Exemption Request Form

Date of submission: 19 January 2020

1. Name and contact details

1) Name and contact details of applicant:

Company:	VDMA e.V.	Tel.:	+49 (0) 69 6603-1454
Name:	Roger Starke	E-Mail:	roger.starke@vdma.org
Function:	Printing and Paper Technology	Address:	Lyoner Straße 18, 60528 Frankfurt/Main

The VDMA is acting as an authorized representative for the companies listed in Annex IV. 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:	

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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)

Proposed or existing wording: Mercury in other discharge lamps for special purposes not specifically mentioned in this Annex

Duration where applicable: maximum period of validity of five years / 21.07.2026

☐ Other:

3. Summary of the exemption request / revocation request

The application for prolongation of the existing exemption refers to mercury-containing UV discharge 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)

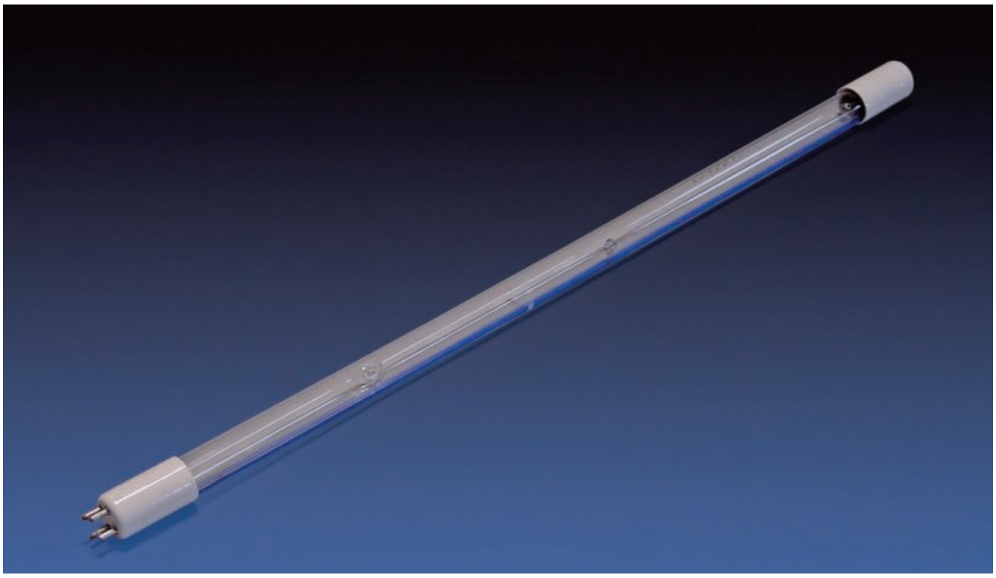
The application includes the following lamp types:

— **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 UV medium-pressure lamps can be doped with iron, gallium or lead in addition to the mercury they contain. This changes the spectrum and adapts it to specific process requirements. Since metal halides are used for this purpose, these lamps are also referred to as metal halide lamps.

— **UV low-pressure discharge lamps for special purposes** in the high power range.



Examples of UV low-pressure discharge lamps for water disinfection

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, ink-jet, screen printing, narrow web) on different substrates (paper, board, cardboard, foils, metal sheets, rigid and flexible materials, even 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 printing (e.g. books, brochures, advertising prints, posters...)

1.1.2 Curing of ink and coating layers in packaging printing (folding boxes, food packaging, 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 cardboard, glass, plastic bodies ....)

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

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

1.2 Curing of coatings in the decorative sector (e.g. floor coverings, 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 process)

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 and displays, post-crosslinking of plastics, (functional) coatings on surfaces (eyeglasses, contact lenses, automotive industry)

2 Disinfection

2.1 Water disinfection

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 waste water (e.g. ballast water on ships)

2.1.4 Water treatment in public swimming pools

2.1.5 Control of microbiological growth (fish farming, cooling water)

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 into contact with the product or packaging material.

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

2.4 Disinfection 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)

The industry is making efforts to reduce the use of UV lamps containing mercury. Despite it is technically not possible to replace mercury in special UV lamps with other materials/chemicals in order to achieve the same widespread radiation distribution. As an alternative, LED-based technologies are increasingly being used, which in certain applications (e.g. curing) also offer many advantages over mercury-containing UV lamps (e.g. lower heat generation, faster switching). Nevertheless, LED technologies cannot be used as an equivalent replacement in many applications. This has the following reasons:

- limited emission spectrum, narrow band emission, emitted wavelengths do not exactly match the absorption spectrum of UV-reactive chemistry
- 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 applications are to be evaluated as worse than with the use of UV special 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 depending on the number of required radiation units
- Existing systems cannot be replaced immediately for reasons of economy (high investment costs, long depreciation, long service life) and environmental impacts (manufacturing of new plants and utilization of old plants), and therefore UV mercury discharge lamps are needed as spare parts for many years to come.

In the printing sector, printing machines with LED dryers operating in the UVA range have been developed in recent years. Nevertheless, the available spectrum 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 many years.

For drinking water treatment, UV low-pressure discharge lamps are preferred, but medium-pressure discharge lamps are also used (e.g. for large installations in municipal waterworks).

It is difficult to forecast the development (performance increase) of UV LEDs in the shorter wavelength range (UVC, UVB), which are indispensable for a safe process in many areas, and of suitable UV-reactive materials. In addition to technical challenges, market economy aspects must also be considered. The manufacturers of UV LED based lamp systems are dependent on the commercial availability of suitable UV LEDs and can only influence the development to a limited extent, since the market is limited.

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

VDMA member companies are manufacturers of special UV lamps and UV built-in components as well as machine manufacturers who integrate these systems into machines and systems. The VDMA is the largest European association of the capital goods industry with approx. 3200 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 lamps, pure mercury (=100%) in liquid form is contained in

sealed lamps. In low-pressure lamps in which the mercury is inserted as amalgam, the mercury content is higher than 10% in the homogeneous material.

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

Currently we do not have access to detailed market figures or statistics 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

This estimate is based on the following assumptions: an average price per lamp; European market share: 21%; share of lamps for curing: 35%; average mercury content per lamp: 0.5 g Hg in 2015/ 0.66 g in 2018 (the average content depends on the average lamp length per year). As the topic of UV is increasingly in demand in sheetfed presses, 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. printing press).

We do not have any studies or statistical data on the field of disinfection. In this respect, we can only make a rough estimate of the amount of mercury.

We estimate that the total quantity of mercury in UV lamps for disinfection purposes placed on the EU market annually is less than 100 kg.

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.
1) Extract from: UV LEDs - Technology, Manufacturing And Application Trends 2018 report, Yole Développement, May 2018 (http://www.yole.fr/UVLED_StatusIndustry.aspx#.XaBTSUYzZPY)

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

7. Environmental Assessment: Please refer to Environment Protection Agency (http://www.epa.gov/mercury/eco.htm

   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. 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 265 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. (see Annex V, example of certification – waste management company of IST Metz, Nürtingen)
Users who do not return their lamps 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.

With the Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE Directive), the EU sets certain requirements for the collection and recycling of waste electrical and electronic equipment, including in particular gas discharge lamps. In Germany, some manufacturers have set up a nationwide take-back system for gas discharge lamps and LED lamps: Lightcycle Retourlogistik und Service GmbH. With this system, old lamps can be returned to more than 9,000 collection points. The recovery rate of mercury in used lamps is high and high-purity mercury (99.9%) is recovered by appropriate processes, which can be used again for new products.

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

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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

There is no alternative chemistry for mercury for the creation of a typical UV spectrum, especially in the UVC range, that is known of. Therefore, UV LED is presented in comparison in the following statement as an alternative technology.

(B) 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 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 and often only under certain restrictions.
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).

6 (B) 1.1 Digital printing

In digital printing, e.g., for large-format inkjet printing systems, UV LED units have been used successfully for the so-called pinning[1)] for some years already. The

1) 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 UV dryers based on medium-pressure mercury discharge lamps..

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. 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. In single-pass digital printing systems, in addition UV mercury discharge lamps are often used in end-of-press drying in order to guarantee sufficient curing of the layers.

6 (B) 1.2 Conventional Printing

The situation 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 most commonly 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.

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. In recent years, UV medium-pressure mercury discharge lamps doped with iron have increasingly been used. These systems have been established on the market under various names since 2012: LE-UV (Low Energy, Heidelberg); HR-

UV (High-Reactive UV Technology, Koenig & Bauer); H-UV (Hyper-UV, Komori) and LEC-UV (Low Energy Curing, manroland sheetfed).
Printing systems with iron-doped UV lamps generally require fewer dryers in the machine because the ink is more reactive. 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, cold foil application, 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. A large number of formulations are used to create the coating effects, which essentially require UVC light in order 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. Due to the web guiding, intermediate dryers are necessary after each printing unit, therefore a large number of UV lamps per machine is 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.

In order 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. 15 times lower.
- Power approx. 40 times lower.
- Service life (L80 value) approx. 20 to 30 times lower.
- Costs per mW approx. 1000 times higher.

There is currently no UVC LED technology available to economically produce and run an UVC LED system for the curing. Thus the UV LED use is limited to a few applications with UVA LED systems, typically in the commercial sector with printing of 4 process colours, Black, Cyan, Magenta, Yellow.
There is also a lot of development work still to be done on spot color inks, 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 ink produced.

Furthermore, the ink manufacturers state that the development of new UV LED printing inks, their CMR (CMR=Carcinogenic, Mutagenic and toxic to

Reproduction) testing and approval takes 5 to 7 years and, therefore, is not economically reasonable considering the present market volume.

6 (B) 2 Alternative situation in the disinfection sector

6 (B) 2.1 Water disinfection

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).

UV-LEDs cannot be used for disinfection because powerful UVC LEDs are currently not available. 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 260 and 285 nm. At the moment they are in the research and development stage. For example, the power output could be improved from 10mW in 2014 to 100mW in 2017 at 280 nm. (Source: https://www.i-micronews.com/water-disinfection-applications-will-be-worth-650m-in-2023/). At present, the efficiency (wallplug) is between 2 and 6%, 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://www.i-micronews.com/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 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.

According to §11 of the drinking water regulation in Germany a list has been established by the environmental federal agency (UBA) listing approved treatment and disinfection processes for drinking water . This table currently lists UV Disinfection with mercury discharge lamps. Using e.g. UV LEDs for drinking water disinfection in Germany is normative not yet approved.

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.

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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.

(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 forty.

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. [2)]

[2)] 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 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 especially 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. 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 costs and narrow banded emissions 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 pollution 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) Environmental impacts: http://www.epa.gov/mercury/eco.htm
   2) Health impacts: http://www.epa.gov/mercury/effects.htm
   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 Metz GmbH, Integration Technology, Heraeus Noblelight, Hönle AG, 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 sector, a large number of systems on the market will no longer be usable and a whole range of products will be 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 useful life. Overhauling and retrofitting allows 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 organisation of the printing industry, the European printing industry comprises some 112,000 companies with around 625,000 employees and a total turnover of around 80 billion euros. It is difficult to estimate the share of UV printing presses in the market, about 20 to 25 % of new printing 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 finishing 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 manpower 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 currently higher than those of UV printing inks. One reason is the higher proportion of photo-initiators in order to achieve adequate curing. The investment costs of the UV LED modules for the curing process are substantially higher compared to UV lamps (variety of chips required, integration of optical components and the related construction and connection technology). High expenses are needed for the development of suitable materials (e.g. inks) 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 of the very high layer thicknesses (up to 50µm). 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 quaranteed.

Innovative and environmental 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 commonly 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 m³/a prefer disinfection with UV light.

The installed base of equipment using high power 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 amount 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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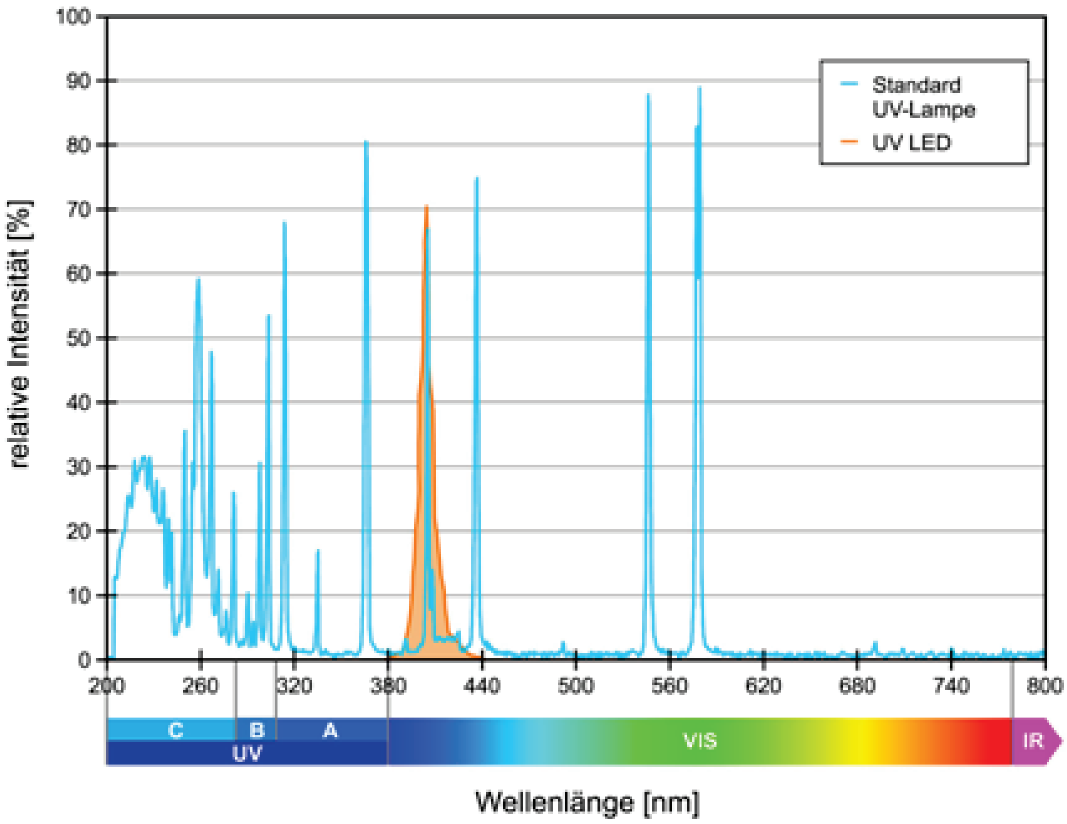
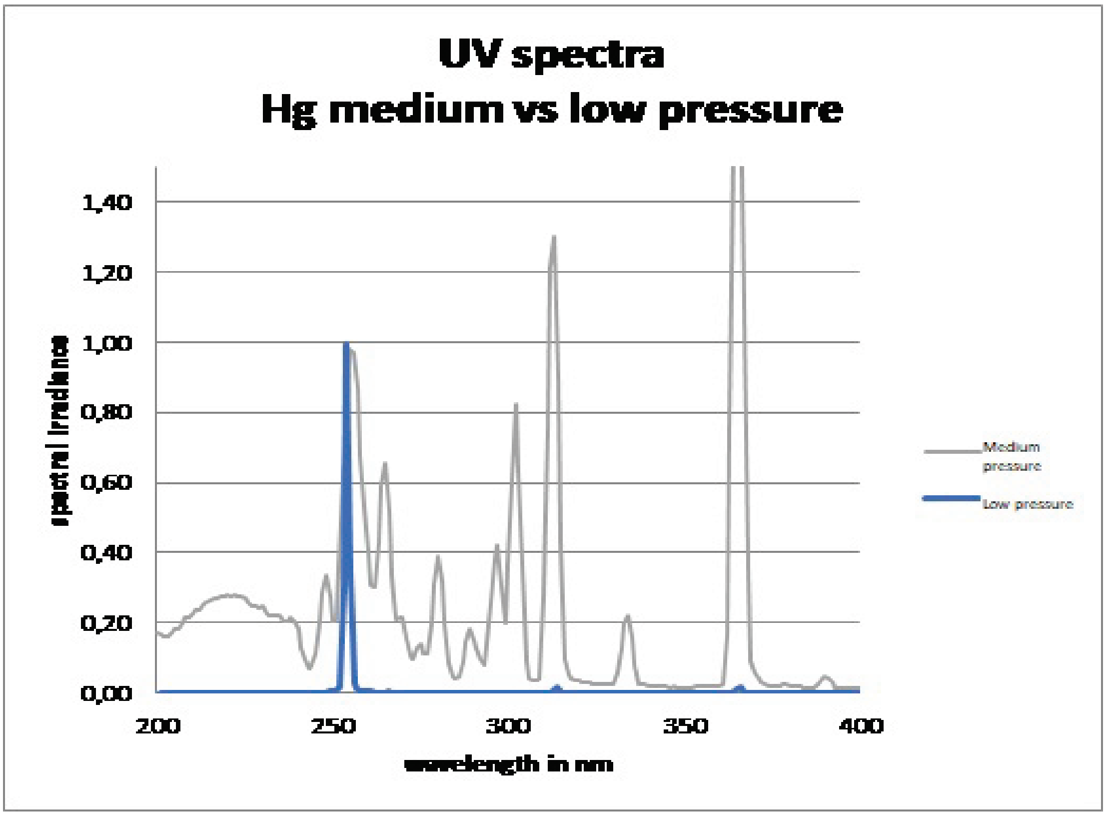
10. Information that should be regarded as proprietary

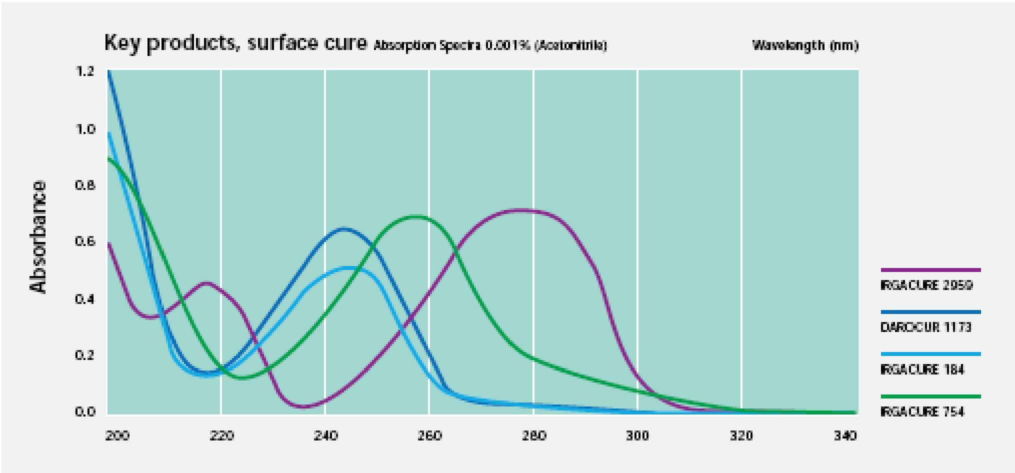
Please state clearly whether any of the above information should be regarded as proprietary information. If so, please provide verifiable justification:

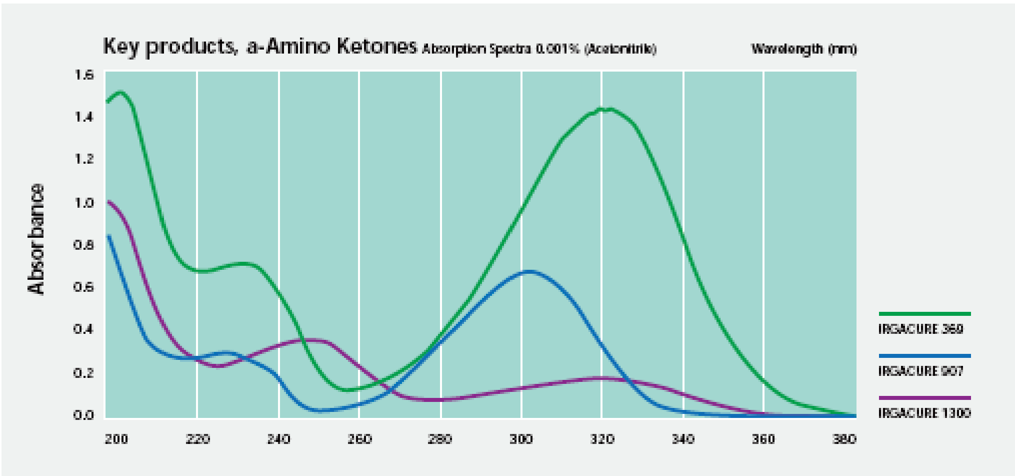
ANNEX I: DIFFERENT LAMP SPECTRUM

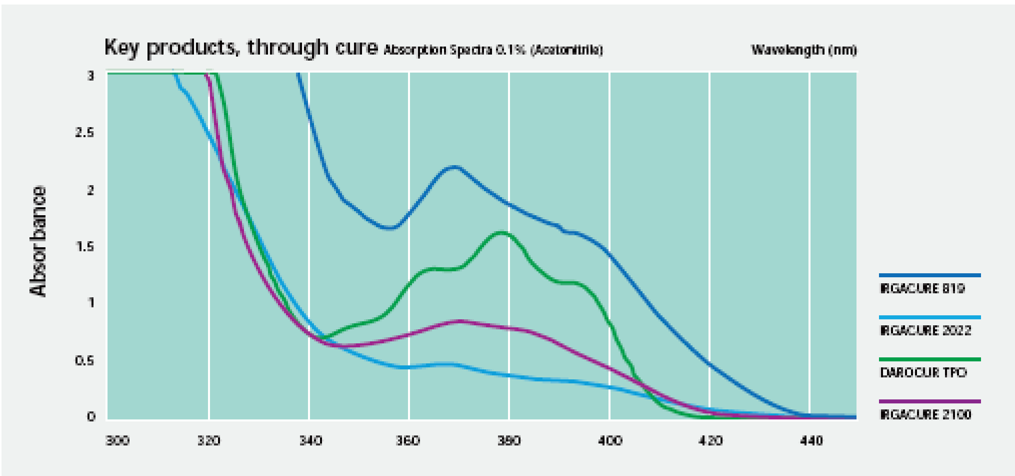




ANNEX II: ABSORBANCE OF PHOTOINITIATORS

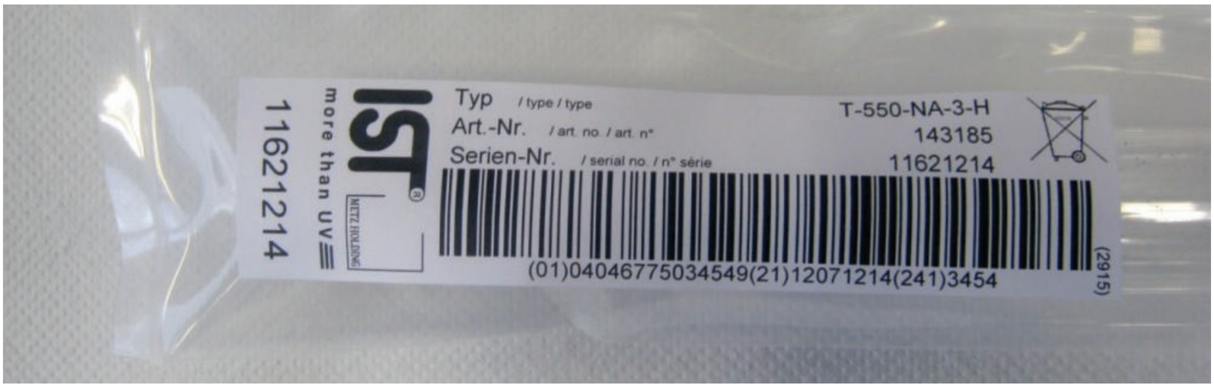






ANNEX III: Marking

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:

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
69168 Wiesloch
Contact person:
Mr. Klaus Blank
Phone: (+49 6222) 82 68872
E-mail: klaus.blank@heidelberg.com
Internet: www.heidelberg.com

Heraeus Noblelight GmbH
Heraeusstraße 12-14
63450 Hanau
Contact person: Mr. Hanno Zager
Phone: (+49 6181) 35 3467
E-mail: hanno.zager@heraeus.com
Internet: www.heraeus-noblelight.com

Dr. Hönle AG
UV Technology
Lochhamer Schlag 1
82166 Gräfelfing
Contact person:
Mr. Dieter Stirner
Phone: (+49 89) 85608 134
E-mail: dieter.stirner@hoenle.de
Internet: www.hoenle.de

IST METZ GmbH
Lauterstr. 14-18
72622 Nürtingen
Contact person:
Mr. Stefan Feil
Phone: (+49 7022) 60 02-7 00
E-mail: stefan.feil@ist-uv.com
Internet: www.ist-uv.com

Koenig & Bauer AG
Friedrich-Koenig-Str. 4
97080 Würzburg
Contact person:
Mrs. Mariann Thutewohl
Friedrich-List-Str. 47
01445 Radebeul
Phone: (+49 351) 8 33-29 53
E-mail: mariann.thutewohl@koenig-bauer.com
Internet: www.koenig-bauer.com

manroland sheetfed GmbH
Mühlheimer Str. 341
63075 Offenbach am Main
Contact person
Mr. Robert Thieme
Phone: (+49 69) 8305 3606
E-mail: robert.thieme@manrolandsheetfed.com
Internet: www.manrolandsheetfed.com

ProMinent GmbH
Im Schuhmachergewann 5-11
69123 Heidelberg

Contact person:
Mr. Wolfgang Matheis
Phone: (+49 6221) 842-1476
E-mail: w.matheis@prominent.de
Internet: www.prominent.com

SINGULUS TECHNOLOGIES AG
Hanauer Landstrasse 103
63796 Kahl am Main

Phone: (+49 61 88) 4 40-0
E-mail: postmaster@singulus.de
Internet: www.singulus.de

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

Contact person:
Mr. Karlheinz Mohn
Phone: (+49 6086) 96 26-24
E-mail: k.mohn@technigraf.de
Internet: www.technigraf.de

UV-Technik Speziallampen GmbH
Gewerbegebiet Ost 6
98693 Ilmenau

Contact person:
Marie-Christin Machalett
Phone: (+49 36785) 520-47
E-mail: marie-christin.machalett@uvtechnik.com

Internet: www.uvtechnik.com

ANNEX V:

Example of certification – waste management company of IST Metz, Nürtingen.

ZER-QMS

QUALITÄT KOMPETENZ

ZERTIFIKAT

Die ZER-QMS
bescheinigt hiermit, dass das Unternehmen

AREIS GmbH
Entsorgung & Industrieservice A.RUESS
Benzstr. 20, 72649 Wolfschlugen

einen Überwachungsvertrag, Nr. **942/2534/Efb** abgeschlossen hat.

Im Rahmen dieses Überwachungsvertrages wurde der Nachweis erbracht, dass das Unternehmen die Anforderungen der Entsorgungsfachbetriebeverordnung erfüllt und daher nach § 56 KrWG berechtigt ist, die Bezeichnung

Entsorgungsfachbetrieb

für den in der Anlage näher bezeichneten Standort und die zugehörigen Tätigkeiten zu führen. Die Anlage ist Bestandteil der Urkunde und umfasst **drei** Seiten.

Begutachtungsdatum: **04.11.2013**
Nächste Begutachtung: **November 2014**
Dieses Zertifikat ist gültig bis: **03.05.2015**

Köln, den 26.11.2013

(Zertifizierungsstelle)

(Reinhold Naß, Sachverständiger)

ZER-QMS, Zertifizierungsstelle,
Qualitäts- und Umweltgutachter GmbH,
Volksgartenstr. 48, 50677 Köln

ZER-QMS
Zertifizierungsstelle,
Qualitäts- und Umweltgutachter GmbH

Anlage zum Zertifikat
Überwachungsvertrag Nr. 942/2534/Efb
der ZER-QMS

(Zertifizierungsstelle, Qualitäts- und Umweltgutachter GmbH, Volksgartenstr. 48, 50677 Köln)

Das Zertifikat ist gültig für die nachstehende Betriebsstätte und die zugehörig aufgeführten Tätigkeiten bis zum 03.05.2015:

AREIS GmbH
Entsorgung & Industrieservice A.RUESS
Benzstr. 20
72649 Wolfschlugen

Entsorgernummer, Beförderernummer, Entsorgernummer: H03400367

Sammeln und **Befördern** von
allen Abfällen nach der Verordnung über das Europäische Abfallverzeichnis
(AVV - Abfallverzeichnis-Verordnung)

Lagern von
Abfällen mit den nachfolgend aufgeführten Abfallschlüsselnummern:

ASN	Bezeichnung
02 01 08*	Abfälle von Chemikalien für die Landwirtschaft, die gefährliche Stoffe enthalten
02 01 09	Abfälle von Chemikalien für die Landwirtschaft mit Ausnahme derjenigen, die unter 02 01 08 fallen
02 02 04	Schlämme aus der betriebseigenen Abwasserbehandlung
03 02 01*	Halogenfreie organische Holzschutzmittel
03 02 02*	Chlororganische Holzschutzmittel
03 02 03*	Metallorganische Holzschutzmittel
03 02 04*	Anorganische Holzschutzmittel
03 02 05*	Andere Holzschutzmittel, die gefährliche Stoffe enthalten
03 02 99	Holzschutzmittel a. n. g.
06 01 01*	Schwefelsäure und schweflige Säure
06 01 02*	Salzsäure
06 01 03*	Flusssäure
06 01 04*	Phosphorsäure und phosphorige Säure
06 01 05*	Salpetersäure und salpetrige Säure
06 01 06*	Andere Säuren
06 01 99	Abfälle a. n. g.
06 02 04*	Natrium- und Kaliumhydroxid
06 02 05*	Andere Basen
06 02 99	Abfälle a. n. g.
06 03 14	Feste Salze und Lösungen mit Ausnahme derjenigen, die unter 06 03 11 und 06 03 13 fallen
06 04 04*	Quecksilberhaltige Abfälle
06 07 03*	Quecksilberhaltige Bariumsulfatschlämme
07 01 03*	Halogenorganische Lösemittel, Waschflüssigkeiten und Mutterlaugen
07 01 04*	andere organische Lösemittel, Waschflüssigkeiten und Mutterlaugen
07 02 03*	Halogenorganische Lösemittel, Waschflüssigkeiten und Mutterlaugen
07 02 04*	andere organische Lösemittel, Waschflüssigkeiten und Mutterlaugen
07 02 08*	andere Reaktions- und Destillationsrückstände

ZER-QMS Zertifizierungsstelle, Qualitäts- und Umweltgutachter GmbH Volksgartenstr. 48 50677 Köln