Request to renew Exemption 2(a)(2)

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

2(a)Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp):
2(a)(2) Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 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(a)(2) of Annex III***
LightingEurope proposes to continue using the existing wording which is:	*2(a) Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp):* *2(a)(2) Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 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(a)(2) 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(a) Mercury in double-capped linear fluorescent lamps for general lighting purposes not exceeding (per lamp):
2(a)(2) Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 mg may be used per lamp after 31 December 2011

T5 are among the most energy efficient lamps, reaching levels up to 115 lumens per watt and a lifetime of 20khrs for the regular lamps. They are widely used in offices, schools and industrial buildings as well as residential homes, with hundreds of millions of installed light points in many configurations. T5 lamps contain a small amount of intentionally added mercury in the discharge tube, which is essential to convert electrical energy in light. Mercury consumption of fluorescent tubes dropped approximately 90% in the past 20 years by implementing energy efficiency regulations, RoHS requirements and innovation programs.

The market for linear triband phosphor T5 lamps increased from 2009 to 2013 from ca. 57 Mio lamps to ca. 76 Mio lamps in EU-28 (+ 33%; VHK/VITO Study 2014, see 4.2.4). Nevertheless the corresponding overall mercury amount put on the market decreased (-16%, decrease per lamp: -40%) due to mercury reduction measures in lamp manufacturing.

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.

To the best knowledge of LightingEurope, on the European market there are relatively few T5 products available based on LED (light emitting diode) technology allowing direct replacement of T5 lamps in existing applications. They all require refurbishment (rewiring or complete luminaire replacement) of the existing fixture and the involvement of 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 requires technical changes to the luminaire (rewiring), especially in T5 luminaires which are exclusively equipped with electronic control gears.
2) Applicable legal and compliance requirements like conformity assessments, declaration, and labelling of the changed luminaire are needed. The person installing the LED based solution is responsible to perform testing and measures to ensure the new system fulfils these requirements.
3) Different light distribution: due to the LED tubes changed optical characteristics vs. the existing linear fluorescent lamps.

Very good performance and slim design of a T5 lamp, requires a break-through in electronics miniaturization and heat management to meet the high T5 energy efficiency standards, at somewhat reasonable costs. This is still difficult.

LED lamps do contain electronic components as well as materials which like nearly all other electronic equipment use the RoHS regulated substance lead in applications exempted by Annex III of the Directive.

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. With a conservative assumption of the replacement of 200 million luminaires 100 billion € would be needed (500€ per luminaire incl. installation) creating 2 Mio tons WEEE (10 kg each) of still functional and energy efficient equipment.

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 tri-band phosphor linear fluorescent T5 lamps for general lighting not exceeding 3.0 mg per lamp as summarized in Table 1:

Requirement according RoHS Article 5(a)	Status for mercury in linear triband phosphor fluorescent T5 lamps for general lighting not exceeding 3 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 T5 linear fluorescent lamps is scientifically and technically impracticable. Currently there are no significant T5 LED lamps available in the market. Alternatively installed luminaires can be replaced with very high socioeconomic impact by mercury-free fixtures. This solution requires lead in materials and electronic applications currently exempted according Annex III of the RoHS Directive.
the reliability of substitutes is not ensured,	There are no fully compatible T5 LED lamps aiming at direct replacement of conventional T5, hence their reliability cannot be judged, Correctly installed LED based 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.	LED based luminaires so far do not reveal a clear general environmental benefit, e.g. energy efficiency is not higher than in conventional luminaires based on T5 lamps

Table 1: Requirements according RoHS Article 5/a) and their fulfilment for mercury in T5 linear fluorescent lamps for general lighting not exceeding 3 mg per lamp

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.

4 Technical description of the exemption request

4.1 Description of the lamps and their applications

4.1.1 Lamps covered by this exemption

This exemption covers Mercury in double-capped linear fluorescent Tri-band phosphor lamps for general lighting purposes with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5). The maximum allowed mercury dose is currently 3 mg per lamp.

All lamps currently put on the EU market by members of LightingEurope are T5 lamps with standardised dimensions and base. These lamps with a diameter (d) of ca. 16 mm and different lengths (l) are very economical, offer a good quality of light having an excellent luminous flux. They are extra slim and compact with good average lifetime with suitable electronic control gear. Regarding the main applications (see 4.1.2) the lamps are in use mainly in professional areas but also in private homes.

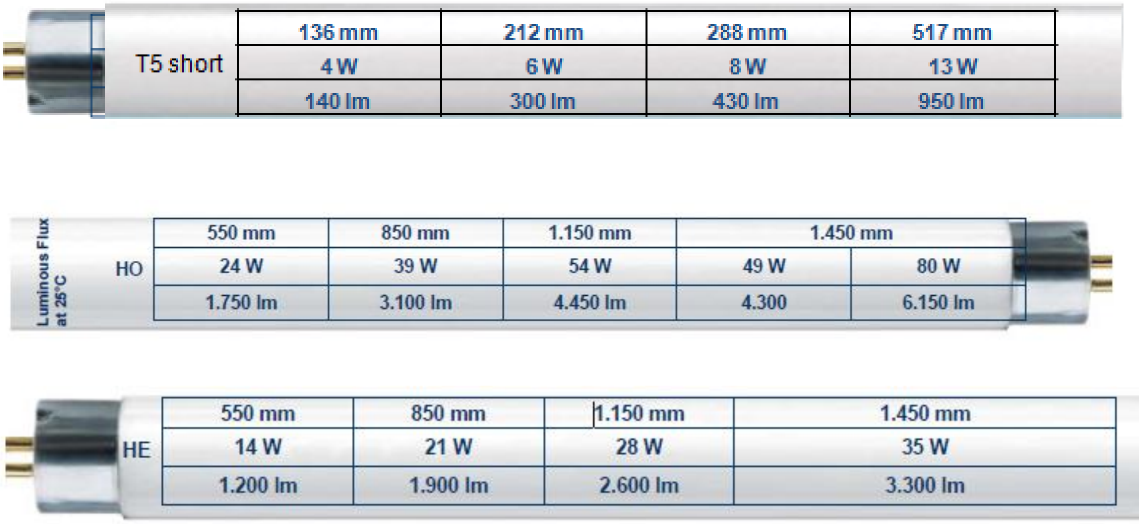

Figure 1: Picture of T5 lamps indicating different types, lengths, Wattages, lumen output (HO = limps with high lumen output, HE = lamps with higher efficiency)

Further description:

- Available types and wattages (main types used in EU): 4- 80 W
- Available Colour Temperatures: 2.700K up to > 6.500K
- Typical Colour Rendering Index (Ra): 80- >90
- Average Lifetime[1]: Typically ca. 20.000h on an electronic control gear
- Base (standard designation acc IEC/EN60061): G5 (bi-pin),
- Dimmable

Figure 2: Picture of a T5 lamp base G5 (bi-pin)

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

[1] Here: **Average rated lamp life (B50)** which is the average value of the life values of individual lamps operated under standardized conditions (50 % failure). In other words, this is the operation time at which for a standardized 3-hour switching cycle (165 minutes on/15 minutes off in accordance with IEC 60081 and IEC 60901) 50 % of asample population of lamps have failed.

voltage. T5 luminaires are operated nearly exclusively with electronic control gears (ECG) which brought several advantages compared to conventional control gears (CCG) regarding power consumption, lifetime, maintenance costs, temperature behaviour, switching, flicker, dimming etc..

There are numerous different control gears available on the market offering various functionality. They are used depending on the customers/users requirements, such as dimming, temperature range, light management systems, emergency lighting, single or multi lamp drive, stand-alone luminaire vs. multi-luminaire lighting system etc.. 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 Applications covered by this exemption

T5 fluorescent lamps are designed for operation in standardised luminaires, operating with an electronic control gear in nearly all areas of public and private life, e.g. offices, public buildings, museums, shops, supermarkets and department stores, industry, restaurants, tunnels and many more, see figure 3.

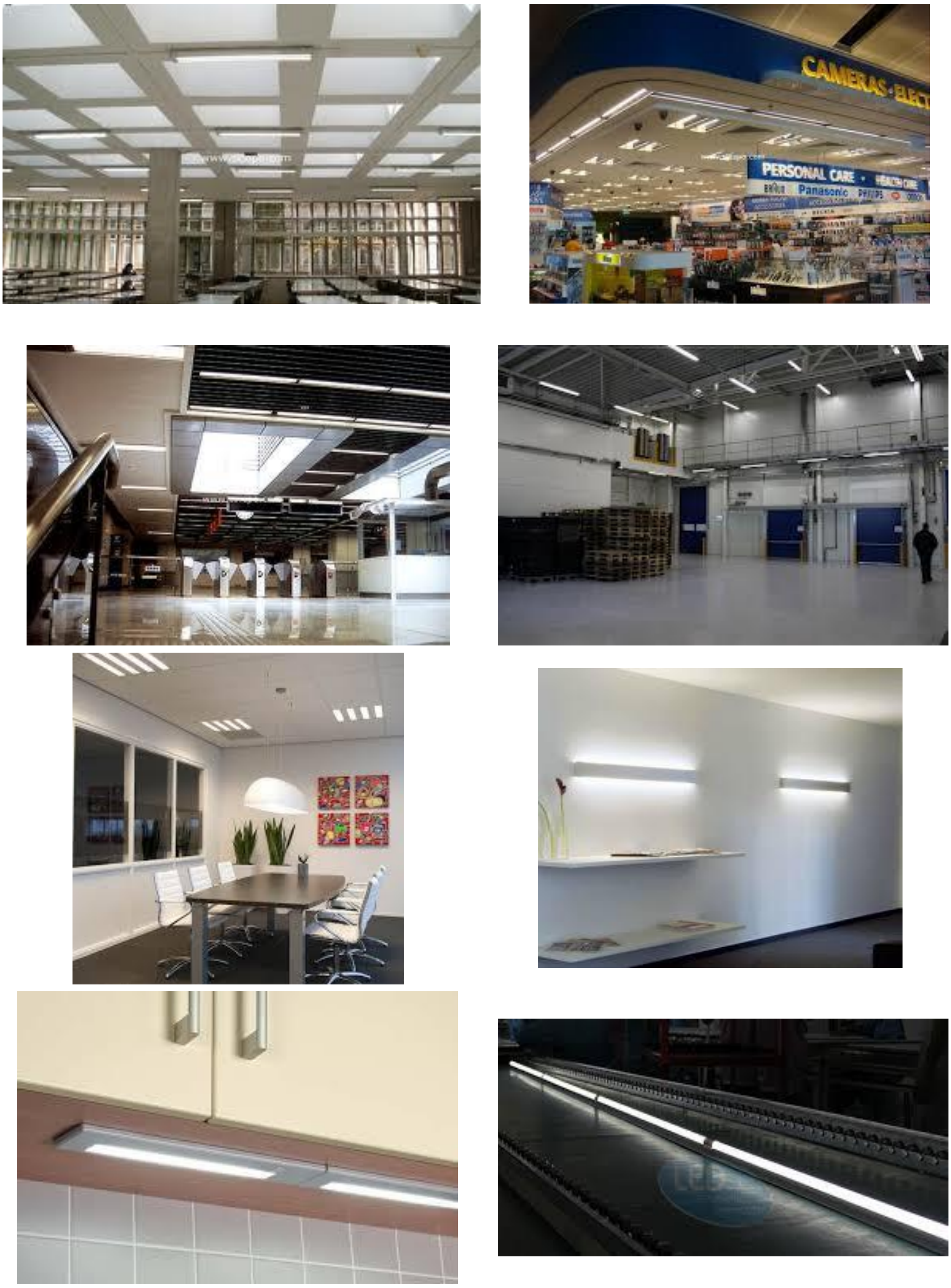

Figure 3: T5 linear fluorescent lamps are used in nearly all areas of private, economical or public life

4.1.3 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(a)(2) 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.

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 4 below). The composition of the coating determines light colour and colour rendering.

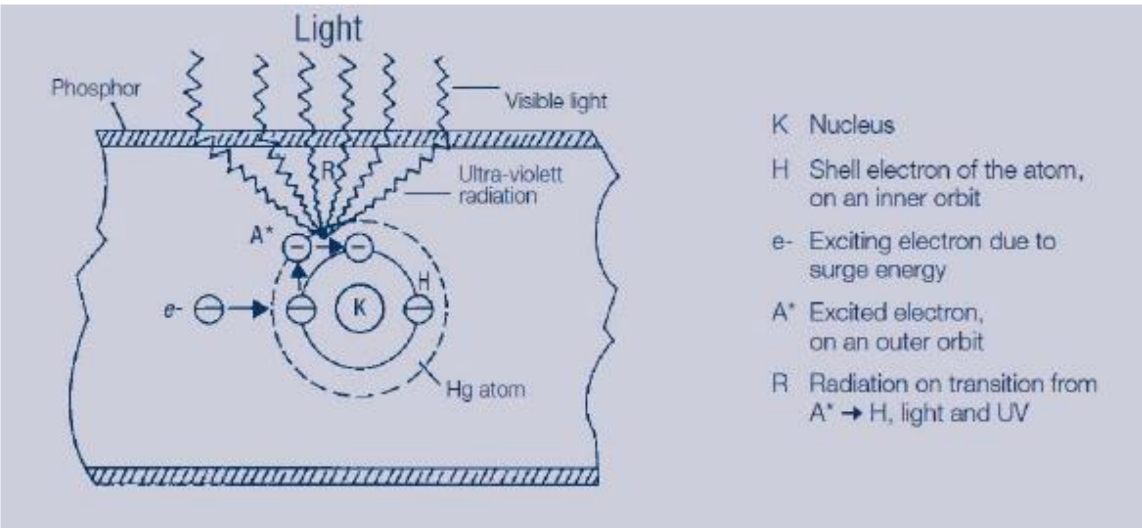

Figure 4: Electrical current is passed via the two filament electrodes through the tube which is filled with partially ionized gas. The electrons excite mercury atoms to emit short-wave ultra-violet light, which is converted into visible light in the phosphor layer on the inside of the tube. Different light colors are produced depending on the phosphor mix [2].

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

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 5.

- 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

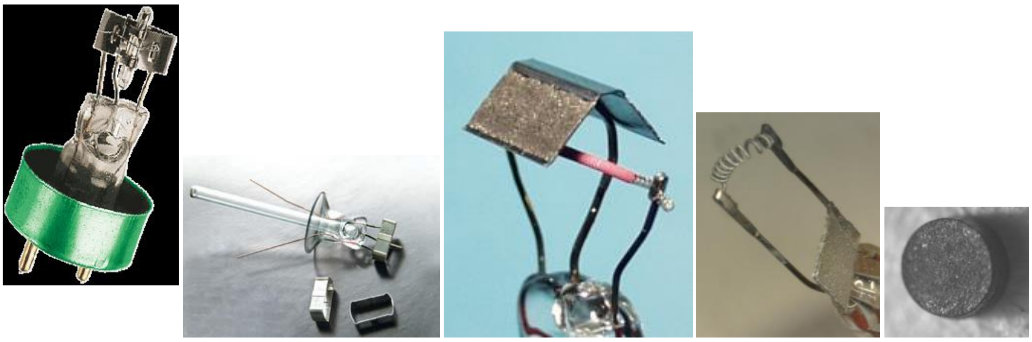

Figure 5: Mercury dosing technologies
From left: Hg-capsule; metal-alloy[3], metal alloy "roof", metal alloy "flag", HgFe pill

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.

[3] I. Snijkers-Hendrickx et. al., Low-mercury containing discharge lamps, 2007,

During lamp life, mercury is consumed inside the discharge tube itself. It is bound amongst others to the phosphor layer and the glass.[4]

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 around the nominal dose, while the threshold value as set by RoHS Directive sets a maximum limit of 3 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[5] with effect between 2012 and 2013. The maximum mercury content of linear T5 lamps had to be reduced from 5 mg to 3 mg per burner as of 1st Jan 2012.

In order to be able to dose the required amounts of mercury well below 5 mg, precise technologies are necessary and available[6]. 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 2.5 mg can vary between 1.5-3.5 mg (see Figure 6). 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 2.0 mg, the needed RoHS value in this example may be as high as 3 or higher[7].

Figure 6 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

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[4] *Reference: I. Snijkers-Hendrickx et al, Low-Mercury Containing Discharge Lamps. Sustainable and Environmental Friendly Lighting Solutions, LS 11*

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

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

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

mercury content as X.X mg in their product documentation according to ErP Implementing Measure requirement[8].

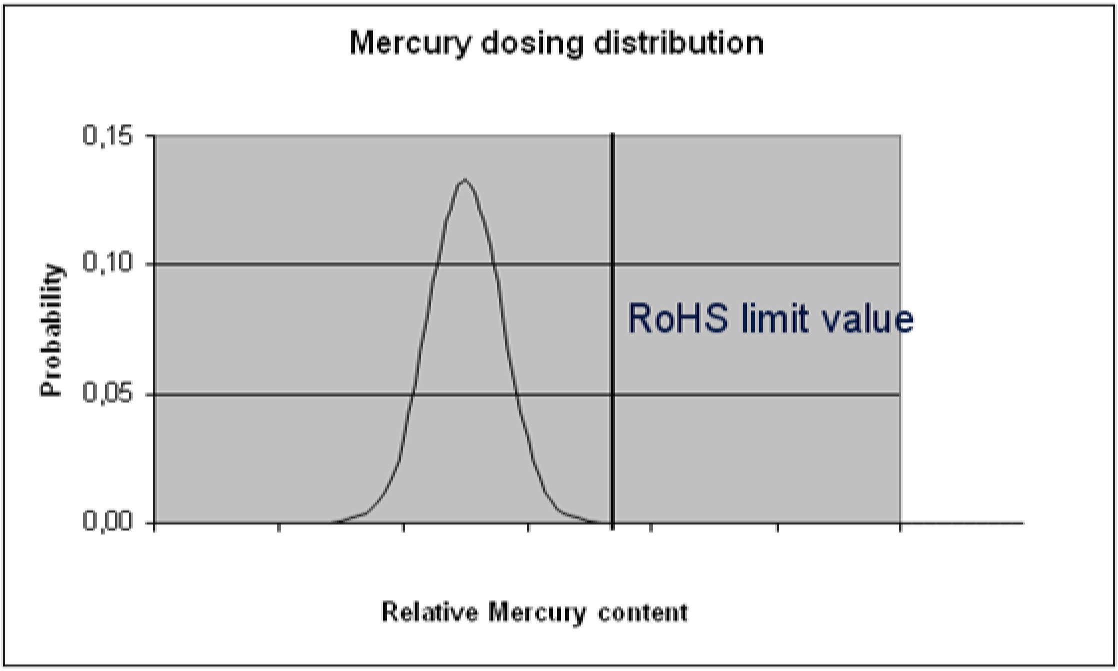


Figure 6: Simplified illustration (example only) of the effect of mercury dosing variance, where average value needs to be chosen lower than the RoHS limit value. The graph displays measurements of the mercury content in dosing units performed as quality control during their production, here FeHg pill.

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 per lamp. But there are many processes within the burner that 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 not shortened due to a too low available amount of mercury. Therefore a balance has to be found taking into account mercury needed over lifetime, mercury

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

variance per dosing unit but also the measurement failure when estimating the amount of mercury in a lamp for market surveillance.

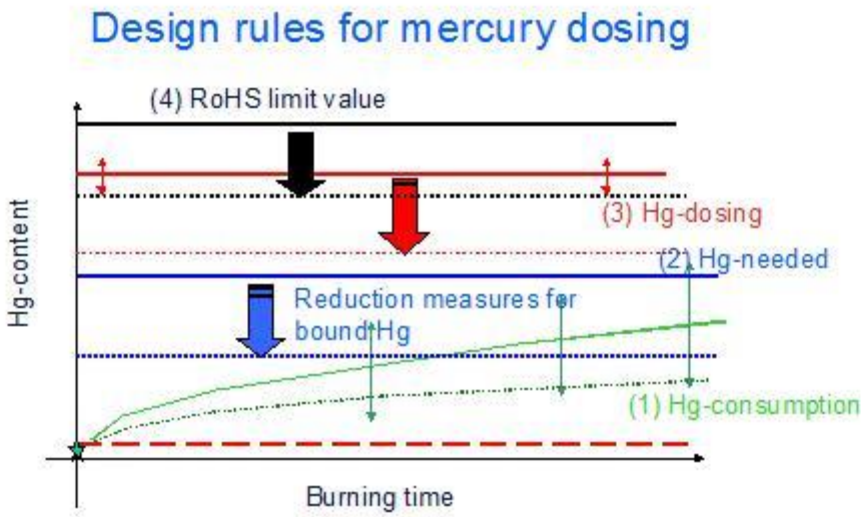


Figure 7: Design rules for mercury dosing in fluorescent lamps, schematically showing the process of setting RoHS limit values based on insights in mercury consumption and mercury dosing.

The lowest (red dashed) line in figure 7 gives the ideal situation for a low pressure mercury discharge: there is just enough mercury for the discharge to properly function. For a T8 fluorescent lamp this is typically in the order of 60 micrograms per lamp (in the gas-phase), depending on the lamp dimensions. However, because of the several mercury consumption mechanisms a significantly higher amount must be dosed (which will be explained below). So up to now a lamp with normal functional properties over lifetime, but dosed with only 60 microgram could not be designed.

In practice, mercury from the discharge gets consumed over lamp life. The amount of this consumption is much higher than that what the gas discharge needs for functioning. The mercury gets mostly deposited and effectively bonded to the glass and the phosphor layer. This is reflected by the solid green curve (1) in figure 7, 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). To obtain the designed lamp life, the right amount of mercury has to be dosed, taking into account the consumption during lamp lifetime and the variance. In figure 7 solid blue line 2 represents the typical amount that is needed and solid red line 3 is the amount that also incorporates the variance. Alternatively, this target value is called nominal or average value, and can be listed in catalogues. This average value is lower than the threshold value so the actual amount per lamp is lower than the limit set by the directive.

The solid black line 4 in figure 7 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[9],[10](the lifetime and performance are regulated) and

(2) to be able to demonstrate in internal manufacturer's tests and in market surveillance tests 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. Figure 7 shows the dosing variety relatively to the RoHS threshold value.

Next to the important effect the variance in mercury dosing has on setting the average dose lower than the threshold value as prescribed in the RoHS directive, there is another effect on the low end-side of the dosing. The lower the amount that is available in the lamp, the lower the lamp lifetime as mercury is consumed during operation. This can result in too early failure, thus a customer risk as already mentioned, but next to this there

[9] *Commission regulation (EC) No. 244/2009, March 18, 2009*
[10] *Commission regulation (EC) No. 245/2009, March 18, 2009*

are criteria set on lamp lifetime and lamp survival factor in other directives and regulations[11],[12].

Key to the reduction of mercury that has been applied by lamp manufacturers in the previous decades is influencing the factors that determine mercury consumption. These include:

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

Path	Mechanism	Main Promoter	Source	Location of bound Hg
Oxidation	Hg+ + x O → HgOx	impurities prematerials	processing coating	coating
Amalgamation	Hg+ + Me → 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 2: Main mercury consumption mechanisms oxidation, amalgamation, adsorption and absorption. 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.

Table 2 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.

In figure 8 below is the measurement of the Mercury consumption of a certain T5 lamp.

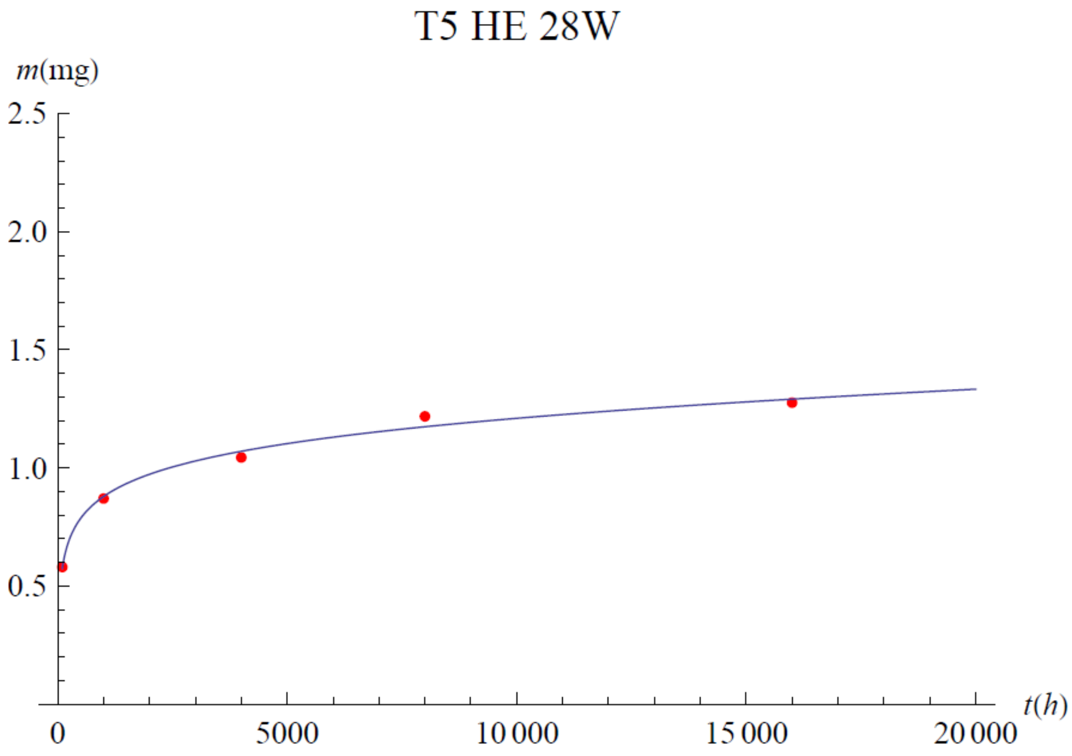


Figure 8: Mercury consumption of a certainT5 lamp 28 Watt with a Hg dosing of 2.2 ± 0.3 mg

Measurements of mercury consumption as displayed in Figure 8 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 T5 lamps marketed in EU-28:

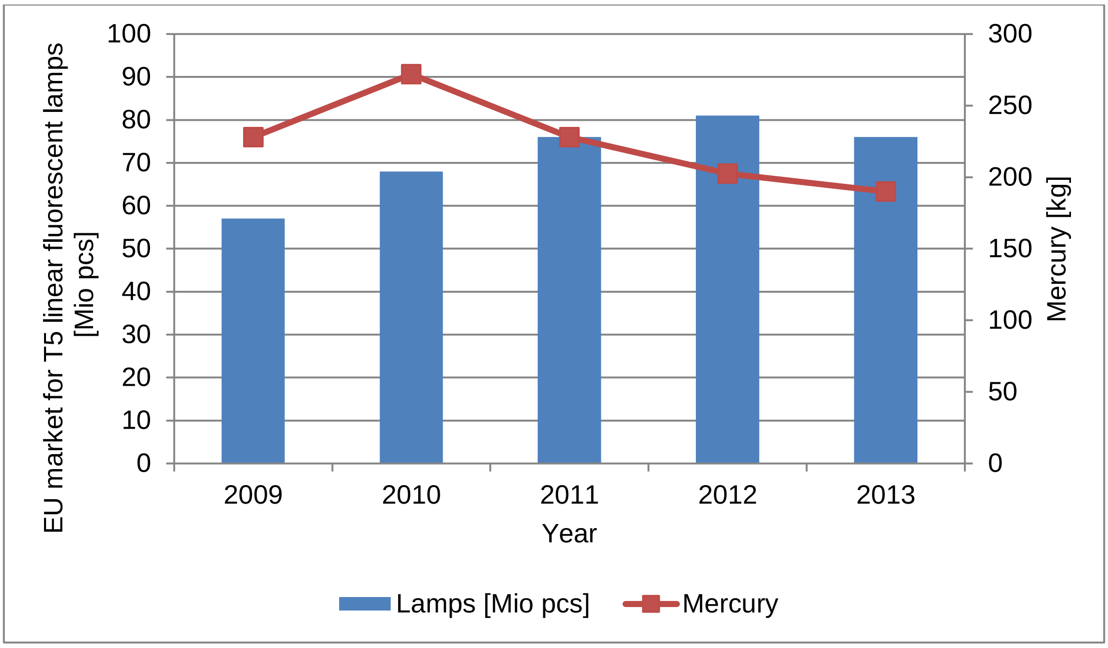
Linear T5 lamps for general lighting as covered by exemption 2(a)(2) is a very big segment of all linear fluorescent lamps.

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[13]. 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 3,0 mg was introduced and the estimated 2.5 average is close to the corresponding Max-value. The data show a growing market for T5 from 2009 to 2013 (+33%) while the overall estimated mercury decreased (-16%, decrease per lamp: -40%).

EU-28	2009	2010	2011	2012	2013
T5 (14 - 80w) [Mio pcs]	57	68	76	81	76
Mercury [kg]	228	272	228	203	190
Average Hg amount per lamp [mg]	4	4	3	2.5	2.5

Table 3: Linear T5 fluorescent lamps [Mio pcs] and corespondingl mercury amount put on the EU market (see text) per year[14]. Estimation of mercury amounts was done by LightingEurope.

[13] 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
[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



Tables 4: Overall market of linear T5 fluorescent lamps [Mio pcs] and overall mercury amount put on the EU market (see text) per year[15]. Although sales of T5 lamps increased (33%) the overall amount of mercury put on the market decreased(-16%),

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.[16] This means that currently the efficacy of the lamp is the main determining parameter. Specifically regarding mercury, the biggest amount of mercury is released to the environment by power plants when generating electrical energy (especially when coal is the primary power source).[17] Technological advancements in the lighting industry have resulted in a significant reduction in the amount of mercury used in many types of fluorescent lamps over the last

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[15] 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
[16] *(see Enlighten report, Section 5, Ch. 3 fig. 4 & 5)*
[17] *(see Enlighten report, Section 5, Ch. 3 fig.6)*

two decades.[18] Manufacturers have developed technology that enables a small amount of mercury to be 'dosed' or placed inside a fluorescent lamps such as T5.[19]

For the future however the manufacturing part in the LCA becomes more relevant[20], because the energy consumption by the lamp is already dramatically reduced (higher efficacy leads to decreased negative environmental impact).

The total life cycle environmental impact of the light sources is relevant due to the importance of the lighting sector in the total energy consumption. The lighting sector contains many different light sources of different shapes and sizes. The environmental and economic performance comparison of those various types is difficult, due to lack of established rules for the LCA of light sources. As a result, it creates distortion and makes it difficult to numerically compare the results of the LCAs. The recyclability of TL fluorescent lamps is close to 100% (glass, metal, mercury is reused, tri-band phosphor recycling under investigation).

Historically the comparison was done with respect to incandescent lamps[21] where it was concluded that the net mercury emission over life cycle is reduced when changing from incandescent to CFL lamps. More recently LCA is done in comparison with LED sources[22], however here it is even more challenging to compare these various-shaped LED light sources to conventional lamps and luminaires. LED technology provides new possibilities

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[18] *ENERGY STAR. (2012). Frequently Asked Questions Information on Compact Fluorescent Light Bulbs (CFLs) and Mercury. Retrieved March 29, 2012, from: http://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf, UNEP toolkit, p.106*

[19] *Complete paragraph UNEP toolkit, p.106*

[20] *Life cycle assessment of light sources – Case studies and review of the analyses Leena Tähkämö, Aalto University publication series DOCTORAL DISSERTATIONS 111/2013*

[21] *Pfeifer RP.Comparison between filament lamps and compact fluorescent lamps. International Journal of Life Cycle Assessment 1996; 1: 8—16.; Parsons D. The environmental impact of compact fluorescent lamps and incandescent lamps for Australian conditions. The Environmental Engineer 2006; 7: 8—14; Gydesen A,Maimann D. Life cycle analyses of integral compact fluorescent lamps versus incandescent lamps: RightLight, Stockholm, Sweden, 1991*

[22] *Department for Environment, Food and Rural Affairs (DEFRA).Life Cycle Assessment of Ultra-Efficient Lamps.Navigant Consulting Europe Ltd. 2009.; Analysis and comparison of incandescent, compact fluorescent lamps and light emitting diode lamps in residential applications, The scientific consulting group inc. (2010) submitted to the U.S. environmental protection agency office of the science advisor; Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products, The U.S. Department of Energy (DOE) building technologies office; Life cycle assessment of light sources – Case studies and review of the analyses, Leena Tähkämö, Aalto University publication series DOCTORAL DISSERTATIONS 111/2013; Life Cycle Assessment of Ultra-Efficient Lamps SPMT08_069, Navigant Consulting Europe, Ltd. A research report completed for the Department for Environment, Food and Rural Affairs,*

for manufacturers to design luminaires, lamps, components and packages containing LED chips, thus the question on which basis those should be compared remains.[23]

LED lamp product manufacturing uses considerably more energy than does the manufacturing of a fluorescent lamp with comparable light output[24]. However one must consider the improving LED alternative in the right perspective: according to reference[25] the LED sources are expected to have a real advantage in the total life cycle over time, at least if efficiency keeps improving at the same rate and given their relatively long life.

For T5 lamps no significant LED retrofit solutions are currently available in the EU market, which can be used in a T5 luminaire. Instead new LED solutions are replacing T5 lamps/luminaires in new products, such as LED luminaires.

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[23] *Life cycle assessment of light sources – Case studies and review of the analyses Leena Tähkämö, Aalto University publication series DOCTORAL DISSERTATIONS 111/2013, p. 17-18*

[24] *U.S. Department of Energy. (2012). Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products. Retrieved March 10, 2012 from*

[25] *Life-Cycle Assessment of Energy and Environmental Impacts of LED Lighting Products, The U.S. Department of Energy (DOE) building technologies office*

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. Below picture shows the various steps in the recycling process:

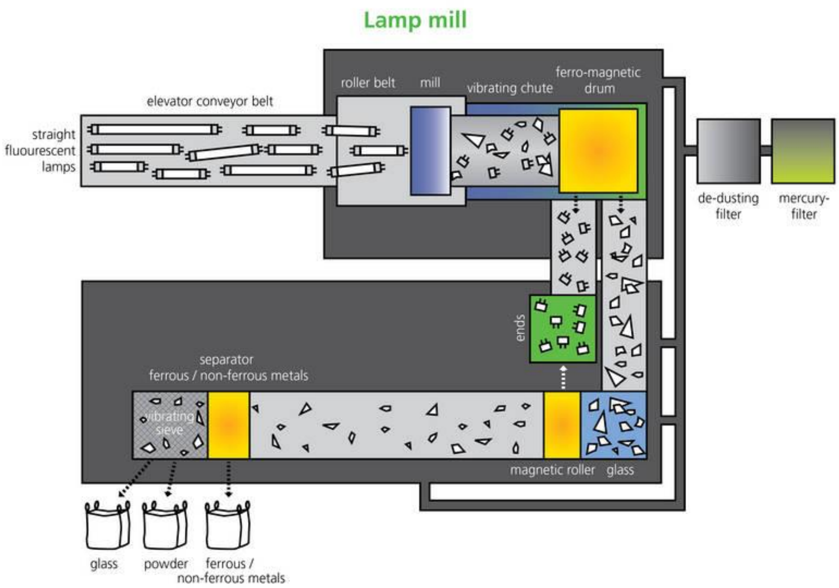

Figure 9a Recycling steps of fluorescent lamps in Indaver (Belgium).
Source: www.indaver.be/waste-treatment/recycling/mercurial-waste.html

The next picture illustrates the specifics of recycling the mercury:

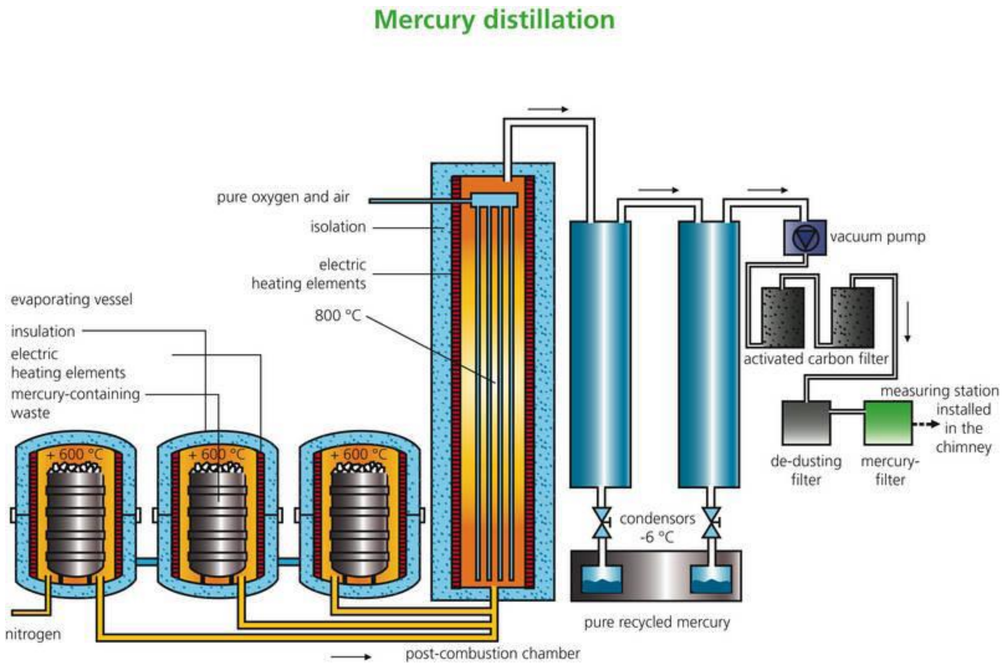

Figure 9b Specific recycling steps of mercury in Indaver (Belgium

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 10: 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:

Linear T5 lamps for general lighting as covered by exemption 2(a)(2) is a very big segment of all linear fluorescent lamps.

The market for linear triband phosphor T5 lamps increased from 2009 to 2013 from ca. 57 Mio lamps to ca. 76 Mio lamps in EU-28 (+ 33%; VHK/VITO Study 2014, see 4.2.4). Nevertheless the corresponding overall mercury amount put on the market decreased (-16%, decrease per lamp: -40%) due to mercury reduction measures in lamp manufacturing.

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.

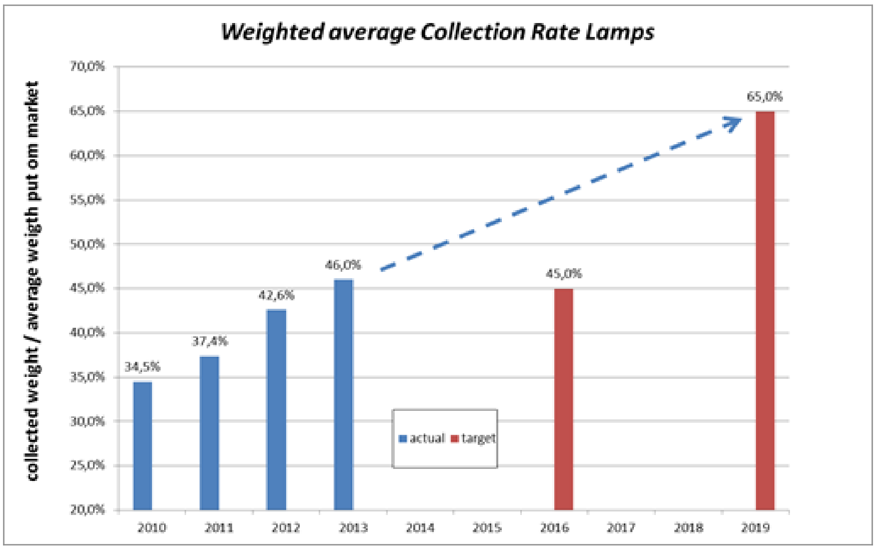

Figure 11: Weighted average Collection Rate Lamps (all lamps): 2010 – 2013 (blue) and targets 2016-2019 (red)

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

- 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 12, status per 2009).

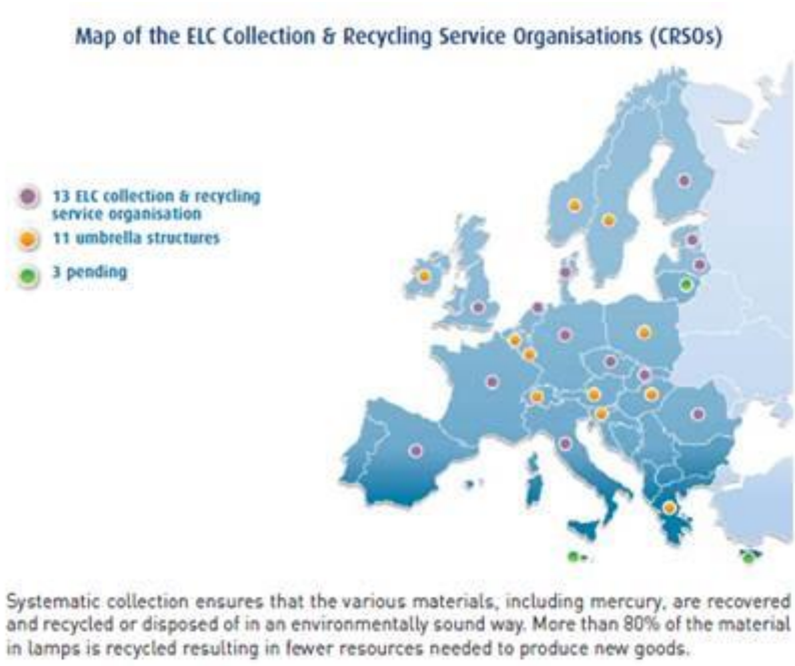

Figure 12: Map of ELC Collection and Recycling Service Organisations (CRSOs). Source: Environmental aspects of lamps[26]

6 Substitution

Can the substance of this exemption be substituted?

☐ Yes, by
- ☐ Design changes:
- ☐ Other materials:
- ☐ Other substance:

☒ No
Justification: see in below chapters

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

6.1 Substituting mercury in the fluorescent technology

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 13)

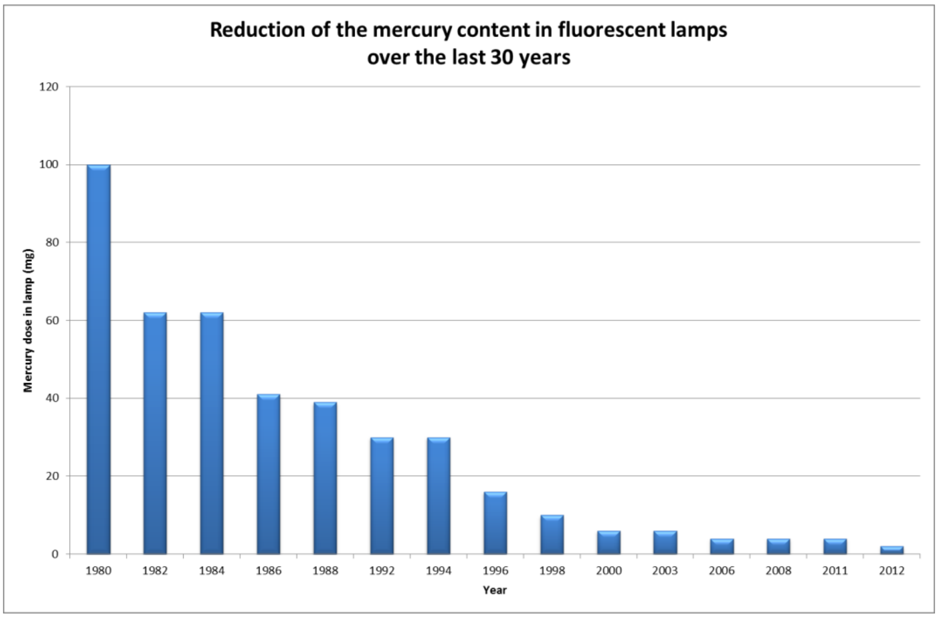

Figure 13: Mercury content of fluorescent lamps

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[27].

Attempts to generate UV with noble gases succeeded partially[28]. 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[29] prohibited progress in this direction.

[27] *M Haverlag, Mercury-free discharges for lighting, J. Phys. D: Appl. Phys. 40 (2007)*
[28] *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)*
[29] *J. Dexpert-Ghysa, Re-processing CRT phosphors for mercury-free applications, J. of Luminescence, 129, 1968, (2009)*

Other alternatives investigated are low pressure metal halides (for example InI, InBr, GaI3)[30]. Such plasma's generate the visible light directly without the Stokes shift of the phosphor[31]. 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 lm/W. As no solution for improvement has been found and regular Hg 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 require a very large R&D effort. As considerable research has already been carried out without success further research is also not likely to develop alternatives to mercury in fluorescent lamps and any alternative will probably be less efficient having 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[32]. 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 manufacturers laboratories as

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[30] *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.*

[31] *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.*

[32] 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;

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 Lighting Applications”, published 2011 at the university of Augsburg, S. Briefi shows that currently about 30lm/W might be reached with a potential to get up to 60lm/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

Considering mercury free lamps, they have been present on the market since years, e.g. incandescent or tungsten halogen lamps. However those cannot be treated as proper replacement for linear fluorescent lamps in existing or new applications. Lamps and luminaires based on LED technology, show much more opportunities and are rapidly entering the market. However they have specific technical and performance characteristics that need to be considered and that prevent immediate change-over. Those will be discussed in this chapter in detail.

6.2.1 Feasibility of alternatives

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). Currently LightingEurope is not aware of any relevant T5 LED replacement lamps being available on the EU market.

LightingEurope describes four key aspects that need to be considered when evaluating potential LED based replacement for conventional T5 based lighting applications: (1) electrical compatibility, (2) Light distribution and lumen output, (3) Lack of standards.

Replacement lamps

The LED T5 replacement market is in its very initial stage. The key challenge, relates to very slim design of a T5 lamp. It requires efforts in electronics miniaturization and heat management, while meeting T5 energy efficiency standards at reasonable costs. To the best knowledge of LightingEurope members this has not been broadly solved yet. None of the key players offer direct T5 LED lamps replacement. Only limited examples of such lamps can be found on European market and none of them can be considered as fully compatible with existing applications, due to following issues:.

(1) Electrical compatibility

T5 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. ECG drivers are 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.

For the purpose of this exemption renewal request LightingEurope would like to refer and adapt definitions used in a document "LED lamps as substitutes for fluorescent lamps" [33], by the German associations ZVEI[34] and VDE[35]. This document explains the use of double-capped LED lamps with G13 caps (e.g. LED tubes) in existing luminaires. Two possible situations of replacing a linear fluorescent lamp with G13 cap (e.g. fluorescent T8) are mentioned there being the retrofit and conversion *lamps*. Lighting Europe prefers to refer to the retrofit and conversion *routes.* LightingEurope is of the opinion that those definitions can be also applied to T5 situation.

- Retrofit route: a fluorescent lamp is substituted by a LED tube. The luminaire itself is not rebuilt[36] and the control gear remains in the installation[37]. 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[38].

Contrary to T8 LED based lamps, which are available in both retrofit and conversion route options at present retrofit route for T5 LED replacement lamps is not possible. End-user, customer and consumer will be forced to refurbish his existing installation. Either by taking

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[33] ZVEI and VDE document LA-T 2012-025: "LED lamps as substitutes for fluorescent lamps", 2012 http://www.zvei.org/Publikationen/LED%20tubes%20-%202012-01-26%20english.pdf

[34] ZVEI - Zentralverband Elektrotechnik- und Elektronikindustrie e.V, Eng: German Electrical and Electronic Manufacturers' Association, www.zvei.org;

[35] VDE - Prüf- und Zertifizierungsinstitut, Eng: VDE Testing and Certification Institute, www.vde.com

[36] Op.cit. ZVEI

[37] 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

[38] Op.cit. ZVEI

out the control gear from his existing application (rewiring) or changing complete luminaire.

In assessing the suitability of any specific product or installation the user must make his own judgement and/or take appropriate advice[39]. 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*[40] *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 applicable to the modified luminaire. In this case, the modified luminaire would be considered as a new product"*[41].

The above provided information clearly indicates that replacing T5 fluorescent lamp with LED tubes is a complex process, as currently lamp T5 LED lamps are not available in retrofit route option.. 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[42]": "the use of LED tubes as replacement lamp for fluorescent lamps is a typical product causing

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[39] 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

[40] 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

[41] 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

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

controversy." There is a lack of standardization and inspection to evaluate solid state lighting (SSL) products[43] often resulting in overstated and misleading manufacturer performance claims[44]. 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 13a and 13b)[45]. 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[46].

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).

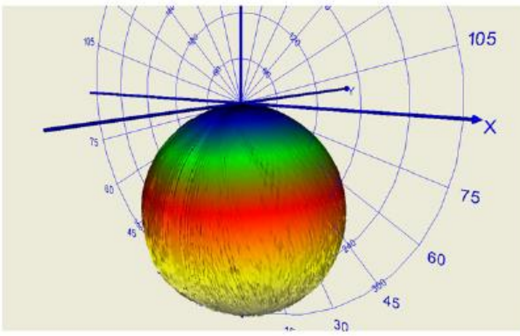

Figure 13a Luminous intensity distribution (3D) – brand K. Source: "Linear LED tubes…" W.R. Ryckaert and others, p. 431

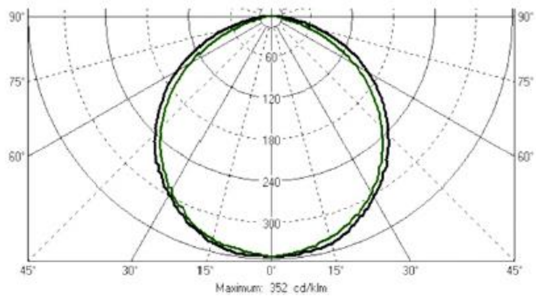

Figure 13b Luminous intensity distribution C0-180 (black) and C90-270 (green) – Brand K. Source: "Linear LED tubes" W.R. Ryckaert and others, p. 431

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[43] 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

[44] 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

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

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

(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 an 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.

New Installations

Linear LED luminaires are providing a viable alternative to the traditional fluorescent tube with such features as: efficacy, energy efficiency, and design flexibility and appearance. But the quality and performance of LED products varies among manufacturers.[47] Many conformity and performance related issues are solved. Dedicated designed luminaires directly comply as a system with all safety and standardization legislations is tested and confirmed by the luminaire manufacturer.

If a luminaire is broken in an existing installation or a customer wants to refurbish an existing installation with build in, recessed luminaires in the ceiling, the replacement LED luminaire should be able to fit in the existing space and give the same light distribution. Described earlier challenges that customer might be confronted with (e.g. illuminance), will not be solved in many cases with one-to-one luminaire replacement. A customer will be forced to refurbish his ceiling and/or building, make a new lighting design and replace all existing luminaires, while many of them still operating properly.

47 “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

6.2.2 Feasibility and availability of the alternatives

Currently there are no substantial amounts of LED based lamps for direct T5 replacement in existing applications. Main reasons are the architecture of a T5 lamp, technical and safety requirements. Although developments in electronic circuitry and lumen/watt improvement are ongoing, it is not clear when those improvements can be introduced to the market.

This is why the T5 lamps are still needed in the market, for new luminaires as well as for replacement in installed, fixtures, equipment, appliances, installations or luminaires.

6.2.3 Impacts of substitution

As T5 LED replacement lamps are not broadly available the impact of such a substitute cannot be estimated. Also LightingEurope is not aware of comparisons between T5 fluorescent lighting solutions and new LED based technologies. This kind of comparison could be difficult as these two solutions might not be one to one comparable. 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. Some aspects of a potential substitution should be mentioned here:

6.2.3.1 Environmental impact of substitutes

Overall T5 linear fluorescent lamps are very efficient light sources with efficiencies of up to >115 lumen per Watt and excellent light quality.

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.

Energy saving by dimming or switching of the light in the absence of people in the room is both possible for discharge lamps with a suitable controller and LED based systems.

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 linear fluorescent T5 lamp, including exchange of the lamps by professionals. It is inevitable that linear T5 LED replacement lamps would also be installed by people who are not qualified professionals if T5 fluorescent 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 T5 lamps.

In case T5 fluorescent lamps would no longer be available for existing installed lighting solutions, 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. 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. With a conservative assumption of a replacement need of 200 million luminaires 100 billion € would be needed (500€ per luminaire incl. installation) creating 2 Mio tons WEEE (10 kg each) of still functional and energy efficient equipment.

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 (EU-28) but mostly in Asia.

Material and manufacturing costs on one-to-one basis are significantly higher for LED tubes than conventional T8.

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.

Allowing this exemption will not affect innovation into new LED technology. Innovative R&D into T5 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 an increase of the use of LED based technologies. On the other hand the number of T5 lamps sold in EU is still very high due to the extraordinary energy- and resource efficiency as well as optical properties. T5 lamps are very reliable as they are in the market since decades and do not contain electronic components. The lamps are easily replaceable. In 2013 ca 76 Mio lamps were marketed in EU-28, data forecast for 2014 is not yet available.

Due to the very wide range of applications LightingEurope believes that there is a market need for lamps covered by this exemption for more than 20 years.

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
  - ☐ Proposal inclusion Annex XIV
- ☐ Restriction
  - ☐ Annex XIV
  - ☐ Annex XVII
  - ☐ Registry of intentions
- ☐ Registration

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 T5 linear fluorescent lamps as described above. No technologies could be developed having similar high efficiencies.

8 Reduction of mercury content of lamps

For fluorescent lamps a high effort was necessary to implement all limit changes coming in force in 2010[48] with effect between 2012 and 2013. The maximum mercury content of T5 lamps had to be reduced from 5 mg to 3 mg per burner as of 1st Jan 2012. Also further reductions have been made for certain lamp types, improving mercury consumption as described above in detail.

Further reduction of mercury might technically be possible with high economic effort and R&D resources. 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.

[48] 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

Table 5: Regulation on mercury added lighting products in Minamata Convention 2013

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