LIGHTINGEUROPE
THE VOICE OF THE LIGHTING INDUSTRY

Request to renew Exemption 2(b)(4)

under Annex III of the RoHS Directive 2011/65/EU

2(b) Mercury in other fluorescent lamps not exceeding (per lamp):
2(b)(4) Lamps for other general lighting and special purposes (e.g. induction lamps): 15 mg may be used per lamp after 31 December 2011

Date: 15. Jan. 2015

Contents

1 Name and contact details

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2 Reason for application

LightingEurope submits this application to:	request for extension of existing exemption **no. 2(b)(4) of Annex III**
LightingEurope proposes to continue using the existing wording which is:	2(b) Mercury in other fluorescent lamps not exceeding (per lamp): 2(b)(4) Lamps for other general lighting and special purposes (e.g. induction lamps): 15 mg may be used per lamp after 31 December 2011
LightingEurope requests a duration of	Maximum validity period required

3 Summary of the exemption request

Per DIRECTIVE 2011/65/EU Article 5(2) Annex III Exemption 2(b)(4) will expire automatically per 21/07/2016, unless an application for renewal has been made to the Commission in accordance with Annex V.

With reference to the above, this request concerns the extension of the current Annex III exemption

2(b) Mercury in other fluorescent lamps not exceeding (per lamp):
2(b)(4) Lamps for other general lighting and special purposes (e.g. induction lamps): 15 mg may be used per lamp after 31 December 2011.

Annex III of RoHS Directive explicitly names the following fluorescent lamp technologies and families:

- Compact fluorescent lamps (Exemptions 1(a)-1(f))
- Linear triband phosphor lamps for general lighting (2(a)(1) – 2(a)(5))
- Linear and nonlinear halophosphate lamps (2(b)(1) – 2(b)(2)
- Nonlinear triband phosphor lamps (2(b)(3)
- Cold cathode fluorescent lamps (3((a) – 3(c).

These exemptions do not cover the full range of fluorescent lamps. The scope of exemption 2(b)(4) includes all other fluorescent lamps for general lighting and special purposes, which do not belong to any of the above listed families and technologies.

Fluorescent lamps are low-pressure discharge lamps containing a phosphor coating. Low- pressure discharge lamps without a fluorescent phosphor layer (e.g. UV-lamps) as well as medium and high pressure discharge lamps are covered by exemptions (4(a) – 4(f).

Exemption 2(b)(4) includes an inhomogeneous group of lamps with amongst others different

- Form factors and bases, e.g. linear, circular, square shape
- Technologies e.g. induction, external ignition
- Colours, e.g. white, coloured, black light blue
- Applications and purposes, e.g. general lighting, colour, explosion protection, tanning, horticultural lighting, color comparison, medical use

Fluorescent lamps are very energy- and resource efficient lamps highly required in the market. They contain a small amount of intentionally added mercury in the discharge tube, which is essential to convert electrical energy to light. Mercury consumption of fluorescent tubes dropped approximately 90% in the past 20 years by implementing energy efficiency regulations, RoHS requirements and innovation programs. Lamps in the scope of exemption 2(b)(4) are in a wide variety of different lamp families with mercury content from < 2 mg up to 15 mg. They are mainly niche products with low market shares compared to the other fluorescent lamps.

There are no specific market data available for the lamps covered by this exemption. Considering EU-28 sales data for lamps covered by the exemption 1(e), 2(b)(2), 2(b3), 2(b)(4) and 4(a) of Annex III, RoHS Directive, marketed in EU-28 there is a decreasing market from 2009 to 2013. In 2013 ca. 19 Mio non-linear and special purpose lamps

(*"Other lamps*") have been marketed[1]. The overall roughly estimated yearly mercury input decreased from 2009 to 2013 from ca 510 kg to 190 kg (-63%, decrease per lamp: -33%; see chapter 4.2.4).

With its limited sets of components, fluorescent tubes are very resource efficient. There are systems in place for efficient recycling (WEEE), resulting in reduced impact of mercury and other materials on the environment.

There is a growing market for mercury-free lamps based on LED technology with features such as energy efficiency and design flexibility. At present to the best knowledge of LightingEurope none of the key players on the market offers LED based alternative solutions for most of lamps in the exemption. The portfolio offered to the market in this request addresses fragmented, specialized applications. With a vast variety of parameters (form factor, length, spectrum, etc.), that cannot be easily replaced by LED in all situations. The functional objective of the special lighting application might not be met, if a LED source will not be chosen properly. It must be decided case by case, if the LED based solution can be an effective replacement for the existing fixture and situation. It mostly requires involvement of people with professional expertise due to the following issues:

1) Electrical compatibility: A LED tube has to operate on the installed control gear without any problems. It is essential to know what kind of control gear is present in the luminaire. It can require technical changes to the luminaire (rewiring), especially in luminaires equipped with an electronic control gear. Full compatibility with all installed conventional or electronic control gears is not possible.
2) Applicable legal and compliance requirements like conformity assessments, declaration, and labelling of the changed luminaire, fixture or other electrical or electronic equipment are needed. The person installing the LED based solution is responsible to perform testing and measures to ensure the new system fulfils these requirements including when the original lamp type is installed again. It is inevitable that LED retrofit and conversion lamps will also be installed by people who are not qualified professionals if corresponding fluorescent lamps are no longer available. There is a risk that this will not be carried out correctly. This risks safety for consumers or that the lighting will not be suitable.
3) Different light distribution: due to the LED tubes changed optical characteristics vs. the existing lamp the light plan could be no longer optimized for the application. Expert knowledge is needed to get a good result.

[1] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19) Draft Interim Report, Task 2, Nov.2014, VITO, VHK

4) Restricted choice in the LED based lamps, only a fraction of the existing lengths are available, not all colours and for example no direct replacement in emergency lighting.

For most of the lamps covered by this exemption there is currently no significant market for LED retrofit or conversion lamps.

Another growing market approach is the use of integrated LED luminaires, but this requires full luminaire replacement including the additional high investment and negative environmental impact. There are no data available about number of luminaires, equipment and fixtures using non-linear lamps. With a conservative assumption 500€ per luminaire incl. installation would be needed for replacement creating 5-10 kg WEEE for each still functional and energy efficient equipment. For special electrical or electronic equipment in which lamps covered by this exemption are used this figures are assumed to be much higher.

In the absence of public funding and support programs conventional technologies such as fluorescent support the investment of new LED development almost exclusively. Thousands of FTE's are employed in the manufacturing and supplies of Fluorescent lamps today in Europe.

The requirements mentioned in Article 5(a) of the RoHS Directive for the inclusion of materials and components of EEE for specific applications in the list in Annex III are met for mercury in fluorescent lamps covered by exemption 2(b)(4) not exceeding 15 mg per lamp as summarized in Table 1.

For this reason an exemption for mercury in lamps covered by the exemption is required with a maximum validity period and with no expiry date.

Requirement according RoHS Article 5(a)	Status for mercury in fluorescent lamps covered by this exemption not exceeding 15 mg per lamp
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 fluorescent lamps is scientifically and technically impracticable. Lamps in the scope can be replaced in very limited cases mainly by T8 LED lamps. Alternatively installed luminaires can be replaced with very high socioeconomic impact by mercury-free fixtures for some applications. Both solutions require lead in materials and electronic applications currently exempted according Annex III of the RoHS Directive.
the reliability of substitutes is not ensured,	Substitution of fluorescent lamps or the corresponding fixture with LED based solutions, as far as available, require in many cases qualified professionals to perform the installation. This can inevitably not be assured. Correctly installed LED based lamps and luminaires are considered to be reliable.
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 is given if LED-based lamps are installed according the manufacturers advise. In most cases qualified professionals have to do this. Based on recent studies[2] LED based lamps show comparable energy efficiency, hence cannot be considered as more beneficial to environment in all situations. It has to be analyzed case by case whether a fluorescent lamp can be technically replaced and whether the substitute LED based lamp can fully fulfill all required functionalities.

Table 1: Requirements according RoHS Article 5/a) and their fulfilment for mercury in fluorescent lampscovered by this exemption, not exceeding 15 mg per lamp

4 Technical description of the exemption request

4.1 Description of the lamps and their applications

4.1.1 Lamps and applications covered by this exemption

Annex III of RoHS Directive explicitly names the following fluorescent lamp technologies and families:

- Compact fluorescent lamps (Exemptions 1(a)-1(f))
- Linear triband phosphor lamps for general lighting (2(a)(1) – 2(a)(5))

[2] CALiPER, “Application Summary Report 21: Linear (T8) LED Lamps”, p.6

- Linear and nonlinear halophosphate lamps (2(b)(1) – 2(b)(2)
- Nonlinear triband phosphor lamps 2(b)(3)
- Cold cathode fluorescent lamps (3((a) – 3(c).

These exemptions do not cover the full range of fluorescent lamps. The scope of exemption 2(b)(4) includes all other fluorescent lamps for general lighting and special purposes, which do not belong to any of the above listed families and technologies.

Fluorescent lamps are low-pressure discharge lamps containing a phosphor coating. Low- pressure discharge lamps without a fluorescent phosphor layer (e.g. UV-lamps) as well as medium and high pressure discharge lamps are covered by exemptions (4(a) – 4(f), see also figure 1.

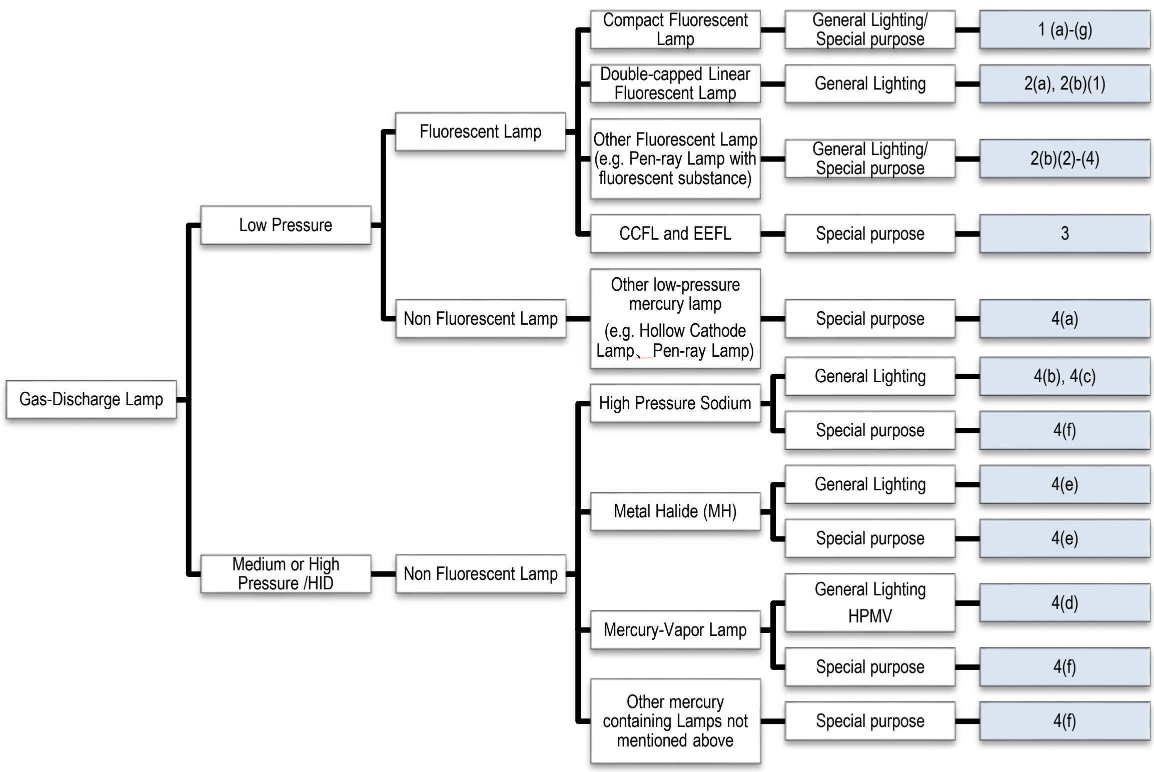

Figure 1: Chart on the hierarchy of lamps and exemptions.

In exemption 2(b)(4) the term “special purpose is introduced. Like for “general lighting” (purpose) there is no definition for special purpose lamps in the RoHS Directive.

LightingEurope Definition of “general purpose” lamps

The regulation[3] on eco-design requirements for non-directional household lamps, defines ’general purpose’ lamps as follows: ”Products subject to this Regulation are designed essentially for the full or partial illumination of a household room, by replacing or complementing natural light with artificial light, in order to enhance visibility within that space.”

Another definition for ’general purpose’ lamps is given in regulation[4] on eco-design requirements for street and office lighting, as follows: *”Products subject to this Regulation are meant to be used essentially for general lighting purposes, meaning that they contribute to the provision of artificial light replacing natural light for the purposes of normal human vision.”*

The regulations 244/2009 and 245/2009 are designed for a relatively narrow scope of lamps from an energy efficiency perspective. RoHS directive embraces a wider scope of lamps, therefore a more extended definition for ’special purpose’ lamps is needed for the RoHS directive. LightingEurope has developed the following definitions for “general lighting” (purpose) as well as “special purpose” lamps:

General lighting lamps are lamps, which are not covered by the “special purpose” lamp definition and are marketed or commercialised primarily for the production of visible light. They have standard shape, dimensions and cap.

In regulation 244/2009/EC (non-directional household lamps) ’special purpose’ lamps are defined as follows:”Special purpose lamps designed essentially for other types of applications (such as traffic signals, terrarium lighting, or household appliances) and clearly indicated as such on accompanying product information should not be subject to the eco-design requirements set out in this Regulation”.

Another definition is given in regulation 245/2009/EC (street and office lighting): ”Special purpose lamps (such as lamps used in computer screens, photocopiers, tanning appliances, terrarium lighting and other similar applications) should not be subject to this Regulation.”

According to LightingEurope the definition of special purpose lamps for the RoHS directive should be as follows:

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[3] Commission regulation 244/2009/EC, 18 March 2009

[4] Commission regulation 245/2009/EC, 18 March 2009

Special purpose lamps have documented and communicated application-specific features. They generally manufactured in accordance with general-purpose lamp making technology. The use of special design, materials and process steps provide their special features.

Where non-visible radiation has importance, for example:

- Medical/(Photo-)Therapy lamps
- Sun tanning lamps
- Black light lamps (e.g. for diazoprinting reprography, lithography, insect traps, photochemical and curing processes)
- Black light blue lamps (e.g. for entertainment, forensics, dermatology, banknote validation)
- Disinfection lamps
- Pet care lamps (e.g. aquaria or reptile lamps)

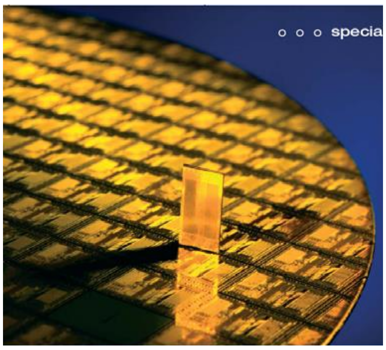
Where different applications require specific lamps, for example:

- Technical lamps for colour comparison
- Coloured lamps (incl. saturated colours, e.g. for Blue Light Therapy)
- Lamps used in horticultural lighting
- Lamps designed for eye-sensitivity of birds and other animals
- Projector lamps
- High colour rendering index lamps like food lighting applications, bakeries, etc.
- Lamps with special ignition features (e.g. external ignition strip)

Exemption 2(b)(4) includes an inhomogeneous group of lamps falling in most of above mentioned examples. They reveal amongst others different

- Form factors and bases, e.g. linear, circular, square shape
- Technologies e.g. induction, external ignition
- Phosphor types
- Mercury content, from < 2 mg up to a maximum of 15 mg

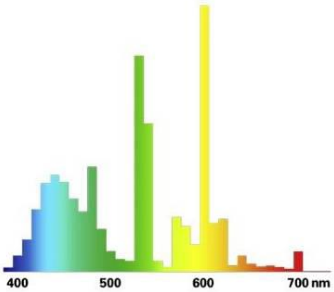
In the following table a non-exhaustive selection of lamps falling in 2(b)(4) is listed.

Lamps and applications	Example
Chip control: Lamps without UV- and blue spectrum (below 500 nm) through special coating, yellow light Applications: semiconductor industry (wafer), printing industry, (lithography)	 

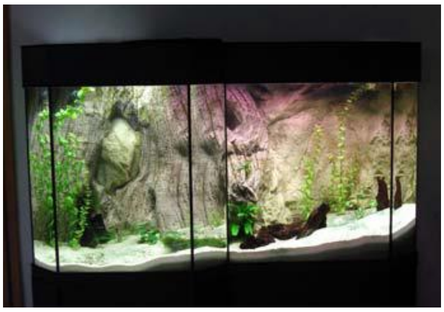
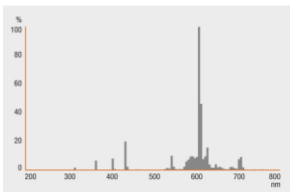
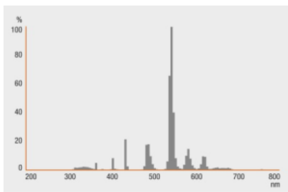
Colour proof lamps
Printing industry, graphic workshops, photographic laboratories, Industrial inspection and colour matching facilities, industry, shops, iIncoming goods inspection

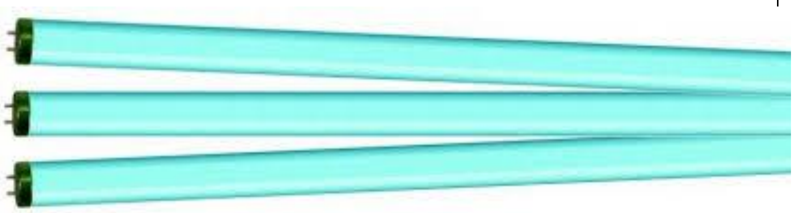
High colour rendering index
Very good color rendering group: 1A (Ra: ≥ 90)

High colour temperature
Colour temperatures > 6500 K range



Medical, Therapy lamps
Special spectra for medical applications

Horticultural lamps Colour spectrum optimized for plant growth; used wherever there is not enough natural daylight for plants, e.g. public buildings, offices, shops, supermarkets and department stores, restaurants **Aquarium lamps** Colour spectrum optimized for plant growth; used wherever there is not enough natural daylight for plants, e.g. public buildings, offices, shops, supermarkets and department stores, restaurants **Lamps for breeding of small animals** Colour spectrum optimized for breeding of small animals e.g. turtles, reptiles	  
Coloured lamps Cost-effective creative illumination and decoration, uniform light along the entire length of the lamp; Areas of application Decorative applications: shops supermarkets and department stores, restaurants, hotels, accent lighting	  

T12 lamps with external ignition strip Improved ignition at low ambient temperatures Applications: street lighting, industry, outdoor applications (only in suitable luminaires)	
T12 lamps for explosion proof luminaires Applications: Industry, places with a heightened risk of fire or explosions, oil rigs; Product features Fa6 base for explosion-proof fixtures Operation without starter	
Blacklight & Blue fluorescent lamps Lamps that emits long wave (UV-A) ultraviolet light and not much visible light. Curing large areas of plastic, hardening paints, lacquers and modern adhesives, artificial material aging, exposure of diazo film material and print masters, fluorescence excitation (with black glass filters)	
Tanning lamps Cost-effective creative illumination and decoration, uniform light along the entire length of the lamp;	

Induction lamps Electrodeless lamps, very long lif time (ca. 100.000hours), 70 – 150 Watt) Wherever relamping is expensive; - Outdoor lighting, tunnel lighting and factory lighting - Street and city lighting - Sports grounds and outdoor facilities - Marine lighting - Outdoor applications only in suitable luminaires	
Medical, Therapy lamps Special spectra for medical applications	

Table 2: Non-exhaustive list of fluorescent lamps falling in exemption 2(b)(4)

Double capped fluorescent lamps are always components of a lighting system. Because of the physics of gas discharge, fluorescent lamps cannot be operated directly on ac line voltage. Conventional control gears (CCG) have traditionally been used to limit the current. Fluorescent lamps in a luminaire with a CCG usually need a so-called starter, an electronic component which is replaced together with the lamp due to a limited life time. The introduction of electronic control gears (ECG) brought several advantages compared to CCG regarding power consumption, lifetime, maintenance costs, temperature behaviour, switching, flicker, dimming etc..

Some of the lamps falling in exemption 2(b)(4) can be used with CCG as well as with ECG. There are numerous different control gears available on the market offering various functionalities. They are used depending on customer requirements, such as dimming or temperature range. International standards make sure that lamps, control gears and light management systems can be operated in a safe and efficient way and that lamps and control gear can be exchanged while keeping a reliable system. It is essential that only suitable combinations of lamps and luminaires are installed and maintained.

4.1.2 Annex I category covered by this exemption

List of relevant Annex I categories for this exemption

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☒ 5

☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11

Lamps covered by exemption 2(b)(4) are considered to be category 5: “Lighting equipment”.

Application in other categories, which the exemption request does not refer to:
Not applicable, see comment below

Equipment of category 8 and 9: not applicable, see comment below

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 is of the opinion that lamps in general are category 5 because the most are used for general illumination. However, they have some of the characteristics of components (used in luminaires), consumables (finite lifetime and regularly replaced) and spare parts (lamps in luminaires have to be replaced when they cease functioning). Some manufacturers of electrical equipment in other RoHS categories may install fluorescent lamps into their equipment for general illumination purposes and so they will need to use lamps that comply with the RoHS directive, however the products that they place on the market are not category 5 but may be household appliances, medical devices or potentially in any RoHS category 1 - 11.

LightingEurope is aware of the difficulty to unambiguously classify certain lamps in the category set out by RoHS legislation. For lamp manufacturers it is essential to have legal certainty regarding the possibility to put the products on the market irrespective of the planned application as manufacturers are not able to control the use of the lamps in products falling in other categories in or out of the RoHS scope. In practice, most lamps are installed in buildings for lighting applications (category 5). The way that lamps are used has no effect on lamp design so will not affect this exemption request.

Therefore lamp manufacturers do consider the lamps in scope of this document to belong to category 5 as individual products.

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.

4.2 Description of the substance

4.2.1 Substance covered by this exemption

LightingEurope is asking for exempting

☐ Pb ☐ Cd ☒ Hg ☐ Cr-VI ☐ PBB ☐ PBDE

4.2.2 Function of mercury in lamps

Mercury is intentionally applied to fluorescent lamps in homogenous materials exceeding the limit value of 0.1% weight. Fluorescent lamps are low-pressure discharge lamps. When electric current flows through the lamp bulb (=discharge tube), the mercury atoms in a gas phase inside it are excited and produce UV radiation. This UV light is then converted into visible light by the fluorescent coating on the internal surface of the glass tube of the lamp bulb (see figure 2 below). The composition of the coating determines light colour and colour rendering.

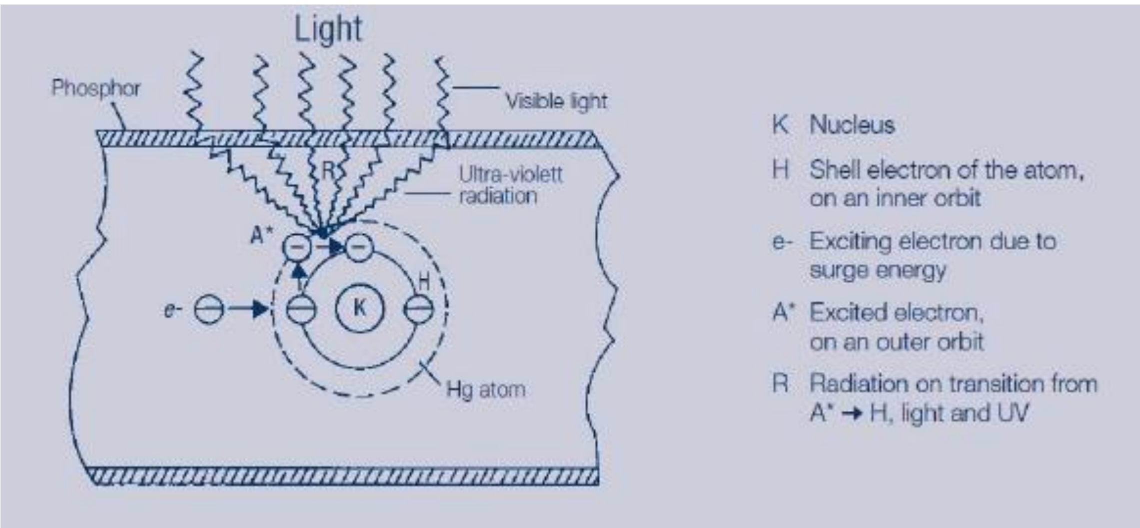


Figure 2: Electrical current is passed via the two filament electrodes through the tube which is filled with partially ionized gas. The electrons excite mercury atoms to emit short-wave ultra-violet light, which is converted into visible light in the phosphor layer on the inside of the tube. Different light colours are produced depending on the phosphor mix. [5]

4.2.3 Location of mercury in lamps

Mercury is present in the so-called discharge tube or burner. There are various technologies to add it to the discharge tube, the so-called dosing techniques. Over the last decennia the dosing techniques became much more accurate, so less mercury can be applied with a specific variance. This is needed to guarantee both the lifetime of the lamp and to fulfill the RoHS requirements of a maximum mercury dose at the same time. Below the most common dosing technologies for single- and double capped fluorescent lamps are listed and displayed in figure 3.

[5] http://www.osram.com/media/resource/hires/334404/dulux-fibel.pdf

- Manual pipetting or needle injection of liquid mercury
- Semi- or fully automatic dosing, disc needle injection of liquid mercury
- Glass capsules containing a specified amount of mercury
- Pressed pills containing Fe, Cu with Hg
- Metall alloy shield with Ti_3Hg, an inter-metallic compound
- Dosing amalgams Sn-Hg / Zn-Hg / Bi-Hg/ Bi-In-Hg
- Steering (or control) amalgams Bi-In-Hg / Bi-Sn-In-Hg

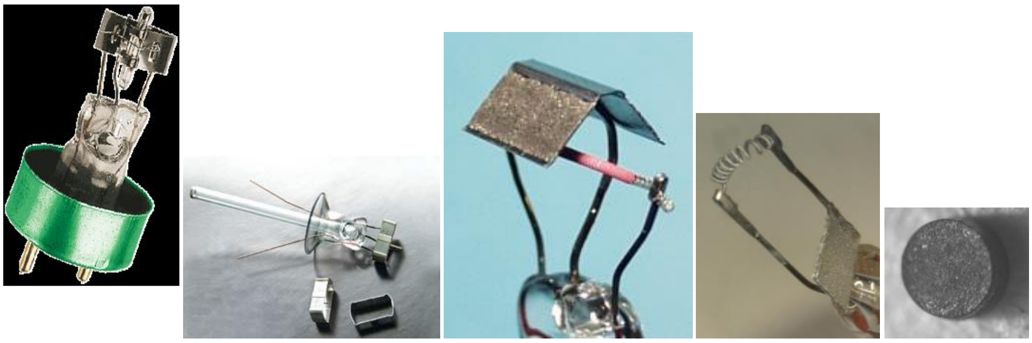


Figure 3: Mercury dosing technologies
From left: Hg-capsule; metal-alloy[6], metal alloy "roof", metal alloy "flag", HgFe pill

4.2.4 Amount of mercury

Mercury is dosed in the discharge tube during lamp manufacturing as homogeneous material (pill, capsule). This technology enables dosing of the small and accurate amount of mercury that is needed, without unintended losses. The amount of mercury dosed per lamp depends on aspects like lamp power, optical performance and anticipated lamp life. During lamp life, mercury is consumed inside the discharge tube itself. It is bound amongst others to the phosphor layer and the glass.[7]

Coating of phosphors and glass can give a reduction of the Hg consumption over lamp life, but in general it remains a function of the lamp dimensions and the lifetime. Next to this, processing has its influence, for instance because the actual dose per lamp scatters

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[6] I. Snijkers-Hendrickx et. al., Low-mercury containing discharge lamps, 2007,
[7] Reference: I. Snijkers-Hendrickx et al, Low-Mercury Containing Discharge Lamps. Sustainable and Environmental Friendly Lighting Solutions, LS 11

around the nominal dose, while the threshold value as set by RoHS Directive sets a maximum limit of 15 mg for the lamps covered by this exemption.

For fluorescent lamps a high effort was necessary to implement all limit changes coming in force in 2010[8] with effect between 2012 and 2013. The maximum mercury content of lamps covered by this exemption had to be reduced to 15 mg per burner as of 1st Jan 2012.

In order to be able to dose the required amounts of mercury precise technologies are necessary and available[9]. But even with accurate technologies there is a certain distribution of the amount of mercury per single dose. The different dosing techniques have different variances. So for example the effective mercury content of lamps with a target or average value of 8 mg can vary between 6,5-9.5 mg (see figure 4). For manufacturers, an additional "safety margin" (as explained above) is essential to have legal certainty that a product is within the limit. So while in practice the average value may be 8.0 mg, the needed RoHS value in this example may be as high as 10 or higher[10].

Figure 4 also shows that the average value in lamps is clearly much lower than the limit value required per lamp or burner. Manufacturers communicate usually this average lamp mercury content as X.X mg in their product documentation according to ErP Implementing Measure requirement[11].

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[8] Commission Decision 2010/571/EU of 24 September 2010

[9] Lamp manufacturers have developed their own proprietary solutions, or have co-developed with independent suppliers, who can offer also solutions to other lamp manufacturers.

[10] ELC Exemption request, 2012 http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_VI/Request_7/ELCF_Exemption_Request7_Mercury_long_life_CFL.pdf

[11] Regulation (EC) No 245/2009 amended by Regulation (EC) 347/2010

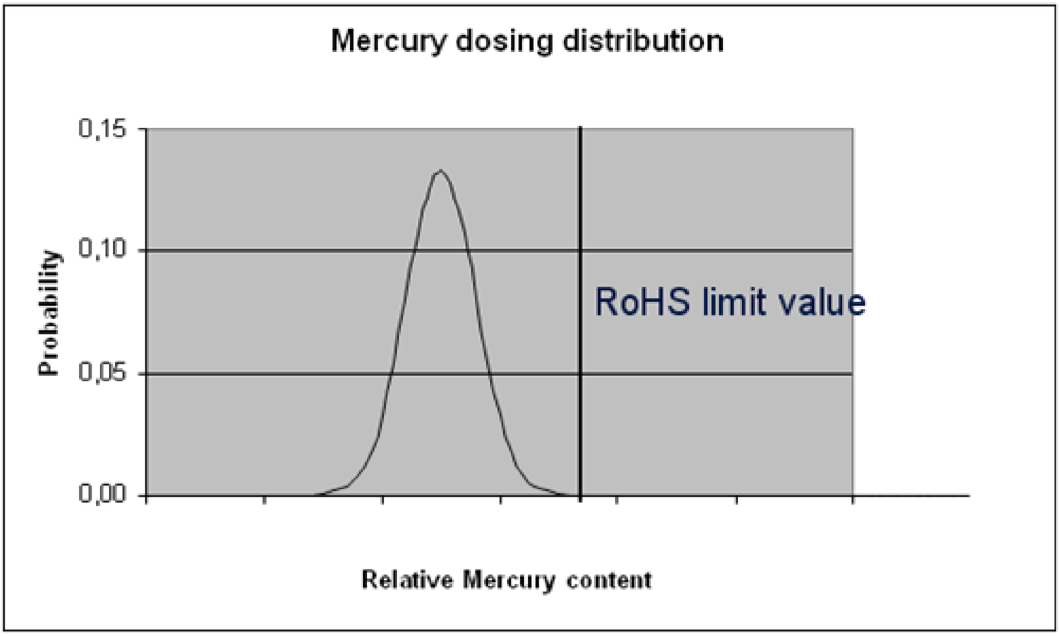

Figure 4: Simplified illustration (example only) of the effect of mercury dosing variance, where average value needs to be chosen lower than the RoHS limit value. The graph displays measurements of the mercury content in dosing units performed as quality control during their production.

The most important aspect of Hg content in lamps is the so-called *mercury consumption.*

The amount of mercury which is needed for the low pressure discharge process is very low, significantly below 100 µg for a double capped linear fluorescent lamp. But there are many processes within the burner, potentially more than 100 have been identified, which make a part of the mercury unavailable for the discharge over lifetime. This is called mercury consumption and is the reason why more mercury has to be dosed, so that the intended lifetime is shortened due to low available mercury. Therefore a balance has to be found taking into account mercury needed over lifetime, mercury variance per dosing unit but also the measurement failure when estimating the amount of mercury in a lamp for market surveillance.

It is important to understand the basic design rules regarding mercury in fluorescent lamps. One aspect is the dosing technology. As described in 4.2.3 there are different dosing technologies in use developed and implemented by the different manufacturers. The low mercury content nowadays used in modern lamp manufacturing, has resulted in well controlled, safe dosing technologies.

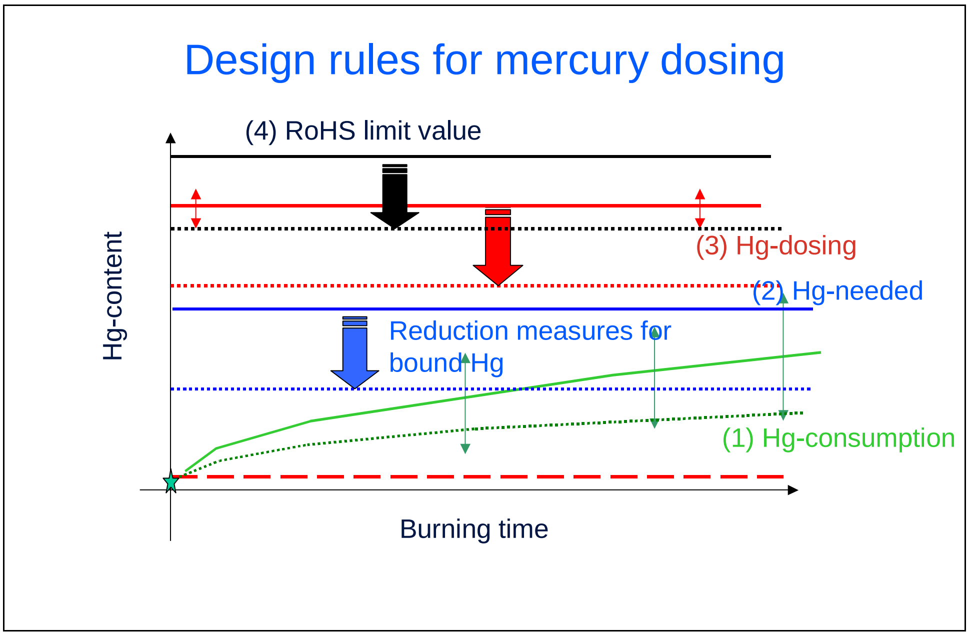

Figure 5: Design rules for mercury dosing in fluorescent lamps, schematically showing the process of setting RoHS limit values based on insights in mercury consumption and mercury dosing.

The lowest (dashed) red line in figure 5 gives the ideal situation for a low pressure mercury discharge: there is just enough mercury for the discharge to properly function. For a typical fluorescent lamp [T8: 26 mm diameter, about 1.2 m length] this is about 60 micrograms per lamp. For CFL lamps this would be even lower. However, up to now a lamp with normal functional properties could not be designed, as explained below.

In practice, mercury from the discharge gets consumed over lamp life, meaning that it is not available anymore for the proper functioning of the lamp. The mercury gets mostly deposited and effectively bonded to the glass and the phosphor layer. This is reflected by the green solid curve (1) in figure 5, which represents more or less a square root relationship with lamp life. The longer the burning time, the higher the amount of mercury needed. The variance in this mercury consumption, as depicted by the arrows, is considerable and depends on many factors (see below for counteracting measures). One could say that, in principle, a fluorescent lamp receives an overdosing of mercury, but that it is required to maintain lamp performance over time.

In order to maintain the properties over lamp life, one determines for a particular lamp design the amount of mercury needed (blue solid line 2 in figure 5). The target mercury dosing (red solid line 3) while taking its own variance into account, should be sufficient to allow for proper lamp life. Alternatively, this target value is called nominal or average value, and can be listed in catalogues.

The black solid line 4 in figure 5 is the line representing the RoHS limit (expressed as mg per lamp), the value of which has to take into account both variances of mercury consumption and of mercury dosing. On the one hand, we like to have this value as low as possible, but on the other hand, it should be safely chosen to (1) eliminate the customer risk of a non-performing product over the designed lamp life and (2) to be able to demonstrate in internal manufacturer's tests and in market surveillance tests, with the least effort, that products comply with the RoHS Directive. This leads to a built-in safety margin on top of the target mercury dose, finally leading to RoHS content limit.

Key to reduction of mercury is influencing the factors that determine mercury consumption. These include:

- Glass type and protective coating
- Type phosphor material
- Interaction with gasses and impurities
- Lamp processing during manufacturing
- Lamp-ballast interaction during operation

Once mercury is bound to these, it is no longer available to emit ultraviolet light. The schematic effect is the lowering of the solid curve 1 to the dashed curve in figure 5.

Table 4 shows an overview on the different major paths of mercury consumption which is oxidation, amalgamation, adsorption and absorption. A part of the mercury dosed in a lamp is "consumed" meaning that it is no longer available for the light-producing discharge process. Mercury diffuses into the glass tube or can be found as "inactive" mercury compounds in the phosphor coating. Depending on many different factors such as phosphor composition, lamp chemicals (e.g. getter, emitter), production, use etc. consumption is individual for every lamp.

It is also important to take into account the technical capability to reduce both the absolute mercury dose to very low values, and to reduce its variance. Hence, by combining a series of interlinked and complex measures, in a consistent manner, the mercury could be reduced, based on scientific and technical progress in the recent years.

Path	Mechanism	Main Promoter	Source	Location of bound Hg
Oxidation	Hg^{+} + x O $\rightarrow$ HgO_x	impurities prematerials	processing coating	coating
Amalgamation	Hg^{+} + Me $\rightarrow$ HgMe Me: e.g Ba, Na, Sr,...	emitter impurities glass	processing emitter electrode	coating
Adsorption	Hg^{+} - adsorption on surfaces	surface charge, electronegativity	Hg+, e-, Ions, electric potentials.	coating
Absorption	Hg^{+} - diffusion/Incorporation in bulk	prematerials glass	Hg+, e-, Ions, chemical potentials.	glass, coating, components

Table 4: Main mercury consumption mechanisms oxidation, amalgamation, adsorption and absorbtion. Mercury diffuses into the glass tube or can be found as “inactive” mercury compounds in the phosphor coating and is no longer available for the discharge process.

Non-linear fluorescent lamps always need more mercury compared to linear lamps, also special phosphors and additives are causing higher mercury consumption in lamps falling in exemption 2(b)(4).

Measurements of mercury consumption are performed under controlled, optimized laboratory conditions using standardised switching cycles. Operation conditions can significantly increase the consumption (e.g. depending on dimming, switching frequency, high/low temperatures, use as emergency lighting, mains voltage, ballast etc.). This has to be taken into account to find the necessary Hg dosing amount. It is very important that mercury does not reach the limiting factor for the lifetime.

In summary, one has to distinguish between maximum limit value and the mercury content, that on average needs to have a much lower, average or nominal value, to account for variance in lamp manufacturing and operation and to account for market surveillance, with adequate protection of both customer and producer.

Annual Mercury content of lamps covered by this exemption EU-28:

In the following table the market (number of produced lamps [Mio pieces]) and the corresponding mercury amount put on the EU-28 market is listed from 2009 to 2013[12].

[12] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements (‘Lot 8/9/19) Draft Interim Report, Task 2, Nov.2014, VITO, VHK

The lamps in table 5 (“Other FL”) are all lamps covered by the exemption 1(e), 2(b)(2), 2(b3), 2(b)(4) and 4(a) of Annex III, RoHS Directive. The average mercury amounts per lamp are estimated by LightingEurope member companies as displayed in the table. The corresponding average mercury amount per lamp is also displayed. This can be seen more as a worst case estimation, especially for 2012-2013, where a maximum limit of 15 mg was introduced. The data show a decreasing market from 2009 to 2013. In 2013 ca. 19 Mio non-linear and special purpose lamps have been marketed The overall roughly estimated yearly mercury input decreased from 2009 to 2013 from ca 510 kg to 190 kg (-63%, decrease per lamp: -33%).

EU28	2009	2010	2011	2012	2013
Other FL [Mio pcs.]	34	32	27	23	19
Mercury [kg]	510	480	324	230	190
Average Hg content of lamps [mg]	15	15	12	10	10

Table 3: Market and mercury content of lamps covered by the exemptions 1(e), 2(b)(2), 2(b)(3), 2(b)(4) and 4(a) of Annex III, RoHS Directive [Mio pcs.]. Data represent sales in EU-28[14].Mercury content has been estimated by LightingEurope.

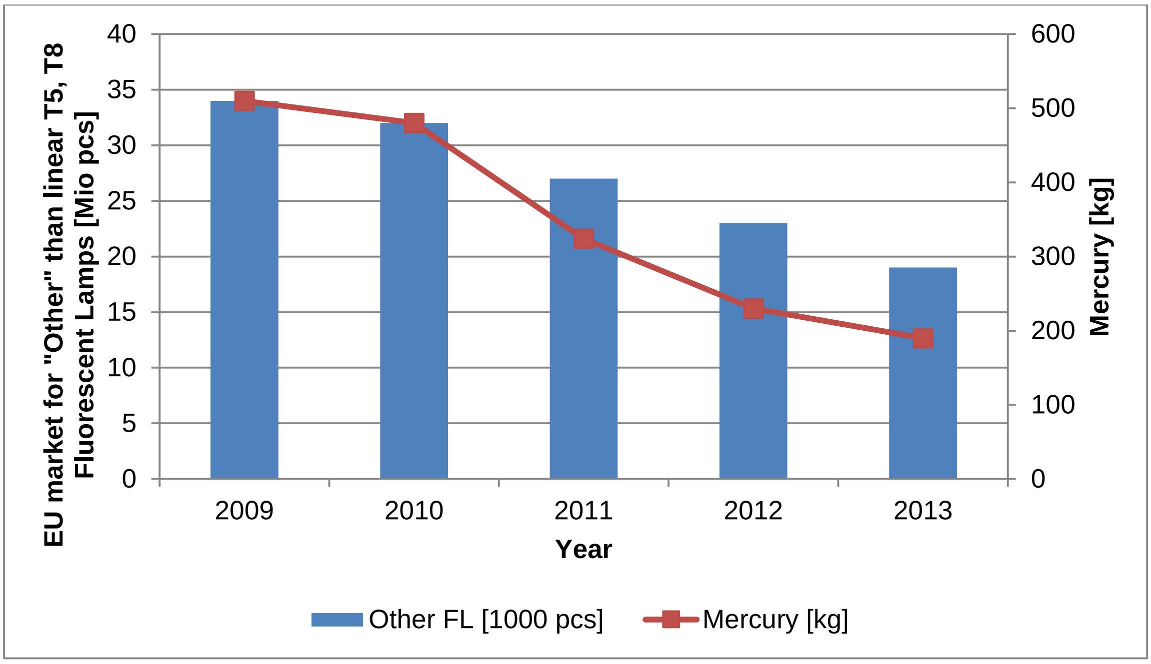

Table 4: The graph displays the lamp sales as well as the total mercury input of table 3

4.2.5 *Environmental assessments, LCAs*

There are several external LCA's performed regarding lighting. There is general agreement, that the main environmental impact is created during the use phase, meaning through electricity consumption when burning the lamp.[13] This means that currently the efficacy of the lamp is the determining parameter. On the other hand for lamps covered by the exemption 2(b)(4) the specific purpose is essential. It only makes sense to perform a LCA comparing it with a lead- and mercury-free lamp if the specific characteristics and requirements to the fluorescent lamp are met. LightingEurope is not aware of such LCAs.

5 Waste management

5.1 Waste streams

☒ 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

Double capped linear fluorescent lamps are in the scope of EU Directives 2002/96/EC - WEEE and 2012/19/EU – WEEE Recast. Take back systems are installed in all EU Member States: end users and most commercial customers can bring back the lamps free of charge. Double capped linear fluorescent lamps are collected separately from general household waste and separately from other WEEE waste. Also a dedicated recycling process exists for lamps because, according to legislation, the mercury shall be removed from the gas discharge lamps. Mercury is recovered in specialised facilities by distillation.

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[13] *(see Enlighten report, Section 5, Ch. 3 fig. 4 & 5)*

Below picture shows the various steps in the recycling process:

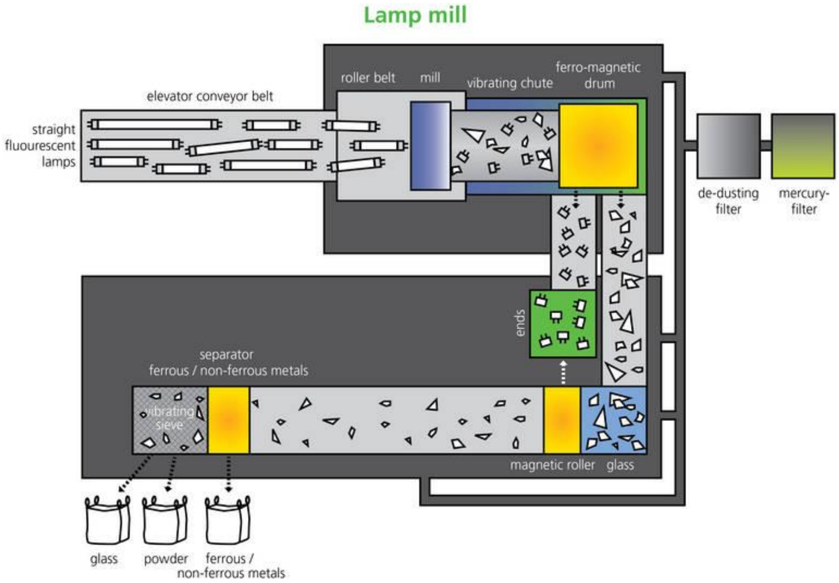

Figure 6a Recycling steps of fluorescent lamps in Indaver (Belgium). Source: www.indaver.be/waste-treatment/recycling/mercurial-waste.html

The next picture illustrates the specifics of recycling the mercury:

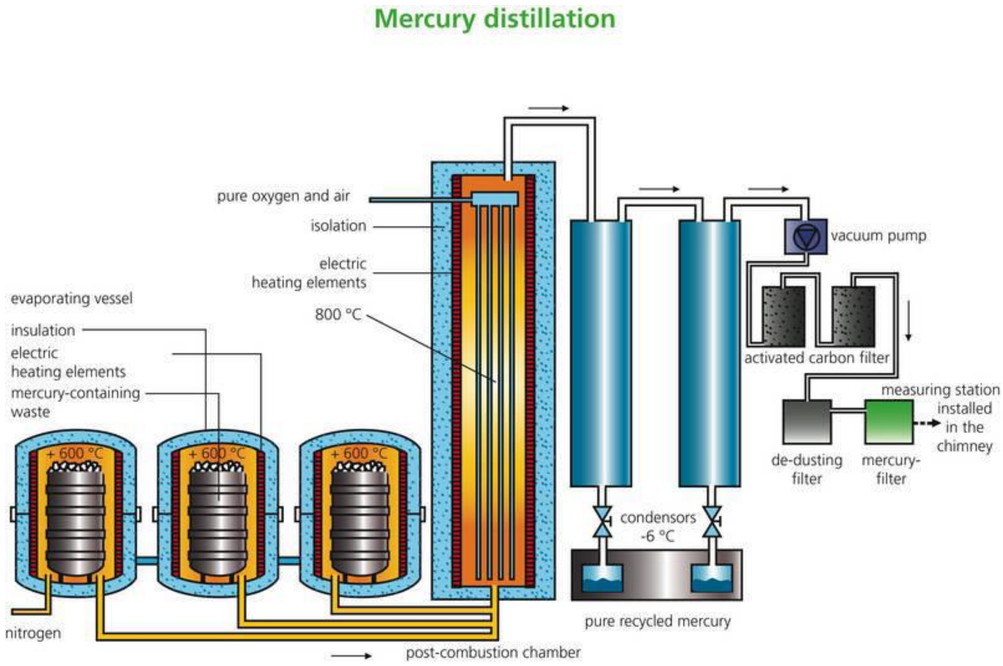

Figure 6b Specific recycling steps of mercury in Indaver (Belgium

European legislation on Waste Electrical and Electronic Equipment makes producers responsible for end of life products within this category as from August 13th, 2005.

Target setting as consequence of the present legislation is 45% of EEE placed in the market by 2016, rising to 65% in 2020 per year for all categories.

European Lamp Companies have founded Collection & Recycling Organizations in the EU Member-States, with the objective to organize the collection and recycling of gas discharge lamps. Goal is to comply with present and probable future EU legislation and meet or exceed national targets.

In general the following channels have been established in the respective member-states providing countrywide coverage:

- Direct collection from large end users:

  Containers have been made available, ad hoc or permanently, and will be collected upon notification by the end user that the container is full.
- Collection through distribution:

  Wholesalers and Retailers place collection means at their premises respectively in their shops. Collection is done upon notification.
- Collection through municipalities:

Where infrastructure allows collection means are placed at municipality depots.

Figure 7: Stibat/Wecycle-collection street as present in the Dutch Do-it-yourself shops of Gamma.

Campaigns are being executed or have been planned to re-enforce the role of the government to educate the population that gas-discharge lamps have to be disposed of in an environmentally friendly way.

Mercury content market:

Lamps covered by exemption 2(b)(4) is a small but very important segment of all fluorescent lamps.

In table 3 of chapter 4.2.4 the market (number of produced lamps [Mio pieces]) and the corresponding mercury amount put on the EU-28 market is listed from 2009 to 2013[14]. The overall roughly estimated yearly mercury input of all lamps covered by the exemptions 1(e), 2(b)(2), 2(b3), 2(b)(4) and 4(a) of Annex III, RoHS Directive decreased from 2009 to 2013 from ca 510 kg to 190 kg (-63%).

The collection rate of lamps in Europe compared to the average amount of lamps put on the market during 2010 – 2013 is shown in below graph. It also includes the targets set for 2016 and 2019. Please be aware that this graph includes all lamp types, not specific ones.

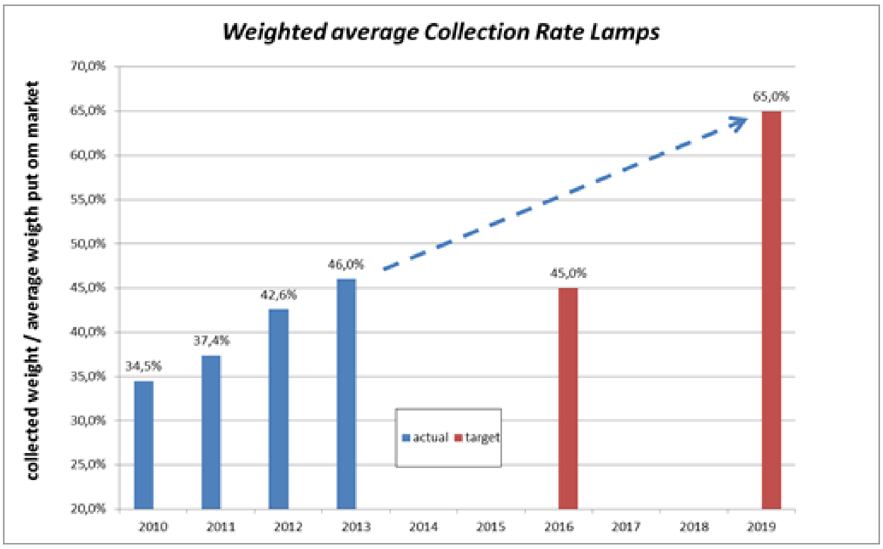

Figure 8: Weighted average Collection Rate Lamps (all lamps): 2010 – 2013 (blue) and targets 2016-2019 (red)

Reporting on the collection of lamps is available on 2 groups:

[14] Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements (‘Lot 8/9/19) Draft Interim Report, Task 2, Nov.2014, VITO, VHK

- CFL lamps and other non-linear low- or high pressure lamps as well as LED retrofit lamps
- Fluorescent tubes, long CFL without integrated ballast

Linear fluorescent lamps are recycled separately. It is also important to note that almost every country within EU has a collection and recycling service organisation (figure 9, status per 2009).

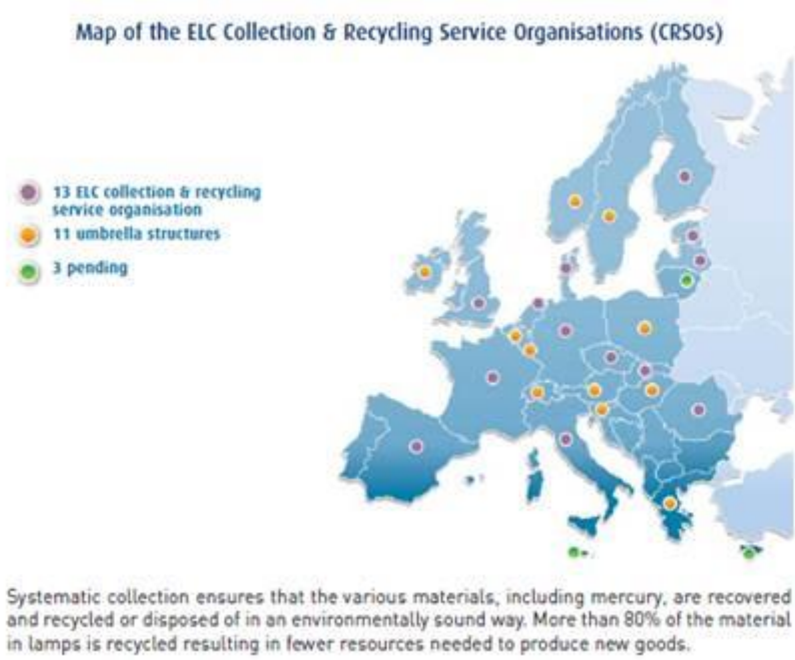

Figure 9: Map of ELC Collection and Recycling Service Organisations (CRSOs). Source: Environmental aspects of lamps[15]

6 Substitution

Can the substance of this exemption be substituted?

☐ Yes, by ☒ No

☐ Design changes: Justification: see in below chapters

☐ Other materials:

☐ Other substance:

6.1 Substituting mercury in the fluorescent technology

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[15] ELC: Environmental aspects of lamps, second edition, APRIL 2009
http://www.elcfed.org/documents/090811_elc_brochure_environmental_aspects_lamps_updated_final.pdf

Fluorescent lamps need a certain amount of mercury since it is consumed over life. Technology has evolved over the last decade. And the average amount of mercury within fluorescent technology per lamp is considerably reduced (Figure 10)

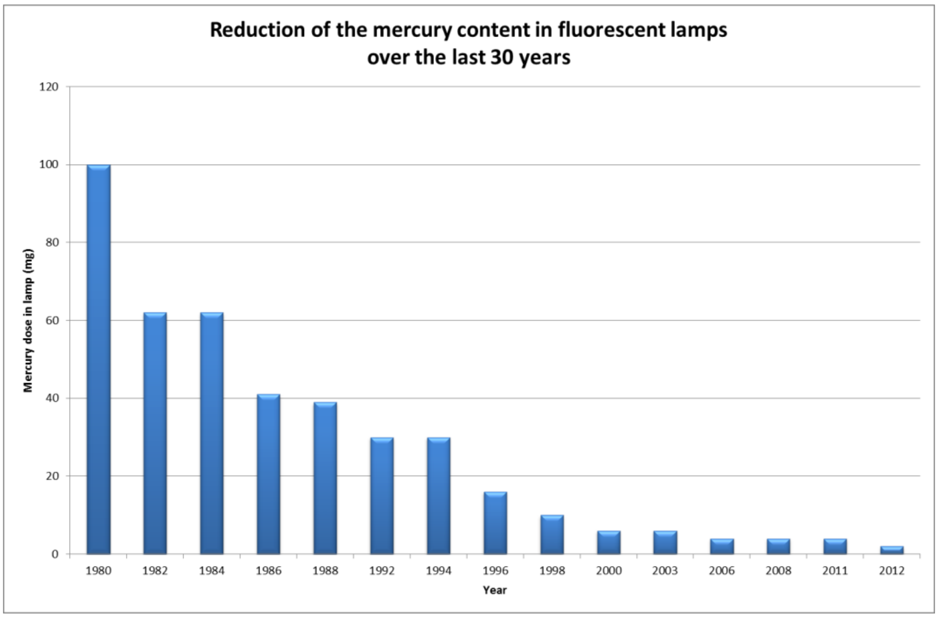

Figure 10: Mercury content of fluorescent lamps

During the last decades several approaches have been made to design low pressure discharge lamps where the light producing element Hg is replaced by a less hazardous material. So far no approach yielded a result with comparable luminous efficacy, product cost and product availability as the still state of the art Hg low pressure discharge lamps.

The mercury discharge is highly efficient in transforming electrical energy into light. There are only two drawbacks: first the generated UV radiation needs to be transformed into visible light, where large losses occur: this is due to the Stokes shift (an energetic UV photon generates, a much lower energy, visible photon) and secondly the discharge contains mercury[16].

Attempts to generate UV with noble gases succeeded partially[17]. However the plasma radiates in the deep UV. At these wavelengths, the Stokes shift is even larger causing lower efficiency. The lack of suitable phosphors[18] prohibited progress in this direction. Other alternatives investigated are low pressure metal halides (for example InI, InBr,

[16] *M Haverlag, Mercury-free discharges for lighting, J. Phys. D: Appl. Phys. 40 (2007)*
[17] *R Bussiahn, S Gorchakov, H Lange, D Loffhagen and D Uhrlandt, Ac operation of low-pressure He–Xe lamp discharges, J. Phys. D: Appl. Phys. 40, 3882 (2007)*
[18] *J. Dexpert-Ghysa, Re-processing CRT phosphors for mercury-free applications, J. of Luminescence, 129, 1968, (2009)*

GaI3)[19]. Such plasma's generate the visible light directly without the Stokes shift of the phosphor[20]. There are alternatives from research but the efficiency in prototypes lamps is significantly reduced to approx. 40lm/W level or below. Mass production is not (yet) feasible.

One approach has been the dielectric barrier discharge, which uses a Xe excimer as light producing species. It had been developed into a product with an efficacy of about 20 lumen/W. As no solution for improvement has been found and regular Hg linear fluorescent lamps operate at up to 120 lm/W these products were not very successful in the market and used only for very special purposes.

Using rare gases instead of mercury leads to a dramatic efficiency drop. Upgrading to similar performance would imply unjustifiable efforts with unknown chance of success (limit of the technology reached) and possibly resulting in a larger negative environmental impact.

Low operating temperature and immediate lumen output could be reached if a light producing species is used which is in gaseous state at room temperature. There had been the theoretical idea that it might be possible to find a suitable operating regime for a nitrogen - rare gas low pressure discharge. In cooperation with the University of Augsburg and the Bayerische Forschungsstiftung (BFS) a project has been started to develop such a light source. The status of research work has been published in a Diploma Thesis and a publication[21]. In 2013 it became quite clear that an efficacy of more than 10lm/W cannot be realized with the approaches followed so far. Therefore the BFS cancelled the project support and in consequence the whole research work has been stopped.

Another approach has been to use metal halide compounds as light source in low pressure discharge. This activity has been carried out in manufacturer's laboratories as well as in cooperation with the University of Augsburg. In his PhD thesis "Spectroscopic Investigation of Indium Halides as Substitutes of Mercury in Low Pressure Discharges for

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[19] *D.Smith, J. Michael, V. Midha, G. Cotzas and T. Sommerer D. Smith et al Efficient radiation production in a weakly ionized, low-pressure, nonequilibrium gallium-iodide positive column discharge plasma J. Phys. D: Appl. Phys. 40 3842 (2007). More references can be found in the series: International Symposium on the science and technology of Lighting LS1-14.*

[20] *An example if a UV photon of 256 nm from mercury is transformed in a visible photon of 555nm (maximum eye sensitivity) 56% of the energy is lost to heat. In xenon the UV photon is formed around 185 nm this looses 67% of the energy when transformed into the same visible photon.*

[21] Diploma Thesis "Spektrale Intensität der N2-Strahlung in einer Argon-Niederdruck-Bogenentladung für den Einsatz als Lichtquelle", published 2009 by R. Friedl at the University of Augsburg; „Spectral intensity of the N2 emission in argon low-pressure arc discharges for lighting purposes", R. Friedl, U. Fantz, New J. Phys. 14 043016 ,2012;

Lighting Applications", published 2011 at the university of Augsburg, S. Briefi shows that currently about 30 lm/W might be reached with a potential to get up to 60 lm/W. This efficacy is still much lower than Hg containing LPD lamps show. Furthermore, a metal halide LPD lamp needs to be heated up to > 200°C to get the lighting salt evaporated. This causes special issues for safety and very slow run-up behavior.

With the arrival of equally efficient LED light sources, research to alternative discharges has stopped at most companies and universities.

6.2 Substituting florescent technology by mercury free technology

Two key ways to use LED technology in order to substitute fluorescent lamps can be distinguished: (1) replacement lamps, (2) new installation (either new buildings or refurbished areas).

6.2.1 Feasibility of the alternatives

LightingEurope describes four key aspects that need to be considered when evaluating potential LED based replacement for conventional fluorescent based lighting applications: (1) electrical compatibility, (2) Light distribution and lumen output, (3) Lack of standards.

1. Replacement lamps

(1) Electrical compatibility

Non linear fluorescent lamps are uniformly used with all possible lamp drivers designed according to the relevant IEC standards. The key for usage of a LED tube as a replacement lamp in an installed luminaire is its electrical compatibility with the existing control gear. However this is far from comprehensive due to the complexity of the installed park with respect to control gear. Two main driver systems installed in the market are conventional control gears CCG (electromagnetic 50/60Hz) with additional external starter as well as electronic control gear ECG (high frequency) drivers with integrated starter circuits. The ECG drivers are also available in various kinds, ranging from electrode pre -heated to cold start drivers and from current-, power- and voltage-controlled to fixed output and dimming drivers.

Lamp replacement can go two ways:

- Retrofit route: a fluorescent lamp is substituted by a LED tube. The luminaire itself is not rebuilt[22] and the control gear remains in the installation[23]. Driver compatibility is assumed here.
- Conversion route: the fluorescent lamp is replaced, and technical changes also need to be made to the luminaire: ballasts and/or internal wiring may need to be replaced or altered[24].

As explained in the earlier paragraph retrofit route can be taken if driver compatibility is secured. However unskilled end-user, customer and consumer might be confronted with compatibility issues and wrongly (also unintentionally) chosen LED tube, which will work improperly in existing application. In such situation one will be forced to take out the control gear from his installation and directly connect a LED source to mains voltage (rewiring).

In assessing the suitability of any specific product or installation the user must make his own judgement and/or take appropriate advice[25]. Conversion route can be considered as: (1) complicated, (2) requiring additional compliance and conformity efforts.

Lighting Europe would like to refer to: (1) ZVEI document, where is stated that "*luminaires may only be adapted to accept conversion lamps[26] by appropriately trained personnel. Conversion of the luminaire shifts the responsibility for the technical and the safety consequences of the conversion to the party carrying out the conversion. There is no separate safety standard for the conversion lamps. Converted luminaires must conform to the basic requirements of the low voltage and EMC directive. A new conformity assessment is required for rebuilt luminaires used with conversion lamps, which needs to be carried on case-by-case basis.*"; (2) LVD ADCO: "*For a modified luminaire, the manufacturer of the original luminaire will generally no longer be seen as responsible for the safety of the product". Any modifications made to the original luminaire may alter the characteristics of the original product e.g. safety aspects of the original luminaire, and hence risk assessment of hazards posed by the original luminaire may no longer be*

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[22] Op.cit. ZVEI

[23] The replacement of a glow starter compliant with IEC 60155 with other devices does not constitute a modification of the luminaire itself, however the use of such a starter needs to be safe when used in luminaires

[24] Op.cit. ZVEI

[25] CELMA position paper: T5 and T8 Fluorescent Lamp and LED Lamp/Module Adaptors "Retro-fit Conversion Units" for T8, T10 & T12 Luminaires; http://www.valosto.com/tiedostot/CELMA_LED(SM)054C_CELMA_position_paper_on_ADAPTORS_FINAL.pdf

[26] Conversion lamps as originally stated in ZVEI document, relate to conversion route adapted by LightingEurope of for the purpose of this exemption renewal request. These concerns lamps, which require modification in the existing luminaire to ensure proper operation

applicable to the modified luminaire. In this case, the modified luminaire would be considered as a new product"[27].

The above provided information clearly indicates that replacing nonlinear T8 or T9 fluorescent lamp with LED tubes would be is a complex process. Replacement opportunities with regards to electrical compatibility are far from comprehensive. An end-user, customer and consumer needs to either have a broad technical knowledge or reach out to professionals to ensure the changed luminaire is safe and operates in a proper manner and is compliant with relevant legislation. It requires case-by-case feasibility and measurements.

According to an article "Linear LED tubes versus fluorescent lamps: An evaluation[28]": "the use of LED tubes as replacement lamp for fluorescent lamps is a typical product causing controversy." There is a lack of standardization and inspection to evaluate solid state lighting (SSL) products[29] often resulting in overstated and misleading manufacturer performance claims[30]. The key potential differences that need to be considered when choosing for LED tube replacement will be discussed here.

(2) Light distribution and lumen output.

The light distribution of a LED tube differs significantly from fluorescent tubes. A fluorescent lamp emits light in all directions, uniformly around the axis of the lamp (360°). This is easily achievable, since the gas discharge responsible for the light emission is omnidirectional. In contrast, LED packages emit light directionally, they are (lambertian) directional light source emitting light in a downward-hemispherical arrangement (Figure 12a and 12b)[31]. It is difficult to achieve an omnidirectional luminous intensity distribution, while also meeting needs for thermal management and electrical regulation. As a result the emitting surface of linear LED lamps often covers only half of the surface area[32].

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[27] LVD ADCO Recommendation on "Safety of LED T-type replacement tubes and modified luminaires" http://ec.europa.eu/enterprise/sectors/electrical/files/lvd-adco/recomm-led-replac-tubes_en.pdf

[28] "Linear LED tubes versus fluorescent lamps: An evaluation", W.R. Ryckaert K.A.G. Smet, I.A.A. Roelandtsa, M. Van Gils P. Hanselaer

[29] A. Poppe, G. Farkas, G. Molnaacuter, B. Katona, T. Temesvoumllgyyi, J.-W. He, Emerging standard for thermal testing of power LEDs and its possible implementation, in: Proceedings of SPIE - Tenth International Conference on Solid State Lighting, San Diego, CA, USA, August, 2010., per: "Linear LED tubes …" W.R. Ryckaert and others

[30] M.A. Myer, M.L., Paget, R.D. Lingard, CALiPER Benchmark Report–Performance of T12 and T8 Fluorescent Lamps and Troffers and LED Linear Replacement Lamps, Prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory, PNNL-18076, 2009, per: per: "Linear LED tubes …" W.R. Ryckaert and others

[31] "Linear LED tubes versus fluorescent lamps: An evaluation", W.R. Ryckaert K.A.G. Smet, I.A.A. Roelandtsa, M. Van Gils P. Hanselaer

[32] CALiPER, "Application Summary Report 21: Linear (T8) LED Lamps", p.6 http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/caliper_21_t8.pdf

This is also recognized by the EU regulator in regulation 1194/2014, which includes additional product information requirements for LED lamp replacing fluorescent lamps without integrated ballast (1194 Annex III, art. 32).

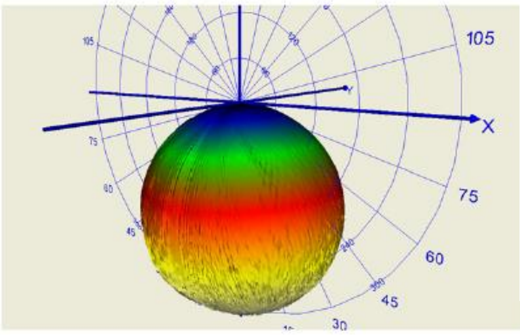

Figure 12a Luminous intensity distribution (3D) – brand K. Source: "Linear LED tubes…" W.R. Ryckaert and others, p. 431

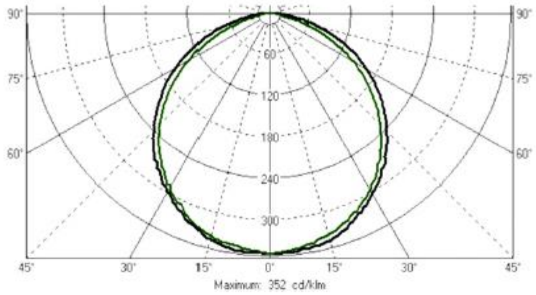

Figure 12b Luminous intensity distribution C0-180 (black) and C90-270 (green) – Brand K. Source: "Linear LED tubes" W.R. Ryckaert and others, p. 431

(3) Lack of standards

A standard covering double capped linear retrofit LED tubes is in preparation (EN62776). As long as this standard is not available manufacturers are recommended to use draft standard 34A/1642/CDV (ZVEI, 2014). For the electromagnetic compatibility of LED retrofit lamps a EMC assessment is in preparation at IEC/CISPR (current draft CISPR/F/628/CDV). For conversion lamps there is no own safety standard available so far. Therefore the requirements of the lamp components must be met, e.g. EN61347-2-13 for the control gear. Also 34A/1642/CDV might be taken into account. After rewiring of a luminaire conformity assessment of the luminaire has to be performed (among others: low voltage directive, electromagnetic compatibility). Prior to operation lumen output, energy efficiency, light colour and colour rendering have to be assessed. As long as there is no own standard available EN 62612 „Self-ballasted LED-lamps for general lighting services — Performance requirements" can be taken into account. So for the subjects glare, flickering, dimming, safety and blue light hazards standards are currently in work.

2. New Installations

Linear LED luminaires are providing a viable alternative to the traditional fluorescent lamps for general lighting with such features as: efficacy, energy efficiency, design flexibility and appearance. But the quality and performance of LED products varies among manufacturers.[33] Many conformity and performance related issues are solved. Dedicated

33 "Replacing the Fluorescent Lamp with Linear LED Luminaires" James Brigagliano, LC, IESNA, November 2012 Downloaded on 7th November 2014: http://continuingeducation.construction.com/article_print.php?L=223&C=947

designed luminaires directly comply as a system with all safety and standardization legislations is tested and confirmed by the luminaire manufacturer. New installations might be especially relevant for 2(b)(4) as LED luminaires can offer many different optical and performance characteristics.

6.2.2 Availability of substitutes

Currently LightingEurope has no reliable market data about LED retrofit/conversion lamps which could be used as substitute for lamps falling in exemption 2(b)(4). Many existing and new lamp manufacturers are working on new products. Standards are in preparation in order to address above mentioned technical challenges.

6.2.3 Impact of substitutes

6.2.3.1 Environmental impact of substitutes

LED light sources are a promising technology to improve energy efficiency of a lighting system as a whole.

LCA data of several lighting systems clearly showed, that the system efficacy (use phase) has the highest impact on the environment during the Product Life Cycle. For an optimal system where the LED solution gives exactly the designed light distribution and an acceptable glare level, the LED solution can save energy and have a smaller footprint. Since the LED efficiency as such, is not much higher than that of fluorescent lamps, and the lifetime is comparable, the difference in LCA is small.

But the purpose of every single luminaire at its place of operation always has to be considered, especially regarding lamps falling in exemption 2(b)(4).

Especially the new functionalities of LED solutions (colour changing, flexible form factors, tailor made seizes etc.) could lead to new lighting options and extension of the use of these products.

From material composition it is also necessary to have a case by case view. Fluorescent lamps contain glass, metals, phosphors and mercury. These components can be effectively recycled. LED based alternatives contain electrical and electronic components such as a control gear and a light engine with mounted LEDs. Like in most other electrical and electronic equipment electronic LED luminaires contain components and other materials using substances regulated in RoHS but exempted in certain exempted applications (e.g. lead in high melting temperature type solders in diodes, lead in glass or ceramic in electronic components, lead in aluminium alloys used for the heatsink, lead in copper alloys etc.).

6.2.3.2 Health and safety impact of substitutes

If in new products or applications a LED based substitute is used it is like in all CE relevant products essential to make sure that the equipment is safe.

As described above special care has to be taken for the use of LED retrofit and conversion solutions in systems which were designed for a fluorescent lamp, including exchange of the lamps by professionals. It is inevitable that LED replacement lamps would also be installed by people who are not qualified professionals if these lamps are no longer available. There is a risk that this will not be carried out correctly creating safety risks for consumers or that the lighting will not be suitable.

6.2.3.3 Socio-economic impact of substitution

Economic effects 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:

There is a severe change in the lighting market, also covering the production of lamps covered by exemption 2(b)(4).

In case these fluorescent lamps would no longer be available for existing fixtures, the impact would be by far more than significant. The need to replace or technically change the luminaires, control gears, equipment etc. results in high investments for private, commercial or public customers. This is especially the case when special purpose lamps are part of an other electrical or electronic equipment, e.g. sun tanning lamps in a sunbed. The installed equipment can still be used for many years when replacement lamps remain available. As a consequence the environment will be spoiled unnecessarily with additional waste of the discarded luminaires without having an environmental benefit. There are no data available about number of luminaires, equipment and fixtures using 2(b)(4) lamps. Regarding only standard fixtures with a conservative assumption 500€ per luminaire incl. installation would be needed for replacement creating 5-10 kg WEEE for each still functional and energy efficient equipment. For special equipment the impact is much higher.

The impact on industrial progress and development of new technology in the LED sector is severely hampered if the lamps at stake are removed from the market too early. The transformation process in the European lighting industry towards LED is in full course and high investments in the new technology have to be assured. In the absence of public funding and support programs as they characterize other global regions, the European industry finances this transformation almost exclusively by its own means. Thousands of FTE's are employed in the manufacturing and supplies of fluorescent lamps today in Europe. LED tube alternatives are often not produced in Europe (EU28) but mostly in Asia.

6.2.3.4 Impact of substitution on innovation

LED lighting is a very innovative technology offering a high variety of new functionalities, high and still increasing energy efficiency and overall performance in nearly all areas. It is also important to take into account the technical capability to reduce both the absolute mercury dose to very low values, and to reduce its variance. Hence, by combining a series of interlinked and complex measures, in a consistent manner, the mercury could be reduced, based on scientific and technical progress in the recent years.

In the absence of public funding and support programs conventional technologies such as Fluorescent support the investment of new LED development almost exclusively.

Allowing this exemption will not affect innovation into new LED technology. Innovative R&D into fluorescent lamps has already ceased as LEDs are seen as the future substitute, but only after sufficient time to resolve the technical issues described here and to allow EU users time to make changes without negative safety or socio-economic impacts.

6.2.4 Future trends of substitution

As described above in new products and applications there is a fast increase of the use of LED based technologies. On the other hand LED retrofit or conversion lamps replacing lamps covered by exemption 2(b)(4) are nearly not available in the EU market. Fluorescent lamps are very efficient and reliable as they are in the market since decades.

6.3 Links to REACH, according to RoHS Directive Article 5(1)(a)

Do any of the following provisions apply to the application described? : no

- ☐ Authorisation
- ☐ SVHC
- ☐ Candidate list
- ☐ Restriction
- ☐ Annex XIV
- ☐ Annex XVII
- ☐ Registration

☐ Proposal inclusion Annex XIV ☐ Registry of intentions

Provide REACH-relevant information received through the supply chain: not applicable

7 Removal of mercury from lamps

Can mercury be eliminated?

☐ Yes.

☒ No.

Mercury cannot be removed from fluorescent lamps as described above. No technologies could be developed having similar high efficiencies.

8 Reduction of mercury content of lamps

For fluorescent lamps falling in exemption 2(b)(4) it was necessary to implement a maximum limit of 15 mg coming in force in 2010[34] with effect between 2012 and 2013. But only a part of the lamps had to be changed. Most of them already had significantly lower mercury content as similar mercury reduction measures could be realized like in linear fluorescent lamps for general lighting. Many of the lamps are produced on the same production lines. Higher mercury consumption in 2(b)(4) fluorescent lamps compared to normal linear fluorescent lamps is mainly caused by additives in the fluorescent powder. But the difference is not too big in many cases.

Further reduction of mercury might technically be possible with high economic effort and R&D resources. But these financial and human resources are needed for the investments and the running transfer to LED technology. The major part of development resources of lighting companies have already been allocated on LED based alternatives. On the other hand the lamps are required for the existing base of fixtures systems and luminaires, which are also highly efficient and have a long life time.

[34] Commission Decision 2010/571/EU of 24 September 2010

9 Other relevant information

During the UNEP Minamata Convention on Mercury end 2013 in Japan agreements have been made on limitation of mercury in various products, including linear fluorescent. This treaty has been agreed upon and signed by 94 countries around the globe. The agreed mercury level for linear fluorescent is 5 mg.

Mercury-added products	Date after which the manufacture, import or export of the product shall not be allowed (phase-out date)
Compact fluorescent lamps (CFLs) for general lighting purposes that are ≤ 30 watts with a mercury content exceeding 5 mg per lamp burner	2020
Linear fluorescent lamps (LFLs) for general lighting purposes: (a) Triband phosphor < 60 watts with a mercury content exceeding 5 mg per lamp; (b) Halophosphate phosphor ≤ 40 watts with a mercury content exceeding 10 mg per lamp	2020
High pressure mercury vapour lamps (HPMV) for general lighting purposes	2020
Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays: (a) short length (≤ 500 mm) with mercury content exceeding 3.5 mg per lamp (b) medium length (> 500 mm and ≤ 1500 mm) with mercury content exceeding 5 mg per lamp (c) long length (> 1500 mm) with mercury content exceeding 13 mg per lamp	2020

10 Information that should be regarded as proprietary

LightingEurope provides to the European Commission under confidentiality a comprehensive list of lamps with average mercury content, which are in the scope of the obligation to publish such data according to the ErP Directive Implementing Measures 244/2009, 245/2009, 1194/2012 and produced by LightingEurope member companies.

List of abbreviations

ADCO	Administrative Cooperation Group
BASI	Bioanalytical Systems, Inc
BSP	Barium Synthetic (Pb^{2+}) phosphor
CCG	Conventional Control Gear
CDM	Ceramic Discharge Metal Halide
CDV	Committee Draft for Voting
CFL	Compact fluorescent lamp
CRI	Color rendering index
CRSO	Collection & Recycling Service Organization
DEFRA	Department for Environment Food and Rural Affairs
DOE	Department of Energy
ECG	Electronic Control Gear
EEE	Electrical and Electronic Equipment
ELC	European Lamp Companies Federation
EM	Electromagnetic: lamp control gear based on a magnetic coil (= CCG)
EMC	Electro Magnetic Compatibility
ERP	Energy related Products; Directive 2009/125/EC establishing a framework for the setting of eco design requirements for energy-related products
FTE	Full Time Equivalent, indicates the workload of an employed person
HF	High frequency: lamp control gear based on high frequency (= ECG)
HID	High intensity discharge lamps
HPS	High Pressure Sodium (vapor) lamps
Hz	Hertz
K	Kelvin: Unit of color temperature (2700 K warm color, 5600K cool daylight)
Lm	Lumen
LFL	Linear Fluorescent Lamps
LCA	Life cycle assessment
LED	Light Emitting Diode
LPD	Low Pressure Discharge lamp
LVD	Low Voltage Directive

mg Milligram

MH Metal halide lamps

OEM Original equipment manufacturer

OLED Organic Light-Emitting Diode

PCA Poly-crystalline alumina

PLL Pi shaped Long Length, compact fluorescent lamp

R&D Research and Development department(s)

REACH Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals, 1907/2006/EC

RoHS EU Directive 2011/65/EU on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

SSL Solid State Lighting

SVHC Substances of Very High Concern

TF Task Force

UMICORE global materials technology group which focuses on application areas where its expertise in materials science, chemistry and metallurgy makes a real difference.

UNEP United Nations Environnent Programme

UV Ultraviolet

VDE German Association for Electrical, Electronic and Information Technologies

W Watt unit of (electrical) power

WEEE Waste Electrical and Electronic Equipment

ZVEI German Electrical and Electronic Manufacturers´ Association