals with the production of advertising printed matter, business printed matter, forms and other non-periodic printed matter, which is usually not produced by publishers.
In this area (classic 4-colour offset printing) UV cured products are particularly in demand when very little time is available from order placement to delivery. This highly reactive ink is matched to the UVA wave range. These ink formulations have been adapted to the UV LED spectrum in the UVA range by minor modifications. This is why most UV LED dryers are used in sheet-fed offset printing for commercial printing.

b) Packaging printing (folding boxes, labels and foils):
In packaging printing, the main emphasis is on high-quality finishing with numerous coating effects and, in some cases, metallic ("cold foil") application (transfer of very thin aluminium layer), an attractive feel and higher layer thickness or the processing of metallized substrates. High demands are placed on packaging, including a scratch-resistant and chemical resistant surface that must not yellow. Many formulations are used to create the coating effects, which essentially require UVC light to meet the requirements reliably. Since high-performance UV LED dryers for the UVC range are currently not feasible, UV

medium-pressure mercury discharge lamps still have to be used for these applications.

c) Printing of products with low migration requirements:
These are products that can come into indirect contact with food in the food packaging sector. To ensure that these products do not pose any risks, the best possible curing is required. Reliable curing is also needed for compliance with the European requirements for low migration of substances from food packaging materials (Regulation (EC) No 1935/2004 on materials and articles intended to come into contact with food). Since ink layers act as filters for UV light depending on the colour, ink formulations that react very broad-band to UV light are necessary. Only UV medium-pressure mercury discharge lamps provide the necessary radiation spectrum.

6 (B) 1.3 Narrow web printing machines

For label printing, narrow-web presses are preferably used, which can combine a variety of printing methods in one machine (in addition to flexo printing). The majority of narrow-web printers produce very different products for different customers with many special applications on one machine. Approximately 90% of narrow web label machines are equipped with UV dryers. Both UV Hg lamps and UV LED lamps are used in these machines. Due to the web guiding, UV dryers are necessary after each printing unit, therefore many UV Hg lamps and UV LED lamps per machine are necessary. Many labels are used in food and cosmetic packaging. Since the cosmetics industry has similar requirements as the food industry, UV lamps also offer advantages here. In addition, there is the limited availability of all varnishes/coatings/inks formulated for UV LED drying. Thus, a change to LED dryer technology poses an incalculable economic risk for printing companies specializing in label printing.

6 (B) 1.4 Further information on applicability in printing

To replace UV medium-pressure mercury discharge lamps in further printing applications by UV LEDs as well, much more durable, powerful and cost-effective

UVC LEDs are required. At the same time, appropriate ink formulations must be developed, tested and approved.

The state of the art of UVC LEDs compared to UVA LEDs currently is as follows:

- Efficiency approx. 10 times lower.
- Power approx. 15 times lower.
- Service life (L80 value) approx. 10 times lower.
- Costs per mW approx. 300 times higher.

Therefore, UVC LED technology is economically not used to produce and run under production conditions. Thus, the UV LED use is limited to applications with UVA LED systems, typically in the commercial sector with printing of 4 process colours, Black, Cyan, Magenta, Yellow.
There is also development work to be done on special inks and coatings.

The development of printing inks which are suitable for the radiation spectra of the UV LEDs is also impeded by the limited availability of suitable photo-initiators for UV printing inks (see Annex II with the photo-initiators most commonly available on the market). Due to the new CLP classification of the photo-initiators, their number in the market will continue to decrease. Although there has been progress in the use of UV LED dryers in printing in recent years, the CMR classification of photoinitiators has hampers the LED ink development. photoinitiators such as pi 369, tpo or thx, which have been frequently used so far, can no longer be used and alternatives must be found.

The synthesis, approval and registration (REACH) of new suitable photo-initiators requires substantial research efforts and tests which, at the moment, are disproportionate considering the amounts of UV ink produced.

6 (B) 1.5 Comparison data between UV Hg and UV LED in curing

The comparison must also consider the desired properties of the end product, process-related requirements and the limitations of materials. When considering the substitution of mercury, the necessary and more reactive chemistry of UV

LED inks should also be considered. A disposal problem certainly also arises from the use of LEDs.

	Hg Low Pressure		Hg Medium Pressure		UVC LED	
	From	To	From	To	From	To
UVC Wall Plug Efficiency / %	30	35	5	17	5	10
Output Power per UVC source / W	40	1000	1000	35000	0,05	0,4
Life Expectancy at full power / h	12000	16000	2000	10000	2500	7500
Cost per source / $	5	100	50	250	0,5	15
Cost per W UVC / $/W	$0,417	$0,286	$1,000	$0,042	$5.000,00	$750,00
Cost per µJ UVC / $/µJ	$0,010	$0,005	$0,139	$0,001	$555,556	$41,667

6 (B) 2 Alternative situation in the disinfection sector

6 (B) 2.1 Water disinfection

Disinfection systems based on mercury containing UV lamps have been in use in public drinking water supply since the end of the 1990s. According to a DVGW survey on the water regulations from 2008[3] , in which the basic data on water production and treatment were collected, around 50 % of 954 water supply companies surveyed disinfect the drinking water to be supplied. Disinfection with UV Hg lamps is the most frequently used method for disinfecting drinking water (42 %) compared to disinfection with chlorine dioxide, chlorine/hypochlorite or ozone. Especially smaller drinking water suppliers with a turnover volume of up to 3 million m^3/a prefer disinfection with UV Hg systems.

Only UV Hg medium-pressure or low-pressure lamps are used here. UVC LEDs cannot be used due to the very poor radiation yield and the large amounts of water and cannot be approved due to the lack of test specifications.

In recent years, the share of UV Hg disinfection in the disinfection processes used has increased significantly, so that it can be assumed that this share is now well

[3] Niehues, B., DVGW survey Regelwerk Wasser - Ergebnisse der Umfrage aus 2008. DVGW energie I wasser-praxis 3/2009.

over 50 % of the drinking water to be continuously disinfected at the waterworks outlet.

For drinking water treatment, UV low-pressure mercury discharge lamps are preferably used as they emit mainly in the UVC range which makes them highly efficient, but also UV medium-pressure mercury discharge lamps for large installations in municipal waterworks.

UVC LEDs are used in water dispensers, but they have limited water flow rates.
Chemicals such as chlorine, chlorine dioxide and ozone are widely accepted disinfectants and might be an alternative disinfection method to UV treatment. However, the chemical disinfection methods do have limitations and cannot be used for all water sources. There are some water relevant pathogens (for example parasites such as Cryptosporidium and Giardia Cysts) which cannot be effectively inactivated within the maximum allowable dose rates. Additionally, the chemicals can react with water constituents (for example organic matter) to form disinfection by-products such as THMs (Trihalogen methanes), chlorate or bromate. These by-products are a health concern and can provoke chronic diseases. There are maximum contaminant levels in the drinking water directive defined. Depending on the composition of the raw water, a safe disinfection cannot be reached with chemicals without violating the maximum contaminant levels.

If chemicals can be used for disinfection e.g. of water is amongst others dependent on the ambience of where the disinfection system should be established. It isn’t allowed for example to transport chemicals into water protection areas. Moreover, dosing devices for chemical disinfection systems are complicated and require well trained personnel as well as constant maintenance, especially smaller municipalities are consciously opting for UVC systems that are much easier to maintain and safe in use. UV radiation is, however, a safer option since germs may become also resistant to chemical substances.

Due to the high market potential, the focus of UVC LED development is on the wavelengths between 255 and 285 nm. Currently they are in the research and development stage. For example, in 2018, it was estimated that the output power would go from 10 mW in 2014 to 150 mW in 2024. (Source: https://www.yolegroup.com/industry-news/water-disinfection-applications-will-be-worth-650m-in-2023/). At present, the wall plug efficiency is between 5 and 10%, but commercial use is not possible for the reasons mentioned above. In addition, UV LED reactors in drinking water treatment require different designs than conventional UV systems (e.g. flow paths) to increase the efficiency of the reactors. A simple replacement of the existing UV lamps would therefore not be possible. Increasing system efficiency is a lengthy learning process and requires the development of prototypes and testing. It was not until mid-2019 that the world's first test system with UVC LEDs was installed in a municipal water supply in England. (Source: https://envirotecmagazine.com/2019/06/14/worlds-first-municipal-scale-uv-led-water-treatment-project/). Even if UVC LEDs become more cost-effective and more powerful in the coming years, the corresponding systems must be approved by accredited test institutes before they can be used in drinking water treatment and appropriate test specifications must be drawn up. The currently existing test specifications refer to UV systems with UV mercury discharge lamps. In Germany, a standard series DIN 19294 is being developed for this purpose. Other European countries also test according to analogous regulations. Furthermore, a continuous monitoring of the irradiance is necessary. The sensor technology used for this cannot be simply transferred to UV LED systems because UV Hg gas discharge lamps and UV LEDs have very different radiation characteristics.

Drinking water disinfection systems are subject to regulatory approval by the relevant authorities. In Germany, the permissible treatment substances and disinfection processes are specified in § 20 of the Drinking Water Ordinance (TrinkwV 2023). Currently, only UV disinfection systems utilizing mercury-based low-pressure and medium-pressure UV lamps are approved and must undergo type certification. The technical requirements for these systems are defined in the DVGW worksheets W 294-1 to -3[4]. For medium-pressure UV systems, the upcoming standards DIN 19294-2[5] (Devices for the disinfection of water using ultraviolet radiation — Part 2: Devices equipped with UV medium-pressure lamps – Requirements and testing) and DIN 19294-4[6] (Devices for the disinfection of water using ultraviolet radiation — Part 4: Reference radiometers for devices equipped with UV medium-pressure lamps – Requirements and testing) will set the specific criteria for system validation and sensor calibration. The general requirements for UV systems and dose monitoring are outlined in DIN 19294-1[7] and DIN 19294-3[8], respectively.

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[4] https://shop.wvgw.de/DVGW-Regelwerk/DVGW-Regelwerk-Wasser/

[5] DIN 19294-2:2025-08 – Entwurf, Geräte zur Desinfektion von Wasser mittels Ultraviolettstrahlung - Teil 2: Geräte mit UV-Mitteldrucklampen - Anforderungen und Prüfung, available in German language (https://www.dinmedia.de)

[6] DIN 19294-4:2025-07 – Entwurf; Geräte zur Desinfektion von Wasser mittels Ultraviolettstrahlung - Teil 4: Referenzradiometer für Geräte mit UV-Mitteldrucklampen - Anforderungen und Prüfung; available in German language (https://www.dinmedia.de)

[7] DIN 19294-1:2020-08; Geräte zur Desinfektion von Wasser mittels Ultraviolettstrahlung - Teil 1: Geräte mit UV-Niederdrucklampen - Anforderungen und Prüfung (https://www.dinmedia.de)

[8] DIN 19294-3:2020-08: Devices for the disinfection of water using ultraviolet radiation - Part 3: Reference radiometers for devices equipped with UV low pressure lamps - Requirements and testing (https://www.dinmedia.de)

Waterworks prefer medium-pressure UV systems (MPUV) where operational needs exceed the capacity of low-pressure system UV systems. Reasons therefore are:

- **High Flow Rates:** MPUV reactors offer significantly higher UV output per unit lamp length and volume, enabling treatment of large water volumes with minimal space requirements.
- **Variable Water Quality:** Unlike low-pressure systems, MPUV systems are less sensitive to changes in transmittance, turbidity, and color, making them more robust in real-world conditions.
- **Microbial Spectrum:** The broad emission range of MPUV lamps targets a wider variety of pathogens, including highly UV-resistant viruses and protozoa.
- **System Redundancy and Retrofitability:** MPUV systems can be integrated into existing treatment trains as an additional disinfection barrier or as a chemical-free replacement for chlorine-based methods.

Numerous waterworks throughout Germany and Europe have successfully installed MPUV systems as part of their core treatment infrastructure.They report:

- High disinfection efficacy with consistent log-reduction performance.
- Significant reduction in the use of chlorine or other chemical disinfectants.
- Minimal maintenance and high system uptime when operated under proper monitoring conditions.
- Full compliance with national (DVGW) and EU-level microbiological safety standards, including E. coli, enterococci, and Clostridium perfringens.

The upcoming DIN 19294-2 and 19294-4 standards will formalize and harmonize testing requirements, helping ensure the continued safety and technical reliability of MPUV systems for drinking water applications. However, until these new standards are fully implemented and the corresponding systems certified, MPUV installations will continue to rely on RoHS-compliant mercury lamps as no equivalent substitute technology exists with the necessary spectrum, output, and proven compliance record.

There is still no standard or technical rule that describes the requirements for UV LED systems for water disinfection and their measurement technology. Since UV LED modules consist of several individual chips, it is also unclear whether it is sufficient to monitor an assembly of several UV LEDs or whether each individual chip must be monitored. Since there is still no test specification for UV LED disinfection systems in Germany and other EU countries, this cannot be anchored in the ordinances like the Drinking Water Ordinance and therefore an UV LED systems cannot be approved. Using e.g. UV LEDs for drinking water disinfection in Germany is normative not yet approved and the development of the standard will take at least another 1-2 years.

Medium-pressure mercury UV lamps remain irreplaceable in many high-performance disinfection applications due to their uniquely high UV output power, broad spectral emission (200–600 nm), and proven effectiveness in municipal water and wastewater treatment. In contrast, commercially available UV-LEDs exhibit significantly lower optical power, with single-chip outputs typically limited to below 140 mW and wall plug efficiencies (WPE) ranging from only 4% to 7.5% at peak wavelengths between 265 nm and 280 nm. Additionally, UV-LEDs are subject to rapid degradation of radiant power during operation, especially under elevated temperatures or high drive currents, which directly reduces their disinfection efficacy over time. The limited UV penetration depth, narrower emission spectra, and substantial energy losses further reduce their viability for large-scale or high-throughput disinfection tasks where MPUV lamps deliver kilowatts of optical power with robust and stable output. As such, UV-LEDs cannot yet match the performance and reliability standards required in critical disinfection infrastructures. Premature restriction of MPUV lamps would create legal uncertainty for existing systems, undermine planning security for future installations, and potentially compromise public health protection. It is therefore critical that the RoHS 4(f)-IV exemption remains in place until technically equivalent and regulatory-compliant alternatives are available and widely deployable.

6 (B) 2.2 Disinfection of packaging, as well as machine parts in the food and pharmaceutical industry

The use of UV mercury discharge lamps is a proven technology for the disinfection of packaging and surfaces in packaging and food processing machines.

The UV lamps are used here as an alternative to chemical disinfection processes. Cups, lids, foils and bottle caps are treated with UVC. For low-germ packaging, UV irradiation is a simple, environmentally friendly and above all cost-effective solution.

The replacement of UV lamps by UV LED modules is currently not possible, as the performance, cost and service life of the necessary UVC LEDs would be contrary to their economical utilisation. UV lamps with mercury discharge lamps are still in demand in the retrofit sector. The long-term availability of UV mercury discharge lamps as spare parts is necessary for installed machines, some of which are in production for 20 years or more.

6 (B) 2.3 Comparison data between UV LED, low pressure/ medium UV Hg lamps and flash lamps in disinfection (240 – 280 nm)

Both flash lamps and UV Hg gas discharge lamps have their use cases in the disinfection sector. Flash lamps have advantages, for example, in the sterilisation of cups for the food industry. UV LEDs are only used in a niche application (very low throughput) for disinfection and cannot be used industrially. The radiant efficacy of UVC LEDs is about 5% (see table). In comparison, low-pressure mercury lamps have an optical yield of over 30 %-40 %, and medium-pressure lamps up to 20%. To achieve a comparable optical yield with UV LEDs, the material effort would increase significantly and the electrical power requirement would rise fivefold due to the approx. 80 % lower optical yield. From an ecological point of view, the current use of UVC LEDs on an industrial scale is therefore not sustainable and leads to increased energy and material consumption.

NOTE: The optical yield indicates how much electrical power is converted into radiant power at the desired wavelength. For disinfection the characteristic wavelength for or Hg low-pressure lamps is 253.4 nm. With an electrical lamp power of 370 W, Hg low-pressure lamps have an optical yield > 30% and thus approx. 120 W radiant power.

In addition, the service life of UVC LEDs for disinfection is much shorter than that of LEDs that emit in the visible range and is usually in the range of 5000 …7500 hours.

Particularly from a pandemic perspective (COVID-19), the further availability of UV Hg medium-pressure and low-pressure lamps for air and surface disinfection is essential because of their high efficiency.

	UVC LEDs	low pressure Hg lamps	medium-pressure Hg lamps	flash lamps
Wall Plug Efficiency for UVC / %	5-10	30-40	10-20 (undoped)	2-4
Electrical power / W	0,1-10	4-1000	150-36.000	100 – 3000
Power output / W	0,05-0,3[c]	1,2-400	15-7.200	2 - 120
Life expectancy / h	5000 …7500	8000-16000	4000-8000	5 - 10 million flashes[d]
Cost (only lamp, chip)/ $	10-15 per Chip[a]	5 - 100	50 - 250	180[b]
Disinfection efficiency	not applicable[f]	99,99 % log 4[e]	99,99 % log 4[e]	99,9999% log 6[e]

a System costs for a 1000 W UV power system are estimated to be 40 times higher compared to a state-of-the-art system with UV Hg low pressure lamps

b Costs for Flash Systems are more than 5 times higher than systems with low pressure lamps

c LED package

d (corresponds to 1400 - 2800 hours at 1 Hz), 2-3 times shorter than low pressure lamps

e Factor of the germ reduction, log 4 means reduction from 100,000,000 to 10,000 microorganisms, at log 6 to 100

f not effective enough and economical for industrial use

7. Proposed actions to develop possible substitutes

(A) Please provide information if actions have been taken to develop further possible alternatives for the application or alternatives for RoHS substances in the application.

Shorter LED wavelengths are technically available in R+D, but are expensive and not powerful enough for the applications covered by this request.

Due to the promising application possibilities, research is being conducted worldwide in various research clusters on the further development of UV LEDs with shorter wavelengths (especially in UVC range). The main driver here is the disinfection area. Researchers also refer to this as the Deep UV range (DUV)[9].
Progress has also been made in recent years regarding efficiency and service life. Today UVC LEDs are available in certain wavelengths. However, they are still not relevant for industrial use. Reasons are the significantly higher costs, as well as the lower stability and service life, the latter also in connection with the total costs of an entire UV LED system.
A system for water disinfection today would cost 30 to 300 times as much as a system based on UV Hg gas discharge lamps. The situation is similar for many applications in the UV curing sector.
The development of UVC LEDs is very challenging and there are physical limits. On the one hand, this concerns the semiconductor materials themselves, and on the other, the optics combined with them, which become blind over time due to the UVC light.
The most promising semiconductor material is aluminium gallium nitride. Despite progress in development, the external quantum efficiency (EQE) under laboratory conditions is currently 20 % and the wall plug efficiency (WPE) only about 10% for the wavelength range above 250 nm. See publications on this topic. Quotation::" *AlGaN-based deep ultraviolet light-emitting diodes (DUV LEDs) offer great potential to replace mercury discharge lamps in various applications, including sterilization, water purification, medical diagnostics, phototherapy, and*

[9] https://compoundsemiconductor.net/article/112266/The_Evolution_Of_The_Deep-UV_LED/feature

UV curing [1]–[3]. Currently, however, the performance of the devices is still poor…” [10][11]

Generally, the shorter the wavelength, the greater the development challenges. In the UVB range, development is at least 5 years behind.

(B) Please elaborate what stages are necessary for establishment of possible substitute and respective timeframe needed for completion of such stages.

Short-wavelength LEDs should be available commercially, and output must be increased at least by a factor of fifteen.

The development of the LED technology in the UVC range is mainly driven by the requirements of the application for disinfection and sterilisation and focuses on wavelengths between 260 and 285 nm. Compared to UVA LEDs, the structure of UVC LEDs is much more complex. Due to unfavourable material properties in the applicable semiconductor materials, such a high efficiency as with UV-A (>50%) can never be achieved with UVC and UVB LEDs from today's point of view. [12)]

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[10] H. K. Cho et al., "Enhanced Wall Plug Efficiency of AlGaN-Based Deep-UV LEDs Using Mo/Al as p-Contact," in IEEE Photonics Technology Letters, vol. 32, no. 14, pp. 891-894, 15 July15, 2020, doi: 10.1109/LPT.2020.3003164. https://ieeexplore.ieee.org/document/9119464/metrics#metrics

[11] Kneissl, M., Seong, TY., Han, J. et al. The emergence and prospects of deep-ultraviolet light-emitting diode technologies. Nat. Photonics 13, 233-244 (2019). https://doi.org/10.1038/s41566-019-0359-9

[12)] Kneissl, M., Seong, T., Han, J. et al. The emergence and prospects of deep-ultraviolet light-emitting diode technologies. Nat. Photonics 13, 233–244 (2019) doi:10.1038/s41566-019-0359-9

8. Justification according to Article 5(1)(a):

(A) Links to REACH: (substance + substitute)

1) Do any of the following provisions apply to the application described under (A) and (C)?

☐ Authorisation

☐ SVHC
☐ Candidate list
☐ Proposal inclusion Annex XIV
☐ Annex XIV

☐ Restriction

☐ Annex XVII
☐ Registry of intentions

☐ Registration

2) Provide REACH-relevant information received through the supply chain.
Name of document:

(B) Elimination/substitution:

1. Can the substance named under 4.(A)1 be eliminated?

☐ Yes. Consequences?

☒ No. Justification: Mercury is the functional component of a mercury discharge lamp and is used due to its unique characteristics like low boiling temperature and its emitted UV line spectrum. So far, no alternative substance/chemistry has been found to replace mercury in these lamps. A reduction of the amount of mercury in a certain range or the complete elimination in the lamp is not possible. Please refer also to 4 (B) and 6 (A).

2. Can the substance named under 4.(A)1 be substituted?

☐ Yes.

☐ Design changes:
☐ Other materials:
☐ Other substance:

☒ No.

Justification: Mercury discharge lamps generate UV radiation in a range between 200 and 440 nm. This UV spectrum will fulfil the requirements set up in the industry with respect to mechanical properties (abrasion resistance, durability), non-yellowing, intensitivity to day light, avoiding inhibition and killing of germs.

UV-LEDs as an alternative:

For some special kinds of application, UV-LED technology is a suitable alternative to the technology based on UV mercury discharge lamps. For these application fields, special chemical formulations have been developed. But nevertheless, these are only a few applications which can be processed with UV-LED. This is due to the technical properties of the UV-LEDs (please consider the monochromatic nature of the emitted UV radiation of an LED; referring to the state of technology: only wavelengths ≥ 365 nm with good optical exploitation are currently available; in addition, the UV-LED is more expensive at wide working width in comparison to mercury discharge lamps.) In the field of disinfection, UV-LEDs are not yet considered as an alternative, since no powerful LEDs are available in the UVC wavelength range.

Excimer lamps as an alternative:

A Excimer lamp is a kind of high pressure gas discharge lamp, which emits quasi-monochromatic radiation similar to LEDs in an inert atmosphere. The operation of an excimer lamp is based on the formation of excimers (molecules that are stable only in the excited state). The spectral maximum is specified by a working excimer molecule. The lamps are filled with pure rare gas or rare gas halide systems.

Due to higher system and operating costs and narrow banded emissions and low outputs applications are limited. A typical application in curing is matting by microfolding of top coating layers with 172 nm excimer, but not through-curing.

ElectroBeam (EB) as alternative in curing:

The electrons are generated by conducting an electrical current through a tungsten filament and then accelerated in an electrical field that is applied. This is done in a vacuum, which is closed off by a titanium foil window that is permeable to electrons. The surface with the ink/coating to be cured is guided underneath the titanium window for exposure to the beam. An inert atmosphere (very pure nitrogen) is necessary because the presence of oxygen causes a number of undesired reactive bonds in the coating.

Due to the high effort (inertisation, high voltage), enhanced safety requirements (shielding) and high investment costs, but also due to energy consumption and space requirements, EB dryers are extremely rare in curing applications. They cannot be used in many processes either, as they can modify/destroy materials.

Flash lamps as an alternative in disinfection:

A flash lamp is also a gas discharge lamp, filled with xenon gas, krypton gas or sometimes a mixture of krypton/xenon. They produce an extremely intense white light for microsecond durations. Comparing flash lamps with UV low-pressure lamps for disinfection, the costs for flash systems are more than 5 times higher than systems with low-pressure lamps. The lifetime of flash lamps is 2-3 times shorter than low-pressure lamps, which results in even higher costs and more electrical waste for replacement parts as the lamps have to be replaced more often. Noise emmission when operating flash lamps is high at the workplace and handling of photobiological safety is more complex due to the high intensity in UV radiation per flash.

3. Give details on the reliability of substitutes (technical data + information): Please see justification above (B 2.)
4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to
   1) https://www.unep.org/globalmercurypartnership/resources/report/global-mercury-assessment-2018
   2) Health impacts: https://www.epa.gov/mercury
   3) Consumer safety impacts: There is no impact if UV equipment is used in a proper way and the instruction handbook is respected

⇨ Do impacts of substitution outweigh benefits thereof?
Please provide third-party verified assessment on this: There is no chemical substitution for the UV range available, only a limited substitution by LED technology.

(C) Availability of substitutes:

a) Describe supply sources for substitutes:
UV-LEDs
There are various manufacturers who assemble UV curing systems based on UV LED chips. Please find below a list of producers: IST INTECH, Excelitas Noblelight, Hönle AG, Ushio etc. (listing without claim of completeness). But nevertheless, UV LED technology cannot replace UV mercury discharge lamps in most applications.

b) Have you encountered problems with the availability? Describe:
UV-LEDs:
UV LED chips with reasonable optical outputs at wavelengths down to 365 nm are available. But for most of the applications also radiation at a lower wavelength is needed. (More precisely: the broad UV spectrum of a medium-pressure mercury discharge lamp is needed). At lower

wavelengths, there are no UV LED chips with good optical yields and reasonable prices available.

c) Do you consider the price of the substitute to be a problem for the availability?

☒ Yes ☐ No

d) What conditions need to be fulfilled to ensure the availability? The technology of UV LED chips production needs to be improved to produce powerful chips also at lower wavelengths in the UV range.

(D) Socio-economic impact of substitution:

⇨ What kind of economic effects do you consider related to substitution?

☒ Increase in direct production costs

☒ Increase in fixed costs

☒ Increase in overhead

☒ Possible social impacts within the EU

☒ Possible social impacts external to the EU

☐ Other:

⇨ Provide sufficient evidence (third-party verified) to support your statement:

Impact on printing industry:

When dryers based on UV mercury lamps are no longer available in the printing industry, a large number of existing systems on the market will become unusable and a wide range of products will end up being produced outside the EU. Due to their long service life and high investment costs (depreciation of 10 years with single-shift operation), printing machines are still used well beyond their planned lifespan. Overhauling and retrofitting allow machines to be used over a very long period of time (> 10 years) without any reduction in quality or efficiency. Conversion to other dryer systems, especially for older machines, is uneconomical. Since UV LED drying cannot be used for all products and printing applications, there is theoretically the possibility to switch to traditional oil-based inks with conventional drying methods (hot air/infrared). However, the desired product properties and, in many cases, fast and reliable drying could no longer be achieved. Additional drying times must be planned before further processing and drying with infrared and hot air means a significantly higher energy consumption than with UV drying. For printing companies specialized in UV curing, this means business discontinuation or a change in the business model combined with incalculable risks. One consequence would be that the production of time-uncritical printed matter would be outsourced to non-EU countries. A changeover to other drying systems also means a change in the ink system and processes. Drying with oil-based inks is often supported by powder, which in turn is a step backwards from a health point of view.

It is difficult to quantify how many printing companies would be affected by closure and the economic damage that would be caused by a ban. According to Intergraf (www.intergraf.org), the European umbrella organization of the printing industry, the European printing industry comprises some 110,000 companies with around 610,000 employees and a total turnover of around 70 billion euros. It is difficult to estimate the share of UV printing presses in the market, about 30% new sheet fed printing presses and 90% of label presses are equipped with UV dryers. A ban would not only have an impact on the printing industry itself, since many UV-cured print products are further processed in other industries, such as packaging in the food, pharmaceutical and cosmetics industries. This would change value chains. The production of certain printed products could be transferred to other regions of the world, which would have direct effects on the employment situation in the European printing industry. Importing UV-cured products from non-EU countries also poses risks for the environment, occupational health and safety if products are not manufactured according to accepted rules or if the printing inks used contain substances of concern.

The associated decline in the degree of embellishment of packaging could lead to a loss of value of products, since their value is also supported by the packaging design (e.g. luxury goods). Overall, a ban would mean a decline in the competitiveness of the European printing industry. Europe is still the most important and innovative printing location in the world, and the leading printing press manufacturers are also based here. The relocation of print production would lead to a long-term loss of workerforces in Europe.

Also the changeover to UV LED systems, where it is possible (Retrofittability of machines, availability of appropriate materials, suitable product requirements) poses economic risks. The prices of UV LED inks are usually higher than those of UV printing inks. One reason is the higher proportion of photo-initiators to achieve adequate curing. The investment costs of the UV LED modules for the curing process are typically higher compared to UV lamps. High expenses are needed for the development and the implementation of reliable processes along the total value chain.

Impact on coating processes in industry:

In the wood and furniture industry, solvent-based coatings with a solvent content of 70 to 80 percent are still predominantly used for coating. However, UV coatings are increasingly being used in multi-stage coating processes for reasons of environmental protection as well as occupational health and safety (today approx. 9% market share). For furniture and decorative surfaces, high mechanical and chemical resistance is required, so UV mercury medium-pressure discharge lamps are used for reliable curing. A ban on UV mercury discharge lamps would mean a switch back to solvent-based coatings in this industrial sector.

The production of optical discs (CDs, DVDs, BluRay) would no longer be possible if UV lamps were banned in the EU, as there is no appropriate alternative technology for curing the layers. Potential alternative UV light sources are either less efficient, or limited in the wavelength spectrum, or they do not continuously emit UV light. Curing of lacquers or bond material for optical data storage can hardly be achieved with alternative UV light sources due to process and material limits. The product quality and safety could not be guaranteed.

Innovative and environmentally friendly metallic coatings on three-dimensional plastic surfaces, e.g. for car interiors, could no longer be applied. These surfaces have to withstand high mechanical and chemical stresses. UV lacquer based pre-coating and finishing in combination with vacuum metallization is an ecological and sustainable alternative to chrome-plated surfaces, which are affected by a REACH regulation banning chromium trioxide. Fast and efficient curing of the coatings with potential alternative UV light sources is strongly limited by an improper wavelength spectrum or by discontinuous light emission. The size and form factor of alternative UV light sources are also limiting their application in 3D part coating. Efficient processing with a high degree of productivity and product safety requires UV mercury discharge lamps.

Impact on disinfection processes in industry:

Since UV LED systems cannot be used for disinfection for the reasons mentioned above, a ban on UV mercury discharge lamps would have unforeseeable consequences for the health of the EU population. On the one hand, this usually means a changeover to chemical disinfection, which leaves residual chemicals and possibly resistant germs. In the case of food, this could have a negative impact on food safety and the minimum shelf life of food products.

Impact on water treatment:

A survey from 2008, published in the journal “energie / wasser-praxis 03/2009” shows that 43 % of the 1094 drinking water suppliers in Germany that delivered input to this survey, disinfect their water. Disinfection with UV light is with 42% the most used method for disinfection of drinking water compared to disinfection with chlorine dioxide, chlorine/hypochlorite or ozone. Especially smaller drinking water suppliers with a conversion rate of up to 3 million m^3/a prefer disinfection with UV light.

The installed base of equipment using high power UV lamps, especially in drinking water disinfection cannot be replaced by other equipment with reasonable effort and within a reasonable time. Even if UVC LEDs would be available in terms of performance and emitted spectrum, they cannot be used as retrofit replacement in existing applications.

Impact on food industry:

Besides water disinfection there also is a high number of applications for surface and air disinfection purposes especially in the food processing industry due to the ongoing demand for flawless food product quality and extended shelf live. Especially the largest meat production facilities in Europe (Tönnies Fleisch, Danish Crown, Vion Group) but also many other companies use high performance UV installations to grant a stable product quality either by UVGI (Ultra-Violet Germicidal Installations) for conveyor belt disinfection, installations inside their air handling units, UV emitters in combination with their HVAC systems (Heating, Ventilation, Air Conditioning) or very often by decentralised indoor air disinfecting devices. All is done to keep air quality to the lowest germ count possible and thus to enhance product quality and shelf life. As air velocity inside industrial applications is pretty high and microbial UV exposure in most of the cases is less than a second, germicidal UV energy has to be extremely high to be efficient (dose principle).

⇨

9. Other relevant information

Please provide additional relevant information to further establish the necessity of your request:

UVC radiation generated by UV mercury discharge lamps is currently the most effective way for safely curing coatings to achieve high physical and chemical resistance and to kill germs in a reliable and environmentally friendly way.

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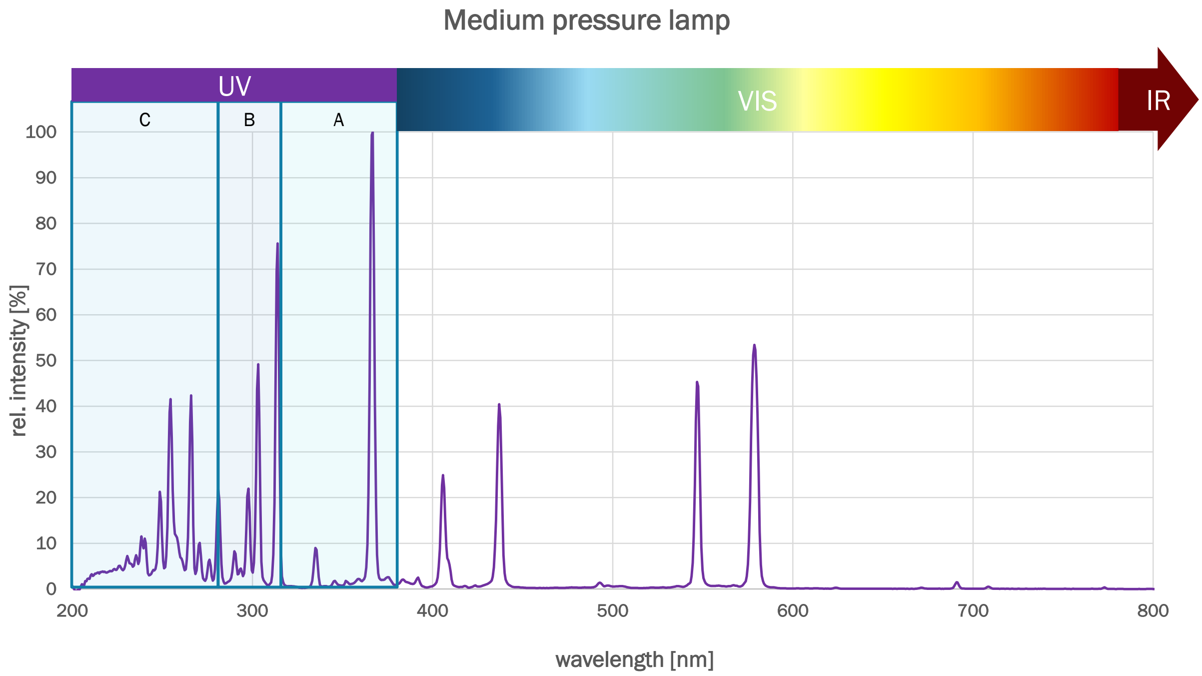
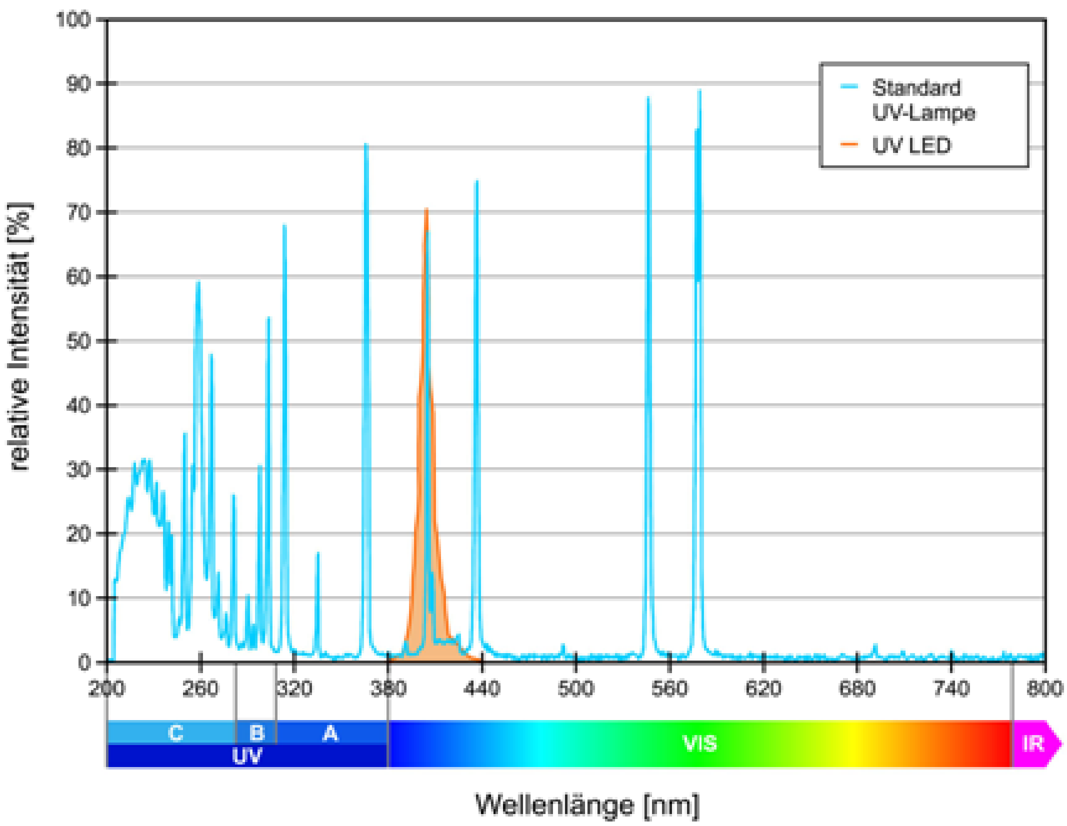
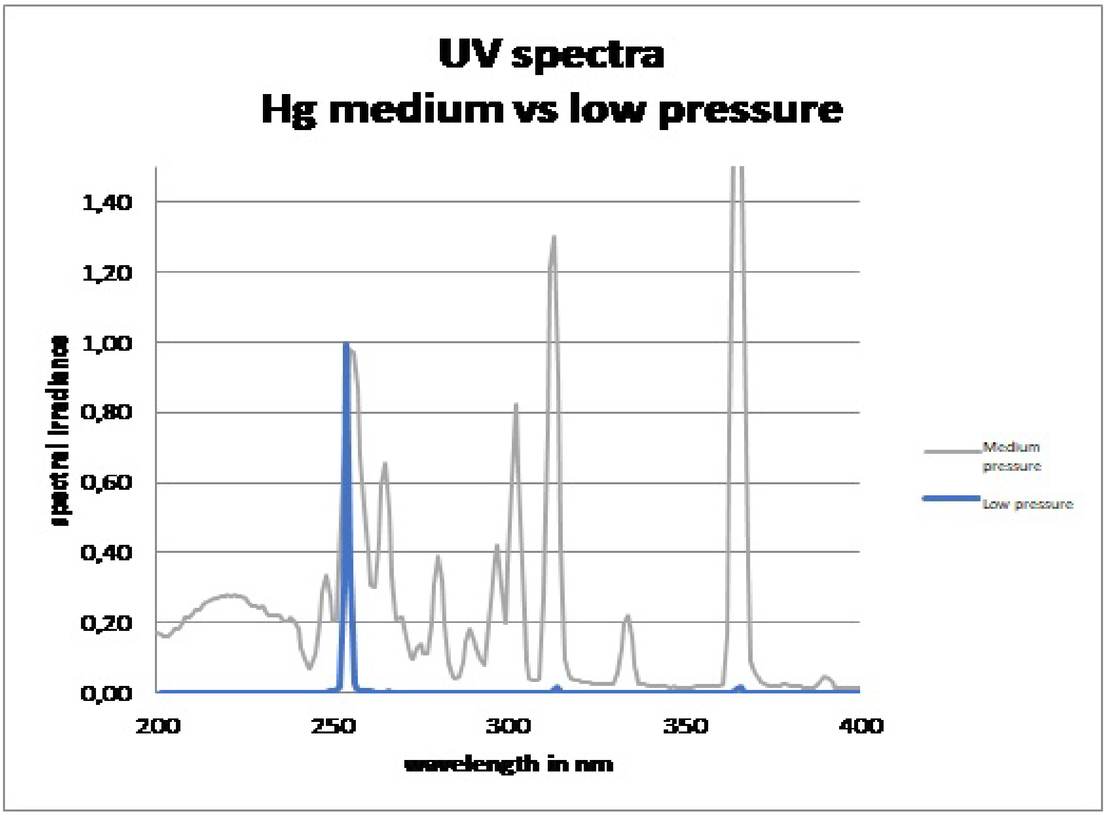
10. Information that should be regarded as proprietary

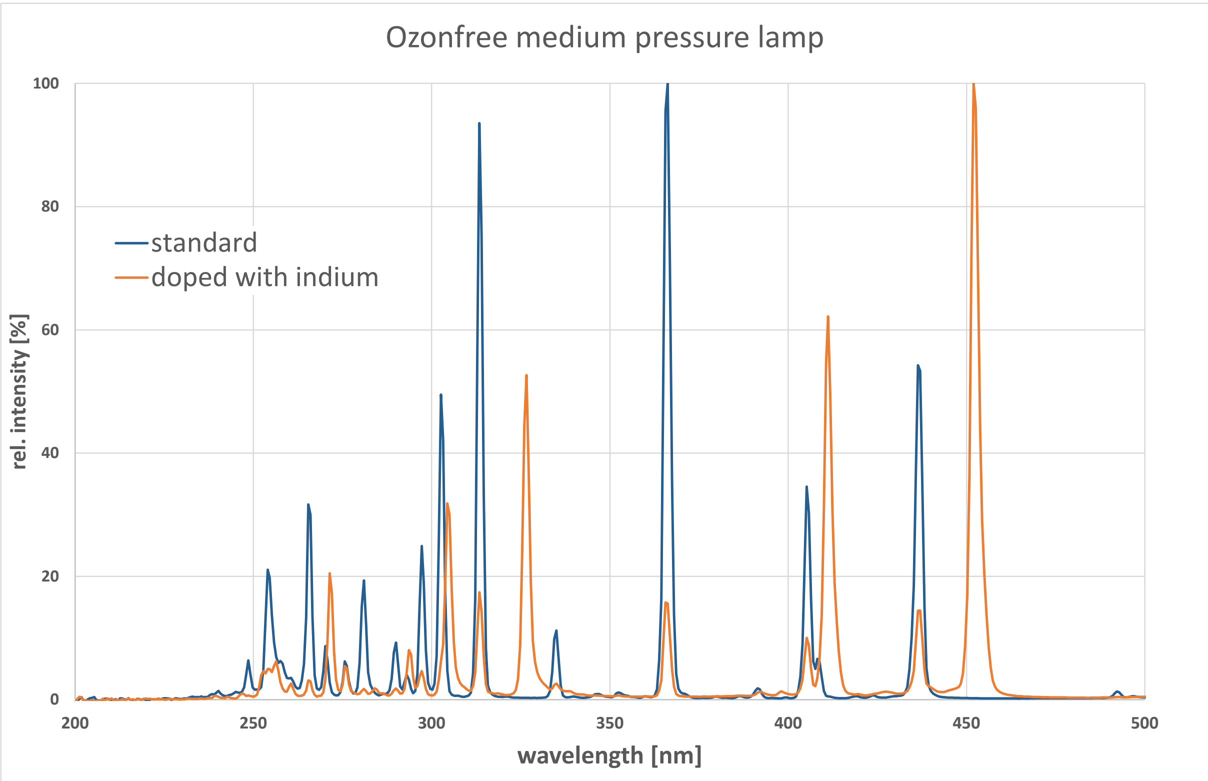
Please state clearly whether any of the above information should be regarded as proprietary information. If so, please provide verifiable justification:

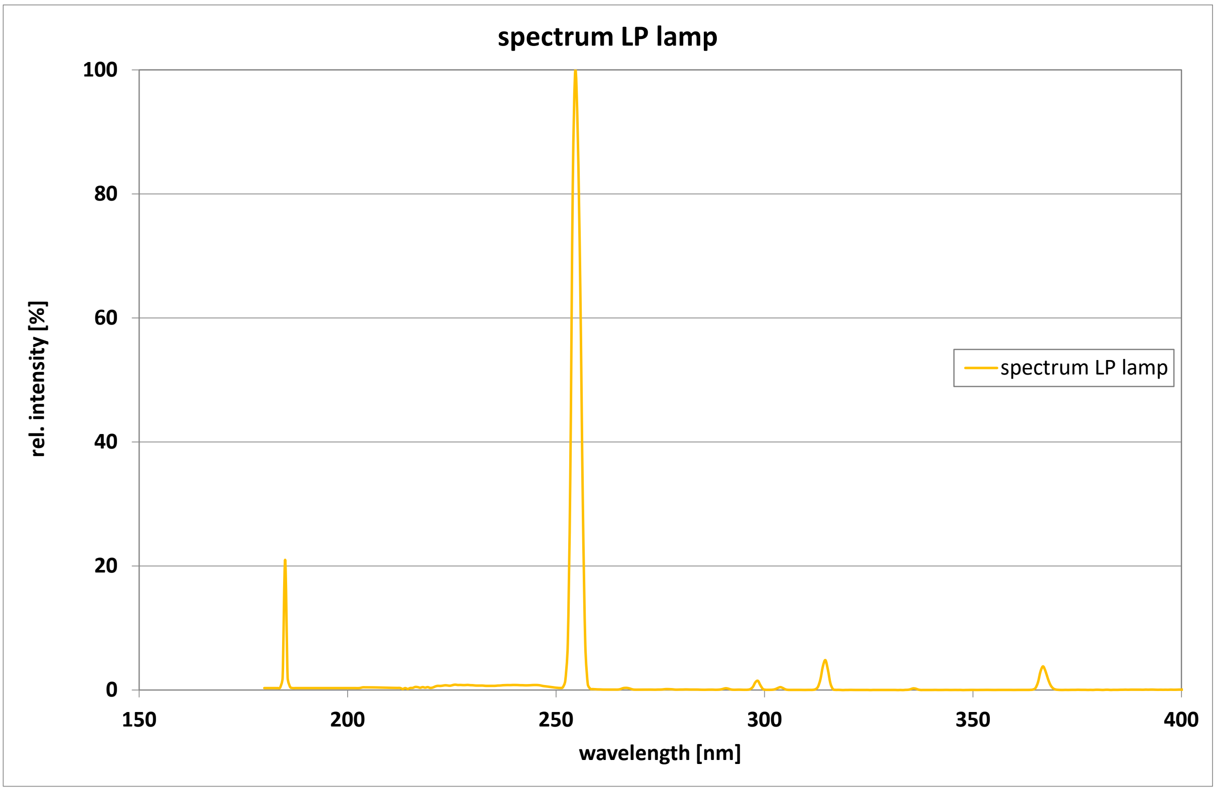
ANNEX I: DIFFERENT LAMP SPECTRUM



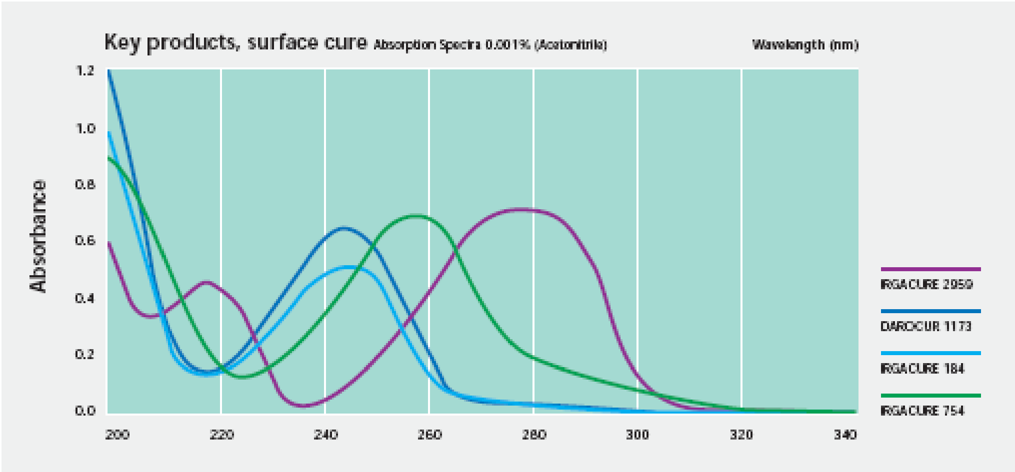


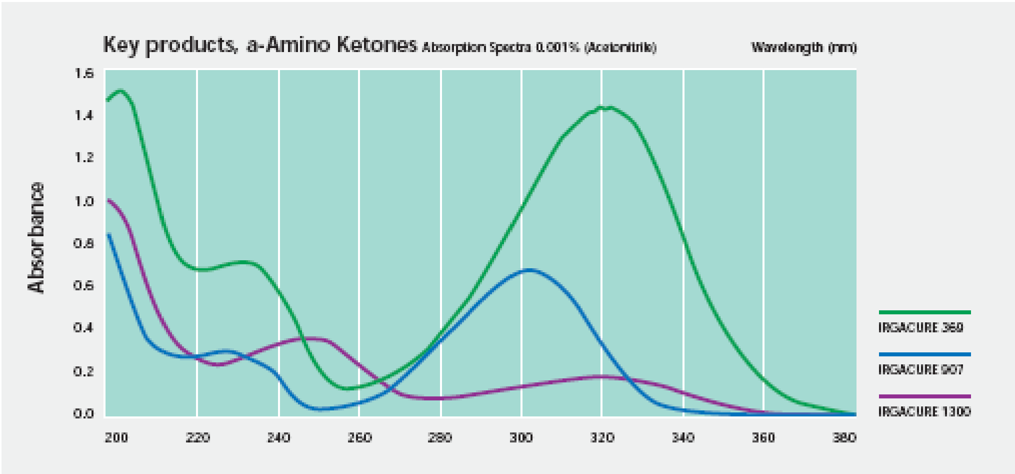

UV spectra
Hg medium vs low pressure
spectral irradiance
1,40
1,20
1,00
0,80
0,60
0,40
0,20
0,00
200
250
300
350
400
wavelength in nm
Medium pressure
Low pressure

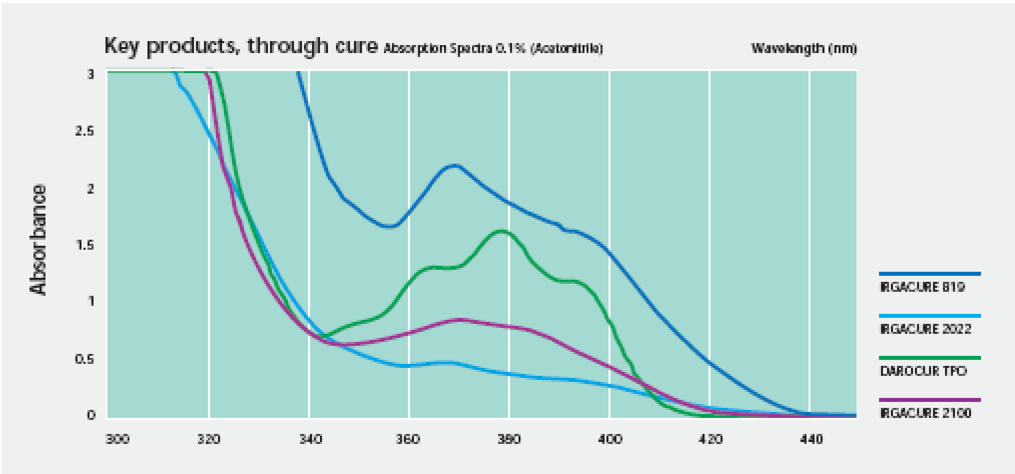

Ozonfree medium pressure lamp
rel. intensity [%]
100
80
60
40
20
0
standard
doped with indium
200
250
300
350
400
450
500
wavelength [nm]


spectrum LP lamp
100
80
60
40
20
0
rel. intensity [%]
spectrum LP lamp
150
200
250
300
350
400
wavelength [nm]

ANNEX II: ABSORBANCE OF PHOTOINITIATORS

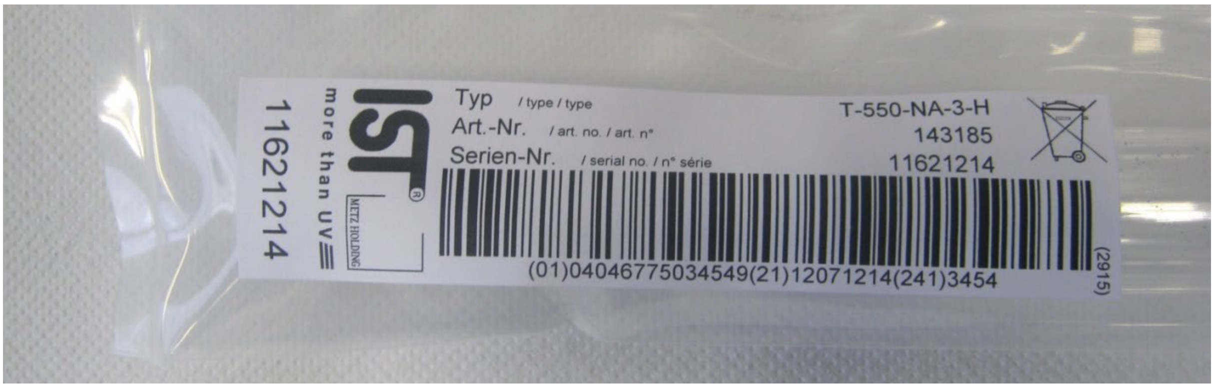






ANNEX III: Marking

UV medium-pressure discharge lamps shall be marked with a symbol (crossed-out wheeled bin) according to 2012/19/EU, Annex IX, which indicates the duty of separate collection.



ANNEX IV: Examples for machines and equipment with medium-pressure Hg UV lamps affected by RoHS

UV Hg systems are not only installed in large machines and supplied from a single source. Existing machines are also retrofitted with UV Hg dryers.

There is also smaller equipment for small carpentry manufacturers, digital printing shops (e.g. for advertising), special applications and laboratory equipment (e.g. for the development of UV-curable materials).

There are also smaller installations in the disinfection sector that are not LSFI and LSSIT. Examples are mobile systems for hospital disinfection and systems for air disinfection. There is also an increased need for small or mobile disinfection systems from a pandemic point of view (Covid-19). The effectiveness of UVC radiation in eliminating germs, bacteria and viruses (including coronaviruses) has been proven. Accordingly, the demand for disinfection systems for air and surface disinfection is increasing.

UV Hg curing machine for small carpentry manufacturers 130 cm x 200 cm, not for industrial-scale production. Source: Robert Bürkle GmbH

UV Hg curing machine for small digital printing shops 130 cm x 130 cm, not for industrial-scale production, plug-in installation. Source: Robert Bürkle GmbH

UV Hg laboratory equipment for testing inks, varnishes and adhesives; weight: 170 kg, Example of size: 120 x 97 x 76 cm, Source: IST Metz

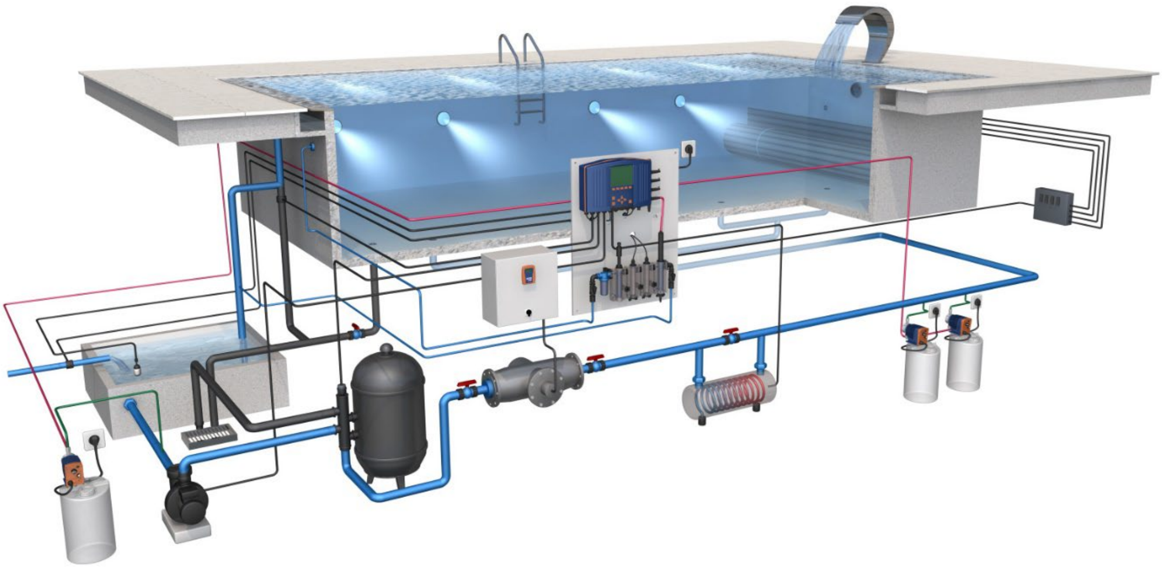
Belt dryer, continuous table-top device for rapid curing of UV Hg inks, UV coatings and UV adhesives in the small-format printing sector for testing or production on flat material and moulded parts, Example of size: (L×H×W) 105 x 40 x 50 cm, appr. 45 kg

Air disinfection device; Source Sterilsystems (Member of Hönle Group)

UV Water disinfection devices ; Source Sterilsystems (Member of Hönle Group)

Benchtop Conveyor System for UV curing suitable for laboratory and R&D applications,
Source: Excelitas Noblelight (former Heraeus Noblelight)

Small UV system for disinfection of swimming pool water: The UV reactor contains one medium-pressure UV lamp that is mainly used for halomethane reduction and disinfection of swimming pool water. This system is small and has 1x1kW MP lamps. In general, this system can be larger containing up to 3x3kW medium-pressure UV lamps. A Cabinet with a Touchscreen panel to control the UV reactor and measure the UV irradiance. The main function of the medium-pressure UV system is to reduce the disinfection byproduct in swimming pool water, the chloramines. Due to the high intensity of the medium-pressure lamps in the UV spectrum at various wavelengths, it is the best method to eliminate all the chloramines in swimming pools just by irradiation of UV light. Source: Prominent GmbH



Schematic drawing of a swimming pool with a medium-pressure UV disinfection system for point disinfection and for chloramine reduction. The medium-pressure UV system is directly connected behind the big filter system in the circulation of swimming pool water. Source: Prominent GmbH.

ANNEX V:

The VDMA is acting as an authorized representative for the below listed companies. The submitted request form is an elaboration of information of the named companies.

Heidelberger Druckmaschinen AG
Gutenbergring
69159 Wiesloch
Internet: www.heidelberg.com

Excelitas Noblelight GmbH
Reinhard-Heraeus-Ring 7
63801 Kleinostheim
Internet: www.noblelight.com

Dr. Hönle AG
Nicolaus-Otto-Str. 2
82205 Gilching
Internet: www.hoenle.de

IST METZ GmbH
Lauterstr. 14-18
72622 Nürtingen
Internet: www.ist-uv.com

Koenig & Bauer AG
Friedrich-Koenig-Str. 4
97080 Würzburg
Internet: www.koenig-bauer.com

manroland sheetfed GmbH
Mühlheimer Str. 341
63075 Offenbach am Main
Internet: www.manrolandsheetfed.com

ProMinent GmbH
Im Schuhmachergewann 5-11
69123 Heidelberg
Internet: www.prominent.com

Robert Bürkle GmbH
Stuttgarter Str. 123
72250 Freudenstadt
Internet: www.noblelight.com

Technigraf GmbH
Auf der Struth 4
61279 Grävenwiesbach
Internet: www.technigraf.de

uv-technik Speziallampen GmbH
Gewerbegebiet Ost 6
98693 Ilmenau
Internet: www.uvtechnik.com

Venjakob Maschinenbau GmbH & Co. KG
Augsburger Straße 2-6
33378 Rheda-Wiedenbrück, Germany
Internet: www.venjakob.de