Exemption Request Form

Date of submission: 16.01.2015

1. Name and contact details

(A) Name and contact details of applicant:

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With support from:

American Chamber of Commerce to the European Union (AmCham EU) ID no.: 5265780509-97	**European Committee of Domestic Equipment Manufacturers (CECED)** ID no.: 04201463642-88	**Communications and Information network Association of Japan (CIAJ)**
European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry (COCIR) ID no.: 05366537746-69	**DIGITALEUROPE** ID no.: 64270747023-20	**European Passive Components Industry Association (EPCIA)** ID no.: 22092908193-23

European Semiconductor Industry Association (ESIA) ID no.: 22092908193-23	**Information Technology Industry Council (ITI)** ID no.: 061601915428-87	**IPC – Association Connecting Electronics Industries**
Japan Business Council in Europe (JBCE) ID no.: 68368571120-55	**Japan Business Machine and Information System Industries Association (JBMIA)** ID number: 246330915180-10	**Japan Electronics and Information Technology Industries Association (JEITA)** ID no.: 519590015267-92
Japan Electrical Manufacturers´ Association (JEMA)	**National Electrical Manufacturers Association (NEMA)**	**RadTech Europe**
SPECTARIS ID no.: 55587639351-53	**TechAmerica Europe (TAE)** ID no.: 2306836892-93	**Zentralverband Elektrotechnik- und Elektronikindustrie e. V. (ZVEI)** ID number: 94770746469-09

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:

LightingEurope submits this application to request for extension of existing exemption no. 4(f) of Annex III and proposes to continue using the existing wording which is:

"Mercury in other discharge lamps for special purposes not specifically mentioned in this Annex"

Duration where applicable:

Maximum validity period required

☐ Other: _____

3. Summary of the exemption request / revocation request

The scope of exemption 4(f) covers all the lamps for special lighting purposes, which do not belong to any of the groups identified in the exemptions 1(a)-4(e) by technology and application in Annex III of RoHS Directive 2011/85/EU.

LightingEurope believes that this exemption is absolutely essential and needs to be kept valid. It is justified due to the fact, that discharge lamps today need mercury for the generation of energy efficient light in the visual and non-visual range.

Annex III of RoHS Directive specifically names the following lamp technologies:

Low Pressure Discharge technology for general and special lighting purposes is covered by the exemptions 1-4(a), such as:

- Compact fluorescent lamps,
- Fluorescent lamps,
- Cold cathode fluorescent lamps and
- UV lamps without phosphor coating operating at the same pressure.

The following High Pressure discharge lamps (i.e. other than low pressure lamps) are defined in exemptions 4(b)-4(e)::

- High Pressure Sodium (vapour) lamps (HPS) for general lighting
- High Pressure Mercury (vapour) lamps (HPMV) for general lighting

- Metal Halide lamps (MH)

The exemptions 1(a)-4(e) do not cover the full range of lamps. Exemption 4(f) covers mercury in lamps, which are special purposes discharge lamps, others than low pressure discharge lamps, used for example in short-arc mercury lamps for producing LED components, in lamps for projection or in UV curing applications. In the figure and table below we try to project the hierarchy of lamps and currently existing Annex III exemptions for mercury in lamps as well as giving a non-exhaustive list of examples of lamp types used in various fields.

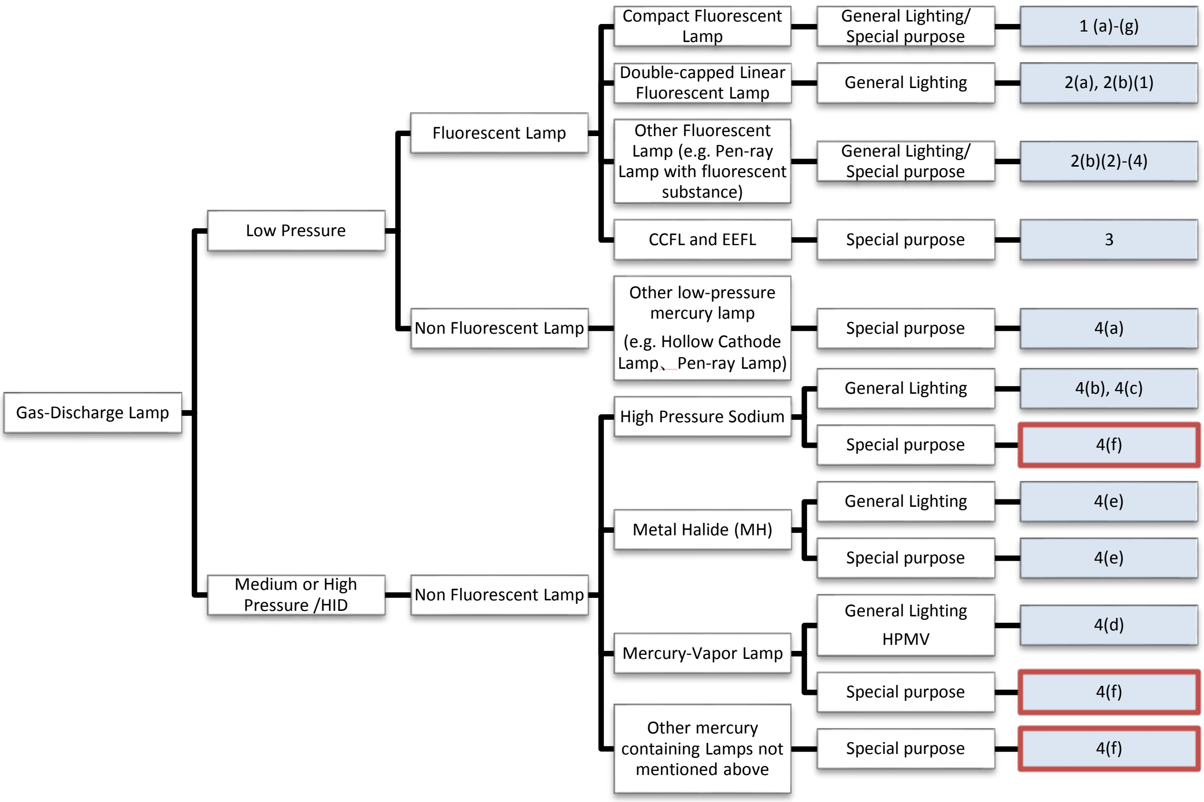
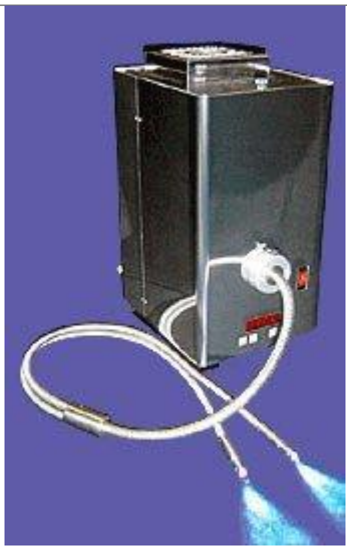


Figure 1: Chart on the hierarchy of lamps and exemptions

The scope of exemption 4(f) is thus covering those lamps, which

- are non-fluorescent,
- and have higher internal pressure compared to fluorescent lamps
- and are used for special purposes.

Lamp types	Examples of application
UV lamp types (non High Intensity Discharge - HID)     UV curing lamps	<u>UV light range</u> UV technology is used in • Curing lamps • Photochemistry • Development of polymers, • Cross-linking of resins in varnishes or inks • Surface modification processes Currently medium pressure lamps containing mercury are used in a wide range of manufacturing applications – including amongst others wood finishing, PCB manufacture, glass bottle decoration, metal container decoration, sewer rehabilitation, contact lens manufacture, plastic bottle decoration, optical fiber coating, ink jet printing, plastic parts coating etc.: • Vacuum ultraviolet (VUV) irradiation for surface cleaning • Hardening and drying of UV-hardened ink, coating and adhesive • Hardening of liquid crystal substrates bonded by dripping • Bonding of CD and DVD • Preliminary tests at chemical reaction plants • Resin coating and others • Photochemistry, e.g. photolysis of H_2O_2 • Skin tanning • UV sterilisation with applications in municipal and industrial plants: sewage sterilisation, compact drinking water sterilisation plants • UV oxidation e.g. activated wet air oxidation



UV radiation system for ultraviolet curing resin

High UV power densities, up to 30 W/cm in the UV-C, can be obtained from mercury arc discharges that are operated at medium pressure of a few bars. They have a broad, pronounced line spectrum in the ultraviolet and visible spectral range.

HID Lamp types

Projector lamps 	<u>Visible light range</u> • Projection
High Pressure Mercury Short Arc lamps   	High pressure mercury short arc lamps are mainly used in • Microlithography for producing integrated circuits, liquid crystal displays (LCDs) and printed circuit boards (PCBs). • Visual and fluorescence microscopy, irradiation for photo polymerisation (used in manufacturing processes for, among other things, efficient printing ink , reliable adhesives and effective compound materials) • Boroscopy (used in particular in the aviation industry as part of maintenance work on turbines, engines and other technical equipment) • Semiconductor production

High Pressure Electrodeless Ultra-Violet Light Sources 	
High Pressure Sodium (HPS) lamps for special purposes  	High Pressure Sodium vapour lamps are used in the following special purpose applications: • Horticultural lighting • Resin curing • Plastics polymerisation

Table 1: Examples of lamps and applications for exemption 4(f)

As we show in the above table, LightingEurope members have a fairly good idea which lamps belong to exemption 4(f). We are, however, aware that we could not list all lamp types, as it is impossible to give a complete overview of all design features and applications. We know that there are numerous very special lamps from non-member manufacturers, importers, equipment producers with small market shares for very special applications.

The lamps of exemption 4(f) are essential for industrial processes, in commercial, medical or scientific environment, but can even be found in private areas. They are used in equipment having a much longer life-time than the lamps have.

Thus the lamps must remain available on the market

- For new equipment as there are no, nearly no or for certain applications no alternatives available in the EU market
- For equipment in the field to replace end of life lamps in order to avoid that the equipment turns into electronic waste before due time.

LightingEurope would like to stress that Exemption 4(f), and the belonging lamp types represent a small market share and are responsible for a small part of mercury use compared to the other lighting exemptions.

In the following table a summary is given why exemption 4(f) is still needed:

Requirement according RoHS Article 5(a)	Status for Mercury in other discharge lamps for special purposes not specifically mentioned in this Annex
their elimination or substitution via design changes or materials and components which do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable,	The replacement of Mercury in the lamps covered by this exemption is scientifically and technically impracticable. In addition replacement lamps using a different technology such as Light Emitting Diodes (LED) are available only in very exceptional cases and even then only for part of the application. These laser or LED solutions require lead in materials and electronic components currently exempted according Annex III of RoHS Directive.
the reliability of substitutes is not ensured,	In case electrical or electronic equipment using new technologies instead of a lamp the reliability of the products can be assumed and is indicated with the CE mark.
the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof.	Consumer safety can be assumed if new mercury-free technology is used in new EEE. In case LED-based replacement lamps are installed according the manufacturers advice qualified professionals have to make sure that users can operate the equipment in a safe way. The question whether a mercury-free substitution in new EEE or in a replacement lamp has a positive or a negative environmental impact compared to the conventional solutions can only be answered case by case, product by product.

Therefore we suggest to follow the principle of precaution, and to keep both the scope and the mercury limit of this exemption open.

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:

The scope of exemption 4(f) is thus covering those lamps, which

- are non-fluorescent,
- and have higher internal pressure compared to fluorescent lamps
- and are used for special purposes.

These lamps are used in a wide area of applications as described in the chapter above.

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

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

LightingEurope is of the opinion that lamps in general are category 5 products, but having a character of a component, a consumable as well as a spare-part.

There are numerous applications where lamps can also be regarded as component of a product belonging to any of the other categories 1 - 11 e.g. lamps/lighting in ovens, refrigerators [1], clocks [2], copy machines, projectors [3] TV sets [4], background lighting of tools [6], video games [7], UV lamps in medical equipment [8], control panels for industrial installations [9], UV in automatic dispensers [10] or lamps fixed installed in furniture [11].

LightingEurope believes that lamps covered by exemption 4f might not belong to category 5 equipment only if it is specifically designed as part or component of <u>only one</u> specific other category and there is no intended possibility to use it in others. Examples for the latter case are specific lamps for medical equipment, which have a certain special function in such equipment only, e.g. lamps for vitreoretinal surgical systems... But also projector lamps can be considered as category 3+4 components.

Please note that exempted applications for categories 8 and 9 will be reviewed in 2021 at earliest, and are not covered in the current review for other categories, although these applications will continue to need these lamps after July 2016.

LightingEurope is aware of the difficulty to unambiguously classify certain lamps in the category set out by RoHS legislation. For lamp producers it is essential to have legal certainty regarding the possibility to put the products on the market irrespective of the planned application as we are not able to control the use of the lamps in products. While for general lighting it is easier comprehensible that they cannot be considered as “spare parts of a luminaire” application specific special purpose lamps indeed can be considered also as a spare part (or consumable) in certain applications such as projectors.

b. Please specify if application is in use in other categories to which the exemption request does not refer:

Not applicable, see 4 A 1 a;

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

LightingEurope considers lamps in general to belong to category 5 even if they are in use or put on the market in category 8 and/or 9 products. Exemptions for lamps used exclusively for a special purpose in category 8 or 9 products on the other hand could also be considered to be listed in Annex IV of the Directive.

But as mentioned above the standpoint is valid that the requested exemptions will also be applied in monitoring and control instruments, in-vitro diagnostics or other medical devices

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:

The function of Hg in mercury gas discharge lamps lies within the light generating process to convert electricity into light. Electrons are emitted from a heated electrode colliding with mercury atoms which elevates their electrons to an excited state. When these fall back to their original energy state they emit photons either in the ultraviolet (UVC, UVB, UVA & UVV) or in the visible light wavelength range, depending on the technology.

By using a mix of different element atoms in the hot gas plasma, each emitting at specific wavelengths, the spectral distribution of the lamp as a whole as well as the quality of colour rendition properties can be controlled.

The use of mercury allows that these needed properties are achieved.

Mercury has been used for many decades because it has a unique combination of properties that no alternative has been found to provide. Mercury has a relatively low boiling temperature so is readily able to produce a vapour of suitable pressure. The heavy mercury atom slows down the fast electrons on their track though the plasma. Upon collisions of the electrons with the mercury atom UV light is generated very efficiently.

The mercury vapour is essential: all of the mercury is evaporated and the resulting pressure is chosen in such a way that

- the system can provide the exact power to the lamp,
- the discharge radiates as effective as possible,
- generates the required wavelengths for the desired application and finally
- with a brightness that allows the most effective collection of the light.

Since the applications for 4(f) differ also the designs and the amount of mercury differs widely. For example very high power lamps, need a certain lamp volume to prevent that the heat generated in the discharge melts the wall of the discharge vessel. If the same high power lamp is used for projection the arc must be very compact. This requires a very high mercury pressure. The combination of a very high pressure and a large discharge volume leads to the necessity of a large amount of mercury (up to 100 gram), e.g. in short arc mercury lamps. Other lamps require very efficient UV generation for instance for water purification. Here the generated UV must escape from the discharge without radiation trapping, these lamps have a medium mercury pressure (below 1 bar).

4. Content of substance in homogeneous material (%weight):

The RoHS Directive (2011/65/EU) defines homogenous material as a material which cannot be further mechanically disjointed. In the case of lamps, mercury is inserted or dosed into the burner in various forms, in medium or high pressure discharge lamps this is in most cases liquid mercury. Also other forms are in use, e.g. Mercury-Sodium amalgam in HPS lamps.

Mercury is present in the so-called discharge tube or burner. In nearly all mercury discharge lamps for special purposes a very specific amount of mercury is needed.

The dosing is mostly as liquid mercury or amalgam sticks. The concentration of mercury per „homogenous material“ is (per definition) 100% for liquid mercury and a few % less in amalgam, but still orders of magnitudes higher than the threshold level of 0,1%.

Below the most common dosing technologies are listed for lamps covered by this exemption:

- Manual pipetting or needle injection of liquid mercury (100% Hg)
- Semi- or fully automatic dosing, disc needle injection of liquid mercury (100% Hg)
- Mercury-Sodium amalgams Na-Hg (ca 20% Hg)
- Amalgam sticks (ca. 20-50% Hg)

5. Amount of substance entering the EU market annually through application for which the exemption is requested:
   Please supply information and calculations to support stated figure.

There is no single database or reliable evaluation that would give accurate data. The figures below are coming from different market studies or input from single companies to LightingEurope. The amount of mercury is the best estimation of LightingEurope.

Lamp type	*Mercury range per lamp*	*Mercury put on EU market*
Lamps for projection purposes	*10-40 mg depending on Wattage, average 15mg*	*45 kg maximum*
Short arc mercury lamps	*Up to 100g per lamp, average ca. 1g*	*20 kg*
UV Curing lamps	*Typical range 10-3000 mg*	*Estimated for 2014: 75kg*
Other high pressure	*No information available*	*No information available*

Table 2: Estimation of the amount of mercury put on the market per year in lamps covered by exemption 4(f) of RoHS Annex III.

According LightingEurope estimation around 10 Mio projector lamps are marketed worldwide per year. Calculating a market share of 30% for Europe will lead to 3 Mio lamps containing 45 kg mercury.

According to a market report 2012[1], the worldwide market for UV curing mercury lamps is 440.000 pieces. Calculating a market share of 30% for Europe will lead to 132.000 lamps. These lamps (long and short lamps) will content roughly 66 kg of mercury. With a yearly market increase by 6 % 75 kg in total can be estimated for 2014.

There are several reasons for lack of data: Lamps for projections are mainly marketed by lamp manufacturers outside the EU to producers of projectors. A part of the lamps is reimported contained in a projector as a projector spare part. A big portion of the UV lamp producers are smaller producers not being members of Lighting Europe, often located outside EU. Their lamps are mainly imported as part of the system in which they are used as well as related spare parts.

6. Environmental Assessment:

☐ Yes
☒ No

There is no environmental assessment available.

[1] "UV LED Market" report from Yole Dveloppement, 2012

(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 inserted into the discharge tube or burner for converting electrical energy into light.

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

Mercury has been used for many decades because it has a unique combination of properties that no alternative has been found to provide. Mercury has a relatively low boiling temperature so is readily able to produce a vapour of suitable pressure. The heavy mercury atom slows down the fast electrons on their track though the plasma. Upon collisions of the electrons with the mercury atom UV light is generated very efficiently.

The mercury vapour is essential: all of the mercury is evaporated and the resulting pressure is chosen in such a way that

- the system can provide the exact power to the lamp,
- the discharge radiates as effective as possible,
- generates the required wavelengths for the desired application and finally
- with a brightness that allows the most effective collection of the light.

Lamps emitting light in the visible wavelength range

High pressure mercury gas discharge lamps can emit radiation directly as visible light. The use of mercury allows that the needed properties are achieved.

Projection lamps:

Projection applications are very demanding for the light source. In order to reach sufficient brightness, the light of the lamp has to be efficiently collected onto the imaging display. This can only be achieved with a lamp that resembles a point source, i.e. a lamp with a high luminance and a short arc.

For UHP lamps, the high luminance of the plasma is reached by using pure mercury (1) at a very high pressure (2).

(1) The fact that only mercury is used, results in the best luminance arc: compared to lamps with spectrum additives (high performance metal halides), the luminance is a factor of 2 higher[2]. Next to that, in a pure mercury gas it is possible to design a halogen cycle which keeps the wall clean. This is necessary to obtain long lifetimes with lamps of small sizes. Mainstream projector lamps currently have lifetimes of 6000 to 10000h, whereas typical high performance metal halide lamps (with a lower pressure less mercury reach around 1000h.

[2] New UHP Lamp Technologies for Video Projection, Holger Mönch, 2001, *SID-ME Meeting on display Materials and Components Fall 2001*

(2) The high pressure reduces the load on the electrodes by reducing the current and serves as a buffer gas to insulate the arc from heat losses. The high pressure limits diffusion of tungsten atoms away from the hot electrode. Next to the halogen cycle, these properties are required to enable long lifetimes compared to other high luminance lamps. The high pressure also improves the spectrum of the lamp so that it matches the required output spectrum for good picture imaging (according REC709 standards). The good colour quality is due to the extreme pressure and the Bremsstrahlung (i.e. deceleration radiation) generated by collisions of electrons with mercury atoms[3].

(3) In horticulture lamps the mercury broadens the sodium radiation from yellow light towards the red part of the spectrum and increases the efficiency of the lamp.

UV Lamps

Medium pressure ultraviolet curing lamps are utilised in special purpose industrial accelerated curing applications, disinfection and surface modification processes. Typical examples include, but are not limited to, sheet fed printing, digital inkjet printing, semiconductor, applications in wood, glass and plastic finishing, metal decorating, fibreoptics, CD manufacturing, electronics, and in water, air and packaging disinfection processes.

<u>Medium pressure UV lamps</u> contain a mixture of mercury and argon gas inside a sealed quartz tube. In operation, this mixture is heated to create a stable, mercury plasma which emits radiation at specific wavelengths within the UV range (100-400nm), and which are characteristic of mercury. UV curable inks, coatings and adhesives are formulated to absorb the UV light at specific wavelengths by selecting photo initiators whose absorption profiles match the emission spectrum as closely as possible. In germicidal applications, the spectra have to be optimized to match the wavelengths required for cell deactivation.

<u>Short Arc mercury lamps</u> contain a mixture of mercury and xenon gas inside a sealed quartz tube. They are mainly used in

- Microlithography for producing integrated circuits, liquid crystal displays (LCDs) and printed circuit boards (PCBs).
- Visual and fluorescence microscopy, irradiation for photo polymerisation (used in manufacturing processes for, among other things, efficient printing ink, reliable adhesives and effective compound materials)
- Boroscopy (used in particular in the aviation industry as part of maintenance work on turbines, engines and other technical equipment)
- Semiconductor production

[3] Bremsstrahlung radiation from electron–atom collisions in high pressure mercury lamps, J E Lawler 2004 *J. Phys. D: Appl. Phys.* **37** 1532

Infrared continuum radiation from high and ultra-high pressure mercury lamps, J E Lawler, A Koerber and U Weichmann ,2005 *J. Phys. D: Appl. Phys.* **38** 3071

UV curing: Using the 2 atomic lines of mercury to polymerize the inside of the adhesive for UV ray curing at 365nm and to polymerize the surface layer of the adhesive at 248nm. That is why several wavelengths are necessary on one optical axis.

Photolithography: For the exposure of the 193nm photo resists of semiconductors, UV rays having a specific wavelength between 193 and 250nm are used. The high energy of intensified light is needed to get the necessary discrimination between exposed and unexposed areas.

Therefore, the bright line spectra of the mercury-arc lamp are indispensable.

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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

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

In the EU all lamps (and equipment in which they are installed) are subject to Directive 2002/96/EC WEEE as well as 2012/19/EU (WEEE recast) and the respective country specific implementation of the directives. Products using Mercury containing lamps have to be dismantled, the lamp has to be removed for separate treatment according the mentioned legislation, e.g. projector lamps have to be removed from projectors prior to further recycling or shredder processes.

The lamps covered by exemption 4(f) are used in a wide variety of applications which have different waste routes. Most of these lamps are in use by professional/commercial customers in industry, municipalities, authorities etc.. This equipment is usually not disposed of in household waste, due to its large size, but is collected mainly by business-to-business collection schemes set up according WEEE legislation. Only a small portion could end in private households in projectors or back projection TV sets.

Lamp type	Field of use (industrial, commerce, domestic etc.)	Collection scheme
High pressure mercury lamps for special purposes	Industrial, commerce, municipalities	National collection schemes according WEEE legislation (2012/19/EU)
High Pressure Short Arc Mercury lamps	Industry, scientific institutes	National collection schemes according WEEE legislation, contractual recyclers of commercial customers
Lamps for projection purposes	Commercial customers, public and private	National collection schemes according WEEE legislation
High Pressure Sodium lamps for special purposes	Commercial customers, Industry	National collection schemes according WEEE legislation, contractual recyclers of commercial customers
Other lamps	Commercial customers, Industry	National collection schemes according WEEE legislation, contractual recyclers of commercial customers

Table 3: Nearly all lamps covered by exemption 4f are in the scope of the WEEE directive 2012/19/EU.

For medium pressure lamps used in UV curing applications, the total amount of mercury is, in the worst case the 75 kg, which will enter the European market when new lamps are sold. If lamps last longer than one year, then this amount is reduced. All lamps are covered by the scope of WEEE. Therefore, for all lamps there is a commitment to a closed loop recycling process. Lamp manufacturers within Europe describe the procedure for disposal of these lamps within their product manuals and state that only certified organizations have permission for recycling. This will ensure the recycling process.

Statistics for recycling of lamps used in electronic equipment

With reference to question no. 3 of this section on the quantity of RoHS substance in EEE waste we would like to note the following:

- Producers have little influence on the actual disposal route end users choose for products with lamps. Producers finance and partially steer collection schemes and such schemes typically contract recyclers to perform the treatment. Alternatively equipment producer directly contract recyclers e.g. in the B2B take-back.
- Recyclers are mandated to remove any gas discharge lamps from products (WEEE Annex VII requirement). Recyclers collect such removed lamps, combine them with other lamps and hand them over to lamp recyclers. No statistics on the origin of the lamps is made[4].

[4] Information from recyclers on recycled weight of products containing mercury is that the data is not split down by the brand of the product or even the compliance scheme. They recycle mercury in large batches that are mixed from different sources; the majority of mercury comes from public street lighting.

- Equipment producers are required to provide treatment relevant information to recyclers (WEEE2 Art 15 & Annex VII) to facilitate environmentally sound treatment.
- Statistics on the type of equipment collected and treated partially backed up by sampling are not detailed enough to break out specific electrical and electronic equipment and estimate this on a European basis5.
- Therefore equipment producer do not have European data on end of life statistics on electrical and electronic equipment becoming WEEE and in particular on lamp treatment and their final disposal.

(B) 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

This stratement only refers to the lamps used in electrical or electronic equipment, not to the EEE. Recyclers are mandated to remove any gas discharge lamps from products

(C) 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 < 150 kg

☐ In articles which are sent for energy return

☐ In articles which are landfilled

As stated above there are no suitable statistical data available. All products come under the regime of WEEE take back obligations. With reference to table 2 above and according the information and data available for LightingEurope 150 kg mercury might be put on the market in lamps falling in this exemption.

[5] Reports from compliance collections schemes only details the amount of mercury in total collected from WEEE. See example compliance scheme report from Switzerland http://www.google.co.uk/url?url=http://www.swicorecycling.ch/downloads/dokumente/technical-report-swico-sens-slrs-2013.pdf/1400&rct=j&frm=1&q=&esrc=s&sa=U&ei=0kgAVP7uOcjcPYbrgcAH&ved=0CBQQFjAA&usg=AFQjCNGVOdg1ECkVykqDSTAYOAszUgPSAA page 15 showing less than 0.00% mercury collected from all WEEE

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

Mercury has been used for many decades because it has a unique combination of properties that no alternative has been found to provide. Mercury has a relatively low boiling temperature so is readily able to produce a vapour of suitable pressure. The heavy mercury atom slows down the fast electrons on their track though the plasma. Upon collisions of the electrons with the mercury atom UV light is generated very efficiently.

The mercury vapour is essential: all of the mercury is evaporated and the resulting pressure is chosen in such a way that

- the system can provide the exact power to the lamp,
- the discharge radiates as effective as possible,
- generates the required wavelengths for the desired application and finally
- with a brightness that allows the most effective collection of the light.

Since the applications for 4(f) vary the designs and the amount of mercury differs widely. For example very high power lamps, need a certain lamp volume to prevent that the heat generated in the discharge melts the wall of the discharge vessel. At the same time if the same high power lamp is used for projection, the arc must be very compact. This requires a very high mercury pressure. The combination of a very high pressure and a large discharge volume leads to the necessity of a large amount of mercury (up to 100 gram). Other lamps require very efficient UV generation for instance for water purification. Here the generated UV must escape from the discharge without radiation trapping, these lamps have a medium mercury pressure (below 1 bar).

Alternative elements for mercury either lack the required vapour pressure at a low enough temperature, or do not radiate efficiently upon collisions with electrons or react violently with the transparent quartz wall and block the light when the lamp becomes older.

All single elements, stable combinations of elements and stable compounds with suitable vapour pressure have been evaluated as possible alternatives to mercury and none give either the same broad UV spectrum or the required wavelengths with sufficient intensity to perform the required necessary functions. Therefore the only potential future alternatives to use of mercury could be from different technologies. The suitability of alternative technologies differs per application. Alternatives for horticulture lighting differ from alternatives for water purification and projection lamps. For horticulture lighting alternatives are LED’s and are discussed under the chapter for horticulture lighting. Alternatives for water purification are chemicals like chlorine and can be found under the UV lamp chapter. For the projection lamps LED’s and lasers are alternatives.

Application with alternative technology

There is no alternative technology with the same performance characteristics like what mercury containing lamps provide. In some areas first products are available based on opto-semiconductor and laser technology, as described below.

Lamps for projection purposes: lamp technology, mercury free

Hg free discharge technology based on Zn is available[6]. For projection applications this technology is not suited due to a too low metal gas pressure which leads to a low lamp voltage. This results in low energy efficiency. Efforts have been made to develop a high pressure Zn discharge lamp in order to reach reasonable energy efficiency in a projection application. These efforts have been stopped because there was no technical solution to cope with the required extreme high operating temperatures. Further, the zinc atoms violently react with the quartz, damaging the transparency. The loss in transparency reduces the brightness of the source and makes the lamp unfit for the application. This makes zinc no alternative for mercury.

Xenon-lamps can offer the required high luminance for projection purposes, but they suffer from very low energy efficiency. Xenon-lamps are by about a factor of 4 less efficient than Ultra High Pressure-lamps, leading to much larger lamps. As a result, they are used in very limited projection applications[7].

Lamps for projection purposes: solid state technology

For projectors the ANSI Lumen (Lm) level on the screen determines the market segments. It is regarded as a basic requirement for a projector to have at least 2000 ANSI Lm brightness level. For lit environments, a brightness minimum level of 3000 ANSI Lm is regarded as the standard. All projectors between 2000 and 5000 Lm are defined as mainstream projectors.

Some projector producers have started several years ago to use solid state light sources within a limited area. These can be categorized as: White LED (1), Scanning Laser (2), RGB LEDs (3), LED/Laser (-phosphor) Hybrid (4), Laser-phosphor (5) or RGB Laser (6).

White LED (1) and Scanning Laser (2): these technologies will not be able to alternate the conventionally mainstream projectors mounted with mercury containing lamps. The luminance level of White LEDs (1) is too small to reach more than 500 Lm. For Scanning Lasers, safety requirements limit the scanning beam intensity. Usage of both White LED (1) and Scanning Laser (2) will be limited to the pico projector segment.

RGB LEDs (3) used for projectors are a surface light source and have a limitation in luminance level. High luminance is required for optical imaging. It does not add value to increase total light flux by increasing the light emitting area, which is a typical design choice for LED illumination. As a result, light intensity is limited when RGB LEDs (3) are used as a light source in projectors. The range of RGB LED projectors currently available on the market only covers lumen levels up

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[6] Patent WO2006046171

[7] Proc. SPIE 5740, Projection Displays XI, April 10 2005

to 1500 ANSI Lm (commercially specified). The measured brightness level is currently still limited to around 800 ANSI Lm[8]. This means that RGB LEDs (3) do not play a role in the mainstream segment.

The remaining laser-based technologies (LED/Laser (-phosphor) Hybrid (4), Laser-phosphor (5) or RGB Laser (6)) entered the market quite some years ago, but the penetration rate is very low. For several years now, the level of projectors with hybrid or laser solution is stable at approximately 1.5% of the total market[9].

This slow penetration rate can be explained by the technological difficulties to make laser-based projection systems:

1) For laser-based (incl. hybrid) projectors, the cooling of the semiconductors requires bulky, heavy and/or noisy cooling systems, which makes them not well fit for mobile use.
2) For RGB Laser (6), a measure for “Laser speckle noise” has to be taken for laser illumination without phosphor conversion. “Laser speckle noise” is created by mutual interference of the laser’s coherent light waves and results in a varying intensity of light spots in the projected image. The suppression of the speckle noise is necessary for laser-based projectors. This is also applied to Scanning Laser (2).
3) Measures for safety have to be taken as the light source is a class 4 laser.

Conclusion: Solid state light sources ((1)-(6)) are not sufficiently mature to be used for mainstream projection purpose. Remark: LED, Laser/LED Hybrid, and Laser light sources are not backwards compatible with projectors mounted with mercury containing lamps.

Lamps for UV curing applications

UV LED lamps are available and may be considered as an alternative technology for medium pressure mercury lamps used in UV curing applications, but their performance characteristics are very different to UV mercury lamps.

Currently medium pressure lamps containing mercury are used a wide range of manufacturing applications – including amongst others; printing, wood finishing, PCB manufacture, glass bottle decoration, metal container decoration, sewer rehabilitation, contact lens manufacture, plastic bottle decoration, optical fiber coating, ink jet printing, coating plastic parts etc. These applications are used in a wide range of well-known markets and industries, e.g.:-

- Coating of polycarbonate headlamp lenses for all the major European (and global) automotive manufacturers
- Coating of wide range of plastic components for the automotive industry, cosmetic and consumer goods for international companies
- Coating of wood and MDF products for furniture companies
- Coating of beverage cans for all the European (and global) can manufacturers
- Coating optical fibers for telecommunication

[8] See product reviews at e.g. www.projectorcentral.com, e.g. projectors HD91, DG-757, LGPF85U, ...

[9] Source: Futuresource-consulting

- Pressure sensitive adhesives manufactured by well-known, international companies used in tapes and label products
- Wide web, high speed printing and coating packaging for many well-known companies across Europe and beyond.

The inks, coatings and adhesives developed for these processes have been designed to respond very efficiently to the broad emission spectrum from the medium pressure mercury lamps to deliver a finished product that meets a wide range of very demanding product specifications.

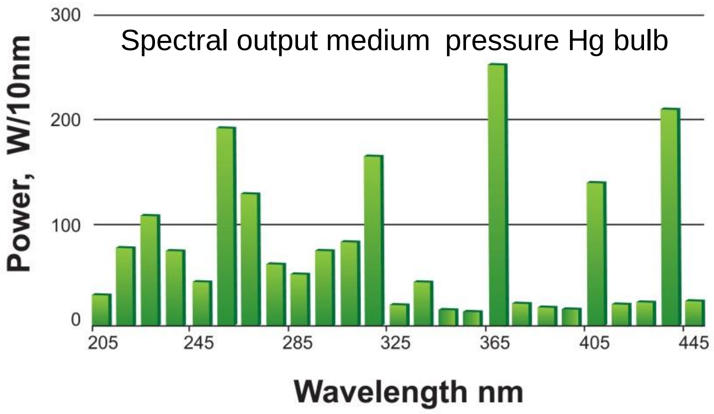

Figure 2: Spectral output of medium pressur mercury lampsiiiiiiiNearly

The broad band emission from the medium pressure lamps is important because it allows the photo initiator, the component in a UV formulation that absorbs the light, to absorb a wide range of wavelengths and thereby enable the ink, coating or adhesive to deliver the required combination of properties. For example, in coatings on interior plastic parts for cars, a hard, scratch resistant surface together is required and this can be delivered by utilizing the shorter wavelengths (280-320nm). Other required properties such as resistance to aggressive solvents or adhesion to plastic surfaces can be aided by utilising the longer wavelengths (320-365nm).

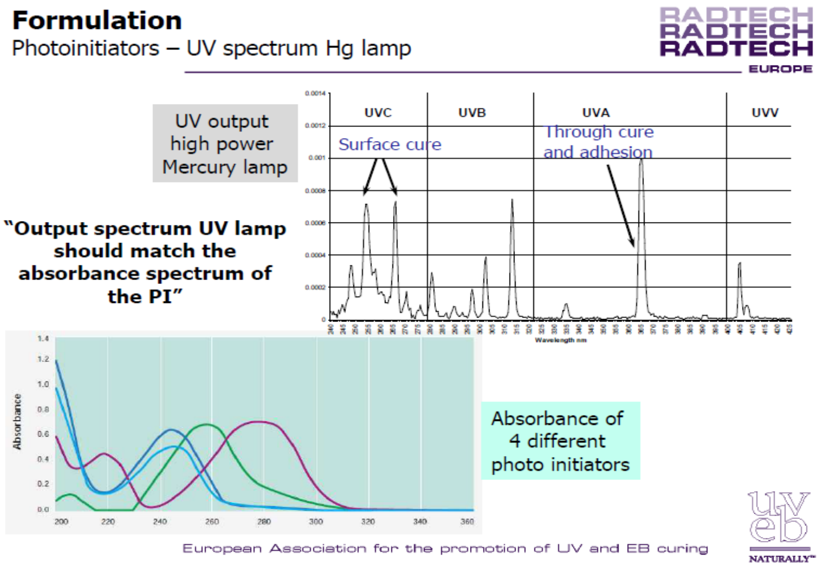

Figure 3: Spectral data of mercury based UV lamps

UV LED lamps are a potential alternative technology that has been introduced into UV curing applications. However, to date their commercial success has only been on a relatively small scale, in some specific niche applications, for example; adhesives in assembly operations such as PCBs in consumer goods; ink jet printing on labels or in wide format printing for point of sale displays; flexographic printing on heat sensitive films; in some coating applications in wood finishing, sometimes in combination with medium pressure mercury lamps.

One of the drawbacks of the UV LED is that the light is only produced in a very narrow band. UV LED lamps delivering 405nm, 395nm, 385nm and 365nm wavelengths are the most common, commercially available products. The most widely used products deliver 395nm and 385nm; these products have the highest output and the longest lifetimes.

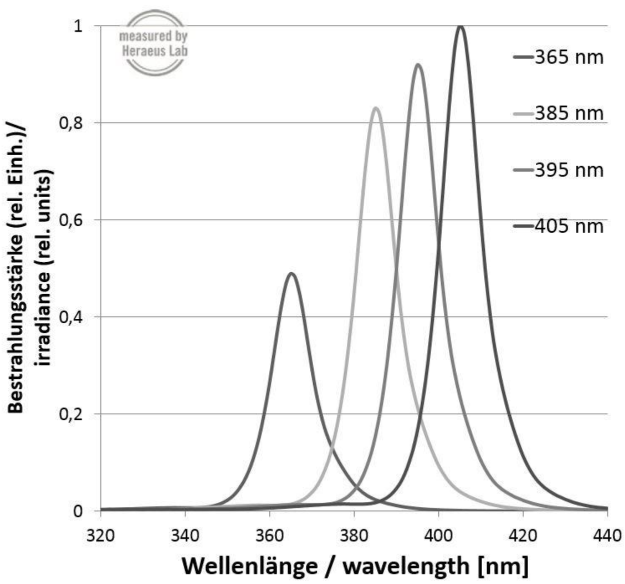

Figure 4: Spectra of 4 different UV LED lamp types

Furthermore, the lack of output from the UV LED in the UVB and UVC region means that it can be more difficult and sometimes not possible to produce the hard, scratch resistance coatings required by applications such as coating plastic parts for the automotive industry.

In addition the output power of the UV LED is relatively low compared to the medium pressure lamps resulting in much slower processing speeds.

Output power of UV LEDs is at present very low in comparison to mercury UV lamps.

- UV lamps maximum power rating for example, 0.370 to 1.26 watts[10]
- HID UV lamp 250 – 400 W lamps are widely used and more than 25kW are available.

[10] http://www.philipslumileds.com/products/luxeon-uv

Lamps for disinfection applications

UV energy can be used to disinfect water, surfaces and air. The process reduces the pathogen count in an economical and environmentally friendly way without the need for the addition of chemicals. Furthermore, the UV process can be used to kill-off chlorine resistant pathogens such cryptosporidium.

Applications for water disinfection include municipal water treatment for household drinking water and sewage treatment, industrial water treatment for process water and also aquaculture and agriculture as well as ballast water for ships holds. Disinfection of air using UV is used to provide low germ air to improve hygienic and storage conditions in the pharmaceutical and food processing industries, clean rooms and highly frequented areas such as airports. Surface disinfection of packaging materials is also carried out by UV; for example, on filling lines for dairy products and beverages where cups, tops, lids and packaging foils etc are exposed to UV to kill germs on the surface.

UV disinfection is effective at wavelengths between 200-300nm: the spectral region for the most effective cell deactivation. The germicidal action curve having a maximum at 265nm. UV-C radiation has strong bactericidal effect. It is absorbed by the DNA of the microorganism, destroys its structure and inactivates the living cells. Microorganisms such as bacteria, yeasts and fungi are destroyed in a few seconds with UV radiation.

Some mercury vapour lamps used in disinfection applications (sometimes referred to as germicidal lamps) are designed to emit a narrow band radiation at a wavelength of 254nm.

These mercury lamps have a wall plug efficiency of up to 50% for generating UV-C photons at 254nm. The stronger version, also mercury based, uses an amalgam to enhance the photon flux, but with a lower wall-plug efficiency of ~35%.

A possible mercury free solution could be a XeBr*- excimer lamp emitting at 282nm or a XeI*-excimer lamp emitting 253nm photons. In both alternative cases, the wall-plug efficiency is below 10%. So this is not a realistic alternative given the power consumption comparison with Hg lamps and the poor efficiency. Furthermore the power supply technology is by far more complex and significantly more expensive compared to conventional ones used to drive Hg-based lamps.

Another alternative might be a Xe2*- excimer lamp emitting 172nm photons with an efficiency of up to 40%. A phosphor might convert the radiation into the germicidal range around 265nm. Assuming a quantum efficiency for the phosphor of 90% and the Stokes shift being ~65% the total electrical lamp efficiency will come down to ~23%. This low value might only be partly compensated by a larger germicidal action due to the wavelength. Lifetime values for the Hg-based conventional low pressure lamps easily exceed 10000h, very hard to achieve with a 172nm based Hg-free version.

Currently, mercury free solutions, such as excimer lamps have only been successful in a few applications in niche markets.

Other Hg free alternatives include Xe flash lamps but these have a very low germicidal efficiency.

UV LED lamps are not a suitable alternative technology because UV-C LEDs are not commercially available; the current R&D prototypes have a very low power output, low efficiency, low lifetimes and high costs.

Lamps for Horticulture applications

This exemption covers the High Pressure Sodium (HPS) lamps for use in Horticulture, a member of the High Intensity Discharge Lamps (HID) group. The HPS lamps for Horticulture are designed to stimulate plant growth (examples are: tomatoes, cucumbers, flowers). The efficiency of the lamps is not expressed in lumens/W since the plant growth responds to the photons almost universally: each photon is of about the same efficiency (**Error! Reference source not found.**). Research at universities and applied agricultural research stations has demonstrated that the rate of photosynthesis is related to the amount of photons roughly between 400– 700 nm. This is called 'Photo synthetic Photon Flux' (PPF). This is expressed in micro mole of photons per second (µmol / s)[11].

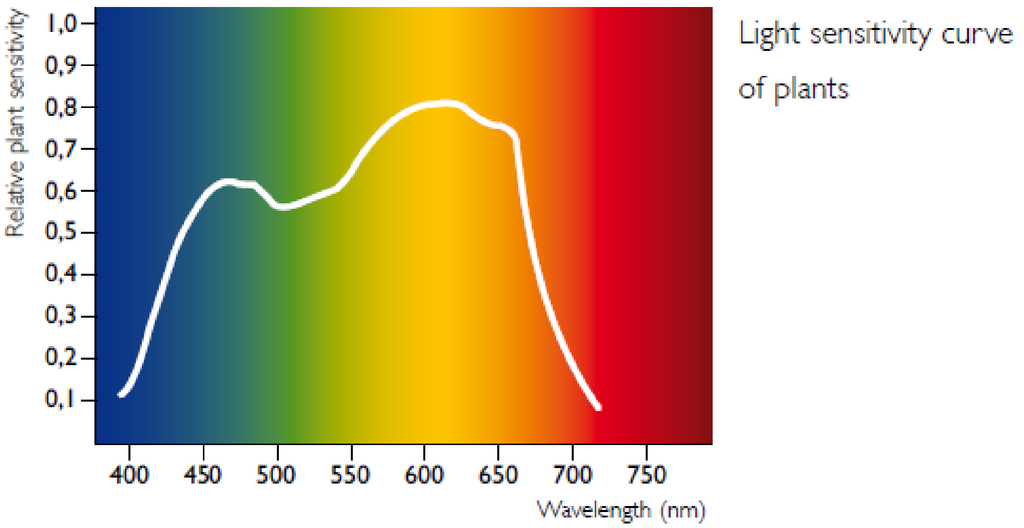

Figure 5: Light sensity curve of plants

The PPF value ranges from 2.1(micro mole photons/Watt), for the most efficient 1000W lamp to 1.6 (micro mole photons/Watt) for the 250W lamps.

Since plants are used to receive light from above, these lamps are mounted above the plants and should be as compact as possible. The small size is to avoid blocking the useful sunlight. The luminiare might block the light even when the growth light is not used, for instance during summer. The lamps are handled by technically skilled installers and sold by specialized distributors or as part of lighting equipment.

A recently found, secondary effect is the irradiation with infra-red light. Many crops benefit from infrared radiation from above from the direction of the sun, especially during the winter. The flux depends on the plant but for tomatoes it is about 25-30 W/m^2 which is easily provided by the

[11] Accuracy of quantum sensors measuring yield photon flux and photosynthetic photon flux. Barnes C[1], Tibbitts T, Sager J, Deitzer G, Bubenheim D, Koerner G, Bugbee B, HortScience. 1993 Dec 28(12):1197-200.

HPS lighting. In LED lighting this radiation is absent. In modern greenhouses the HPS lamps are combined with LED lamps both for their own purpose[12].

The customers are farmers with greenhouses. Especially greenhouses that are equipped with cogeneration equipment to generate their own electricity and use the CO_2 and heat produced in this process to stimulate growth of the crops.

De Groot and Van Vliet[13] give a comprehensive review of the operation principles of the HPS lamp. Further developments are discussed in a paper by Geens and Wyner[14].

High Pressure Sodium lamps are characterized by very long life (30,000 to 50,000 hours) and very high luminous efficiency (from 80 lm/W to 150 lm/W). HPS lamps can only operate on designated drivers that switch the lamp on and regulate the power. These drivers can be an electro-magnetic ballast (inductive/capacitive load) to stabilize the lamp current in combination with a high voltage pulse generator (ignitor) to ignite the lamp. Nowadays, also electronic drivers are used to stabilize the lamp at the correct power.

Alternatives:

High intensity discharge lamps are compact and are in general high power lamps. In the application it is required that HID lamps operate in closed luminaires. Since over 90% of the power supplied to the HID lamp leaves the burner as radiation (visible light, infrared radiation and some UV) the temperature of the luminaire and the lamp is stabilized without the need for heat sinking.

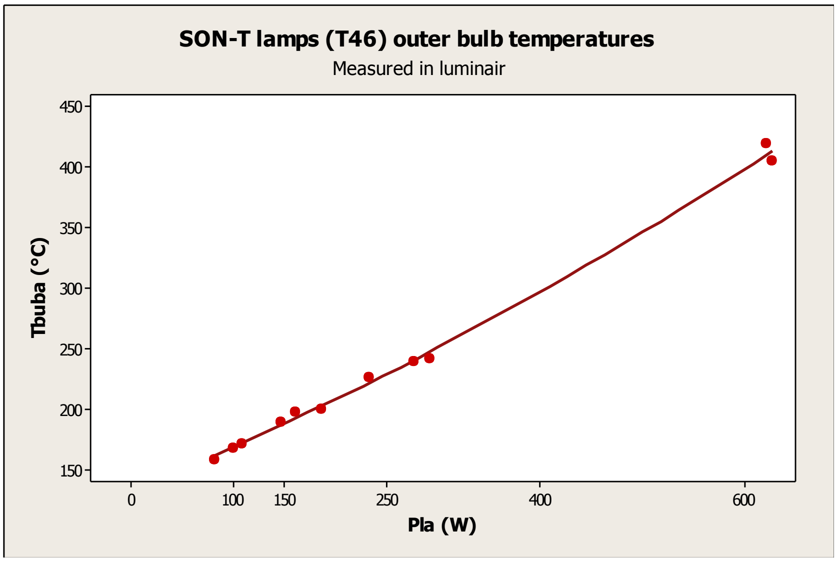

Figure 6: Measured temperatures of the outer bulb of HPS lamps of various power

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12 http://www.energiek2020.nu/fileadmin/user_upload/energiek2020/onderzoek/licht/docs/Warmtevraagstuk_led_in_tomaat.pdf http://www.energiek2020.nu/uploads/media/Stralingswarmte_en_led.pdf

13 J.de Groot and J. Van Vliet, The High Pressure sodium lamp, Kluwer Techische Boeken B.V. Deventer, ISBN 9020119028 (1986)

14 R. Geens and E. Wyner, Progress in High Pressure Sodium Lamp Technology", IEE Proceedings-A Vol. 140 No. 6, November 1993

The glass surface of the outer bulb of the lamp is heated by conduction of the heat generated in the burner (10% of the supplied power) and by absorption of half of the infrared radiation from the burner. In total the glass envelope is heated by approximately 40% of the lamp power[15] [16].

As argued in the introduction, the infrared radiation generated by the hot HPS lamp is not lost but is beneficial to the plants too. The heat stimulated plant growth during the cold winter season.

For the currently available most efficient LED lamps the power that is transformed into light is about 40% and there is no IR or UV. So 60% of the power is transformed into heat that has to be removed by convection/radiation to the surrounding air in the closed luminaire. This makes the design of the luminiare difficult especially since the environment temperature in the greenhouse is high and the size of the luminiare is limited because of the demand to minimise blocking of direct sunlight.

The heat loss of the most efficient LED's is higher than of HPS lamps. So measurement of the envelope temperature of the HPS lamps in a luminaire will predict the temperature of the envelope of the future LED lamp with the same size. Since the transport of heat in a lamp via the lamp base is limited, the only path for the heat to disappear is via conduction to the air surrounding the lamp. In a closed luminaire, warm air limits the transport, but even if the lamp would operate in open air, the compact size needed to fit as a retrofit lamp in the closed luminaire limits the cooling opportunities.

Error! Reference source not found. gives an indication of the measured surface temperature of HPS lamps of different power. The 1000W lamp is even warmer and is measured around 700°C.The LED retrofit lamps will reach at least the same temperature. This surface temperature from 400-700°C is much higher than the optimal LED junction temperature of 100oC. This means that LED replacement lamps with the same size as the current HPS lamps cannot exist in the coming decades or that the emitted light flux is lower and/or the lifetime is limited.

Moreover, there is an issue with safety and responsibility of a luminaire where the HPS lamp is "retrofitted" with an LED lamp. HPS lamps are operated on electrical systems that generate high voltage pulses to ignite the lamps. These ignition pulses are typically 1800V-3300V. The igniters have to be taken out of the system (if not integrated in the electronic driver) and rewiring in the luminaire is needed if LED's would be designed to replace the HID lamps. The installer needs to take the responsibility for safe replacement and needs to label the luminaire accordingly.

About the suitability of alternative technology as spare part

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[15] *Jack, A.G. and Koedam, M., "Energy Balances For Some High Pressure Gas Discharge Lamps," Ilium. Eng. Soc., July 1974 (other reference needed: Thesis A. Rijke)*

[16] *Janssen, J.F.J., Rijke, A.J., Nijdam, S., Haverlag, M., Dijk, J. van, Mullen, J.J.A.M. van der & Kroesen, G.M.W. (2012). A comparison between simulated and experimentally determined energy balances for HID lamps. In R. Devonshire & G. Zissis (Eds.), Poster : Poster presented at the 13th International Symposium on the Science and Technology of Lighting (LS-13 2012), june 24-29, 2012, Troy, New York, USA, (pp. CP040-175/176). Sheffield: FAST LS ltd.*

It is not possible to replace the mercury containing lamps in existing equipment by alternative technology.

Lamps have to be replaced several times over the life-time of the equipment. The replacement lamps must fit into the existing fixture, and must deliver the same performance, safety and reliability, which the equipment was designed and tested for.

It should also be recognized that lamps are consumable items that are mainly utilized in high value equipment which is already in service. The systems were designed for mercury lamps and there is no alternative chemistry that will produce a suitable spectral output that will operate with the power electronics contained within the existing plant. Hence, even if a new technology becomes available in the future, there will be a requirement for mercury lamps as replacement spare parts for legacy capital equipment for a considerable period.

In certain cases in new electrical or electronic equipment (EEE) there are some limited solutions where lamps have been replaced by electronic technology such as laser or LED. But it should also be noted that these solutions require, like nearly all electronic products, lead in materials and electronic components currently exempted according Annex III of RoHS Directive.

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

As far as non-mercury technologies are available they are considered to be reliable. No alternatives are available for Hg in discharge lamps.

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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.

Mercury has been used for many decades because it has a unique combination of properties that no alternative has been found to provide. Mercury has a relatively low boiling temperature so is readily able to produce a vapour of suitable pressure. The heavy mercury atom slows down the fast electrons on their track though the plasma. Upon collisions of the electrons with the mercury atom UV light is generated very efficiently.

The mercury vapour is essential: all of the mercury is evaporated and the resulting pressure is chosen in such a way that

- the system can provide the exact power to the lamp,
- the discharge radiates as effective as possible,
- generates the required wavelengths for the desired application and finally
- with a brightness that allows the most effective collection of the light.

Since the applications if 4(f) vary, the designs and the amount of mercury differs widely. For example very high power lamps, need a certain lamp volume to prevent that the heat generated in the discharge melts the wall of the discharge vessel. At the same time if the same high power lamp is used for projection, the arc must be very compact. This requires a very high mercury pressure. The combination of a very high pressure and a large discharge volume leads to the necessity of a large amount of mercury (up to 100 gram). Other lamps require very efficient UV generation for instance for water purification. Here the generated UV must escape from the discharge without radiation trapping, these lamps have a medium mercury pressure (below 1 bar).

Alternative elements for mercury either lack the required vapour pressure at a low enough temperature, or do not radiate efficiently upon collisions with electrons or react violently with the transparent quartz wall and block the light when the lamp becomes older.

All single elements, stable combinations of elements and stable compounds with suitable vapour pressure have been evaluated as possible alternatives to mercury and none give either the same broad UV spectrum or the required wavelengths with sufficient intensity to perform required the necessary functions. Therefore the only potential future alternatives to use of mercury could be from different technologiesThe suitability of alternative technologies differs per application. Alternatives for horticulture lighting differ from alternatives for water purification and projection lamps. For horticulture lighting alternatives are LED’s and are discussed under the chapter for horticulture lighting. Alternatives for water purification are chemicals like chlorine and can be found under the UV lamp chapter. For the projection lamps LED’s and lasers are alternatives.

Application with alternative technology

There is a high variety of applications using special purpose lamps. While for some applications solutions based on new technology, mainly LED solutions, are in work, in other areas substitution is not possible.

UV LEDs are clearly not as mature as LED technology emitting in the visible region and which are used for general lighting. The reason for this is that the market for general lighting is many orders of magnitude larger than the UV applications market, thus the pull from the market is much higher and so are the resources that are put into developing corresponding solutions. Due to the smaller UV applications market, the UV LED technology develops slower and costs of the devices is much higher than in the visible range.

One of the main areas of R&D for UV LED lamps is to deliver products which have high output and high efficiency in the UV-C and UV-B regions. This would allow the LEDs to work more efficiently with a wider range of formulations and produce the required film properties for a wider range of applications. In particular, to produce better surface cure and produce scratch resistant coatings required by many applications, including wood finishing, coatings for plastic components, metal decorating etc.

However, most companies working in development of UV LED lamps with output in the UV-C and UV-B region, are small or start-up companies. Hence, the supply chain is uncertain. Most UV LED lamp system manufacturers do not have such highly expensive semiconductor production technology in house, so the risks of uncertain supply chains need to be covered, which is difficult as the technology is still developing and in an early stage.

The current efficiency of UV LED emitting in the UVA region is 20-30% with typical lifetimes of 10,000hours but UV LEDs emitting in the UV-C or UV-B region have only a 1-2% efficiency with lifetimes less than 1,000 hours. This makes UV-C and UV-B LEDs unsuitable for many applications. The expected timeline for the development work to overcome these limitations and achieve a secure supply chain is not less than 7-10years, with market maturity 15+ years. Furthermore, the gap between costs of the mercury based lamp technology and UV LED technology is high; at least 1-5 orders of magnitude depending on the emission range and complexity of the lamp.

The measure for the efficiency of LED's is the wall plug efficiency: it divides power of the useful radiation in the UV by the power used from the wall plug. In the UVC (100-280nm) and UVB (280-315nm), the wall plug efficiency of LEDs is below 1% , where the wall plug efficiency of medium pressure UV lamps are close to 20%. See below pictures in which public data from several manufacturers are put together in one graph.

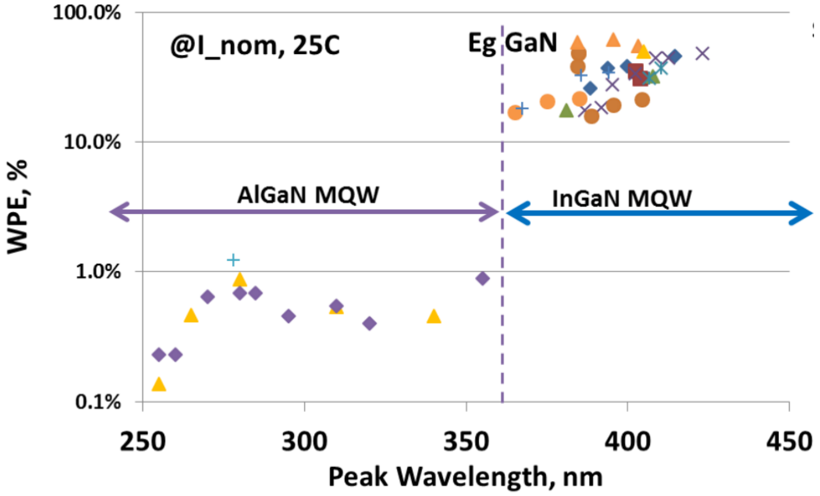

Figure 7: LED efficiencies for various semiconductor technologies data from several manufacturers

Since the major impact on the environment of lamps is during the use phase, the UV LED's are no alternative beneficial to the environment yet

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

Not foreseeable for most applications. For existing equipment where the lamps are used, a mercury free alternative is not possible.

It should also be noted that these solutions require, like nearly all electronic products, lead in materials and electronic components currently exempted according Annex III of RoHS Directive.

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)?

not applicable

☐ 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:

Not applicable

(B) Elimination/substitution:

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

☐ Yes. Consequences? _____

☒ No. Justification:

Hg is essential for the conversion of electrical energy in light; Mercury free discharge lamps for the scope of exemption 4f are not available

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

☐ Yes.

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

☒ No.

Justification:

Hg is essential for the conversion of electrical energy in light; Mercury free discharge lamps for the scope of exemption 4f are not available.

3. Give details on the reliability of substitutes (technical data + information):

Not applicable

4. Describe environmental assessment of substance from 4.(A)1 and possible substitutes with regard to
   1) Environmental impacts: not applicable
   2) Health impacts: not applicable
   3) Consumer safety impacts: not applicable

⇨ Do impacts of substitution outweigh benefits thereof?
Please provide third-party verified assessment on this: not applicable

(C) Availability of substitutes:

Not applicable

a) Describe supply sources for substitutes:

b) Have you encountered problems with the availability? Describe:

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?

(D) Socio-economic impact of substitution:

Not applicable as substitution is not possible

⇨ 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:

No LCA is available, as there is no substitution for mercury in these lamps

9. Other relevant information

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

No additional information

10. Information that should be regarded as proprietary

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