

**MINAMATA
CONVENTION
ON MERCURY**

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**Conference of the Parties to the
Minamata Convention on Mercury
Fourth meeting**

Online, 1–5 November 2021*

Item 4 (a) (i) of the provisional agenda**

**Matters for consideration or action by the Conference of
the Parties: mercury-added products and manufacturing
processes in which mercury or mercury compounds are
used: review of annexes A and B**

Review of annexes A and B**Organized and enhanced compilation of information submitted
by parties and stakeholders****Note by the secretariat**

1. As is explained in the note by the secretariat on the review of annexes A and B (document UNEP/MC/COP.4/4), the Conference of the Parties, in its decision MC-3/1, established an ad hoc group of experts to prepare a document in which it would enhance and organize the following information submitted by parties:

(a) Information on mercury-added products and on the availability, technical and economic feasibility, and environmental and health risks and benefits of non-mercury alternatives to mercury-added products;

(b) Information on processes that use mercury or mercury compounds, and on the availability, technical and economic feasibility, and environmental and health risks and benefits of mercury-free alternatives to manufacturing processes in which mercury or mercury compounds are used.

2. The ad hoc group organized the information received from parties and others in a tabular format under the following headings:

- (a) Category of product or process
- (b) Further description of the product or process
- (c) Information on the use of the product or process
- (d) Information on the availability of mercury-free alternatives or those with less mercury
- (e) Information on the technical feasibility of alternatives
- (f) Information on the economic feasibility of alternatives

* The resumed fourth meeting of the Conference of the Parties to the Minamata Convention on Mercury is to convene in person in Bali, Indonesia, and is tentatively scheduled for the first quarter of 2022.

** UNEP/MC/COP.4/1.

- (g) Information on the environmental and health risks and benefits of alternatives
- (h) Additional information being submitted on mercury-added products pursuant to paragraph 4 of article 4 of the Convention not addressed above (e.g., manufacture and general trade or other information), if any
- (i) Other relevant information pursuant to decision MC-3/1
- (j) References

3. The annex to the present note, which has not been formally edited, contains the enhanced and organized compilation of the information and comprises the 10 sections listed below:

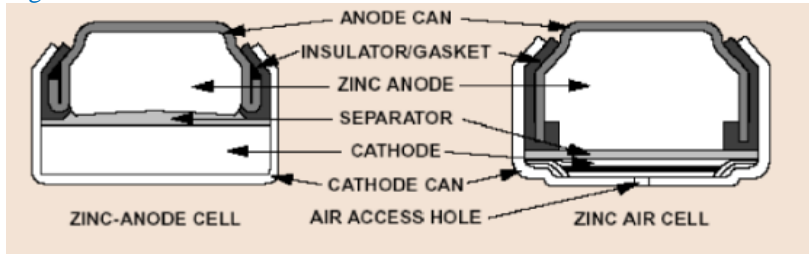
- (a) I. Batteries
- (b) II. Switches and relays
- (c) III. Lamps
- (d) IV. Non-electronic measuring devices
- (e) V. Other electronic devices
- (f) VI. Other non-electronic products
- (g) VII. Cosmetics
- (h) VIII. Pesticides, biocides and topical antiseptics
- (i) IX. Satellite propulsion
- (j) X. Manufacturing processes in which mercury or mercury compounds are used

4. The summary report of the ad hoc group is set out in annex I to document UNEP/MC/COP.4/4.

Annex*

I. Batteries

Information received from EU, Canada, Japan, Indonesia, USA and other stakeholders (BAJ, IPEN, NRDC, ZMWG)

1. Category of mercury-added product	Batteries
2. Further description of the product	Mercury-containing button cells
3. Information on the use of the product	<p>EU</p> <p>Currently, there are three types of button cell batteries that contain mercury: zinc air, silver oxide and alkaline. These batteries contain mercury in small amounts (typically 0.1-2%) and the purpose of mercury in the cell is to prevent the build-up of hydrogen gas. The mercury acts as a barrier to the production of hydrogen and as such prevents the cell swelling and becoming damaged.</p> <p>Figure 1 – Cross Section of Zinc Anode Button Cell and Zinc Air Button Cell (European Commission, 2014)</p>  <p><u>Range of mercury content/consumption per unit product</u></p> <ul style="list-style-type: none"> - 0.1 – 2 weight-% (button cells with intentionally added mercury) - 0.0005 weight-% (button cells without intentionally added mercury) <p>Canada</p> <p>Button batteries are used for powering high drain devices such as watches, calculators, and hearing aids.</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>EU</p> <p><u>Main alternatives: Mercury-free zinc air batteries</u></p> <p>Mercury free versions are commercially available for all applications of the main types of button cells (lithium, silver, oxide, alkaline and zinc air). The most frequently used types make use of zinc air technology (European Commission, 2014). Since October 2015, mercury-containing button cell batteries have been prohibited in the EU following the expiry of the exemption granted under the Batteries Directive.</p>

* The annex has not been formally edited.

Canada

Alternatives: mercury-free silver oxide batteries, mercury-free zinc air batteries, lithium batteries

Mercury-free alternatives have been available from major battery manufacturers since the late 1990s and early 2000s (e.g. Sony, Panasonic, Duracell, Rayovac, Energizer, Maxell). It was reported that representatives of the battery industry agreed that mercury-free alternatives would be widely available in the USA by 2011 and would have comparable prices.¹

Mercury-free alternatives come in the same shape and size as both mercury-containing zinc air and silver oxide batteries.

Japan

BAJ's member companies have already completed the replacement of mercury-added button zinc silver oxide batteries and button zinc air batteries with mercury-free products.

Regarding mercury-free button zinc air batteries, though there used to be a challenge on the risk of rupture and leakage due to the removal of mercury which has a function to prevent the gas generation, hearing-aid manufactures have started to use the mercury-free zinc-air batteries since the technological advancement enabled them to ensure its safety.

Indonesia

Material substitution and technologies for mercury free already available more than 20 years ago. One out of 4 (four) manufacturing dry cell batteries still use mercury content in product. Plan for total mercury free for all dry Battery manufacturing on progress.

IPEN

Mercury-free silver oxide batteries, mercury-free zinc air batteries, lithium batteries are a commonly available alternative for button batteries.

NRDC

Global availability of mercury free zinc air and silver oxide buttons cells has substantially increased. Many manufacturers now provide these battery types mercury free. In the case of zinc air button cells, used primarily for hearing aids, the following global companies offer mercury free products: Sony, Power One, Varta (Montana Tech), Renata, Duracell, Energizer, Rayovac (Spectrum), iCell Technologies, Toshiba, Kodak, Nexcell, and Camelion. Battery manufacturer associations in Japan, Europe, North America and Latin America report all their member companies successfully phased out mercury use.

In China, zinc air button cells are manufactured by Zeni Power (Zhuhai ZhiLi), one of the largest global hearing aid battery manufacturers. Other Chinese companies producing or marketing mercury free hearing aid batteries include Shenzhen Euni Battery Company, Shenzhen Everwin, Guangzhou Great Power Energy & Technology, Naccon Power Technology, NAFU, Guangdong TIANQIU Electronics Technology, Shenzhen Doublepow Electronic Technology, Shenzhen Estar Battery Company, and Fuzhou TDRForce Technology Co. In addition, imported mercury free batteries are available on the Chinese market from providers not otherwise listed above, such as Resound, Soundmend, and SMENGD.

	<p>In the case of silver oxide batteries, often used in watches, major global manufacturers/marketers include Renata, Maxell, Sony, Seiko, Varta, Camelion, Energizer, Duracell, and Panasonic. Again, battery manufacturer associations in Japan, Europe, North America, and Latin America report all their member companies successfully phased out this mercury use. Chinese manufacturers include Shenzhen Vtery (Weineng), Dongguan Enchi Electronics, Shenzhen THUMBCELLS, Dongguan Ditu, Shenzhen Anderui, Shenzhen XSYCELL, Huizhou JinYu, Shenzhen Dualwin Technology Company, Ningbo Baisheng Electronic Technology, and Dongguan Liantong Photoelectricity Technology Company.</p> <p>Battery Associations of Japan, Europe, North America and Latin America All members of BAJ, EPBA, NEMA and ALPiBa have ceased manufacturing mercury-added button batteries and supply mercury-free alternatives. We believe our products collectively represent 90% of the global market.</p> <p>Battery Association of Japan (BAJ) <u>Global availability and situation of mercury-free button cell batteries</u></p> <ul style="list-style-type: none"> China: In Nov. 2020 China notified WTO/TBT for circulation of the national standard titled “Content Limitation of Mercury, Cadmium and Lead for Zinc Anode Primary Battery”, which limits allowable mercury content in button batteries to 0.0005% (G/TBT/N/CHN/1503) India has no button battery manufacturers in its territory, but has easy access to mercury-free alternatives. Silver oxide batteries are mainly imported from China. Zinc air batteries mostly come from EU via Singapore. Africa also relies on import. To take an example of South Africa in 2019, it imported 84% of silver oxide batteries from Switzerland, US and Japan, those regarded as mercury free. 91% of zinc air batteries were imported from Germany and UK.
5.(i) Information on the technical feasibility of alternatives	<p>EU In the USA following a ban of mercury-containing button cells, there were initial issues relating to performance and usability of mercury-free alternatives however, these have now been overcome following technological developments. Stakeholders have confirmed that performance parameters such as self-discharge, leak resistance, capacity and pulse capability of mercury-free button cells are comparable to traditional mercury-containing cells (BIO Intelligence, 2012).</p> <p>Canada Panasonic reports that their mercury-free zinc air batteries have up to a 20% increased capacity compared to their previous zinc air batteries. They also note that zinc is much lighter and cheaper than lithium, and that their mercury-free zinc air batteries contain twice as much energy as a lithium-ion battery.² Seiko has also suggested that their mercury-free silver oxide battery has better leakage resistance and discharge characteristics in low temperatures compared to those containing mercury.³</p>
5.(ii) Information on the economic feasibility of alternatives	<p>EU Mercury-free alternatives currently cost approximately 10% more than mercury-containing cells to consumers (BIO Intelligence, 2012). There is a marginal cost to button cell manufacturers for investments in Research and Development (R&D) and assembly line adaptations and these costs are likely to be passed on by retailers to consumers which, is expected to be reflected in an increase in retail price by 5-10%. The Lowell Centre for Sustainable Production in Massachusetts conducted a study in 2011 on the economics of converting to mercury-free products including button cell batteries, and found that maintenance of dual production capability between</p>

	<p>mercury and non-mercury products creates inefficiencies increasing the cost of production (Lowell Centre for Sustainable Products, 2011).</p> <p>There are economic benefits to waste collectors and recyclers from mercury-free alternatives in the form of a 30-40% lower cost of recycling button cell waste (BIO Intelligence, 2021).</p> <p>Battery Association of Japan (BAJ)</p> <p>Regarding cost comparison, mercury-free button cells used to be more expensive than mercury-added cells due to the initial capital investments for companies to change their production line and business processes. However, with the course of time, the cost has come down since major battery manufacturers have already shifted to mercury-free. If manufacturers had to allocate production lines for mercury-added products from time to time, it would cost more.</p>
6. Information on environmental and health risks and benefits of alternatives	<p>EU</p> <p>In the EU, it was estimated that in 2009, 88% of button cell batteries were not collected for separate waste collection and as such would have been disposed in landfills or incinerated. This represented an estimated 4.5 tonnes of mercury going to disposal. Due to the difficulty in increasing separate waste collection rates of batteries, substitution of mercury with alternatives is the most effective way of reducing this environmental impact.</p> <p>Canada</p> <p>While recycling of batteries is the preferred option, in some jurisdictions, due to the absence of local disposal facilities for all types of waste, some types of mercury-free button cells (i.e. alkaline) are disposed of as household waste. According to the available information, the components of the mercury-free alkaline battery waste are relatively inert and pose little risks to the environment or human; whereas mercury containing batteries are hazardous waste and require special treatment for disposal.^{4,5} Mercury-free zinc air and mercury-free silver oxide batteries can be recycled with other alkaline battery types and would not need special equipment for processing such as a mercury retort oven.⁶</p>
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	N/A
8. Other relevant information pursuant to Decision MC-3/1	<p>EU (supplemented by US comments)</p> <p><u>Examples of regional or national restrictions</u></p> <p>Mercury has already been eliminated from most batteries (e.g. mercuric oxide batteries) in the EU as a result of restrictions imposed by Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators (Batteries Directive), which prohibits the placing on the market of batteries and accumulators containing more than 0.0005% Hg by weight. This threshold intends to cover trace contamination and reflects current measurement limitations. Mercury-containing batteries are classified as hazardous waste but only a certain proportion are required to be separately collected for further recycling (45% since 2016) by the Directive.</p> <p>In 1996, the USA introduced a national ban on mercury oxide batteries, after which a number of states implemented a ban on all types of mercury containing button cell batteries including Connecticut, Maine, Rhode Island, Louisiana, Wisconsin, and Illinois (Lowell Centre for Sustainable Products, 2011). With respect to mercury or mercury compounds used for the domestic</p>

	<p>manufacture of mercury-added products in the United States, there was 119 lbs. of silver zinc batteries in 2018 and no distribution or export.</p> <p>In 2011, China issued ‘Clean Production Guidelines’ for the battery sector, including recommendations that companies actively promote mercury-free button cells. Mercury content of zinc button cell batteries produced in China has been 0.005 mg per battery (0.25%) since 2013 (Lin et al., 2016). In 2017, the Chinese Ministry of Environmental Protection issued a mercury regulation that states that from 2021 mercury-containing batteries are prohibited, but includes the Minamata exemption for zinc-silver oxide and zinc air batteries containing less than 2% mercury (CIRS-REACH, 2017).</p> <p>ZMWG</p> <ul style="list-style-type: none"> • India: A recent 2019 market study conducted by Toxics Link, in New Delhi (Jungpura and Kalkaji) markets showed that no mercury containing button cell batteries could be found. The interviewed retailers asserted “They no longer sell mercury-added button cell battery; it used to be available before but now most of the shop sells mercury free batteries as the cost of both the batteries is almost the same” (as per retailer from Kalkaji). In these markets mostly Alkaline and Lithium button cell batteries were available. The previous study of Toxics Link1 also reiterated that in India there is no inventory on the use of mercury in button cell batteries in India. What emerged during the discussions with end users in India was that mercury-free button cell batteries are used in key application areas, such as watches, hearing aids, healthcare instruments, children’s toys, etc. The cell batteries are mainly composed of common materials—steel, zinc and manganese – that do not pose a health or environmental risk in normal use or disposal.
<p>9. References</p>	<p>EU</p> <ul style="list-style-type: none"> • BIO Intelligence. (2012). <i>Study on the potential for reducing mercury pollution from dental amalgam and batteries</i>. Retrieved from http://ec.europa.eu/environment/chemicals/mercury/pdf/mercury_dental_report.pdf • CIRS-REACH. (2017). <i>China Enforcing Mercury Convention</i>. Retrieved from http://www.cirs-reach.com/news-and-articles/China-Enforcing-Mercury-Convention.html • European Commission. (2014). <i>Report on the availability of mercury-free button cells for hearing aids, in accordance with Article 4.4 of Directive 2006/66/EC of the European Parliament and of the Council on batteries and accumulators and waste batteries and repealing.../</i>. Retrieved from http://ec.europa.eu/environment/waste/batteries/pdf/COM_2014_632.pdf • European Commission. (2014). <i>Study: Availability of Mercury-free Button Cells for Hearing Aids</i>. Retrieved from https://publications.europa.eu/en/publication-detail/-/publication/16d794d9-1947-48b9-ba5a-4d9d2e3d3c24/language-en • Lin et al. (2016). <i>Material flow for the intentional use of mercury in China</i>. Retrieved from https://pubs.acs.org/doi/suppl/10.1021/acs.est.5b04998/suppl_file/es5b04998_si_001.pdf • Lowell Centre for Sustainable Products. (2011). <i>Economics of Conversion to Mercury-Free Products, Report for UNEP DTIE Chemicals Branch (Referenced in EC, 2014)</i>. <p>Canada</p> <ol style="list-style-type: none"> 1. Maine Department of Environmental Protection. 2009. Mercury-free button batteries: their reliability and availability. Available from: http://www.retailcrc.org/RegGuidance/Lists/RNGList/Attachments/661350/GME00087.pdf 2. Panasonic. (N.D.) Zinc air batteries: for hearing aids of the next generation. Available from: https://www.panasonic-batteries.com/en/specialty/zinc-air

3. Seiko Instruments Inc. (2020). Seizaiken (mercury-free silver oxide battery). Available from: <https://www.sii.co.jp/en/me/battery/products/silver-oxide/>
4. Buchmann, I. (2020). BU-705: How to recycle batteries. Available from: https://batteryuniversity.com/index.php/learn/article/recycling_batteries
5. Recycle Smart. (2019). Mercury (batteries) rising. Available from: <https://recyclesmartma.org/2019/10/mercury-batteries-rising/>
6. Aevitas. (2017). Battery recycling. Available from: <http://www.aevitas.ca/batteryrecycling.html>

Japan

Information was collected through interviews with Battery Association of Japan (BAJ). Share of BAJ's member companies is about 95% of domestic shipment for both silver oxide batteries and zinc-air batteries.

II. Switches and relays

Information provided by **Japan**, **Uganda**, **the USA**, **Canada**, and **Montenegro**

1. Category of mercury-added product	Switches and relays
2. Further description of the product	
3. Information on the use of the product	<p>Japan</p> <p>The major known mercury switches and mercury relays in Japan (classified according to the operating mechanism) are as follows:</p> <ul style="list-style-type: none"> • Type I Mercury reed relays • Type II Mercury displacement relays • Type III Mercury seismic switches <p>Although “<i>very high accuracy capacitance and loss measurement bridges and high frequency radio frequency switches and relays</i> in monitoring and control instruments with a maximum mercury content of 20 mg per bridge, switch or relay” are exempted from the requirements of Minamata Convention, survey conducted in Japan could not confirm the domestic manufacture of bridges, switches or relays for the stated purpose.</p> <p>In Japan, mercury switches/mercury relays are used by incorporating them in equipment.</p> <p>Uganda</p> <p><i>In Uganda, estimated Mercury input in the environment (MIAs report, 2018)</i></p> <p>At the disposal phase, electrical and electronic switches, contacts and relays with mercury batteries contribute to 439kg/Hg/yr</p> <p><u>Product uses</u></p> <p>Power devices may contain elemental mercury for making electrical contact in certain equipment, usually industrial applications.</p> <p>US</p> <p>Major types of elementary mercury-added switches and relays sold in and exported from the United States were</p> <ul style="list-style-type: none"> • Displacement Relay • Float switch • Pressure switch • Temperature switch • Tilt switch <p>The main type of elementary mercury-added switch imported to the US was temperature switch.</p> <p>The main type of mercury compound-added switch sold in and exported from the US was tilt switch.</p> <p>The US EPA, through the information submitted under the mercury inventory reporting rule, has identified additional use of mercury in ‘Lead in water sensor’, in which mercury-compound is added.</p>

	<p>Before the development of the publication of the 2020 mercury inventory (supported by the 2018 mercury inventory reporting rule), the U.S. EPA relied on IMERC data for the amount of mercury in many products sold in the United States. The most recent IMERC data (2010), listed the amount of mercury for switches, relays, sensors, and valves sold in the United States was 39,242 lbs.</p> <p>In designing the mercury inventory reporting requirements, EPA sought not only to collect more recent data, but also to differentiate between the amounts of mercury that such products are made in, imported into, and exported from the United States. Based on the data submitted in the 2018 reporting period:</p> <ul style="list-style-type: none"> • 23,216 lbs of elemental mercury was used to make switches, relays, sensors, and valves in the United States. • 19,723 lbs of elemental mercury was contained in switches, relays, sensors, and valves sold in the United States • 315 lbs of elemental mercury was contained in switches, relays, sensors, and valves exported from the United States • 1 lb of mercury compounds was contained in switches, relays, sensors, and valves imported into, distributed in, and exported from the United States <p>Montenegro Montenegro has no production of the mercury added products. It has information on quantities of imported products, including switches and relays, in 2019. However, most of these tariff numbers cover a wider range of product types which cannot be claimed with certainty to contain mercury. The country welcomes HS codes for mercury-added products.</p> <p>Comments from experts *on thermostats Mercury thermostats use mercury switches to sense and control room temperature through communication with heating, ventilating and air conditioning (HVAC) equipment. Mercury thermostats contain an average of 1.4 mercury switches (i.e. components), with a minimum of 2.8 grams of elemental mercury per switch – the total amount of mercury used in a single thermostat is more than four grams. Industrial-sized thermostats may have multiple switches and thus have reported higher amounts of mercury. Some examples of industrial thermostats reported by manufacturers include low-voltage multi-stage wall thermostats and heat pump thermostats.¹</p>
<p>4. Information on the availability of mercury-free (or less-mercury) alternatives</p>	<p>Japan</p> <ul style="list-style-type: none"> • In Japan, currently, mercury-free relays (reed relays, semiconductor relays) are available and for many applications new use of mercury-based reed relays is not required. • <u>Mercury overcurrent relay</u>: Manufacturers are carrying out replacement, not by mercury-free overcurrent relays, but by IMPs (Internal Motor Protector) which similarly provides the functionality of protecting against overcurrent. • <u>Mercury displacement relay manufactured outside Japan</u>: Mercury-free relay was being used, but the occurrence of a problem resulted in reverting to the use of this product. • <u>Seismic switch</u>: The manufacturer has developed a mercury-free seismic switch, and the manufacture of mercury seismic switch is scheduled to be discontinued by the end of 2020.

¹ IMERC Fact sheet: Mercury Use in Thermostats

	<p>Uganda <u>Switches & Relays containing less mercury</u> Switches & Relays used in high accuracy instruments with < 20 mg Hg per bridge <u>Mercury free Switches & Relays</u> Mercury-free relays include solid-state relays, electro-mechanical, dry magnetic reeds, etc. Mercury-free switches include mechanical, solid-state, dry magnetic reeds, optical, thermal, etc.</p> <p>Comments from experts An expert referred to the exemption listed in Annex A, namely ‘<i>very high accuracy capacitance and loss measurement bridges and high frequency radio frequency switches and relays in monitoring and control instruments with a maximum mercury content of 20 mg per bridge, switch or relay</i>’, for which, according to the compilation paper, Japan has no domestic manufacture. The expert further informed that he himself contacted one of the leading manufacturers of such devices and was confirmed that mercury is no longer used in those devices.</p> <p>An expert from Semiconductor Equipment Association of Japan (SEAJ) responded that there are three companies of SEAJ that use mercury switches and relays for semiconductor manufacturing equipment. He also responded that companies under SEAJ have been trying to find mercury-free alternatives, but there are no alternatives to date that meet their technological and economic requirements.</p> <p>Thermostats There are non-mercury alternatives that are suitable for replacing mercury thermostats. These include electromechanical (i.e. air-controlled, reed switch, vapor-filled diaphragm, snap switch) and electronic programmable thermostats (i.e. digital).²</p>
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² IMERC Fact sheet: Mercury Use in Thermostats

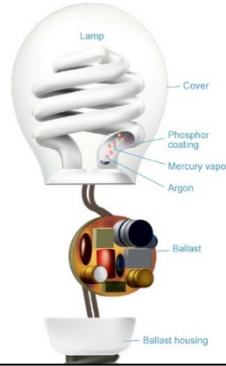

5.(i) Information on the technical feasibility of alternatives	<p>Japan</p> <ul style="list-style-type: none"> • Currently, in Japan, there are products (end use) that are difficult to replace with mercury-free relays due to performance and cost issues, and the necessity to change the circuit when using a mercury-free relay. Due to these reasons, there is still a demand for mercury relays for the maintenance of existing (not easily replaceable) products. • Relevant industrial associations, on their websites, have published a list of uses that should be excluded from regulation by the Act on Preventing Environmental Pollution of Mercury of Japan for products commonly recognized by the Association to currently have no mercury free alternatives. <p>Uganda</p> <ul style="list-style-type: none"> • There is limited knowledge by consumers in Uganda on existence of alternatives • There is limited policy restrictions on importation of listed Switches and relays • There are no incentives on use/importation of alternatives • There is an institutional framework for promoting adoption of alternatives • The alternatives usually cost higher than the more toxic ones • Alternatives are mainly imported, hence transferring taxation costs to the consumer
5.(ii) Information on the economic feasibility of alternatives	NA
6. Information on environmental and health risks and benefits of alternatives	
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	<p>Japan</p> <ul style="list-style-type: none"> • In Japan, 1 company currently manufactures mercury switches (mercury seismic switches) and 4 companies manufacture mercury relays (mercury reed relay : 3, mercury displacement relay : 1). • There are cases where mercury relays manufactured outside Japan are imported and incorporated in equipment.
8. Other relevant information pursuant to Decision MC-3/1	<p>Japan</p> <p>In Japan, mercury switches and mercury relays will be regulated by the Act on Preventing Environmental Pollution of Mercury of Japan after the phase-out deadline of the Minamata Convention (end of 2020). Switches and relays for which no feasible mercury-free alternative for replacement is available are excluded from Annex A of Minamata Convention and will also be excluded from the Act on Preventing Environmental Pollution of Mercury of Japan (scope of the exemption will be judged based on the availability of mercury free alternatives)</p> <p>US</p> <ul style="list-style-type: none"> • US EPA will carefully consider the reporting results in light of such factors as quantities of use and availability of safer, cost-effective alternatives and, as appropriate, will not hesitate to recommend future legal or regulatory actions in accordance with the statute.

	<ul style="list-style-type: none"> On October 5, 2007, EPA issued a final significant new use rule (SNUR) for elemental mercury used in convenience light switches, anti-lock braking system (ABS) switches, and active ride control system switches in certain motor vehicles. <p>Canada Canada is considering removing the exemption in the Products Containing Mercury Regulations for <i>high frequency radio frequency switches and relays</i> due to the fact that there were no imports of these products in 2016.</p> <p>Uganda In terms of waste management in Montenegro, the Decree on the procedure for establishing a system for collection and treatment of electrical and electronic waste ("OG of MNE", No. 24/12) prescribes pre-treatment of electrical and electronic waste and Rulebook on the limit values of the hazardous substances in electrical and electronic equipment ("OG of MNE", No. 067/18) prescribes the limit values for the presence of hazardous substances (mercury, among the others) in electrical and electronic products, the designation of the type of waste and the method of waste management arising from these products.</p>
9. References	<p>Japan Information is collected through interviews with domestic manufacturers of mercury switches/mercury relays and through questionnaire survey targeting recipients of shipments from the relevant manufacturers and member companies of healthcare/measurement/analysis/ control equipment related industrial associations.</p> <p>Uganda Developing National Strategies for Phasing Out Mercury Containing Thermometers and Sphygmomanometers in Health Care, Including in the Context of the Minamata Convention on Mercury, World Health Organization, 2015. Available at http://www.who.int/ipcs/assessment/public_health/WHOGuidanceReportonMercury2015.pdf?ua=</p> <ul style="list-style-type: none"> • UNEP (2013): Minamata Convention on Mercury. Available at http://www.mercuryconvention.org • Minamata Initial Assessments report, 2018 • Mercury Learn - HS codes (2015); COMTRADE database <p>USA EPA. (2020). Inventory of Mercury Supply, Use, and Trade in the United States – 2020 Report</p>

III. Lamps

Information from the African Region, **Canada**, **EU**, **Japan**, **Norway**, **USA** and other stakeholders (CLASP, JLMA, ZMWG, Lighting Europe)

Compact Fluorescent Lamps (CFL)

1. Category of mercury-added product	Lamps
2. Further description of the product	Compact fluorescent lamps (CFL)
3. Information on the use of the product	<p>Compact fluorescent lamps (CFLs) are energy-saving lamps, available in a wide range of wattages, types and sizes. In CFLs, the ballast can either be integrated into the lamp (CFL with ballast (CFL.i) or separated from the lamp (CFL without ballast (CFL.ni)) (Gensch, et al., 2016). CFLs are regularly used for both commercial (i.e. retail, office, hospitality and leisure premises) and residential use, as energy-saving alternatives to incandescent lights (Gensch, et al., 2016). CFL.is are screw-based lamps which can be directly connected to 230V and 110V lightbulb sockets (e.g. E27). CFL.nis can only operate as spare parts in a luminaire, which contain a specific electronic driver or ballast.</p> <p>EU</p> <p>A small amount of mercury is present in all CFLs, as it is necessary for the low-pressure gas discharge (Gensch, et al., 2019). In CFLs, ultraviolet light is generated by driving an electric current through a tube, which contains argon and mercury. This stimulates the phosphor coating to produce visible light. CFLs initially require more energy when they are first turned on compared to alternative lamps, but they tend to use 70% less energy than incandescent bulbs on average. The ballast provides sufficient voltage to initially power the CFL, then regulates the current (US EPA, 2019a).</p> <p>Mercury is considered vital to the conversion of electricity into ultraviolet light, which is then converted into visible light (Gensch, et al., 2019). Lighting Europe suggests that although alternatives to mercury in CFLs, such as noble gases, were considered, they did not provide the same level of lamp performance in regard to lifetime, output or energy consumption (Lighting Europe, 2016).</p> <p>CFL.nis require a variety of different drivers included in the luminaire, enabling operation with different wattages, tube diameters, gas pressures and electrode pre-heating, resulting in application-related light distributions, efficiencies, dimming and lifetimes. CFLs can be divided into normal life and long-life lamp types (>20 000 hours).</p> <p><u>Range of mercury content</u></p> <p>The average mercury content in CFLs has reduced by at least 20% over the past several years (US EPA, 2019b). In the USA, typical mercury content of CFLs is 0.9-4 mg per lamp (COWI and ICF, 2017).</p> <div>  <p>General composition of a CFL.i lamp (US EPA, 2019a)</p> </div> <div>  <p>CFL.ni lamp</p> </div>

African Region

CFLs have been commonly used in both domestic and professional applications, most often indoors in table lamps and downlights, as well as in wall-washers and in some countries, streetlights. These products were developed in the late 1970's / early 1980's with the goal of reducing power consumption for lighting. All CFLs contain mercury. They can take up to five minutes to warm up to full brightness, they are fragile, and they have short lifetimes compared to LED. CFLs come in two types – those which are integrally ballasted (CFLi) and those which are not integrally ballasted (CFLni) – also called “pin-base CFLs”.

- Compact Fluorescent Lamp – integrally ballasted (CFLi): A fluorescent lamp designed to replace an incandescent lamp. Consists of a fluorescent tube that is curved, twisted or folded to fit into the space of an incandescent lamp, and incorporates an electronic ballast in the base of the lamp. Each lamp contains 3-10 milligrams of mercury.
- Compact Fluorescent Lamp – non-integrally ballasted (CFLni): A fluorescent lamp where the ballast operating the lamp is contained inside the fixture into which the pin-base CFLni lamp is inserted. The “ni” stands for non-integrated, meaning the ballast is not integrated within the lamp. Each lamp contains 3-10 milligrams of mercury.

Norway

Contrary to input submitted by other parties, CFLni bulbs should not be classified as “spare parts”. They are a finished, regulated product sold commercially with a CE mark. They are subject to regulations under multiple directives, and have safety standards prescribed for them. CFLni are a finished product that is used in conjunction with another finished product, a lighting fixture. In much the same way that a compact disc (CD) is not a spare part for a CD player, CFLni are not spare parts for CFLni fixtures. The consumer can choose the music and can choose the fluorescent bulb, and both enable the equipment they are put into to provide a service.

Japan Lighting Manufacturers Association (JLMA)

Non-integrated fluorescent lamps without a (electronic) ballast/control gear i.e. linear fluorescent lamps (LFL) and also named non-integrated CFL lamps (CFL-ni) are considered to be maintenance or repair parts for luminaires, and the Japanese government requires that the supply of spare parts comply with the lighting industry's standards of 10-year lifetime of a luminaire. Spare parts are also exempt from RoHS regulations.

ZMWG

India is one of the largest global users of mercury containing lamps, with almost 28 million pieces of CFL lamps and 132 million pieces of LFL sold annually (2018).

Under the RoHS directive <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02011L0065-20200301&from=EN> Art. 4 and Art. 3(1), (2), (27) ‘spare part’ means a separate part of an EEE that can replace a part of an EEE. The EEE cannot function as intended without that part of the EEE. The functionality of EEE is restored or is upgraded when the part is replaced by a spare part;

Furthermore lamps and luminaires are electric and electronic equipment on their own right, and a product cannot be an EEE and a spare part at the same time.

CFL i and ni are part of the lighting equipment category under the EU RoHS directive and not spare parts. Spare parts should also follow the same restrictions as same/similar products under EU law unless previously on the market – also spare parts usually are not

	<p>finished products - CFLnis are finished products. https://ec.europa.eu/environment/system/files/2021-01/FAQ%20key%20guidance%20document%20-%20RoHS.pdf</p> <p>LightingEurope</p> <p>CFL-I lamps are screw-based lamps with an integrated electronic driver that can be connected directly to the mains voltage and are used in luminaires found in many applications, mainly used in residential applications (e.g., homes, garages, gardens etc.)</p> <p>CFL-ni lamps are non-integrated non-screw-based lamps where the electronic driver is situated in the luminaire and not in the lamp. There are many different types of electronic drivers that are used by luminaire manufacturers and also many different standardised sockets. These luminaires are used for a large variety of professional applications and installed and maintained by professionals (for example in corridors, relaxation areas and meeting rooms in dimming controlled applications like offices, retail, hotels, apartments, hospitals, schools, elderly homes, theatres, exit signs, industrial lighting, waterproof or explosive atmosphere applications, residential streetlighting, railway and metro stations, trains, battery powered emergency lighting luminaires, medical applications etc).</p>
<p>4. Information on the availability of mercury-free (or less-mercury) alternatives</p>	<p>EU, supplemented by USA</p> <p><u>Main alternatives: Light emitting diodes (LEDs), incandescent light bulbs, halogens</u></p> <p>There are three potential alternatives to CFLs: LEDs, incandescent light bulbs and halogens.</p> <p>Halogens and incandescent light bulbs consume a lot more energy than CFLs, which is why countries are already phasing them out. The U.S. Energy Star program has demonstrated a 13-watt, 8,000-rated-hour-life CFL (60-watt equivalent; a common light bulb type) that is recycled at the end of its life will save 376 kWh over its lifetime, thus avoiding 4.3 mg of mercury³. In the EU they were banned from sale from September 2018 according to the EU energy regulations (RoHS Directive 2011/65/EU)</p> <p>LEDs therefore offer the most suitable alternative to CFLs. The lighting industry is evolving from a market primarily focused on discharge lamp technology to a market focused on LED technology (Gensch, et al., 2019) for general lighting purposes. In 2013, LEDs comprised only 5% of the market share in the EU, yet this is expected to increase to 60% by 2020 and 80% by 2030 for general lighting purposes. In the US and Canada, LEDs are also expected to gain market share, as they begin to displace CFLs. Many retailers, such as Walmart, and manufacturers, such as General Electric, are moving away from the use and production of CFLs altogether (COWI and ICF, 2017).</p> <p>For CFLs, however, the transition to LEDs is predicted to only be 8% by 2020. Beyond Europe, CFL-ni lamps will remain in the market, as spare parts for installed CFL-ni-based luminaires. Following the EU ban of halogen bulbs under Regulation (EC) No 244/2009 from January 2019, LED lamps are reported to be the only mercury-free technology on the European market (Gensch, et al., 2016). Incandescent light bulbs also do not comply with Regulation (EC) No 244/2009, and as such, the phasing out of inefficient incandescent light bulbs is already underway. There are also a number of new material options for LEDs, such as organic LEDs (OLEDs) and graphene lighting, which may replace the metal-based semiconductors more regularly used today. However, these are new to the market, and it is yet to be determined if their efficiency and lifecycle impacts will be preferable to LEDs (COWI and ICF, 2017).</p>

³ https://www.energystar.gov/ia/partners/promotions/change_light/downloads/Fact_Sheet_Mercury.pdf

Canada

The primary mercury-free alternative to mercury-containing lamps are Light Emitting Diodes (LEDs). LEDs use a semiconductor as a light source and have very high energy efficiency and significantly longer lifespans than fluorescent lamps. LEDs also appear to be the main replacement component for lamp components in infrared light detectors and radiation detectors.¹

LEDs have been on the market for 30 years but have seen a dramatic rise in demand in the last 5 years.¹ Large lighting manufacturers are phasing out the production of traditional lighting products in favour of greater production of LEDs.² Major companies such as GE and Philips are actively promoting the shift from CFL to LED and North America's lighting market is predicted to be 70% LED and 4% CFL by 2020.³

African Region

In the past, CFLs were commonly used in households, offices, schools and elsewhere, but they are increasingly being replaced now by LED. Mercury-free LED replacements for CFLi and CFLni lamps are widely available in lighting markets everywhere. These alternatives are available in thousands of different shapes and sizes, levels of light output, color renderings and color temperatures. LED retrofit lamps are available to operate both in a regular light bulb socket (mains voltage) and on the pins of a fixture that takes CFLni. Research on the availability of CFLni pin bases has shown that of the 19 types of CFLni base types (e.g., 2G7, 2GX-7, 2G11, etc.), LED retrofits are available today for 16 of them, or 85% of the base types. For the three which LED replacements were not immediately available, the reason given was the low volume of sales for these base types. However, suppliers in China said there are no technical impediments for manufacturing LED retrofit lamps for these base types and manufacturers confirm they can be produced within a few months on request. (Swedish Energy Agency, 2020)

Norway

LEDs are a mercury-free alternative which is a cost effective and direct replacement for CFLs. LEDs are twice as efficient as CFLs (they use half the power to produce the same light) so they also reduce mercury emissions from coal-fired power stations. Due to their longer lifetime, efficiency and colour quality, LEDs are suitable for lighting in the home and in professional applications, including office lighting, schools, street lighting and much more (Zissis et al., 2021). LEDs achieve 50-90% energy savings vs traditional lighting technologies and have lifespans of 15,000 to 50,000 hours. LEDs are mercury-free and unlike CFLs are not hazardous waste. Both the United Nations Environment Programme (UNEP, 2021) and the United Nations Industrial Development Organisation (UNIDO, 2021) have established global programmes to phase-out both CFLs and LFLs between 1 January 2023 and 1 January 2025 because they are inefficient and toxic.

Japan Lighting Manufacturers Association (JLMA)

Fixtures that use CFLni should be replaced with LED fixtures to reduce the demand for CFLni. If LED fixtures are cost-prohibitive, there is also a way to replace incandescent light bulb fixtures so that they can be replaced with readily available incandescent bulb substitute LED lamps.

Expert/ZMWG comments on information from EU

In the EU halogen and incandescent were banned from sale from September 2018 according to the EU energy regulations (Ecodesign directive). CFLis will also be banned via the same directive by 1st September 2021.

EU Directive 2011/65 is not banning CFLs, nor incandescent or halogens. The directive 2011/65 limits the maximum allowed content of mercury in CFLs.

However, under the EU Ecodesign directive, which looks mainly at the energy efficiency of products including lighting, **Commission Regulation 2019/2020 of 1st October 2019** agreed, via an energy efficiency formula, to **ban Linear fluorescent Lamps (LFLs) T2 and T12 and Compact Fluorescent Lamps (CFLs) with integrated ballast (CFLi) by 1st September 2021, and certain lengths (2-foot, 4-foot and 5-foot) of T8 linear fluorescent lamps by 1st September 2023.**

The estimate on CFL.nis provided below is now out of date given the latest CLASP /Swedish Energy Agency data.

According to the Oko Institute report published 10 July 2020 –

https://rohs.exemptions.oeko.info/fileadmin/user_upload/reports/RoHS_SEA_Lamps_2020_Revision-Final_10072020.pdf

The Business as usual (BAU) shipments look like this:

Table 3-1: Number of CFLni to be replaced, related energy (cc

All data sets	2021	2022	2023	2024	2025
CFLni projected sales, all sectors (mln)	44.8	41.9	38.1	33.5	28.6
CFLni replaced by LED, residential (mln)	13.3	13.2	12.9	12.3	10.9
CFLni replaced by LED, non-resident. (mln)	31.4	28.6	25.2	21.2	17.6

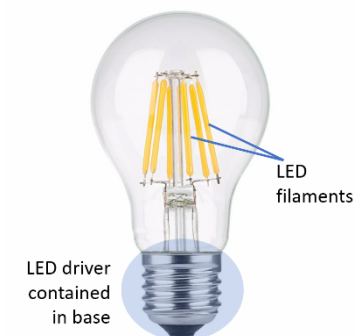
So calculating it for 2021, in Europe we have 44.8 million units sales CFLni and 44.7 million (13.3 + 31.4) unit sales LED to the residential and professional sectors. Thus, it is 50% LED already in the market, not 8%.

Also LED replacements for CFLnis are available. See e.g.

https://products.gecurrent.com/sites/products.currentbyge.com/files/documents/document_file/LEDL007-GE-LED-Replacement-CFL-Plug-In-Sell-Sheet.pdf

CLASP

- CFLi: Retrofit LED lamps are available for 100% of screw/bayonet-base (CFLi) applications – those installations which operate on mains voltage sockets, such as the screw-base or bayonet base sockets commonly found in households. There are both frosted LED bulbs that provide diffuse lighting and there are ones that show a yellow filament made up of LEDs which work well in chandeliers and fixtures that need a ‘sparkle’ effect. The drivers for LED lamps have become so small that they can now fit in the screw cap of the lamp itself, as shown in the picture to the right in this LED filament bulb.
- CFLni: Retrofit LED lamps are available for 88% of pin-base (CFLni) installations (Oko-Institut, 2020). Many new products have been introduced in the last 2 years – for



example, see this webpage for Signify.⁴ LED products are offered for the vast majority of CFLni applications, operating in the same fixture, on the same ballast in the existing luminaire – so there is no need to change the fixture or rewire, it is simply a question of installing the LED retrofit into the existing luminaire and the end-user can enjoy mercury-free lighting which is twice as efficient than the CFL. For the small percentage of applications where direct retrofits are not available, researchers contacted LED retrofit lamp manufacturers and asked about these few (uncommon) base types. The companies, which were based in China, responded that they can produce any LED retrofit lamp that is needed - there is no technical barrier to create LED substitutes for all CFLni, it is just a question of volume (Sweden, 2020).

NRDC

CFLi: there are literally thousands of mercury-free alternatives to general service lamps. LED replacements come in different color temperatures, different base types, a wide range of light levels, and can be diffuse light or not (sparkle effect), and many models are also dimmable. LED lamps were designed as a drop-in retrofit product, so 100% of sockets are retrofittable. No rewiring or alterations are needed. They offer longer service life, instant full brightness and are up to twice the efficiency of CFLs. LED replacement lamps are highly cost effective, whether replacing an incandescent, halogen or CFLi.

CFLni: LED versions for nearly all of the pin-bases are available to replace existing CFLni with no rewiring necessary. For the three base types missing, researchers contacted suppliers in China and enquired why these were not available – the reason given is that they are very low sales volume, so it wasn't worth developing them in LED – however, they confirmed these could be made if an order for 10,000 units was placed. These LED replacements for CFLni bulbs contain no mercury, have up to two to three times longer life (or more) and are roughly twice as efficient – cutting related energy bills in half.

LightingEurope

CFLi

For many applications, LED integrated screw-based lamps are entering the EU market of different efficiency, quality and pricing levels. The situation for other markets on affordability and availability of high-quality LED alternatives might be different than in the EU region.

CFLni & LFL-ni lamps

LED substitutes are entering the market for several applications but are not available for all lamp types, due the diversity of lamps, nor for all applications with various efficiencies, lifetime quality and price levels (from low to high end products). LED substitutes show non-compatibility issues with many drivers used in installed existing lighting fixtures. LightingEurope estimates non-compatibility, and therefore no substitutes, for about 50% of the cases in the EU (ref. Oko Institute 10 July 2020 – Table 2-2) due to the large variety of electronic driver topologies used in installed luminaires. LED lamps are not allowed as replacement lamps in most emergency luminaires. Light distribution and colour is often different compared to CFL.

To avoid quality and safety issues in the application related insurance requirements for buildings, advice from professional installers is inevitable, e.g., to rewire the luminaire or exchange the entire luminaire (both at high cost for the user). See ref. LightingEurope, September 2020 presentation at UN vertical lamps meetings). (see installers guidance links: Signify, Ledvance and Tungsram).

⁴ Some examples of the wide variety of CFLni retrofit lamps: <https://www.lighting.philips.com/main/prof/led-lamps-and-tubes/led-pl-lamps>

<p>5.(i) Information on the technical feasibility of alternatives</p>	<p>EU</p> <p>The technical feasibility of retrofitting LEDs is lower for CFL.ni than for CFL.i. According to information provided by an industry group, CFL.ni lamps do not have adequate substitutes for the full portfolio of lamps. The industry group also states that a lack of control gear compatibility and the series of lamp bases available are likely to force users to replace the entire luminaire. However, CFL.nis comprise a relative minority of the market (The Lightbulb Company, 2019).</p> <p>It is technically feasible to retrofit LEDs for CFL.is for general lighting purposes, although in some cases retrofit products are limited in their capacity to provide the same wattage and lumen output as CFLs (Gensch, et al., 2019). Regarding long-life CFL.is, it has been reported that there are limited LED alternatives available due to differences in weight, light distribution and shape (Lighting Europe (2017).</p> <p>One technical issue with LEDs is their sensitivity to heat. If exposed to temperatures exceeding recommended levels, this can result in a reduction in the lifetime of the product (Gensch, et al., 2019). However, compared to competing technologies, LEDs bear significantly longer lifetimes, benefiting consumers as fewer purchases are required (COWI and ICF, 2017). In addition, relative to incandescent lighting, LEDs are 90% more efficient. Due to their longer lifetime, efficiency and directional nature, LEDs are particularly applicable to commercial settings (US EPA, 2019c). Increasingly, they are also being used in street lighting, garage lighting and for illuminating homes.</p> <p>Regarding special purpose lamps, replacement by alternatives is expected to be less feasible, as these lamps tend to be tailor-made (COWI and ICF, 2017). In recent years, LEDs have been applied to some special purpose lighting applications. However, further developments are expected to be slower than general lighting applications.</p> <p>According to information provided by an industry group, it is technically feasible to lower the mercury content in CFLs below Minamata maximum concentrations. In many countries, for example in the EU and Australia, the mercury content restriction on CFL.is is 50% lower than Minamata standards (2.5 mg per lamp compared with 5 mg per lamp under Minamata).</p> <p>A study by the Swedish Energy Agency (2019) concluded that mercury-free alternatives have the technical feasibility to replace fluorescent lamps, enabling exemptions under Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) for CFLs to be allowed to expire.</p> <p>African Region</p> <p>For CFLi, it is fully technically feasible to retrofit LEDs into sockets that previously had CFLi's. The LED retrofit lamps are smaller, lighter in weight, last longer, are more efficient and are at or near price parity with CFLi. There is simply no reason to maintain any CFLi on the market. Several African countries are moving to phase-out CFLi through a lighting regulation being finalised now in SADC and EAC, under the UNIDO Energy-Efficient Lighting and Appliances project. (SACREEE, 2021)</p> <p>For CFLni, a recent study published by the Oko-Institute and VHK determined that 89% of CFLni lamps are “plug and play retrofit” (Oko-Institut, 2020). This estimate in the Oko-Institut analysis relies on data published by the lighting industry and Sweden/CLASP (Swedish Energy Agency, 2020), and the very large number of new LED retrofits for CFLni lamps that were introduced to the EU market in the last 2-3 years. For example, there are extensive product ranges offered by Signify/Philips (Signify, 2021) and OSRAM/LEDvance (LEDvance, 2021).</p>
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Japan Lighting Manufacturers Association (JLMA)

The technical barriers are completely different between CFL-i and CFL-ni. CFL-i for general lighting except for special applications can be technically substituted. Screw-based CFL-i, like incandescent bulbs, are supplied directly by commercial power and do not have compatibility problems with fixtures.

CFL-ni is powered by the ballast or electronic circuitry built into the lighting fixture. The ballast and electronic circuit are designed to match the characteristics of CFL-i, and there is a risk of electric shock or fire if a lamp other than CFL-i is used. The IEC is also discussing safety concerns about other lamps with the same shape as CFL-ni, and until IEC regulations are established, it cannot be said that they are technically possible to replace them.

CLASP

LED retrofit bulbs are technologically more advanced than both CFLi and CFLni in all the important areas for lighting. LED retrofit lamps do not contain mercury, they last 2-3 times longer than CFLs and they are twice as efficient – meaning LEDs enable households and businesses to cut their energy consumption for lighting in half (or more). LEDs offer many technical advantages as well - including the fact that they are lighter in weight than CFLs, they come on to full brightness when switched on, they are more compact and fit into the same form-factor as the bulbs they are replacing. LEDs are also capable of producing excellent quality light – they are available in all the same correlated colour temperatures and colour rendering indexes as offered by CFLs.

NRDC

For both CFLi and CFLni, in addition to being mercury-free, LEDs offer significantly longer lifetimes, which helps consumers by reducing the number of times the lamps have to be changed. LEDs are also over 90 percent more efficient than incandescent lighting, and 50 percent more efficient than CFL. Compared to CFLs, LED retrofit lamps are smaller and lighter (in total weight) than they were a few years ago, removing a barrier to installation. LED retrofits offer all the same (and better / broader range) of color rendering indexes and correlated color temperatures as are available in CFL. LEDs can be directly installed into the same sockets (screw base or bayonet base) where CFLi are installed on mains voltage (120V/60Hz, 230V/50Hz, etc).

LightingEurope**CFLni & LFL-ni lamps**

Available LED substitutes show non-compatibility issues with many drivers used in installed existing lighting fixture (in about 50% of the cases in EU (ref. Oko Institute 10 July 2020 – Table 2-2) due to the large variety of electronic driver topologies used in installed luminaires) where warranty does not apply and rewiring or replacement of the entire luminaire is needed.

Examples of non-compatibilities with certain drivers/installations where warranty does not apply are e.g. flickering, non-starting, early failures due to overheating of lamp or driver components etc.

The use of LED-ni substitutes is not allowed in modern daylight dimming installations, serial circuited luminaires nor in battery powered Emergency Lighting luminaires due to strict IEC standards (see LightingEurope, September 2020 presentation at UN vertical lamps meetings).

To avoid quality and safety issues in the application related insurance requirements for buildings, advice from professional installers is inevitable, e.g., to rewire the luminaire or exchange the entire luminaire, both at high cost for the user (as presented by LightingEurope during the September 2020 vertical lamps meetings). (See installers guidance links: Signify, Ledvance and Tungsram).

5.(ii) Information on the economic feasibility of alternatives

Canada

LEDs achieve 50-70% energy savings vs traditional lighting technologies and have lifespans of 50,000 to 100,000 hours. The 'catastrophic' failure rate of LED products over 6,000 hours is about 1%.⁴ Estimates made in 2012 predicted that the global lighting market would expand to US\$160 billion by 2020, primarily due to growth in demand for LEDs as their prices decline. The price of LEDs was expected to fall by more than 80% and reach a global penetration of around 60% across all lighting applications by 2020.⁴

Norway

LED replacements for compact fluorescent lamps not integrally ballasted (CFLni) offer very attractive payback periods of between 1.3 and 3.0 years and will last 2-3 times longer than the fluorescent lamp.

EU

Table 1 provides an overview of the lifetime, power rating, colour temperature, colour rendering and price of a range⁵ of CFL.is and LEDs with varying forms and light intensities. Table does not provide a like-for-like comparison of available LEDs with existing CFL.is luminaires. However, the data displays that the lifetime, price, power rating and colour temperature and rendering are much more variable for LEDs than for CFL.is. LEDs have larger upfront costs than CFL.is, however, this is outweighed by higher energy efficiency and longer product life. Furthermore, prices for LEDs have displayed a continuous downward trend since 2011 (LED Inside, 2018).

Table 1 – Comparison of lamp specifications and prices for CFL.is and LEDs (Gensch, et al., 2019)

	CFLi	LED
Lifetime	20 000 hours	20 000 – 50 000 hours
Power rating (range)	10 – 18 W	3,9 – 21 W
Colour temperature	2500 – 2700°K	2100 – 4500°K
Colour rendering CRI (Ra)	80 – 82	80 – 97
Price (€)	9,5 – 18 €	7,5 – 33,5 €

Table 2 provides an estimation, produced by Lighting Europe (2017), of replacement costs of all CFL.nis on the market. The table highlights that there are labour costs involved with the replacement of some CFL.ni fixtures, where the luminaire requires rewiring or conversion.

The Swedish Energy Agency (2019) however found that it is cost-effective to replace CFL.nis with LEDs, finding that LED replacements for CFL.nis offer a quick payback period of between 1.3-3 years, and have the capacity to last 2-3 times longer than CFL.nis. These calculations however did not include labour costs of replacement.

Table 2 – Replacement costs of all CFL.nis on the market (Lighting Europe, 2017)

Lamps on the market in the commercial, industrial and public sector:				
Lamp type	Lamps on the market	Lamps/fixture	Fixtures	
CFL.ni	619 000 000	1,5	412 666 667	
Replacement with LED retrofit, share and costs				
Lamp type	Retrofit share	Product costs	Labour costs	Total costs
CFL.ni	10%	12,5 €	20 €	30 €
Replacement with LED luminaire, share and costs:				
Lamp type	Retrofit share	Product costs	Labour costs	Total costs
CFL.ni	90%	75 €	25 €	100 €
Total replacement costs:				
Lamp type	Retrofit	LED luminaire	Total costs	
CFL.ni	1 341 166 667 €	37 140 000 000 €	38 481 166 667 €	

African Region

Retrofitting CFLs with LED alternatives is highly cost-effective. The payback period associated with LED replacement of a CFL is short: in most cases, less than a year. In fact, in many parts of the world, LED replacements for CFLs are already on price-parity. That is the case in the United States (Schweber, 2018) and in South Africa. Analysis in these markets has shown that LEDs are approximately 50% less expensive to own and operate than a CFL.

The examples below show the cost-effectiveness of LEDs compared with other lighting in South Africa and Uganda. Assuming the bulbs operate for 4 hours per day, the payback periods for LED lamps are only a matter of weeks – yet the lamps operate for years.

⁵ The ranges are based on 5 long-life CFLi and 10 LED alternatives, based on data provided by Philips and Osram websites.

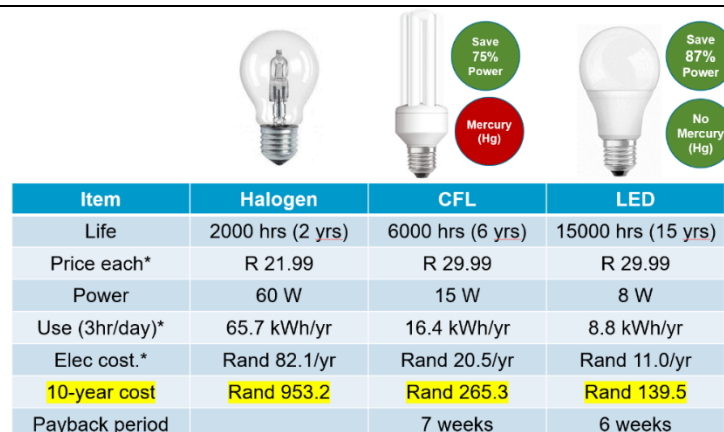


Figure 1. Payback Period for a General Service LED Lamp in South Africa

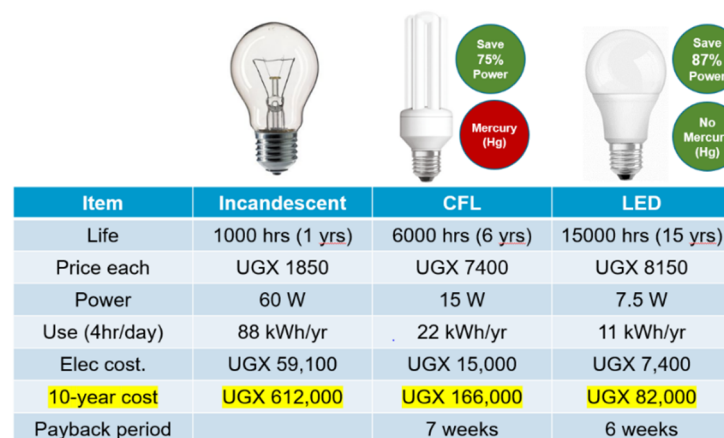


Figure 2. Payback Period for a General Service LED Lamp in Uganda

Similar analysis of general service lamps in Madagascar found that the payback period of moving from incandescent bulbs to an LED retrofit is just 3.5 months. And the net-present value of the savings over a 10-year period (including bulb purchases and electricity to operate the bulb), discounted back to today's value is MAG 560,700. These savings – over half a million Malagasy ariary – far exceed the higher purchase price of the LED (which is MAG 16,100 more expensive than an incandescent lamp).

In Zambia, the payback period of moving from an incandescent lamp to an LED lamp is just 3.9 months. And much like Madagascar, the net-present value of the energy savings over a 10-year period including bulb purchases and electricity, discounted back to today's value is ZMW 1078. Thus, in Zambia consumers will save over 1000 Kwacha (in today's currency) for every socket in their home

where they replace an incandescent with an LED. These savings far exceed the additional 30 Kwacha that it costs to buy an LED lamp compared to an incandescent.

LED lamps are the same price or very close to the price of CFLs, and because LED bulbs are twice as efficient as CFL, they are much less expensive to operate. Thus, the total cost of ownership – the total cost of light in the home - is roughly half with an LED bulb compared to the fluorescent, and there is no mercury. Payback periods were generally a matter of a few months.

Japan Lighting Manufacturers Association (JLMA)

There is no safety issue for compact fluorescent lamp types with a (electronic) ballast/control gear, also named integrated CFL lamps (CFL-i), which are mostly equipped with a screw based lamp cap (e.g. E-type or B-type), directly connected to the mains voltage. Additionally, several LED based alternatives are nowadays available and affordable for these CFL-i lamp types.

Fixtures that use CFLni should be replaced with LED fixtures to reduce the demand for CFLni. If LED fixtures are cost-prohibitive, there is also a way to replace incandescent light bulb fixtures so that they can be replaced with readily available incandescent bulb substitute LED lamps.

ZMWG

More recently, on a global scale, the International Energy Association (IEA)'s May 2019 Tracking Report on Commercial Buildings/Lighting⁶ noted that LEDs are beginning to dominate global markets and are becoming common replacements for linear fluorescent lamps as well as CFLs. Global LED uptake has increased substantially in recent years, rising from a market share of 5% in 2013 to 40% of global residential lighting sales in 2018. LED sales now appear to have overtaken fluorescent sales in the residential sector, and that share is expected to continue expanding. LEDs are now massively produced in many markets, and competition among manufacturers is driving further innovation, wider product choices and lower prices.

CLASP

CFLi: LED lamp retrofits for CFLi are cost-effective around the world, the country of Zambia is benefitting from affordable LED bulbs which were calculated in 2019 to have a 3.9 month payback period compared to incandescent lamps, and would last 15 times longer (CLASP, 2019). And the net-present value of the energy savings over a 10-year period, discounted back to 2019 is US\$90.53 – far exceeding the slightly higher first cost of the purchase of the LED (US\$2.50).

CFLni: The payback period for a CFLni replacements will vary with the LED installed in any given application – but they are positive, allowing end-users to recover their investment. Considering an example in Europe, a pin-based 2D fluorescent tube (OSRAM 2D GR10q 28W) is compared with an LED retrofit alternatives made by General Electric which can operate on the same ballast (i.e., the LED bulb is simply installed into the fluorescent fixture with no rewiring). The LED replacement bulb will last more than twice as long as the fluorescent lamp, and the payback period from installing the lamp is 1.3 years. The research found that for this particular installation, by simply changing one lamp in their offices, they would save €63.25 over the life of that GE LED bulb (Sweden, 2020).

LightingEurope

CFLni: LightingEurope calculations from 2020, show as an example, that a forced LED investment in 2021, including labour costs, results in a payback period of 18 years for a LED luminaire and for a LEDni lamp a payback period of 5 years. This risks facing

⁶ International Energy Association (IEA), *Tracking Report on Commercial Buildings/Lighting*, May 2019, www.iea.org/reports/tracking-buildings/lighting

	<p>substantial opposition by consumers and professional users in the EU, the same way that users were significantly opposed to the former ban of incandescent lamps (despite the short payback period for CFL-is of typically half a year). As LEDni retrofit lamps can only be used in about 50% of the installed luminaires and applications, LightingEurope estimated the cost of a premature phase out for Member States to be 133 Billion Euros for CFL-ni and LFL technologies, mainly to be borne in the next 5 years.</p> <p>Of the core energy end-uses in the buildings sector, only lighting is on track with the IEA's Sustainable Development Scenario due to LED sales, increasingly replacing fluorescent lighting were feasible (IEA report May 2019). Pay back periods depend on the availability and feasibility of plug and play alternatives and vary from a few years for CFL-I applications to many more years for many CFL-ni and LFL-ni applications due to the cost of rewiring luminaires or in case of a switch to LED luminaires.</p> <p>As a result of non-compatibility issues for LED-ni substitutes, LightingEurope foresees the following practical consequences for users:</p> <ul style="list-style-type: none"> - In the absence of functioning substitutes, users will need to allocate sufficient resources to rewire or replace existing luminaires. Hence high costs will be involved (for EU market a total of 133 Billion Euros is estimated for CFL-ni and LFL technologies). - Rewiring and replacing luminaires requires new certification to ensure the safety and quality of the product, in line with insurance requirements for buildings. - Phase-outs should be aligned to luminaire replacement cycles (typically 14 years) to allow users time to allocate the sufficient resources to transition to the alternative technology. The users of these products, together with LightingEurope, have repeatedly called for a smooth transition timetable (see the 2018 Joint Statement cosigned by 17 associations representing the users of these products). <p>The speed of the LED transition for different applications also depends on investments of companies, governments and individuals (see IEA report May 2019).</p>
<p>6. Information on environmental and health risks and benefits of alternatives</p>	<p>EU LEDs are mercury-free and are accepted to have improved energy efficiency compared with CFLs. End-of-life management should consider the copper, nickel and lead content in LEDs due to their hazardous nature and consider to utilise these resources (Seong-Rim, et al., 2011). However, the use of non-mercury alternatives ensures limiting the amount of mercury released to the environment including during the end-of-life phase.</p> <p>African Region LEDs remove unnecessary risk of exposure to toxic mercury for consumers and workers when lamps break in homes, offices, schools, and businesses. They also reduce the amount of mercury contamination at landfill and waste sites due to improper disposal. A European study by the Swedish Energy Agency and CLASP found that despite regulations, enforcement and oversight, only 13% to 50% of fluorescent lamps in Europe are recovered and recycled at the end of life. (Swedish Energy Agency, 2019) The small size and weight of bulbs makes them easy for consumers to mistakenly dispose of in general waste, and consumers may not be aware that they require special disposal. In addition, due to their fragility fluorescent bulbs break easily when discarded in general waste streams, releasing mercury into the environment and putting the health of workers and the public at risk. In addition to the direct mercury use avoided through mercury-free alternatives, the energy savings associated with switching from fluorescent to LED lamps can also indirectly reduce mercury pollution by reducing the use of fossil-fuel-powered generators or coal-fired power use. LEDs generally use 40% - 60% less electricity than a fluorescent lamp to generate the same level of light output.</p>

Mercury emissions from power generation is a major pathway for environmental mercury poisoning, and coal-power-related mercury emissions linked with inefficient lighting can outweigh the mercury used in the lamps themselves. (Swedish Energy Agency, 2019)

Norway

Mercury from fluorescent lighting is a major problem. The practical reality in the field is that recovery rate for fluorescent lamps is lower than rates reported for all WEEE directive products. A recent report found 50-88% of fluorescent lamps placed on the market in Europe today are not disposed of properly – thus, most of the mercury in lighting is not recovered and is causing further damage to the environment and public health (Sweden, 2020). Collection rates in developing countries are going to be significantly lower than Europe. The only way to stop mercury being released by lighting is to stop placing it on the market. There is no technical or economic reason to continue to allow fluorescent lamps on the market. There is no longer a need to tolerate this health hazard in our homes, schools, hospitals, shops and elsewhere. And, it should be noted that LED alternatives for fluorescent lamps are not only mercury free, but also use half the energy which helps to reduce mercury emissions from coal-fired power stations due to the energy savings.

ZMWG

The SEA-CLASP report further quantifies the following benefits⁷ for Europe from removing these exemptions (for CFLni, T5 and T8 lamps) by 2021:

- 4.8 metric tonnes of mercury are avoided; 2.6 metric tonnes from the lighting supply chain and 2.2 metric tonnes avoided emissions from power stations (coal);
- €12.5 billion in energy and replacement lamp savings for businesses and consumers across Europe;
- 138.3 TWh of electricity savings; and
- 40.9 million metric tonnes of CO₂ emission savings.

Canada

LEDs are preferable to mercury-containing lamps from an environmental perspective since they are mercury-free and have higher efficiency and longer lifespans. However, a group of researchers questioned the hazards of certain types of LEDs that contain hazardous substances such as lead.¹⁵ After conducting leachability and other tests, researchers found that LEDs are not hazardous (according to US federal standards) except for the low-intensity red LEDs that were tested, which leached lead at levels exceeding regulatory limits (186 mg/L; regulatory limit: 5).¹⁵ The researchers found that LEDs, had levels of copper (up to 3892 mg/kg; limit: 2500), Pb (up to 8103 mg/kg; limit: 1000), nickel (up to 4797 mg/kg; limit: 2000), or silver (up to 721 mg/kg; limit: 500) making all LEDs except low-intensity yellow LEDs, hazardous according to California standards. This research study was based on a very small sample of an older generation of LEDs and more up to date content data for commonly used current LEDs would be useful. In this regard, a review of Safety Data Sheets for current LEDs from major suppliers indicates that current LEDs do not contain lead or any hazardous materials in reportable quantities and “there are no substances contained within an LED lamp that would cause the lamp to be classified as hazardous waste”.¹⁶

⁷ Benefits in this modelling were calculated for Sweden and CLASP by VHK, the consultants who conducted the lighting market analysis for DG ENER. The estimates were calculated using the same European lighting market model.

	<p>CLASP LED bulbs use approximately 50% less energy than their fluorescent equivalents, resulting in lower emissions at the power stations of both greenhouse gases (CO₂) and mercury emitted due to the burning of coal. A report by the Swedish Energy Agency and CLASP (Sweden, 2020) calculated that eliminating exemptions for fluorescent bulbs in Europe in 2021 would:</p> <ul style="list-style-type: none"> • Eliminate a cumulative 2.9 metric tonnes of mercury from the fluorescent bulbs and avoid a further 2.5 metric tonnes of mercury emissions from coal-fired power plants as a result of the greater energy-efficiency of LED bulbs – totalling 5.4 metric tonnes of mercury avoided in Europe from phasing out CFLni and two types of linear lamps (T5 and certain T8). • Avoid the release of 92.1 million metric tonnes of CO₂ emissions through energy savings by 2035, which is equivalent to the total annual CO₂ emissions of Denmark and Slovakia in 2018. <p>NRDC A lot of research has been conducted into LED light and LED products to determine whether they are safe and sustainable from an environmental point of view. The International Commission on Illumination (CIE) published a report on blue light hazard for example, concluding “that people are normally not at risk of exceeding the internationally agreed blue light hazard exposure limits from white light sources used for illumination.” (LED Professional, 2019) In addition, the US Department of Energy has published research that determined LED lighting is no more harmful than other light sources in use today, and that there is nothing about LED lighting that would prevent it from being fully compliant with relevant safety and performance standard. The conclusion is that “LED lighting is safe to use while adhering to manufacturers' instructions and that its use does not create any health hazards”. (JPost, 2018)</p> <p>LightingEurope - CFLni Compared to the total mercury release from the main anthropogenic sources in the EU (77.2 ton), the proportion of mercury placed on the EU market by lighting LFL T8, T5 and non-linear products, is limited to below 1 metric ton per year and shows a steady decrease since many years due to continuous innovation by LightingEurope companies. The current amount of Mercury release by these lamp types is 0.33 % of the total EU Mercury release in 2020 and decreasing to 0.1% in 2026. (LightingEurope, September 2020 presentation at UN vertical lamps meetings – see slide excerpts below)</p>
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	<div><div><h3>Mercury reduction and trend of CFL lamps for general lighting</h3><ul style="list-style-type: none">Two types of CFL lamps are placed on the market, CFL-i lamps with integrated electronic ballast and CFL-ni lamps without integrated electronics (driver located in the luminaire)Mercury placed on the EU market by lighting CFL-i and CFL-ni lamps, is limited to below 0.4 metric ton per year and decreasing fast</div><div><p>Compact fluorescent Lamps Sold in Europe</p></div><div><table><tr><th>CFL-i</th><th>CFL-ni</th></tr><tr><td></td><td></td></tr></table></div></div> <div><div><h3>Total mercury content from CFL for general lighting (CFL-i & CFL-ni)</h3><table><tr><th>Total EU Mercury by CFLi & CFLni (metric ton per year)</th><th>2020</th><th>2022</th><th>2026</th></tr><tr><td>Total Mercury put on the market</td><td>0.4</td><td>0.2</td><td>0.1</td></tr><tr><td>Total Mercury released in environment (non-recycled lamps)</td><td>0.2</td><td>0.1</td><td>0.05</td></tr></table> <table><tr><th>Ratio CFLi & CFLni of total EU release (of all EU anthropogenic sources)</th><th>2020</th><th>2022</th><th>2026</th></tr><tr><td>Total Mercury put on the market</td><td>0.5%</td><td>0.3%</td><td>0.1%</td></tr><tr><td>Total Mercury released in environment (non-recycled lamps)</td><td>0.3%</td><td>0.2%</td><td>0.05%</td></tr></table><ul style="list-style-type: none">The mercury content released to the environment from CFL lamps is < 1% (0.2 tn in 2020) of the total EU mercury released to the environment of 77.2 tnThe amount is decreasing further to <0.1 % in 2026 due to the natural LED transition in the market.</div></div>	CFL-i	CFL-ni			Total EU Mercury by CFLi & CFLni (metric ton per year)	2020	2022	2026	Total Mercury put on the market	0.4	0.2	0.1	Total Mercury released in environment (non-recycled lamps)	0.2	0.1	0.05	Ratio CFLi & CFLni of total EU release (of all EU anthropogenic sources)	2020	2022	2026	Total Mercury put on the market	0.5%	0.3%	0.1%	Total Mercury released in environment (non-recycled lamps)	0.3%	0.2%	0.05%
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<p>7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)</p>	<p>In Europe, Regulation (EU) 2017/852 on mercury, Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) and the Minamata Convention are of the greatest relevance to CFL.is and associated alternatives.</p> <p>Table 1provides a summary of the CFLs regulated under EU legislation, but not under the Minamata Convention. From December 2018, under Article 5 of Regulation (EU) 2017/852, the manufacture, import and export of CFLs for general lighting purposes for ‘CFLi ≤ 30 watts with a mercury content exceeding 2.5 mg per lamp burner’ is prohibited in the EU. In addition, the RoHS Directive has prohibited the placing of some CFLs exceeding 5mg Hg on the market since December 2011, and CFLs exceeding 2.5mg since December 2012 (Annex III, exemption 1 (a)-(e) and 1(g)).</p> <p>From 1 September 2021, under Regulation (EU) 2019/2020 on the eco-design requirements for light sources and separate control gears, the declared power consumption of a light source will be obliged to not exceed the maximum allowed power, based on specified values for threshold efficacy and end loss factors in Annex II. According to information provided by the European Commission, is unclear whether CFLs will be able to meet these efficiency requirements.</p> <p>Canada has also implemented national regulations for products containing mercury. CFLs for general lighting purposes ≤ 25 W have a maximum mercury content of 4 mg per lamp. In addition, CFLs > 25 W have a maximum mercury content of 5 mg per lamp (Minister of Justice, 2019). It should be noted that this is for different wattages than those prescribed by the Minamata Convention and so is not directly comparable.</p>																												

Table 1 – CFLs regulated by EU legislation but not under the Minamata Convention

Product	Extent of EU restriction	Relevant EU Legislation	Minamata Convention
Single capped (Compact) fluorescent lamps (CFL) for general lighting purposes < 30 W	≤ 2.5 mg per lamp burner	Directive (RoHS), 1(a)g Regulation 2017/852	2011/65/EU Exemption (EU) ≤ 5 mg per lamp burner (all CFL)
CFL for general lighting purposes ≥ 30 < 50 W	≤ 3.5 mg per lamp burner	Directive (RoHS) Regulation 2017/852	2011/65/EU (EU) Not regulated
CFL for general lighting purposes ≥ 50 W and < 150 W	≤ 5 mg per lamp burner	Directive (RoHS)	2011/65/EU Not regulated
CFL for general lighting purposes ≥ 150 W	≤ 15 mg per lamp burner	Directive (RoHS)	2011/65/EU Not regulated
CFL for general lighting purposes with circular or square structural shape and tube diameter ≤ 17 mm	≤ 7 mg per lamp burner	Directive (RoHS)	2011/65/EU Not regulated
CFL for special purposes	≤ 5 mg per lamp burner	Directive (RoHS)	2011/65/EU Not regulated
CFL for general lighting purposes < 30 W with a lifetime equal or above 20 000 h	≤ 3.5 mg per lamp burner	Directive (RoHS)	2011/65/EU Not regulated

Australia has implemented the E3 Programme, which reduces the maximum mercury content of CFLs < 30 W to 2,5 mg. As 80% of products were already in compliance prior to policy implementation, this did not have a significant impact on suppliers (Energy Rating, 2017).

The US enforces standards in the lighting industry through the Energy Star programme, introducing a limit of 2,5 mg for CFLs ≤ 23 W and 3 mg for CFLs > 23 W (UNEP, 2013b).

In Russia and the Eurasian Economic Union (EAEU), Technical Rule EAEU 037/2016 on the restriction of the use of hazardous substances in electrical and radio electronic products placed restrictions on CFLs that go beyond Minamata and are equivalent to those placed by the European RoHS Directive shown in Table 1. **Error! Reference source not found.** Namely, 2.5 mg for CFL <30 W, 3.5 mg for 30-50 W, 5 mg for 50-150 W, 15 mg for >150 W, 7 mg for circular or square bulbs, and 5 mg for lamps for special purposes. The same restrictions for CFLs have been put into force in India (G.S.R338(E) E-Waste (Management) Rules, 2016) (Gazette of India, 2016). At the same time, there has been a gradual discontinuation of manufacturing CFLs in India since 2014. This has been matched by a gradual increase in the sales of LED lamps in the same period (Table 2).

Table 2 – Quantity of lamps sold in India per year by type (million units)

Lamp type	2014	2015	2016	2017	2018
CFL	450	381	205	102	28
LED	4-86	62	251	336	520

In addition, information from an industry body stated that more stringent mercury levels than Minamata, based on the EU RoHS Directive, are implemented in further countries and regions, including Singapore, Thailand, Ukraine, Jordan, Turkey, UAE, Saudi Arabia, Vietnam, South Korea and Japan.

8. Other relevant information pursuant to Decision MC-3/1

African Region

- Overview: CFL is an outdated, inefficient, expensive technology which contains mercury
- Choice: Mercury-free retrofits are available for all regular sockets and virtually all pin-base sockets; a wide selection of light output levels and white light colors
- Economic: LED retrofits are highly cost-effective, payback in 6 weeks compared to halogen; LEDs cost 50% less than CFL to buy and use; LED is the least life-cycle cost option
- Technology: LED continues to improve, getting cheaper and more efficient each year
- Waste: most fluorescent bulbs are not disposed of safely at end of life, even in Europe
- Business: Africa has many new local manufacturing companies producing LED lamps, but there is no manufacturing of fluorescent on the continent
- Policy: Some African countries are phasing out CFLs based on energy savings and cost
- Equity: Risk that suppliers will dump more mercury lighting in Africa as fluorescent lamps are phased-out of the OECD

South Africa published a draft General Service Lamps regulation in their national Gazette on 1 March 2021, and it is currently open for a 60-day comment period (South Africa, 2021). The draft standard phases-out CFLi by setting a minimum efficacy of 90 lm/W for general service lamps (this efficacy level cannot be reached by CFLi). The regulation would take effect most likely in 2022, 12 months after the second publication in the Gazette, which is expected later in 2021. Here is a short news item about the draft policy measure (BusinessTech, 2021).

9. References

EU

- COWI and ICF, 2017. Support to assessing the impacts of certain amendments to the Proposal of the Commission for a Regulation on Mercury. Available at: http://ec.europa.eu/environment/chemicals/mercury/pdf/Final%20Report_KH061714IENN.pdf [Accessed 20/05/2019].
- Energy Rating, 2017. Australia drops mercury levels in fluorescent lighting. Available at: <http://www.energyrating.gov.au/news/australia-drops-mercury-levels-fluorescent-lighting> [Accessed 13/06/2019].
- Gazette of India (2016). Notification New Delhi 23 March, 2016. Available at: <http://moef.gov.in/wp-content/uploads/2017/07/EWM-Rules-2016-english-23.03.2016.pdf>
- Gensch, C.-O. et al., 2016. Study to assess renewal requests for 29 RoHS 2 Annex III exemptions [no. 1(a to e -lighting purpose), no. 1(f - special purpose), no. 2(a), no. 2(b)(3), no. 2(b)(4), no. 3, no. 4(a), no. 4(b), no. 4(c), no. 4(e), no. 4(f), no. 5(b), no. 6(a), no. 6(b), no. 6(c), no. 7(a), no. 7(c) - I, no. 7(c) - II, no. 7(c) - IV, no. 8.
- Gensch, C.-O., Baron, Y. & Deubzer, O., 2019. Study to assess 3 exemption requests (one for mercury and two for lead) (Pack 13) – Final - amended.
- LED Inside (2018). Global LED Lighting Products Price Trend. Available at: https://www.ledinside.com/news/2018/8/global_led_lighting_products_price_trend
- Lighting Europe, 2016. Request to renew Exemption 1(g) under the RoHS Directive 2011/65/EU Mercury in single-capped (compact) fluorescent lamps for general lighting purposes < 30 W with a lifetime equal or above 20000 h: 3,5 mg, 28.06.2016.
- Lighting Europe, 2017. Answers to 1st Questionnaire - Exemption No. 1(g) (renewal request): "For general lighting purposes < 30 W with a lifetime equal or above 20 000 h: 3,5 mg", 15.09.2017. Available at: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_pack_13/Annex_1g/LE_WG_CE_-_TF_RoHS_-_1G_Questionnaire_Response_-_20170915_-_v5-_FINAL.pdf [Accessed 20/05/2019].
- Minister of Justice, 2019. Products Containing Mercury Regulations. Available at: <https://laws-lois.justice.gc.ca/PDF/SOR-2014-254.pdf> [Accessed 13/06/2019].
- Seong-Rim, L., Kang, D. & Ogunseitan, O. a. S. J., 2011. Potential Environmental Impacts of Light-Emitting Diodes (LEDs): Metallic Resources, Toxicity and Hazardous Waste Classification. Environmental Science & Technology, Volume 45, pp. 320-327.
- Swedish Energy Agency, 2019. Evidence of the availability of mercury-free alternative products to certain fluorescent lamps. Available at: <https://meta.eeb.org/wp-content/uploads/2019/11/SEA-and-CLASP-analysis-of-RoHS-exemptions-for-fluorescent-lamps-v2-1.pdf>
- The Lightbulb Company, 2019. A Guide To Compact Fluorescent Lamps (CFL) & Fluorescent Tubes. Available at: https://www.thelightbulb.co.uk/resources/compact_fluorescent_lamps_guide/.
- UNEP, 2013a. Minamata Convention on Mercury.
- UNEP, 2013b. Acceptance on behalf of the United States of America. Available at: <http://www.mercuryconvention.org/Portals/11/documents/submissions/US%20declaration.pdf> [Accessed 13/06/2019].
- US EPA, 2019a. Learn About Compact Fluorescent Light Bulbs. Available at: http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_about [Accessed 20/05/2019].
- US EPA, 2019b. Do CFLs contain mercury?. Available at: <https://energystar.zendesk.com/hc/en-us/articles/212110747-Do-CFLs-contain-mercury-> [Accessed 20/05/2019].
- US EPA, 2019c. Learn about LED bulbs. Available at: https://www.energystar.gov/products/lighting_fans/light_bulbs/learn_about_led_bulbs [Accessed 21/05/2019].
- World Bank, 2019. Capacity Strengthening for Implementation of Minamata Convention on Mercury Project. Available at: <http://projects.worldbank.org/P151281?lang=en>.

African Region

- LEDvance, 2021. Examples of the wide range of CFLni products offered by LEDvance (formerly OSRAM): <https://www.ledvance.com/professional/products/product-stories/osram-dulux-led/index.jsp>
- Oko-Institut, 2020. Study to assess socio-economic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III; Oko-Institut, Germany. 10 July 2020. <https://rohs.exemptions.oeko.info/index.php?id=127>
- Schweber, 2018. "Whatever Happened to CFLs?" by Bill Schweber, Electrical Engineering Times (EE Times). 27 June 2018. Link: <https://www.eetimes.com/whatever-happened-to-cfls/#>
- Signify, 2021. Examples of the wide range of CFLni products offered by Signify (formerly Philips Lighting): <https://www.lighting.philips.com/main/prof/led-lamps-and-tubes/led-pl-lamps>

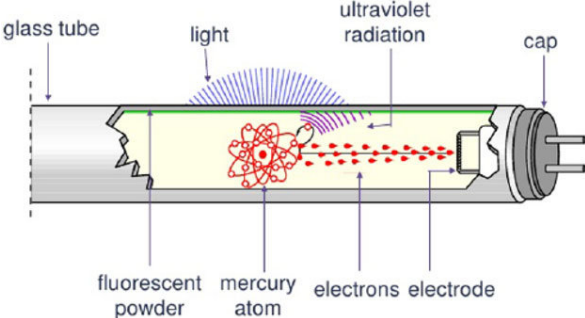
Swedish Energy Agency, 2019. Evidence of the availability of mercury-free alternative products to certain fluorescent lamps: Report to the Committee on the Restriction of Hazardous Substances, Swedish Energy Agency and CLASP, Dec. 2019. Link: <https://www.clasp.ngo/research/all/mercury-free-alternatives-to-certain-fluorescent-lamps-a-report-to-the-european-commissions-committee-on-the-regulation-of-hazardous-substances/>

Swedish Energy Agency, 2020. Assessing Annex III Fluorescent Lamp Exemptions in the Light of Scientific and Technical Progress, Report to the Committee on the Restriction of Hazardous Substances. Swedish Energy Agency and CLASP, 24 February 2020.

BusinessTech, 2021. Government wants to introduce new rules for lightbulbs in South Africa – what you should know, Business Tech, South Africa. 14 April 2021. Link: <https://businesstech.co.za/news/energy/483191/government-wants-to-introduce-new-rules-for-lightbulbs-in-south-africa-what-you-should-know/>

South Africa, 2021. South African Gazette, Government Notices, Department of Trade, Industry and Competition; National Regulator for Compulsory Specifications Act, 2008 (Act no 5 of 2008) as Amended Through Legal Metrology Act: Compulsory Specification for Energy Efficiency and Functional Performance Requirements of General Service Lamps (GSLs) – VC 9109. Link: http://www.gpwonline.co.za/Gazettes/Gazettes/44210_01-03_TradeIndCompetition.pdf

Linear Fluorescent Lamps (LFL)

1. Category of mercury-added product	Lamps
2. Further description of the product	Linear fluorescent lamps (LFL)
3. Information on the use of the product	<p>In LFLs, ultraviolet light is generated by driving an electric current through a tube, which contains argon and mercury. This then stimulates the phosphor coating to produce visible light. LFLs are categorised based on the type of phosphor used. Triband phosphor lamps utilise three combined materials with peaks at blue green and orange lights to create an overall white hue. They are a technical successor of halophosphate lamps.</p> <p>Figure 1: Linear Fluorescent Lamp (Sethurajan et al., 2019)</p>  <p>LFLs are split into different categories based on tube diameter. T2 LFLs (where the ‘T’ represents a tubular lamp, and the number represents the diameter) are a small segment of the market for energy efficient lamps, being used in private homes as well as professional use. T5 lamps are used mainly in professional areas such as offices and industrial buildings. T2, T5 and T8 lamps are operated with electronic control gears (ECG) which have advantages over conventional control gears (CCG) regarding power consumption, lifetime and maintenance costs. Long lifetime lamps are another type produced with lifetimes over 25,000 hours. T8 lamps have a diameter of 26mm and come in 16 different lengths, with high energy efficiency of up to 100 lumens per watt and a lifetime of 20,000 hours. Long-life LFLs have more Hg per lamp due to the mercury using process taking place for longer, however there is less Hg per lumen hour of operation compared with lamps of lower life (Gensch, et al., 2016).</p> <p><u>Range of mercury content/consumption per unit product</u></p> <ul style="list-style-type: none"> - The average mercury content of a triband phosphor T2 LFL is 1.5-3.5 mg (Lighting Europe, 2015). - The average mercury content of a triband phosphor T8 LFL is 2.5 - 3.3 mg - The average mercury content of a triband phosphor T5 LFL is 1.5 - 2.6 mg (Gensch, et al., 2016). - The average mercury content of a halophosphate LFL 8-10 mg (COWI&ICF, 2017)

African Region

Linear fluorescent tubes are commonly used in offices, hospitals, schools and other areas which have the lights on for long periods of time. LFLs for general lighting purposes, including both tri-band phosphor (which is a rare earth) and halophosphate phosphor lamps. Coverage includes LFLs of all diameters (e.g., T5, T8, T12), lengths, and shapes (e.g., straight, U-bend). The Minamata Convention currently covers LFLs which use tri-band phosphors up to 60 watts and LFLs that use halophosphate phosphors up to 40 watts. Based on the economic feasibility and environmental and public health benefits of eliminating mercury-added LFLs, and in light of the near-universal availability of mercury-free alternatives, these products should be banned for manufacture, import and export by 2025. LFLs are declining in sales around the world thanks to the market adoption of LED retrofit tubes. In Europe, all T2 and T12 LFL lamps will be banned by the Ecodesign Directive from 1 September 2021. The most popular lengths of T8 LFLs (2-foot, 4-foot and 5-foot) will be banned by Ecodesign from 1 September 2023.

Japan

The amount of mercury used in a fluorescent lamp produced by JLMA members has been declining. In 2018, the average amount of mercury per fluorescent lamp for general lighting purpose was 5.8 mg. As of the end of 2017, JLMA members have already achieved a reduction of mercury content in their products lower than the level stipulated in Annex A.

With regards to electrodeless fluorescent lamps, which are not regulated under the Convention, there is a possibility that some exist for maintenance purpose, but in a very small quantity.

Japan Lighting Manufacturers Association (JLMA)

Non-integrated fluorescent lamps without a (electronic) ballast/control gear i.e. linear fluorescent lamps (LFL) and also named non-integrated CFL lamps (CFL-ni) are considered to be maintenance or repair parts for luminaires, and the Japanese government requires that the supply of spare parts comply with the lighting industry's standards of 10-year lifetime of a luminaire.

ZMWG

India is one of the largest global users of mercury containing lamps, with almost 28 million pieces of CFL lamps and 132 million pieces of LFL sold annually (2018).

LightingEurope

LFL-ni lamps are non-integrated non-screw-based lamps where the electronic driver is situated in the luminaire and where many different types of electronic drivers are used by luminaire manufacturers (as is the case for CFL-ni lamps). These luminaires are mainly used for a large variety of professional applications, installed and maintained by professionals (e.g., Dimming controlled applications like offices, retail, hotels, apartments, hospitals, schools, elderly homes, theatres, exit signs, industrial lighting, waterproof or explosion atmosphere applications, residential streetlighting, railway and metro stations, trains, battery powered emergency lighting luminaires, medical applications, etc).

Halophosphate lamps

LFL-ni lamps use fluorescent coatings made of 2 types of materials and used for the same kind of applications.

The most efficient lamps use tri-band fluorescent coating made of rare-earth elements and have an efficiency which is approx. 7-8 times that of incandescent lamps. LFL halophosphate lamps are still used in USA, Latin America and Asian countries and do not use the expensive rare earth elements that are scarce materials nowadays. As they are more affordable, they contribute to more efficient

	lighting (5 times that of the incandescent bulbs) in countries that lack the funds to invest in more expensive tri-band technologies or LED technologies.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Halophosphate lamps have been phased out in European Union and the United States. The following information focus on LED lamps as alternatives of the LFLs in general.</p> <p>EU (supplemented by US) <u>Main alternatives: Tubular LED lamps based on Light emitting diodes (LEDs)</u> LED replacements are available for T8 LFLs, however the compatibility of the component (LED lamp) with the electrical system (installed in LFL luminaire) can have limitations that are expected to be resolved in ongoing research, such as low lumen output and low Colour Rendering Index (CRI)⁸ (VHK & VITO, 2015). Information published by the Swedish Energy Authority indicates that in 2019, there are LED bulbs engineered to operate in existing T8 ballasts while minimising labour and recycling costs (SEA, 2019).</p> <p>According to industry sources, there are almost no T2 lamps available based on LED technology that are a direct replacement for T2 lamps in existing applications. Based on previous findings there are still relatively few T5 products based on LED technology, however this is challenged by the recent SEA study which argues that T5 luminaires can easily be updated to LEDs (Gensch, et al., 2016) (SEA, 2019).</p> <p>Halophosphate lamps can be replaced by triband phosphor lamps with a lower mercury content in cases where mercury-free alternatives are not yet feasible. Triband phosphor LFLs are subject to more stringent mercury concentration restrictions of 3-5mg depending on bulb size, while halophosphate lamps, now phased out in Europe (and also not reported on in the 2020 U.S. EPA Mercury Inventory) report, previously had limits set at 10mg.</p> <p>Canada See CFL</p> <p>Norway There are thousands of mercury-free LED replacement lamps available today to replace fluorescent lamps – different sizes, lengths, ballast types (i.e., magnetic/starter and high frequency electronic), colour temperatures, and regular, high output and ultra-high light output levels. Lamps are also available which are “universal” and can operate on a variety of input power configurations. Many of these LED products are designed as direct retrofits into existing fluorescent fixtures to avoid the need to rewire. For example, Philips/Signify states⁴ that there is “No need to change drivers or rewire”, noting that they offer a “plug and play solution that works straight out of the box”. OSRAM/LEDvance state⁵ that their “SubstiTUBE” product is a “Quick, simple and safe lamp replacement without rewiring.” Sylvania lighting advertises that their SubstiTUBE product is “engineered to operate on existing instant start and select programmed rapid start electronic T8 ballasts, these lamps minimise labour and recycling costs.”⁶ Tungsram reports that in addition to “the 2.5-3x longer life (compared to T8 fluorescent lamps operated on electro-magnetic gear) and lower wattages, Tungsram LED T8 tubes provide lower system loss while existing fixtures remain intact.”⁷</p> <p>African Region Today there are literally tens of thousands of mercury-free LED replacement lamps available to replace fluorescent tube lamps, and</p>

⁸ An industry scale from 0-100 indicating how accurate a given light source is at rendering colour when compared to a reference light source

they are available in virtually any size, length, ballast type, color temperature, and light output level. These LED products are designed as direct retrofits into fixtures originally designed to accept fluorescent tubes. In this way, the mercury-free LED tubes are simple drop-in replacements that completely avoid the need for rewiring that was present in some of the first-generation LED tubes. (Swedish Energy Agency, 2020)

ZMWG

LEDs can readily replace almost all types of T8s. Including outdated information in the compilation can be misleading - as potential issues that could have risen at the time have currently been solved by this technology which is moving very fast.

Under the EU Ecodesign directive, which looks mainly at the energy efficiency of products including lighting. Commission Regulation 2019/2020 of 1st October 2019 agreed, via an energy efficiency formula, to ban Compact fluorescent Lamps (CFLs) with integrated ballast (CFLi) as well as Linear fluorescent lamps T2 and T12 by 1st September 2021, and certain lengths (2-foot, 4-foot and 5-foot) of T8 linear fluorescent lamps by 1st September 2023.

[LED replacements are available for T8 LFLs, with 91-93% compatibility with existing luminaires](https://rohs.exemptions.oeko.info/fileadmin/user_upload/reports/RoHS_SEA_Lamps_2020_Revision-Final_10072020.pdf) (Oeko Institut for the European Commission, July 2020). https://rohs.exemptions.oeko.info/fileadmin/user_upload/reports/RoHS_SEA_Lamps_2020_Revision-Final_10072020.pdf

T2 is old technology. It is to be banned in the EU by 1 September 2021 under the Ecodesign directive.

JLMA

Mercury substitute products for mercury reduction should be considered for products approved by laws and regulations. In Japan, LED lighting fixtures and CFL-i are subject to the Electrical Appliance and Material Safety Law, while other products have safety issues and are not recognized by the law. There is no replaceable non-integrated LED lamps (without built-in ballasts) that can be checked for safety in combination with all fixtures.

Mercury use should be reduced by reducing the demand for mercury-containing lamps, so discharge lamp fixtures on the market should be replaced with LED fixtures.

Recently, for reasons that LED lamps (retrofit lamps) that fit into existing fluorescent fixtures are not completely safe, a working group has been set up at the IEC to review a technical document that will set new "ground rules" for the future handling and support of these lamp products when designing retrofit light sources. It should be understood that LED lamps with a mouthpiece for fluorescent lamps currently on the market are incomplete products.

CLASP

There are literally thousands of LED retrofit tubes which can be used in existing fluorescent fixtures – simply changing the bulb to mercury-free LED – a full range of LED tubes are already available today. These include different lengths, tube bulb widths and pin-base types; and it also includes wide ranging correlated colour temperatures, colour rendering indexes, levels of light output, lamp lifetime, dimmability and so-on – all the options necessary are available for lighting applications around the world. In Europe, it has been proven that 91-93% of the fluorescent fixtures can accept direct retrofit LED tubes today (Sweden, 2020), and the technology is available to enable LED substitutes to operate on 99.9% of existing LFL fixtures and applications (Seaborough, 2021).

	<p>NRDC Retrofit LED tubes for LFLs are a mature product, that has been on the market for over ten years now. NRDC has reviewed the Design Light Consortium's database of retrofit LED tubes, and found that there are literally more than 29,000 discrete models of mercury-free LED retrofit tube lamps for LFLs – and this database is only part of the North American market. (DLC, 2021). There are different diameters, lengths, ballast types (magnetic and electronic), color temperatures, color rendering indexes and levels of light output. (DLC, 2021).</p> <p>LightingEurope LFL-ni lamps LED substitutes are entering the market for several applications but are not available for all lamp types, due the variety of lamps, nor for all applications with various efficiencies, lifetime qualities and price levels (from low to high end products). LED substitutes show non-compatibility issues with many drivers used in installed existing lighting fixture (in about 50% of the cases in EU (ref. Oko Institute 10 July 2020 – Table 2-2) due to the large variety of electronic driver topologies used in installed luminaires), where warranty does not apply, and rewiring or replacement of the entire luminaire is needed. To avoid quality and safety issues in the application related insurance requirements for buildings, advice from professional installers is inevitable, e.g., to rewire the luminaire or exchange the entire luminaire (LightingEurope, September 2020 presentation at UN vertical lamps meetings). (see installers guidance links: Signify, Ledvance and Tungsram).</p>
<p>5.(i) Information on the technical feasibility of alternatives</p>	<p>EU Tubular LED lamps and luminaires are entering the market for replacing certain mainstream LFLs, matching LFLs for efficacy, energy efficiency, and appearance. However, there are limited T2 LED lamps available on the market (Lighting Europe, 2015). Tubular LED lamps for T8 replacement are only available for mainstream application in 3 lengths (600, 1200, 1500mm) and in the most common colour temperatures (i.e. not very cool 12000K or very warm 2700K) (Gensch, et al., 2016). The more recent SEA study (2019) argues, however, that both T5 and T8 retrofit LEDs would be technically feasible to replace LFLs, without the need for rewiring. T8 LEDs are omnidirectional while LED tube lamps emit light directionally, resulting in higher glare levels and lower uniformity of lighting levels (Lighting Europe, 2015). Mercury levels in triband phosphor LFLs that can replace halophosphate LFLs are restricted to levels lower than that of Minamata. This indicates that there are no technical feasibility issues associated with reducing mercury content to these levels (see Examples of regional or national restrictions). From 1 September 2021 (and 1 September 2023 in the case of certain sizes of T8 bulbs), under Regulation (EU) 2019/2020 on the eco-design requirements for light sources and separate control gears, the declared power consumption of a light source will be obliged to not exceed the maximum allowed power, based on specified values for threshold efficacy and end-loss factors in Annex II. According to information provided by the European Commission, it is unclear whether T8 LFLs will be able to meet these efficiency requirements.</p> <p>African Region Additional research specific to the African context is needed. However, looking at similar feasibility studies in other regions such as the EU, we found that currently 91 to 94% of fixtures originally designed for LFLs are compatible LED replacement lamps already available in the market today based on a detailed study of the installed stock of European luminaires. (Swedish Energy Agency, 2020b)</p>

Table 1. Revised LED Lamp Compatibility Percentages for T5 and T8 Luminaires in Europe

Lamp Size	Percentage of T5 & T8 in EU Stock	Ballast Type	Percentage of stock by ballast type	Estimated EU Stock of total T5 & T8	Compatibility, Low - High Estimate	Overall EU Stock Compatibility
T5	30%	HF/ECC	100% of T5	30%	79% - 80%	23.7% - 24%
T8	70%	EM/CGG	70% of T8	49%	100%*	49%
		HF/ECC	30% of T8	21%	89% - 97%	18.7% - 20.4%
EU Total:	100%			100%		91.4% - 93.4%

*No compatibility issues with electromagnetic T8 ballasts, LED lamps can retrofit 100% of these installations

The issue of LED retrofit lamp compatibility relates to the ballast installed in the existing fluorescent fixture. There are two types of ballast (the primary electronics component) in fluorescent fixtures: magnetic (also called “choke”) ballasts, which are the most common type in Africa and around the world, and electronic ballasts. All magnetic ballasts are 100% compatible with LED retrofit lamps, supporting simple like-for-like replacement. For electronic ballast fixtures, the rates of compatibility range from 80 to 99% (as per manufacturer declarations). Compatibility can be assessed by consulting with suppliers and published literature. A spreadsheet providing compatibility information for several of the largest global suppliers is posted on the Minamata Secretariat’s website.

For LFL configurations that are not readily available for purchase, research shows that the main barrier is lack of demand not technical impediments. Custom manufacturing is widely advertised for LED lamps of any length, base type, wattage, color rendering index, and color temperature with delivery lead times as short as one month.

In the market today, LED retrofit lamps are available and match all the color rendering indexes (CRI) of fluorescent lamps. Fluorescent lamps range from 77 to 98, and LED replacements for those lamps range from 80 to 98 CRI. As with CRI, there is no technical barrier to LED lamps producing all of the correlated color temperature (CCT) values as those of fluorescent lamps – the CRI is a product design decision that is made when selecting LEDs for the lamp.

Fluorescent lamps are available from 2700K to 12,000K, and LED retrofits are available from 2700K to 20,000K, so LED represents an expansion of the available CCT range.

Norway

Ballast Compatibility Data from technical reports published by several industry suppliers was compiled and published by Sweden/CLASP. The report found that LED retrofit tubes are 91.4 – 93.4% compatible with the installed stock of T5 and T8 fluorescent fixtures in the EU, avoiding the need to scrap or change luminaires, but instead simply change the lamp. (Sweden, 2020). There are direct, plug-and-play retrofit LED lamps for nearly all of the fluorescent luminaires installed in Europe. An independent Dutch consultancy, VHK, conducted a market analysis which confirmed the Sweden-CLASP findings. VHK stated

there are “adequate LED substitutes available for large majority of FL”, and they confirmed that there is “no technical barrier to create LED substitutes also for less widely used FL.”

CLASP

Tubular LED lamps are a mature product that is rapidly gaining in market share and replacing LFLs in all applications all over the world. A report studying the technical feasibility of alternatives to LFL found that the compatibility rate of LED in LFL applications was between 91.4% and 93.4%. Our review of ballast capability is based primarily on the large global suppliers of linear lamps – including Philips/Signify and Osram/LEDvance, two of the largest lighting companies in the world. The report used technical literature published by Philips/Signify and Osram/LEDvance and added data from Sylvania, Oppl and LEDs Change the World. The compiled database is available for public use⁹. The table below summarises the findings, that 91.4% to 93.4% of the existing stock of fluorescent lamps able to be replaced today with mercury-free LED retrofit bulbs (Sweden, 2020b):

Lamp Size	Percentage of T5 & T8 in EU Stock	Ballast Type	Percentage of stock by ballast type	Estimated EU Stock of total T5 & T8	Compatibility, Low - High Estimate	Overall EU Stock Compatibility
T5	30%	HF/ECC	100% of T5	30%	79% - 80%	23.7% - 24%
T8	70%	EM/CGG	70% of T8	49%	100%*	49%
		HF/ECC	30% of T8	21%	89% - 97%	18.7% - 20.4%
EU Total:	100%			100%		91.4% - 93.4%

*No compatibility issues with electromagnetic T8 ballasts, LED lamps can retrofit 100% of these installations

NRDC

For almost all the installed fluorescent fixtures that exist today, LED replacement lamps are readily available on the market around the world that do not require the existing fixture to be rewired. The major manufacturers contain statements on their websites which clearly point to the high level of compatibility as follows:

- Philips/Signify: “No need to change drivers or rewire”, and a “plug and play solution that works straight out of the box” (Signify, 2021b)
- OSRAM/LEDvance state “SubstiTUBE” is a “Quick, simple and safe lamp replacement without rewiring” (LEDvance, 2021)
- Tungsram says in addition to “the 2.5-3x longer life (compared to T8 fluorescent)...LED T8 tubes provide lower system loss while existing fixtures remain intact.” (Tungsram, 2021)

LightingEurope

LED-ni replacement lamps for LFL-ni lamps

Available LED substitutes show non-compatibility issues with many drivers used in installed existing lighting fixture (in about 50% of the cases in EU (ref. Oko Institute 10 July 2020 – Table 2-2) due to the large variety of electronic driver topologies used in installed luminaires) where warranty does not apply and rewiring or replacement of the entire luminaire is needed.

⁹ Link to the database: https://www.mercuryconvention.org/Portals/11/documents/meetings/COP4/submissions/CLASP_AnnexAB_spreadsheet.xlsx

	<p>Examples of non-compatibilities with certain drivers/installations where warranty does not apply are e.g. flickering, non-starting, early failures due to overheating of lamp or driver components etc. Also, the use of LED-ni substitutes is not allowed to be used in modern daylight dimming installations, serial circuited luminaires nor to be used in battery powered Emergency Lighting luminaires due to strict IEC standards (LightingEurope, September 2020 presentation at UN vertical lamps meetings)).</p> <p>To avoid quality and safety issues in the application related insurance requirements for buildings, advice from professional installers is inevitable, e.g., to rewire the luminaire or exchange the entire luminaire (both at high cost for the user). (see installers guidance links: Signify, Ledvance and Tungsram).</p>
<p>5.(ii) Information on the economic feasibility of alternatives</p>	<p>EU</p> <p>If fluorescent lamps would not be available and there would be no plug-in alternative, then the need to replace luminaires, control gears, or complete lighting systems etc. would result in high investment costs for businesses (Gensch, et al., 2016). The socio-economic impact report, published recently by the EU Commission, states that the related costs are substantial: 130-250 Billion € (European Commission, 2019). The sectors involved with the replacement (lamp producers, lighting installation contractors, etc.) would have benefits. However, from an overall economic perspective, premature replacement means a loss of capital and generation of 1-6 Million tonnes of waste (EU commission 2019).</p> <p>According to an industry group, LED alternatives are more expensive than conventional LFLs. However, information published by SEA (2019) indicates that the payback period for replacing T8 LFLs with LED retrofits is between 5 and 11 months from saved electricity, with a service life that is 1.5 to 2.5 times longer, and for T5 LFLs the payback time for LED replacements is 3 to 3.5 years (SEA, 2019).</p> <p>Norway</p> <p>The payback period for replacing a 36W T8 linear fluorescent lamp with an LED retrofit lamp in Europe today is between 5 and 11 months, and the service life of these lamps is 1.5 to 2.5 times longer than fluorescent, saving on replacement costs. LED replacements for T5 fluorescent lamps have longer payback periods of approximately 3 to 3.5 years, however they will operate for approximately 16 years and represent the best option for the end-user, with a net present value life-cycle cost savings of between €5 and €67 for each T5 fluorescent lamp replaced. LED replacements for compact fluorescent lamps not integrally ballasted (CFLni) offer very attractive payback periods of between 1.3 and 3.0 years and will last 2-3 times longer than the fluorescent lamp.</p> <p>African Region</p> <p>The replacement of LFLs with mercury-free alternatives is highly cost-effective. In general, the initial investment in LED retrofit lamps is recovered within one year, with the marginal up-front cost differential offset within just a few months by the substantial energy savings. Replacement lamps also offer labor cost savings due to their longer life spans, typically twice that of LFLs. The short payback periods for LED replacement lamps are typically a key feature advertised by manufacturers, along with other benefits associated with LED lighting (Dansk Supermarked (Signify, 2021), Denmark and Verhoef Access Technology, The Netherlands (Signify, 2021b).</p> <p>An example of a cost-payback calculation with LED retrofit bulbs is shown for South Africa below. We compared a ZAR 49.00 T8 linear fluorescent lamp at 36W (16,000 hours life) with an LED retrofit lamp which is rated for more than double the lifetime and consumes only 18W but produces the same light. Assuming operation for 10 hours per day and R1.25/kWh, the LED option offers a payback of 10 months compared to the fluorescent (and will last 2.5 times longer than the fluorescent lamp). These calculations reflect energy costs and bulb costs, but do not incorporate labor costs saved over time from reduced frequency of bulb changes.</p>

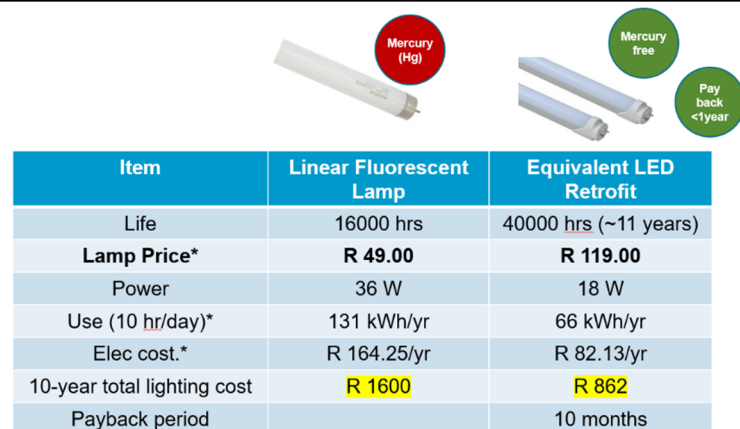


Figure 3. Payback Period for a T8 Magnetic Fluorescent Lamp, South Africa

In Uganda, the payback period for the same LED retrofit bulb is even shorter because the difference in first cost between the fluorescent and the LED tube from the wholesaler is not as large as in South Africa. In both countries the payback period is less than one year.

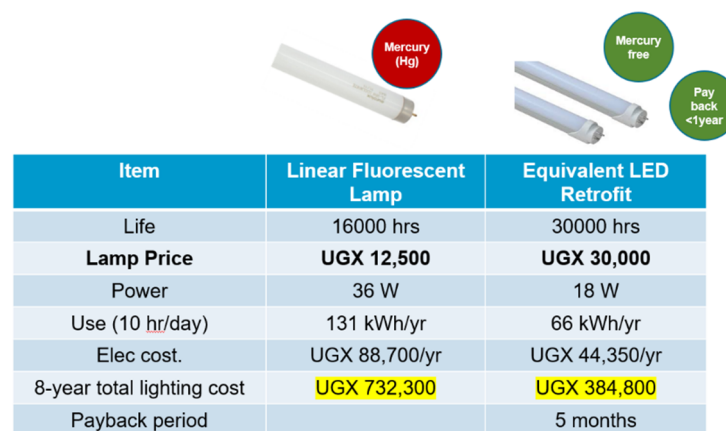


Figure 4. Payback Period for a T8 Magnetic Fluorescent Lamp, Uganda

The economic case for LED retrofit tubes is improving across Africa as more suppliers enter the market, and new businesses are established that offer these products to consumers.

ZMWG

The 2019 Socio Economic report mentioned in the EU submission has been updated by a 2020 Socio Economic report. This information needs to be updated otherwise it can be misleading.

The report “Update of the data provided by the analysis model developed in the course of the ‘Study to assess socio-economic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III’” has been revised: a sensitivity scenario has been added.

The report has been published and can be found here (PDF).

The combined model applied to calculate impacts for this study can be viewed here (excel)

In relation to **LFL T5** lamps, applying the CLASP/SwEA data set results in a total net benefit in the order of 9 304 million euros to be incurred between 2021 and 2035 (benefit of 21.66 euros per lamp).

The 2019 SEA study data set results in total costs in the order of 17 426 million euros (costs of 40.57 euro per lamp). The process of substitution is accompanied by a premature generation of e-waste of between 156 and 643 thousand tonnes (CLASP/SwEA and 2019 SEA study data sets respectively), possibly to be offset in the future in light of lower weight of LED luminaires and tubes which could decrease general e-waste amounts. Both cases avoid 1 064 kg of mercury in lamps being placed on the EU market. Under the Sensitivity data set, the phase-out leads to cumulative benefits in the order of 2 405 million euros for the period between 2021 and 2035 or 5.60 euro per lamp. 279 000 tonnes of e-waste are generated prematurely; mercury amounts not entering the market remain the same in all data sets (1 064 kg).

In relation to **LFL T8** lamps, the CLASP/SwEA data set results in a total net benefit in the order of 17,712 million euros between 2021 and 2035 (benefit of 47.56 euros per lamp). The 2019 SEA study data set results in total costs in the order of 11,749 million euros (costs of 31.55 euro per lamp). The substitution is accompanied with a premature generation of e-waste from rewiring and lamp replacement of between 32 and 704 thousand tonnes of e-waste (CLASP/SwEA and 2019 SEA study data sets respectively), though possibly also with a general decrease in e-waste amounts in light of lower weight of LED luminaires and tubes. Both cases avoid 962 kg of mercury in lamps being placed on the EU market. Under the Sensitivity data set, the phase-out leads to cumulative benefits in the order of 2,879 million euros for the period between 2021 and 2035 or a benefit of 7.73 euro per lamp. 368 000 tonnes of e-waste are generated prematurely; mercury amounts not entering the market remain the same in all data sets (962 kg).

CLASP

LED retrofit lamps for LFLs are highly cost-effective. The payback period for LED lamps will vary with the cost of the lamp, the electricity price and the hours of use in a given application. OSRAM/LEDvance claims, for example, that the payback period for replacing a T8 lamp with one of their retrofit LED tubes can pay back in as little as 4 months. (LEDvance, 2021)

Signify has a number of case studies on their website which attest to the energy savings and economic feasibility of LED retrofit lamps. An installation of 2100 LED tubes at a boat manufacturing plant in the Netherlands called Verhoef Access Technology found that the lighting bill was reduced by 60% and the investment was recovered in only 1 and a half years, with the installation expected to last for 17 years. (Signify, 2019)

	<p>Retrofit LED tubes are cost-effective all around the world. In Europe, researchers compared a €3.68 OSRAM 36W T8 LFL (20 000 hours life) with Philips' CorePro LED tube (30 000 hours life) and Philips' MasterLED tube (50 000 hours life). Assuming 10 hours per day, the CorePro LED offers a payback of 4.9 months compared to the LFL (and will last 1.5 times longer) and the MasterLED offers a payback of 11 months (and will last 13 years, which is 2.5 times longer than the LFL). (Sweden, 2020) It is important to note that the actual payback period will be even shorter than this and the savings greater because these calculations reflect energy and bulb costs only, but do not include consideration of the labour cost savings that would be realised for the LED installation due to the reduced frequency of lamp changes. This published economic analysis found that on a life-cycle cost basis, discounted to its net present value, end-users will save €95.61 (CorePro) or €124.57 (MasterLED) for each T8 fluorescent lamp replaced. (Sweden, 2020) LED retrofit tubes for LFL are highly cost-effective.</p> <p>LightingEurope</p> <p>LED-ni replacement for LFL-ni T5, T8 fluorescent lamps:</p> <p>LightingEurope calculations show as an example, that a forced LED investment in the EU in 2021, including labour costs, results in a payback period of 18 years for a LED luminaire and for a LEDni lamp a payback period of 5 years, which might face substantial opposition by consumers and professional users in the EU, the same way that users were significantly opposed to the former ban of incandescent lamps (despite the short payback period for CFL-is of typically half a year).</p> <p>–As LEDni retrofit lamps are applicable in about 50% of the installed luminaires and applications, LightingEurope estimated the cost of a premature phase out for Member States to be 133 Billion Euros for CFL-ni and LFL technologies, mainly to be borne in the next 5 years.)</p> <p>Of the core energy end-uses in the buildings sector, only lighting is on track with the IEA's Sustainable Development Scenario due to LED sales, increasingly replacing fluorescent lighting were feasible (IEA report May 2019).</p> <p>Pay back periods depend on the availability and feasibility of plug and play alternatives and vary from a few years for CFL-I applications to many more years for many CFL-ni and LFL-ni applications due to the cost of rewiring luminaires or in case of a switch to LED luminaires.</p> <p>As a result of non-compatibility issues for LED-ni substitutes, LightingEurope foresees the following practical consequences for users (see ref LE June 2020 report):</p> <ul style="list-style-type: none"> - In the absence of functioning substitutes, users will need to allocate sufficient resources to rewire or replace existing luminaires. Hence high costs will be involved (for EU market a total of 133 Billion Euros is estimated for CFL-ni and LFL technologies). - Rewiring and replacing luminaires requires new certification to ensure the safety and quality of the product, related to insurance requirements for buildings. - Phase-outs should be aligned to the luminaire replacement cycles (typically 14 years) to allow users time to allocate the sufficient resources to transition to the alternative technology. The users of these products, together with LightingEurope, have repeatedly called for a smooth transition timetable (2018 Joint Users Statement). <p>Besides the production capacity of lighting companies and availability of compatible alternatives for the different applications, the speed of the LED transition for different applications also depends on investments of companies, governments and individuals (see IEA report May 2019).</p> <p>Halophosphate lamps</p> <p>LFL-ni lamps use fluorescent coatings made of 2 types of materials and used for the same kind of applications. The highest efficient lamps use tri-band fluorescent coating made of rare-earth elements and have an efficiency which is approx. 7-8 times of incandescent</p>
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	<p>lamps. LFL Halophosphate lamps are still used in USA, Latin America and Asian countries and do not use the expensive rare earth elements that are scarce materials nowadays. As they are more affordable, they contribute to more efficient lighting (5 times of the incandescent bulbs) in countries that lack the funds to invest in more expensive tri-band technologies or LED technologies.</p> <p>In case efficient (affordable) fluorescent retrofit lamps are not available in markets, and LED retrofit or luminaire solutions are too expensive or not available, a large number of customers will use incandescent or halogen lighting as an affordable alternative which is from an environmental point of view a worse solution (energy use and related Mercury release due to coal plants).</p>
<p>6. Information on environmental and health risks and benefits of alternatives</p>	<p>EU</p> <p>The phase-out of halophosphate LFLs in the EU (in favour of tri-band phosphor lamps) resulted in a 53% decrease in mercury per lamp (Lighting Europe, 2015).</p> <p>There are currently no studies comparing LFLs with LEDs in a life cycle analysis for environmental impacts, however CFLs (functionally similar to LFLs) and LEDs have been shown to be equivalent as early as 2012 (Gensch, et al., 2016). For T5 lamps, LED tubes are nearly at the same level of environmental performance as LFLs according to the European Environment Bureau (Gensch, et al., 2016).</p> <p>According to SEA (2019), restriction of T5 and T8 LFLs from 2021 in the EU would result in a saving of 40.9 million metric tonnes of CO₂ due to reduced energy consumption.</p> <p>African Region</p> <p>LED retrofit lamps remove the risk of mercury exposure and pollution associated with the use and breakage of LFLs. Industrial, commercial, and multi-family residential building staff, who may handle large quantities of LFLs, are particularly at risk from this exposure route, as are waste management workers.</p> <p>Norway</p> <p>Mercury from fluorescent lighting is a major problem. The practical reality in the field is that recovery rate for fluorescent lamps is lower than rates reported for all WEEE directive products. A recent report found 50-88% of fluorescent lamps placed on the market in Europe today are not disposed of properly – thus, most of the mercury in lighting is not recovered and is causing further damage to the environment and public health (Sweden, 2020). Collection rates in developing countries are going to be significantly lower than Europe. The only way to stop mercury being released by lighting is to stop placing it on the market. There is no technical or economic reason to continue to allow fluorescent lamps on the market. There is no longer a need to tolerate this health hazard in our homes, schools, hospitals, shops and elsewhere. And, it should be noted that LED alternatives for fluorescent lamps are not only mercury free, but also use half the energy which helps to reduce mercury emissions from coal-fired power stations due to the energy savings.</p> <p>JLMA</p> <p>In Japan, there are no safety-guaranteed LED lamps that can be attached to existing light fixtures.</p> <p>The luminaires or fixtures, designed for non-integrated lamps (e.g. CFL-ni or LFL), are equipped with an (electronic) ballast/control gear and the life and safety tests are conducted with the original fluorescent lamps installed. The electrical characteristics of alternative LED lamps are so various that it is impossible to test the safety of all the alternative LED lamps. Also, it is impossible for the alternative LED manufacturers to test the safety of all lighting fixtures, supplied by many different small companies and which include a large variety of electronic control gears.</p>

Therefore, it is not possible to ensure the safety of alternative LED lamps for installed electronic control gear in the fixture. To illustrate the safety issues which occur in the market, reports on safety (fire) issues and warnings are published by the Governmental Consumer Affairs Agency of Japan (https://www.caa.go.jp/en/about_us/) and the Tokyo Fire Department.

The Consumer Affairs Agency in Japan has published information on 328 accidents in 10 years. The IEC is also discussing the problems of LED retrofits, and discussions are underway to regulate them as an IEC standard in the future. Philips and OSRAM, major lighting manufacturers, also produce retrofit lamps, but they do not use them in all of their fixtures, and they publish compatibility charts for their own lighting fixtures. Major Japanese lighting manufacturers Panasonic, Toshiba, Mitsubishi, and Hitachi have not succeeded in developing retrofit lamps that can be used in all their fixtures due to safety issues.



While it is technically difficult to replace LFLs, it is already technically possible to replace fluorescent lamp lighting fixtures with LED fixtures, and since many LED fixtures are integrated lamps and fixtures, we should consider whether or not there is a replacement for the lighting fixture rather than a replacement for the lamp itself.

LEDVANCE

Non-Passive Failures – e.g. overheating and risk of fire

Type A vs Type B

There are two types of LED non-mercury linear lamps. Type A is referred to as “plug and play” lamps and are designed as direct Tubular LED (TLED) replacements for fluorescent lamps. Type B lamps require an electrician to rewire the luminaire to bypass the ballast.

Type A “plug and play” lamps can have arcing issues that cause “non-passive failures” – a benign term that refers to higher than expected temperatures and potential risk of fire. Most non-passive failure issues are associated with Type A lamps. The arc created between the LED board and the driver board can lead to this problem. To avoid this, most manufacturers publish compatible ballast lists and incorporate fail safe features that permanently disable lamp operation when the lamp is installed improperly on a non-compatible ballast.

In addition, Type A lamps only work when connected to a compatible fluorescent ballast and will not operate properly (or at all) when connected directly to building mains voltage. Type B lamps cannot be operated on a fluorescent ballast. Some manufacturers offer hybrid Type A/Type B lamps that can be either operated on a compatible ballast, or directly connected to building mains voltage.

Again, while uncommon, most compatibility issues typically manifest in Type A lamps.

Type B lamps are designed to work directly connected to building mains voltage and do not require a ballast to operate. Type B lamps have built in safety features such as thermal fuse protection and safety switches. However, these features are not standardized and so they can vary by manufacturer. Manufacturers have worked to resolve this situation through consensus standards, which would ensure that uniform safety precautions are incorporated into all TLED lamps.

An additional consideration for Type B lamps is that they cannot be easily installed by consumers. Installation requires rewiring of the luminaire (*i.e.*, fixture) in accordance with the local electrical code.

While there are some performance issues with Type B lamps non-passive failures occur much less frequently than in Type A lamps.

Elevated temperature

Lamps in enclosed luminaires operate at higher temperatures and LEDs – unlike fluorescent lamps - do not operate well in heat.

While TLEDs typically have an automatic, thermal cutoff, uniform safety standards have not yet been finalized.

It is noteworthy that – due to these potential issues - manufacturers observe a significant amount of “snap back” behavior whereby consumers become concerned about safety of TLEDs and switch back to the fluorescent lamps that have never caused problems for them.

Summary

In general, there are three limiting factors with respect to universal LED replacement lamps.

1. Wrong lamp type for the fixture (Type A vs. Type B)
2. Incompatibility with the ballast (manufacturers publish lists). Type A has the highest risk of a non-passive failure occurring)
3. Not all products sold include safety switches and other safety measures due to lack of consensus standards and additional costs.

CLASP

There are many benefits from phasing-out fluorescent lighting. The table below as prepared with data published by the Öko-Institut (Öko-Institut, 2020) and supplemented additional calculations (Sweden, 2020). These savings are calculated from the phase-out of certain fluorescent lamps in Europe – the CFLni pin-based lamps, T5 linear lamps and some T8 linear lamps (i.e., those that were not already eliminated by Ecodesign). And even though these are not the complete portfolio of fluorescent lamps in Europe, the experts calculated that over 5 metric tonnes of mercury could be avoided along with over 300 TWh of electricity savings, avoiding over 90 million metric tonnes of CO₂ emissions. And, perhaps most importantly all of these environmental and health benefits are cost-effective, the study calculated a net savings of €29.9 billion to Europe from phasing out these lamps.

Table 11. Net Benefits from Phase-Out of T8, T5 and CFLni Lamps in 2021, Öko-Institute Report

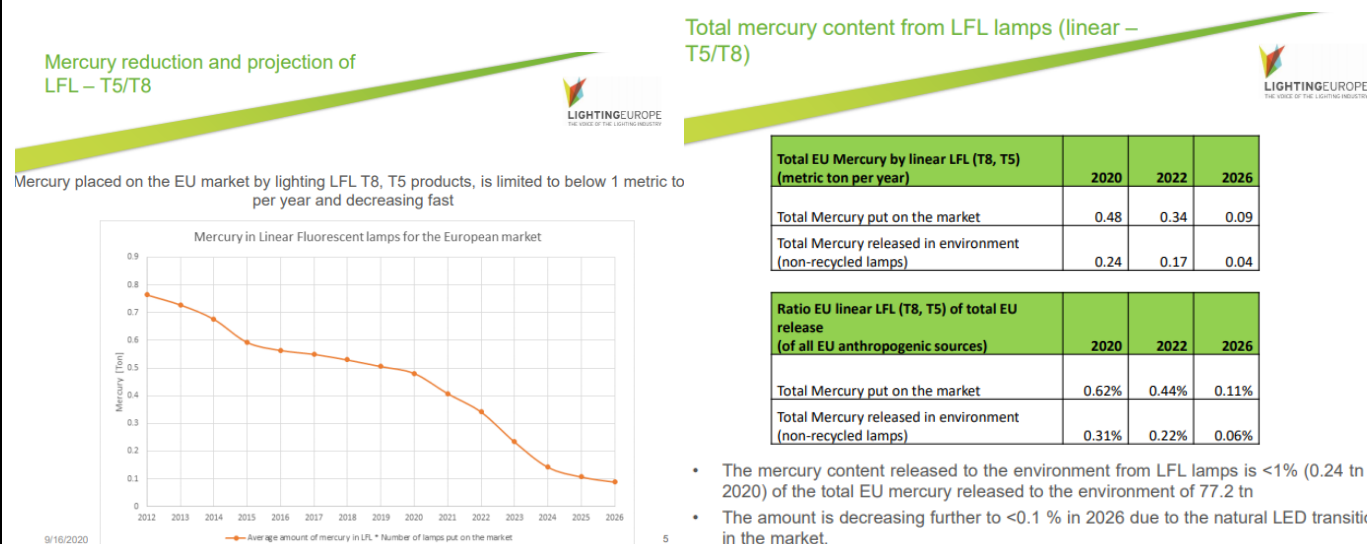
Savings	Cumulative (2021-2035) Savings for:			
	T8	T5	CFLni	Sum
Mercury savings lamps (kg)	962	1064	856	5360 kg
Mercury savings, powerplant (kg)	1218	1032	227	
Electricity Savings (TWh)	152.3	129.0	28.4	309.7 TWh
CO ₂ Savings (MMT)	45.3	38.4	8.4	92.1 MMT CO ₂
Net savings including lamps & electricity (€ billion)	€17.7	€9.3	€2.8	€29.9 billion

Source: Öko-Institute report, 10 July 2020; Mercury and CO₂ savings estimate are calculated by SEA/CLASP.

LightingEurope - LFLni

Compared to the total mercury release from the main anthropogenic sources in the EU (77.2 ton), the proportion of mercury placed on the EU market by lighting LFL T8, T5 and non-linear products, is limited to below 1 metric ton per year and shows a steady decrease

since many years due to continuous innovation by LightingEurope companies. The current amount of Mercury release by these lamp types is 0.33 % of the total EU Mercury release in 2020 and decreasing to 0.1% in 2026. (LightingEurope, September 2020 presentation at UN vertical lamps meetings, see excerpts below)



LightingEurope – Halophosphate lamps

LFL-ni lamps use fluorescent coatings made of 2 types of materials and used for the same kind of applications. The highest efficient lamps use tri-band fluorescent coating made of rare-earth elements and have an efficiency which is approx. 7-8 times of incandescent lamps. LFL halophosphate lamps are still used in USA, Latin America and Asian countries and do not use the expensive rare earth elements that are scarce materials nowadays. They are phased out in the EU. As they are more affordable, they contribute to more efficient lighting (5 times of the incandescent bulbs) in countries that lack the funds to invest in more expensive tri-band technologies or LED technologies.

In case efficient (affordable) fluorescent retrofit lamps are not available in markets, and LED retrofit or luminaire solutions are too expensive or not available, a large number of customers will use incandescent or halogen lighting as an affordable alternative which is from an environmental point of view a worse solution (energy use and related Mercury release due to coal plants).

7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)

NA

<p>8. Other relevant information pursuant to Decision MC-3/1</p>	<p>EU For tri-band phosphor LFLs in Europe, Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) places restrictions on mercury in LFLs that are more specific than the Minamata Convention based on lamp diameter. Double-capped LFLs are subject to an exemption and subject to the following restrictions:</p> <ul style="list-style-type: none"> • Tri-band phosphor with normal lifetime and a tube diameter < 9 mm (e.g. T2): 4 mg • Tri-band phosphor with normal lifetime and a tube diameter ≥ 9 mm and ≤ 17 mm (e.g. T5): 3 mg • Tri-band phosphor with normal lifetime and a tube diameter > 17 mm and ≤ 28 mm (e.g. T8): 3.5 mg • Tri-band phosphor with normal lifetime and a tube diameter > 28 mm (e.g. T12): 3.5 mg • Tri-band phosphor with long lifetime (≥ 25 000 h): 5 mg <p>ZMWG The prohibition of the manufacture, export and import of the above lamp categories as listed under the global section, after 31.12.2020, is covered by the Mercury Regulation (EU) 2017/852 which complements a large body of existing EU environmental law on mercury.</p> <p>However, under the EU Ecodesign directive, which looks mainly at the energy efficiency of products including lighting, Commission Regulation 2019/2020 of 1st October 2019¹⁰ agreed, via an energy efficiency formula, to ban Linear fluorescent Lamps (LFLs) T2 and T12 and Compact Fluorescent Lamps (CFLs) with integrated ballast (CFLi) by 1st September 2021, and certain lengths (2-foot, 4-foot and 5-foot) of T8 linear fluorescent lamps by 1st September 2023.</p> <p>EU Russia and the Eurasian Economic Union (Technical Rule EAEU 037/2016) as well as India (G.S.R338(E) E-Waste (Management) Rules, 2016) set lower limits on tri-band phosphor LFLs than required by Minamata. Limits set are the same as those prescribed by the EU RoHS Directive, as outlined above. There are a number of other countries that have also adopted RoHS-like restrictions setting the same limits on tri-band phosphor LFLs.</p> <p>In Europe, placing on the market of halophosphate LFLs has been effectively prohibited since 2012 when the exemption under Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) expired.</p> <p>Many nations have implemented RoHS-like legislation, which bans mercury-containing LFLs. In Russia and the Eurasian Economic Union (EAEU), Technical Rule EAEU 037/2016 on the restriction of the use of hazardous substances in electrical and radio electronic products are some such examples, and India, Singapore, Thailand, Ukraine, Jordan, Turkey, UAE, Saudi Arabia, Vietnam, South Korea and Japan are examples of other nations implementing RoHS-like legislation which bans mercury-containing halophosphates.</p>
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¹⁰ 2 Commission Regulation (EU) 2019/2020 of 1 October 2019 laying down ecodesign requirements for light sources and separate control gears pursuant to Directive 2009/125/EC of the European Parliament and of the Council and repealing Commission Regulations (EC) No 244/2009, (EC) No 245/2009 and (EU) No 1194/2012 (Text with EEA relevance.) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.315.01.0209.01.ENG&toc=OJ:L:2019:315:TOC

	<p>African Region</p> <ul style="list-style-type: none"> • Overview: LFL is an inefficient, expensive technology which contains mercury • Choice: Mercury-free retrofits are available for virtually all LFLs; with tens of thousands of models available there is a wide selection of light output levels and white light colours • Economic: LED retrofits are highly cost-effective, payback in less than one year for T8 LFL; LEDs cost 50% less than LFLs to buy and use; LED is the least life-cycle cost option • Technology: LED continues to improve, getting cheaper and more efficient each year • Waste: most fluorescent bulbs are not disposed of safely at end of life, even in Europe • Business: Africa has many new local manufacturing companies producing LED lamps, but there is no manufacturing of fluorescent on the continent • Policy: Some African countries are phasing out LFL based on energy savings and cost • Equity: Risk that suppliers will dump more mercury lighting in Africa as fluorescent lamps are phased-out of the OECD <p>ZMWG</p> <p>In India, Mercury containing lamps were brought under the ambit of E-waste management Rules in India in 2016,¹¹ which prescribes the mercury content for different kinds of lamps based on the rationale of ROHS limits for metals as prescribed by the EU, including for LFLs. These limits have been in force since October 2016 and have been followed by all lighting companies registered in India. The allowed limits are lower than the maximum mercury content limits set by the Minamata Convention.</p>
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9. References

EU

- COWI & ICF. (2017). Support to assessing the impacts of certain amendments to the Proposal of the Commission for a Regulation on Mercury. Retrieved from http://ec.europa.eu/environment/chemicals/mercury/pdf/Final%20Report_KH0617141ENN.pdf
- Energy Rating, 2017. Australia drops mercury levels in fluorescent lighting. Available at: <http://www.energyrating.gov.au/news/australia-drops-mercury-levels-fluorescent-lighting> [Accessed 13/06/2019].
- European Commission, 2019. Study to assess socio-economic impact of substitution of certain mercury-based lamps currently benefitting of RoHS 2 exemptions in Annex III. [Online] Available at: <https://publications.europa.eu/en/publication-detail/-/publication/9f8f7878-b72a-11e9-9d01-01aa75ed71a1/language-en>
- Gensch, C.-O. et al., 2016. Study to assess renewal requests for 29 RoHS 2 Annex III exemptions [no. 1(a to e -lighting purpose), no. 1(f - special purpose), no. 2(a), no. 2(b)(3), no. 2(b)(4), no. 3, no. 4(a), no. 4(b), no. 4(c), no. 4(e), no. 4(f), no. 5(b), no. 6(a), no. 6(b), no. 6(c), no. 7(a), no. 7(c) - I, no. 7(c) - II, no. 7(c) - IV, no. 8.
- Lighting Europe, 2014. Globally Harmonized Limits on Mercury for Lighting. [Online] Available at: https://www.lightingeurope.org/images/publications/position-papers/LE_PP_Global_Mercury_limit_20131002_final.pdf
- Lighting Europe, 2015. Request to Renew Exemption 2(a)(1). [Online] Available at: https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_2_a__1-5_Lighting_Europe/2a1_LE_RoHS_Exemption_Req_Final.pdf
- Lighting Europe, 2016. Request to renew Exemption 1(g) under the RoHS Directive 2011/65/EU Mercury in single-capped (compact) fluorescent lamps for general lighting purposes < 30 W with a lifetime equal or above 20000 h: 3,5 mg, 28.06.2016.

¹¹ Indian 2016 E-waste rules <http://cpcb.nic.in/displaypdf.php?id=UHVamVjdHMvRS1XYXN0ZS9FLVdhc3RlTV9SdWxlc18yMDE2LnBkZg==>

- Lighting Europe, 2017. Answers to 1st Questionnaire - Exemption No. 1(g) (renewal request): "For general lighting purposes < 30 W with a lifetime equal or above 20 000 h: 3,5 mg", 15.09.2017. Available at: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_pack_13/Annex_1g/LE_WG_CE_-_TF_RoHS_-_1G_Questionnaire_Response_-_20170915_-_v5-_FINAL.pdf [Accessed 20/05/2019].
- Sethurajan et al., 2019. Recent advances on hydrometallurgical recovery of critical and precious metals from end of life electronic wastes- a review. [Online] Available at: <https://www.tandfonline.com/doi/full/10.1080/10643389.2018.1540760#aHR0cHM6Ly93d3cudGFuZGZvbmxpbmUuY29tL2RvaS9wZGYvMTAuMTA4MC8xMDY0MzY0MDE4LjE1NDA3NjA/bmVIZEFjY2Vzc210cnVlQEBAMA==>
- Swedish Energy Agency (SEA), 2019. Evidence of the availability of mercury-free alternative products to certain fluorescent lamps. Available at: <https://meta.eeb.org/wp-content/uploads/2019/11/SEA-and-CLASP-analysis-of-RoHS-exemptions-for-fluorescent-lamps-v2-1.pdf>
- The Lightbulb Company, 2019. A Guide To Compact Fluorescent Lamps (CFL) & Fluorescent Tubes. Available at: https://www.thelightbulb.co.uk/resources/compact_fluorescent_lamps_guide/.
- UNEP, 2013. Acceptance on behalf of the United States of America. Available at: <http://www.mercuryconvention.org/Portals/11/documents/submissions/US%20declaration.pdf> [Accessed 13/06/2019].
- VHK & VITO, 2015. Preparatory Study on Light Sources for Ecodesign and/or Energy Labelling Requirements ('Lot 8/9/19') - Draft Interim Report. [Online] Available at: <http://ecodesign-lightsources.eu/sites/ecodesign-lightsources.eu/files/attachments/1st%20Stakeholder%20comments%20-%20summary%20and%20answers.pdf>
- World Bank, 2019. Capacity Strengthening for Implementation of Minamata Convention on Mercury Project. Available at: <http://projects.worldbank.org/P151281?lang=en>.
- Zero Mercury Working Group, 2019. Information Relevant to the Review of Annexes A and B. [Online] Available at: http://www.mercuryconvention.org/Portals/11/documents/submissions/ZMWG_Submission_AnnexA_B.pdf

Canada

1. ToxEcology Environmental Consulting Ltd. (2018). Technical background study on products containing mercury in Canada with reference to the recently ratified Minamata Convention on Mercury.
2. For example: 'LEDVANCE to Shut Down Two Facilities to Focus on Solid State Lighting' Jan 23, 2018. Available from: https://www.ledinside.com/news/2018/1/ledvance_to_shut_down_two_facilities_to_focus_on_solid_state_lighting
3. Nunez C. (2016). An unloved light bulb shows signs of burning out. National Geographic: <https://news.nationalgeographic.com/energy/2016/02/1602016-cfl-phase-out-light-bulb-leds/>
4. The Climate Group. (2012). Lighting the clean revolution. Available from: https://www.theclimategroup.org/sites/default/files/archive/files/LED_report_web1.pdf
5. EDN Network (2015). LEDs for liquid crystal display (LCD) backlighting. Available from: <https://www.edn.com/design/led/4438213/LEDs-for-liquid-crystal-display--LCD--backlighting--Part-1>
6. LEDinside. (2013). Direct-type LED TV penetration rate surpasses 60% in 2014. Available from: <https://www.ledinside.com/node/19148>
7. LEDinside. (2016). Overview of micro-LED history and current developments. Available from: https://www.ledinside.com/outlook/2016/8/overview_of_micro_led_history_and_current_developments and refer to footnote 40 for perspective on EEFL as well as CCFL uses in displays
8. For example: A sign of the times, LED is replacing neon (2016). Available from: <http://www.eastoregonian.com/eo/business/20160819/a-sign-of-the-times-led-is-replacing-neon>; Replacing glass neon with flexible LED. Available from: <https://blog.1000bulbs.com/home/neon-sign-repair>
9. LEDs Magazine. (2014). Finally light challenges LED lighting with induction replacement lamp. Available from: <http://www.ledsmagazine.com/articles/2014/05/finally-light-challenges-led-lighting-with-induction-replacement-lamp.html>
10. Buildings Smarter Facility Management. (2015). LED vs Induction lighting: Which Illumination Solution is Right for Your Facility? Available from: <https://www.buildings.com/article-details/articleid/18718/title/led-vs-induction-lighting/viewall/true>
11. Stouch lighting. (N.D.) LED versus high pressure sodium (HPS) and low pressure sodium (LPS). Available from: <http://www.stouchlighting.com/blog/led-vs-hps-lps-high-and-low-pressure-sodium>
12. Stouch lighting. (N.D.) LED versus Metal Halide Lights. Available from <http://www.stouchlighting.com/blog/led-lights-versus-metal-halide>

13. ASD Reports. (2015). Global Automotive Lighting Market 2016-2020: Sample Report. Available from: <https://www.automotive-iq.com/events-autoadvancedlighting/downloads/global-automotive-lighting-market-2016-2020>
14. LEDinside. (2016). Automotive LED market has a bright future with the rise of replacement products. Available from: <https://press.trendforce.com/press/20160707-2544.html#kuqIg3KvXdEWq2xL.99>
15. Lim et al. (2011). Potential environmental impacts of light-emitting diodes (LEDs): Metallic Resources, Toxicity, and Hazardous Waste Classification. *Environ. Sci. Technol.*, 2011, 45 (1), pp 320–327; DOI: 10.1021/es101052q
16. Example Safety Data Sheets for LEDs from GE and Philips. Available from https://products.currentbyge.com/sites/products.currentbyge.com/files/document_file/LED-Lamp-Material-Sheet_0.pdf and <http://www.usa.lighting.philips.com/support/support/literature/msds-sheets#>
17. American Medical Association (2016). Guidance to Reduce Harm from High Intensity Street Lights Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting. Report of the Council on Science and Public Health CSAPH Report 2-A-16.
18. US Department of Energy. (2017). Street lighting and blue light FAQs. Available from: <https://www.energy.gov/sites/prod/files/2018/04/f50/Street%20Lighting%20and%20Blue%20Light%20FAQs.pdf>
19. Lombardo, T. (2017). Are LED Lights bad for your health? Available from: <https://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/14607/Are-LED-Lights-Bad-for-Your-Health.aspx>

African Region

CLASP, 2020. Database of compatibility of T5 and T8 lamps with ballasts in Europe. Published as part of Assessing Annex III Fluorescent Lamp Exemptions in the Light of Scientific and Technical Progress, Report to the Committee on the Restriction of Hazardous Substances; Swedish Energy Agency and CLASP. Link: http://www.mercuryconvention.org/Portals/11/documents/meetings/COP4/submissions/CLASP_AnnexAB_spreadsheet.xlsx

LEDvance, 2021. Website of LEDvance, highlighting the savings of LED. <https://www.ledvance.com/professional/products/product-stories/led-tubes-online-special>

Oko-Institut, 2020. Study to assess socio-economic impact of substitution of certain mercury-based lamps currently benefiting of RoHS 2 exemptions in Annex III; Oko-Institut, Germany. 10 July 2020. <https://rohs.exemptions.oeko.info/index.php?id=127>

Signify, 2021. Dansk Supermarked case study for LED retrofit installation. 53% power savings with Signify Master LED Tube. Signify, Link: <https://www.lighting.philips.com/main/cases/cases/food-and-large-retailers/dansk-supermarked>

Signify, 2021b. Tecnologia Verhoef Access case study for LED retrofit installation. 60% power savings with Signify Master LED Tube. Signify, Link: <https://www.lighting.philips.com/main/cases/cases/industry-and-logistics/verhoef-access-technology>

Swedish Energy Agency (SEA), 2019. Evidence of the availability of mercury-free alternative products to certain fluorescent lamps. Available at: <https://meta.eeb.org/wp-content/uploads/2019/11/SEA-and-CLASP-analysis-of-RoHS-exemptions-for-fluorescent-lamps-v2-1.pdf>

Swedish Energy Agency (SEA), 2020. Assessing Annex III Fluorescent Lamp Exemptions in the Light of Scientific and Technical Progress, Report to the Committee on the Restriction of Hazardous Substances. Swedish Energy Agency and CLASP, 24 February 2020. Link: <https://www.clasp.ngo/research/all/assessing-annex-iii-fluorescent-lamp-exemptions-in-the-light-of-scientific-and-technical-progress/>

Swedish Energy Agency (SEA), 2020b. Clarifications on LightingEurope's Comments to the RoHS Committee. A report for the Committee on the Restriction of Hazardous Substances (RoHS) addressing Lighting Europe's comments on 20 May and 9 June relating to the exemption application for fluorescent lighting. Swedish Energy Agency and CLASP. 12 July 2020. <https://www.clasp.ngo/research/all/clarifications-on-lighting-europes-comments-to-the-rohs-committee/>

Cold cathode fluorescent lamps (CCFL) and external electrode fluorescent lamps (EEFL)

1. Category of mercury-added product	Lamps
2. Further description of the product	Cold cathode fluorescent lamps (CCFL) and external electrode fluorescent lamps (EEFL)
3. Information on the use of the product	<p>Japan Domestic production of CCFL and EEFL has been terminated, and it is assumed that they are rarely distributed, even for maintenance purpose.</p> <p>African Region This product group was used in flat screen television technology until about ten years ago. These very narrow tubes were used in backlit display units, but have since been replaced by LED, and CCFL/EEFL technology has been phased out of the market. This category of fluorescent bulb is defunct, and the exemption can be retired immediately.</p> <p>CLASP Cold cathode fluorescent lamps (CCFL) and external electrode fluorescent lamps (EEFL) are no longer used in new electronic displays. They were used as back-lighting units for electronic displays about 10-15 years ago, but this practice stopped around 2010 and there are no electronic displays manufactured in 2021 using CCFL and EEFL back-lighting units.</p> <p>LightingEurope: There is still some limited usage of sub-miniature CCFL for new and replacement applications. Some examples:</p> <ul style="list-style-type: none"> • Commercial aircraft primary flight instrumentation displays: require original certified replacement parts • Other applications: i.e. instrumentation, disinfection and medical devices and industrial monitoring <p>Some CCFL for special purpose applications are used for a variety of chemical and biological processes (see use chapter) and therefore contribute to several medical and health related applications, e.g.</p> <ul style="list-style-type: none"> • Medical/Therapy lamps • Disinfection lamps e.g. for to inactivate bacteria and viruses (e.g. COVID) • Chemical and biological processes e.g., bio tech processes and monitoring equipment • Light sources for scientific instruments and/or the calibration of instruments
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Canada The primary mercury-free alternative to mercury-containing lamps are Light Emitting Diodes (LEDs). LEDs use a semiconductor as a light source and have very high energy efficiency and significantly longer lifespans than fluorescent lamps.</p> <p>African Region A paper published in 2018 in <i>Waste Management & Research: The Journal for a Sustainable Circular Economy</i> summarized the situation of this technology on the market (Zhuang, 2018): “Cold cathode fluorescent lamps (CCFLs), with mercury as their essential component, were widely used as backlight in liquid crystal display (LCD) appliances before 2008. Since 2008, the mercury-free light emitting diode started to be used as a substitute for CCFLs and the replacement finished in about 2014. Nowadays, CCFLs are obsolete products from the viewpoint of manufacture.”</p>

ZMWG

Cold cathode fluorescent lamps (CCFL) are rapidly being replaced by LEDs in the marketplace and there is an expectation that this trend will continue¹². LEDs have practically replaced CCFLs in LCD backlight applications used for panels in small devices including smartphones and tablets as well as large appliances and electronics such as TVs, PC monitors, and notebooks. Thanks to their higher luminous efficiency and far smaller form factor, LEDs enable more effective positioning of the light sources behind the panel. Furthermore, there is an urgency for ending this exemption and hastening the complete transition to LEDs since CCFLs create health and environmental hazards when products containing them are recycled at the end of their useful life.

For new displays, non-mercury alternatives are available for all or virtually all applications. For replacements, availability can vary based on electronic display specifications and LED availability. Note Annex A already contains exemption for replacement lamps.

CLASP

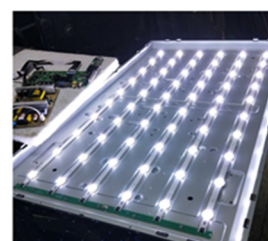
Over the last decade, LEDs have replaced CCFLs and EEFLs in the backlighting of all flat panel displays. LEDs allow for thinner and lighter designs, use less power as they are more energy efficient and enable higher brightness and illuminate the screen more evenly. In addition, LEDs illuminated back lights can improve the viewer's experience through controlled lighting in different areas of the screen; furthermore instantly whereas previous CCFL-backlit displays at first appeared dim and then gradually increased in brightness. LED back-lit displays also have longer life spans than CCFLs and EEFLs. For all of these reasons, CCFL and EEFL were dropped from production lines by suppliers years ago.

NRDC

Electronic displays (flat screen TVs) require a back light to shine through the LCD and filters to create images on the screen. CCFL was common as a back light in flat-screen TVs about 10 years ago. Now this technology has been replaced by LED backlight units and CCFL technology is no longer used. The illustration below shows the difference between a CCFL (or EEFL) and LED backlighting unit for a flat-screen display.



CCFL backlight unit
for a TV
(Old technology)



LED backlight unit
for a TV
(Modern technology)

¹² 2019 Waste Electronic and Electrical Equipment (WEEE) Handbook

	<p>LightingEurope: Some new equipment is being developed based on LED technology for some professional applications. However, for applications where a specific wavelength of CCFL lamps (Visible and non-visible) is needed, LED substitutes are not feasible. There is still some limited usage of sub-miniature CCFL for new and replacement applications. Some examples:</p> <ol style="list-style-type: none"> 1) Commercial aircraft primary flight instrumentation displays: require original certified replacement parts 2) Other applications: i.e. medical, disinfection, instrumentation and medical devices and industrial monitoring
5.(i) Information on the technical feasibility of alternatives	<p>Canada Over the last decade LEDs have largely replaced CCFLs and EEFLs in the backlighting of flat panel displays such as liquid crystal displays (LCD).¹ LEDs allow for thinner and lighter designs in displays, use less power as they are more energy efficient and enable higher brightness and illuminate the screen more evenly.⁵ In addition, LEDs illuminate instantly whereas previous CCFL-backlit displays at first appeared dim and then gradually increased in brightness. LEDs also have longer life spans than CCFLs and EEFLs.¹</p> <p>Previously, LEDs for backlighting displays were more expensive than CCFLs and EEFLs but this is no longer the case as the price of LEDs has fallen. LEDs were predicted to completely replace CCFLs in TVs by 2014.⁶ By 2016 LEDs had almost completely replaced CCFLs and EEFLs in most applications including smartphones, tablets, notebooks, tabletop monitors and TVs.⁷ LEDs are also the main alternative for cold cathode/neon lamp uses including signage applications.⁸</p> <p>African Region Today, LED backlight units have completely replaced CCFL/EEFL; no new displays are being made with this old technology.</p>
5.(ii) Information on the economic feasibility of alternatives	<p>African Region CCFL and EEFL are an old, outdated technology that was used for back-lighting LCD electronic displays about 20 years ago; these lamps have been replaced by LED backlights in new displays starting in 2008.</p> <p>JLMA CCFL lamps are rarely used today, but are used in small quantities as repair and replacement parts for embedded displays in industrial equipment. For the repair of these devices, it is economically difficult to develop new devices that do not use CCFLs, only for repair.</p>
6. Information on environmental and health risks and benefits of alternatives	<p>African Region The clause allowing for spare parts could be retained in Minamata to enable end-users to continue using old monitors, but this is considered to be a very small (non-existent?) market.</p>
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	<p>African Region It should be noted that in the preamble text of Annex A in the Minamata Convention, an allowance is made for CCFL and EEFL where they are being supplied as a spare part:</p>

(c) *Where no feasible mercury-free alternative for replacement is available, switches and relays, cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays, and measuring devices;*

This text can remain in the Convention, to allow for exceptional cases where old electronic displays are still in use and people wish to continue to use them. However, this is very rare as LED has been the dominant display backlighting unit for well over a decade.

9. References

Canada


1. ToxEcology Environmental Consulting Ltd. (2018). Technical background study on products containing mercury in Canada with reference to the recently ratified Minamata Convention on Mercury.
2. For example: 'LEDVANCE to Shut Down Two Facilities to Focus on Solid State Lighting' Jan 23, 2018. Available from: https://www.ledinside.com/news/2018/1/ledvance_to_shut_down_two_facilities_to_focus_on_solid_state_lighting
3. Nunez C. (2016). An unloved light bulb shows signs of burning out. National Geographic: <https://news.nationalgeographic.com/energy/2016/02/1602016-cfl-phase-out-light-bulb-leds/>
4. The Climate Group. (2012). Lighting the clean revolution. Available from: https://www.theclimategroup.org/sites/default/files/archive/files/LED_report_web1.pdf
5. EDN Network (2015). LEDs for liquid crystal display (LCD) backlighting. Available from: <https://www.edn.com/design/led/4438213/LEDs-for-liquid-crystal-display--LCD--backlighting--Part-1>
6. LEDinside. (2013). Direct-type LED TV penetration rate surpasses 60% in 2014. Available from: <https://www.ledinside.com/node/19148>
7. LEDinside. (2016). Overview of micro-LED history and current developments. Available from: https://www.ledinside.com/outlook/2016/8/overview_of_micro_led_history_and_current_developments and refer to footnote 40 for perspective on EEFL as well as CCFL uses in displays
8. For example: A sign of the times, LED is replacing neon (2016). Available from: <http://www.eastoregonian.com/eo/business/20160819/a-sign-of-the-times-led-is-replacing-neon/>; Replacing glass neon with flexible LED. Available from: <https://blog.1000bulbs.com/home/neon-sign-repair>
9. LEDs Magazine. (2014). Finally light challenges LED lighting with induction replacement lamp. Available from: <http://www.ledsmagazine.com/articles/2014/05/finally-light-challenges-led-lighting-with-induction-replacement-lamp.html>
10. Buildings Smarter Facility Management. (2015). LED vs Induction lighting: Which Illumination Solution is Right for Your Facility? Available from: <https://www.buildings.com/article-details/articleid/18718/title/led-vs-induction-lighting/viewall/true>
11. Stouch lighting. (N.D.) LED versus high pressure sodium (HPS) and low pressure sodium (LPS). Available from: <http://www.stouchlighting.com/blog/led-vs-hps-lps-high-and-low-pressure-sodium>
12. Stouch lighting. (N.D.) LED versus Metal Halide Lights. Available from <http://www.stouchlighting.com/blog/led-lights-versus-metal-halide>
13. ASD Reports. (2015). Global Automotive Lighting Market 2016-2020: Sample Report. Available from: <https://www.automotive-iq.com/events-autoadvancedlighting/downloads/global-automotive-lighting-market-2016-2020>
14. LEDinside. (2016). Automotive LED market has a bright future with the rise of replacement products. Available from: <https://press.trendforce.com/press/20160707-2544.html#kuqIg3KvXdEWq2xL.99>
15. Lim et al. (2011). Potential environmental impacts of light-emitting diodes (LEDs): Metallic Resources, Toxicity, and Hazardous Waste Classification. *Environ. Sci. Technol.*, 2011, 45 (1), pp 320–327; DOI: 10.1021/es101052q
16. Example Safety Data Sheets for LEDs from GE and Philips. Available from https://products.currentbyge.com/sites/products.currentbyge.com/files/document_file/LED-Lamp-Material-Sheet_0.pdf and <http://www.usa.lighting.philips.com/support/support/literature/msds-sheets#>
17. American Medical Association (2016). Guidance to Reduce Harm from High Intensity Street Lights Human and Environmental Effects of Light Emitting Diode (LED) Community Lighting. Report of the Council on Science and Public Health CSAPH Report 2-A-16.

18. US Department of Energy. (2017). Street lighting and blue light FAQs. Available from: <https://www.energy.gov/sites/prod/files/2018/04/f50/Street%20Lighting%20and%20Blue%20Light%20FAQs.pdf>
19. Lombardo, T. (2017). Are LED Lights bad for your health? Available from: <https://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/14607/Are-LED-Lights-Bad-for-Your-Health.aspx>

African Region

Zhuang, 2018. Stocks and environmental release of mercury in backlight cold cathode fluorescence lamps. Suning Zhuang, Yu Wang, Wenyi Yuan, Jianfeng Bai, Jingwei Wang; Waste Management and Research: The Journal for a Sustainable Circular Economy. 17 July 2018. Link: <https://journals.sagepub.com/doi/10.1177/0734242X18785727>

Other fluorescent lamps

1. Category of mercury-added product	Lamps
2. Further description of the product	Other fluorescent lamps
3. Information on the use of the product	<p>EU, United States/NEWMOA</p> <p>'Other fluorescent lamps' cover lamps used in professional and consumer applications for purposes other than lighting. These lamps differ from lighting used for general lighting purposes by the use of different glass and phosphors, different technology, wattage, and size, and typically emitting in UV or blue wavelengths (Gensch, et al., 2016).</p> <p>Fluorescent lamps operate at a low gas pressure. They produce light when an electric current pass between electrodes in a tube filled with low-pressure mercury vapour and inert gases. The electric current excites the mercury vapour in the tube, generating radiation primarily in the ultraviolet range. Fluorescent lamps covered by this fiche are not used primarily for lighting and include (NEWMOA, 2014):</p> <ul style="list-style-type: none"> • Bug zappers which contain a fluorescent lamp that emits UV light to attract insects. • Black lights which use a phosphor to convert short-wave UV light in the tube to long-range UV that is used for forensic applications, special effects lighting and testing devices. • Tanning lamps which use phosphor to emit mainly UV-A light and a small amount of UV-B light. • Lamps for the treatment of skin conditions e.g. eczema, psoriasis, acne, vitamin D deficiency. • Induction lamps are used in outdoor and factory lighting applications. <p>Figure 1 – Examples of applications of 'other fluorescent lamps' (Gensch, et al., 2016)</p> 

	<p>Range of mercury content Varies depending on lamp, estimated 2 kg of mercury entering the EU per annum (Gensch, et al., 2016).</p> <p>LightingEurope- Special Purpose lamps: Special purpose lamps and luminaires are designed essentially for other types of application, such as traffic signals, terrarium lighting or household appliances and clearly indicated as such on accompanying product information. Special purpose products have documented and communicated application-specific features. They are mainly manufactured in accordance with general-purpose lamp making technology. The use of special design/specifications, materials and process steps provide their special application features, e.g.: Where non-visible radiation has importance, for example:</p> <ul style="list-style-type: none"> • Medical/Therapy lamps • Sun tanning lamps • Black light lamps (e.g. for diazo printing reprography, lithography, insect traps, photochemical and curing processes) • Black light blue lamps (e.g. for entertainment, forensics, dermatology, banknote validation) • Disinfection lamps (e.g. ultraviolet for air, water or surface treatment for inactivation of bacteria and viruses) • Pet care lamps (e.g. aquaria or reptile lamps) • Chemical and biological processes e.g., Vaccine production processes, monitoring equipment. <p>Where different applications require specific lamps, for example:</p> <ul style="list-style-type: none"> • Technical lamps for colour comparison • Coloured lamps (incl. saturated colours) • Lamps used in horticultural lighting • Lamps designed for eye-sensitivity of birds and other animals • Projector lamps, studio lighting, show effect lighting, theatre lighting • Lamps with specific colour spectrum requirements e.g., adapted to the response of film material • High colour rendering index lamps like food lighting applications, bakeries, etc. • Lamps with special ignition features (e.g., external ignition strip) for cold applications or potentially explosive atmospheres • Lamps required for emergency lighting luminaires • Lighting products which have to withstand extreme physical conditions (such as vibrations or temperatures below – 20 °C or above 50 °C) • Lamps for emergency lighting luminaires • Products incorporating lighting products, where the primary purpose is not lighting, and the product is dependent on energy input in fulfilling its primary purpose during use (such as refrigerators, sewing machines, endoscopes, blood analyzers); • Light sources for scientific instruments and/or the calibration of instruments
<p>4. Information on the availability of mercury-free (or less-mercury) alternatives</p>	<p>EU Main alternatives: LED Lamps, dielectric barrier discharge (DBD) lamps According to Gensch et al. (2016), no research is being performed into improvements of CFL technology with regard to mercury content and as such LED technology is the primary alternative. LEDs are increasingly available for general lighting solutions, however special purpose lamps are a niche market where development of LED alternatives has been slower (Gensch, et al., 2016).</p>

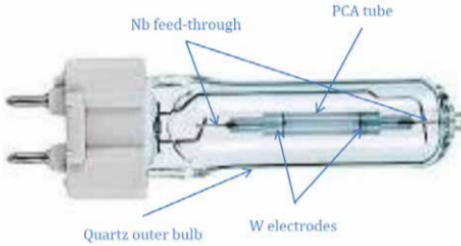
	<p>It was stated by an industry group that in 2019 for blacklight blue, insect traps and tanning beds it is still the case that LED technology is lacking in non-visible UV light. It was however indicated that UVA/B technology based on integrated LED modules are in development which may be possible to replace HPS lamps in some applications. For medical applications, there are no alternatives approved by medical authorities (e.g. for psoriasis and acne treatment).</p> <p>Canada Induction lamps: the costs of LEDs have continued to decline in recent years while the costs of induction lighting have not. Improvements and new technologies for LEDs continue to be made, whereas similar innovation in induction lighting is not expected. As a result, LEDs have become increasingly cost-competitive with induction fluorescents.¹ LEDs are much more energy efficient than induction lamps.⁹ Induction lamps often cannot be dimmed, and induction lamps that can be dimmed are only able to go a few settings below 100% compared to a full range of dimness available for LEDs. In addition, induction lights are much larger than their LED equivalents and when several lights need to be mounted on poles for lighting large spaces (such as parking lots) the smaller size of LEDs can be a significant advantage.¹⁰</p> <p>JLMA Special purpose lamps are used as light sources for e.g. UV disinfection, UV curing, projection, gastric endoscopes, automobile headlamps, analyzers, cultivating cells of organisms and plants, and banknote appraisers, etc. There are many applications that cannot be physically replaced by LEDs, such as requirements for light of a specific color/wavelength as well as brightness.</p> <p>LightingEurope: Mercury-free LED substitutes are still in R&D development phase or entering the market e.g. for some very low power UV applications.</p>
5.(i) Information on the technical feasibility of alternatives	<p>EU LEDs primarily emit only in the visible light spectra and so for applications where the main function of the lamp is to produce light in the non-visible UV range, such as tanning beds, lamps for the treatment of skin conditions, black lights and insect traps, LEDs do not provide comparable performance due to insufficient wall-plug efficiency and non-comparable spectral output. It is possible to produce LEDs with the required non-visible UV light spectra using AlGaIn-LED technology however efficiency is lower (Gensch, et al., 2016):</p> <ul style="list-style-type: none"> • For UV-C and UB-B LEDs (100-315 nm) energy efficiency is currently lower than CFL • For UV-A LEDs (315-400 nm) efficiency is below 380 nm spectral output <p>There are no comprehensive test results available comparing CFL-based equipment with LED-based equipment for effectiveness. The most important application of UV lamps is in tanning devices, with an estimated 50,000 tanning facilities in the EU (Gensch, et al., 2016).</p> <p>There are potential limitations to the application of LED UV lamps due to the fact that CFL lamps radiate generated heat away naturally while LED lamps require heat to be transported away by conduction (Gensch, et al., 2016).</p> <p>In the case of lamps for the treatment of skin conditions, alternatives will require comprehensive testing before use on humans, and light wavelength is important for the treatment to be effective.</p>

	<p>JLMA Special purpose lamps are available in a wide variety of sizes and with different requirements. Many of them require specific wavelengths, and it is technically impossible to replace them with LEDs.</p> <p>LightingEurope – Special purpose lamps: Special purpose lamps are used for a huge variety of applications e.g.medical, Industrial, curing, disinfection, entertainment and stage lighting.</p> <p>Negative impact on a number of industrial manufacturing activities in Europe: As recognised by both the DG Energy and the DG Environment consultants, there are no replacement lamps for applications using mercury-containing discharge lamps. Most special purpose lamps are used in a number of industrial and commercial applications (e.g. micro lithography in semiconductor 1 See for example, “The Model for European Light Sources Analyses, MELISA” developed by VHK and adapted after 2015 European Consultation Forum. 3 production, entertainment lighting, etc).</p>
5.(ii) Information on the economic feasibility of alternatives	<p>EU The replacement of most specialist lamps will require a replacement of the equipment ballast, requiring appropriate care to ensure resources are recycled where possible and at the equipment’s natural end-of-life. For emitting UV light LEDs are currently less energy efficient than CFL and so energy costs may be higher (Gensch, et al., 2016).</p>
6. Information on environmental and health risks and benefits of alternatives	<p>EU A general concern with the phase-out of mercury containing fluorescent lamps in favour of LEDs is the cause of early end-of-life of installations including luminaires, which causes resources in these products to not serve their planned product life potential (Gensch, et al., 2016).</p>
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	<p>EU In Europe, there is an exemption for other discharge lamps for special purposes with a mercury content above 15mg per lamp in the Directive 2011/65/EC (RoHS) Directive). The exemption has a validity period from 2021-2024, depending on devices.</p>

9. Reference

- Advanced-UV, 2019. Advanced UV for Life. Available at: <https://www.advanced-uv.de/en/about/welcome/>.
- EU, 2011. DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011L0065&from=EN>.
- Gensch, C.-O. et al., 2016. Study to assess renewal requests for 29 RoHS 2 Annex III exemptions [no. 1(a to e -lighting purpose), no. 1(f - special purpose), no. 2(a), no. 2(b)(3), no. 2(b)(4), no. 3, no. 4(a), no. 4(b), no. 4(c), no. 4(e), no. 4(f), no. 5(b), no. 6(a), no. 6(b), no. 6(c), no. 7(a), no. 7(c) - I, no. 7(c) - II, no. 7(c) - IV, no. 8.
- Guo, Y. et al., 2018. Enhancing the light extraction of AlGaIn-based ultraviolet light-emitting diodes in the nanoscale. *Journal of Nanophotonics*.
- Helios Quartz, 2016. UV Lamp. Available at: https://www.heliosquartz.com/wp-content/uploads/2016/01/Helios-Quartz_UV-LAMPS_eng.pdf.
- Lighting Europe, 2015a. Request to renew Exemption 4a under the RoHS Directive 2011/65/EU. Available at: https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_a_/Lighting_Europe/4a_LE_RoHS_Exemption_Req_Final.pdf.
- Lighting Europe, 2015b. Response to Oeko-Institut regarding the 1st Questionnaire Exemption No. 4a (renewal request); Exemption for “Mercury in other low pressure discharge lamps (per lamp) – 15 mg may be used per lamp after 31 December 2011” Date of submission: September 15, 20. Available at: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_a_/Lighting_Europe/Ex_4a_LightingEurope_1st_Clarification-Questions_final.pdf.
- Lux Review, 2017. How effective are UVC LEDs?. Available at: <https://luxreview.com/article/2017/09/how-effective-are-uv-c-leds->.
- Seong-Rim, L., Kang, D. & Ogunseitan, O. a. S. J., 2011. Potential Environmental Impacts of Light-Emitting Diodes (LEDs): Metallic Resources, Toxicity and Hazardous Waste Classification. *Environmental Science & Technology*, Volume 45, pp. 320-327.
- University of Cambridge, 2019. UV LEDs. Available at: <https://www.gan.msm.cam.ac.uk/projects/uv>.
- Van der Meer, M., van Lierop, F. & Sokolov, D., 2015. The analysis of modern low pressure amalgam lamp characteristics. Available at: <http://www.dafp.de/wp-content/uploads/2015/10/The-analysis-of-modern-low-pressure-amalgam-characteristics.pdf>.

High intensity discharge lamps (HID)

1. Category of mercury-added product	Lamps
2. Further description of the product	High intensity discharge lamps (HID), including high-pressure sodium lamps (HPS)
3. Information on the use of the product	<p>EU</p> <p>HPS lamps consist of a cylindrical discharge tubes made of poly-crystalline alumina (PCA), in which two electrode assemblies are mounted at each side (Figure) (Gensch et al., 2016).</p> <p>The electrodes are made of tungsten in the shape of a rod, sometimes with coiled windings. Tungsten electrodes are welded to niobium tubes that serve as the electrical feed-through. Inside the discharge tube, xenon is present as a buffer gas. Mercury is dosed in the discharge tube as sodium mercury. The quantity of mercury used per lamp depends on lamp power and optical performance.</p> <p>A high voltage pulse is supplied to the electrode, breaking down the xenon gas and allowing a current to flow through the resulting plasma. The heat released by the discharge warms up the tube and evaporates the sodium and mercury.</p> <p>HPS lamps with increased colour rendering are typically used for outdoor applications where colour rendering is important, such as city centres and parking lots, or indoors in shops where products are displayed in a certain light. The role of mercury in these lamps is to tune the plasma resistance to optimise efficiency - thermal conduction is reduced and as such there is less heat loss from the plasma. The mercury vapour pressure increases the electrical resistance in the discharge which enables putting more power into the discharge, causing sodium and mercury to evaporate further. Additionally, the presence of mercury causes the lamp to have high red rendering properties.</p> <p>The mercury is not consumed in the lamp's life; as the sodium reacts, the fraction of mercury in the amalgam therefore becomes higher over time.</p> <p><u>Range of mercury content in High-pressure sodium lamps</u> 10-50 mg (3-40mg for lamps with improved colour rendering index Ra>60)</p> <p>JLMA</p> <p>Special purpose lamps are used as light sources for e.g. UV disinfection, UV curing, projection, gastric endoscopes, automobile headlamps, high precision analyzers and detectors, and banknote appraisers, etc. These applications use specific wavelengths (including emission lines) as a light source or a very small high intensity emission point as a light source.</p> <p>LightingEurope – HID lamps</p> <p>HID lamps are a wide range of lamp families with extremely high intensity and used for a variety of applications like city streetlighting, façade lighting, highways, Sports facilities, Retail spot lighting, museums theatres, entertainment etc. Globally are installed approx. 500 million professional luminaires with Luminaire lifetime >20 years (in outdoor applications) for which regular lamp replacement is needed, handled only by professionals.</p> <div>  <p>Figure 1 – HPS lamp (Gensch et al., 2016)</p> </div>

4. Information on the availability of mercury-free (or less-mercury) alternatives

Main alternatives: LED Lamps, unsaturated vapour HPS lamp, Xenon HPS Lamp

Mercury can be replaced with xenon in HPS bulbs; however, there are effects on colour warmth (see technical feasibility of mercury alternatives).

HPS lamps can be operated in an unsaturated vapour mode, where all Hg/Na amalgam are vaporised, as such a smaller mercury dosage is needed. This has benefits such as better voltage and power stability and faster warm-up, however there are technical limitations such as increased rate of sodium loss leading to changes in lamp colour properties.

LED lamps offer a number of benefits as an alternative to HPS, notably energy efficiency, longer product life, and absence of mercury. LED luminaires are increasingly being used in outdoor lighting where HPS lamps are commonly applied, with LEDs projected to reach 89% of global market share of streetlights by 2027 (Northeast Group, 2017).

Canada

High pressure sodium lamps: LED lights provide much better colour rendering compared to high pressure sodium vapour lamps. LEDs provide an even white light, which is especially important for obtaining clear security camera footage.¹ Sodium lamps have the worst colour rendering of all lamps on the market with objects illuminated by them appearing shadowy black rather than the colour seen in daylight. LEDs are also much more energy efficient than high pressure sodium lamps resulting in lower operating costs.¹¹

High pressure sodium lamps typically require a “warmup” period which can take up to 10 minutes. As the light heats up it needs more voltage to operate which is balanced by a ballast (a magnetic or electric device designed to provide the light constant current). Over time, high pressure sodium lamps require more and more voltage to produce the same amount of light. Eventually, the voltage exceeds the fixed resistance provided by the ballast and the light goes out (fails). The lights become less efficient over time because they need more and more voltage to produce the same lumen output (brightness). In general, high pressure sodium lamps are usually able to maintain fairly good brightness (roughly 80% of original brightness) at their typical end-of-life (24,000 operating hours).¹

High pressure sodium lamps are particularly useful for outdoor lighting (such as municipal street-lighting or other common areas like parking lots). Compared to incandescent bulbs, fluorescent bulbs, and most high intensity discharge lamps, high pressure sodium lamps are much more efficient and last longer. It is only recently that LED lighting has become more affordable and prevalent enough to surpass high pressure sodium lamps in terms of energy efficiency and lifespan. The upfront costs of installing high pressure sodium lamps can still be lower than LEDs however the lifetime costs (including consideration of reduced maintenance and energy efficiency improvements) are lower for LEDs.¹ High pressure sodium lamps have higher maintenance costs and are more fragile than LEDs – several sodium vapour bulb replacements would be expected within the typical lifetime of an LED.¹¹

Metal halide lamps: Metal halide lamps can be very useful for high intensity applications like vehicle headlamps, athletic facility illumination, or for photographic lighting. The main advantage of metal halide lamps is their high-quality light output generating a very cool white light. LEDs also produce high quality light output with a very broad spectrum available depending on the light; ranging from warm ‘yellow’ to cool ‘blue’ light. Metal halides may still be the best source of high colour-rendering index white light on the market.¹²

LEDs have longer lifespans than metal halides (50,000 to 100,000 hours or more compared to 6,000 to 15,000 hours). In the past, the costs of LEDs were higher, however with the prices of LEDs declining in recent years the upfront costs of LEDs and metal halides are now very close.¹

Metal halide lamps have the longest warmup period of any lamp on the market (between 15-30) and must therefore be operated for longer periods than LEDs and cannot be quickly switched on and off on demand. This results in lights often being left on when not needed to avoid the long warmup period. Due to the long warmup period for metal halides, there must be some anticipation of when

light is required. LEDs have the advantage that they turn on immediately. Both LEDs and metal halides can be dimmed. However, dimming metal halides alters the light characteristics and reduces the efficiency of the light. LEDs are more energy efficient than metal halides. Metal halides emit about 15-20% of the total energy consumed is emitted as heat. LEDs emit very little heat. Metal halide lamps usually start switching on and off unexpectedly as they reach their end-of-life before failing completely. LEDs fail by gradually dimming over time. In many applications (e.g. stadium lighting) a sudden unexpected loss of light would not be acceptable and hence metal halides are often proactively changed out before the end of their useful life. Metal halides are also more fragile than LEDs. LEDs are solid state lights and difficult to damage with physical shocks.¹²

Automotive headlamps: LED lamps have become much more widely used in the global automotive lighting market in recent years. However, their upfront costs are still higher than the alternatives such as halogen bulbs.¹ LED costs continue to fall; however, one market research report on the global automotive lighting market 2016- 2020 expects that the cost of LED lighting may slow the growth of the market during this period.¹³ LED inside predicts that the value of the exterior automotive LED market will increase by 6% per year 2016-2020, continuing to replace traditional lamps in this application.¹⁴ Data from recent IMERC reports indicate that major automakers (e.g. Honda, Nissan, BMW, Subaru, Mitsubishi, Mercedes-Benz) are phasing out uses of mercury-containing headlamps more rapidly than the LEDinside report predicts as many vehicle models had phased out mercury headlamps by the end of 2017.¹

JLMA

Special purpose lamps are used as light sources for e.g. UV disinfection, UV curing, projection, gastric endoscopes, automobile headlamps, high precision analyzers and detectors, and banknote appraisers, etc. These applications use specific wavelengths (including emission lines) as a light source or a very small high intensity emission point as a light source. There are many applications that cannot be physically replaced by LEDs, such as requirements for light of a specific color/wavelength as well as brightness. In some applications that require high brightness, xenon mercury lamps are used to compensate for the insufficient light intensity of xenon lamps. No alternative light source has been developed that can replace xenon lamps as an ultra-small bright spotlight source with the same high light intensity. These special-purpose high-intensity discharge lamps are exempted from RoHS under 4(f).

JLMA response to questions on Automotive headlamps

Q. Are mercury containing HID (high intensity discharge) still used for new vehicles?

⇒ In the Japanese market, mercury containing HID lamps are currently not used for new vehicles. Mercury containing HID lamps were used in vehicles registered before 2012, and mercury containing HID lamps are still available on the market for replacement.

Q. Are mercury free headlamps available on all markets?

⇒ Mercury free headlamps are technically available on all markets. However, as there is difference of lighting control circuit between HID lamps with and without mercury, the lighting control circuit has to be replaced at the same time when the mercury free HID lamps are mounted. In addition, in order to prevent misuse, the shapes of bases and sockets used for HID lamps with and without mercury are different from each other. Therefore, existing mercury containing HID lamps cannot be simply replaced with mercury free HID lamps.

ZMWG

LED lamps can replace many types of High Intensity Discharge lamps (HIDs) including both high-pressure sodium (HPS) and metal halide lamps, which contain a significant amount of mercury. LED lamps are now available in a wide array of sizes,

	<p>wattages and lumen outputs and with a variety of commonly used HID bases (e.g., E27, E40). Suitable applications – both indoor and outdoor – include, but are not limited to: High-bay Lighting, Street lights, Garages, Parking Lots, Area lighting, Pedestrian zones, Parks, Industry, Retail and Museums.</p> <p>The benefits of LEDs over High Pressure Sodium (HPS) lamps are many:</p> <ul style="list-style-type: none"> ○ LED lamps are much more energy efficient than HPS lamps. ○ LEDs also have a longer rated life, which reduces their replacement and installation costs as well as their lifecycle environmental impacts. ○ LEDs emit a higher quality of light, which is white rather than the yellow light that is emitted from HPS lamps. ○ LED lamps do not cycle on and off. ○ LEDs are mercury-free unlike HPS lamps. <p>High-pressure sodium lamps (HPS) are primarily used for street lighting and other exterior lighting applications, although they are rapidly becoming replaced by other technologies including, notably, LEDs because:</p> <ul style="list-style-type: none"> ○ of their poor color quality – many HPS lamps appear yellow because their CRI is typically in the 20s; ○ they cycle on and off, which causes maintenance and safety problems; and ○ their relatively short life. <p>Over the past few years, there has been a significant increase in the number of LED replacements for high-intensity discharge (HID) lamps – particularly LEDs that can replace high-pressure sodium (HPS) lamps up to 400 watts¹³.</p> <p>According to Global Industry Analysts:</p> <p><i>The global market for High Intensity Discharge (HID) Bulbs is forecast to decline to US\$1.0 billion by 2024, constrained by the growing threat of substitution by light-emitting diode (LEDs) and high efficiency plasma lights. HID bulbs which have been used for years to light streets and factories are today being rapidly replaced by LEDs. Rising energy costs and tighter energy-efficiency standards and regulations are playing major roles in accelerating the phase out of HID lighting technology. Few of the benefits of LED driving its popularity as a replacement for HID include higher energy efficiency due to lower quotient of trapped light; high efficiency at higher operating temperatures; greater effectiveness of LED power drivers over HID ballasts; and longer durability with an operating life over 10 to 12 years.</i>¹⁴</p> <p>According to the International Dark Sky Association, “Early LEDs were energy-inefficient and emitted little light, but due to technological advances, LED efficiency and light output have doubled about every three years. Because of their improved quality and</p>
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¹³ Global Industry Analysts, “High Intensity Discharge (HID) Lighting: Market Analysis, Trends and Forecasts, 2018 May, <https://www.strategyr.com/market-report-high-intensity-discharge-hid-lighting-forecasts-global-industry-analysts-inc.asp>

¹⁴ Global Industry Analysts, “High Intensity Discharge (HID) Lighting: Market Analysis, Trends and Forecasts, 2018 May, <https://www.strategyr.com/market-report-high-intensity-discharge-hid-lighting-forecasts-global-industry-analysts-inc.asp>

	<p>falling prices, LEDs are now replacing conventional high-intensity discharge (HID) lamp types for outdoor lighting in communities around the world.”¹⁵</p> <p>LED lamps that can replace HID lamps are available in a variety of color temperatures (typically ranging from 2700K (warm) to 6500K). Their color quality (typically measured in CRI) is quite high, often 70-90, which makes them more versatile than conventional, low-CRI HPS lamps.</p> <p>LED lamps can replace many types of HID lamps including both high-pressure sodium (HPS) and metal halide lamps, which contain a significant amount of mercury. LED lamps are now available in a wide array of sizes, wattages and lumen outputs and with a variety of commonly used HID bases (e.g., E27, E40).</p> <p>Suitable applications – both indoor and outdoor – include, but are not limited to:</p> <ul style="list-style-type: none"> ● High-bay Lighting ● Street lights ● Garages ● Parking Lots ● Area lighting ● Pedestrian zones ● Parks ● Industry ● Retail and Museums <p>Manufacturers tout multiple environmental, safety and health benefits associated with replacing HID lamps with LED lamps. These benefits include significantly improved energy efficiency, longer life (which translates to lower maintenance and replacement costs), instant on (no warm-up time or “cycling”), elimination of mercury, effective thermal management for wide operating temperature range, effective lumen maintenance, and improved visibility, which increases safety. (examples listed in our submission- ZMWG)</p> <p><i>For Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner), limits could be imposed such as below given the availability of such models:</i></p> <p><i>I) $P \leq 155\text{ W}$: 20 mg per burner II) $155\text{ W} < P \leq 405\text{ W}$: 20 mg per burner III) $P > 405\text{ W}$: 25 mg per burner"</i></p> <p>Quartz metal halide lamps – particularly low-wattage models – can be readily replaced with more energy-efficient ceramic metal halide (CMH) lamps, which have a longer rated life and typically have less or the same amount of mercury. Therefore Quartz metal halide lamps could be phased out.</p> <p>According to a 2017 GE Lighting CMH Data Sheet, ceramic metal halide lamps have “up to 24% higher efficacy than quartz metal halide [lamps].” Another benefit of GE’s ceramic MH lamps is that they often have a lower mercury content when compared to its equivalent quartz MH lamp. (examples are provided in our submission)</p> <p>Since quartz and ceramic MH lamps are very often available in the same shape and type of lamps and bases, they are almost always interchangeable.</p>
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¹⁵ International Dark Sky Association, *LED Practical Guide*, <https://www.darksky.org/our-work/lighting/lighting-for-citizens/led-guide/>

	<p>Therefore, offering the RoHS Exemption on the ceramic models only would result in use of these easy, drop-in replacements with multiple environmental benefits, including significant mercury reduction as well as energy savings.</p> <p>Since some metal halides have a similar base, bulb shape and lumen output as the HPS lamps up to 400 watts, there are manufacturers offering LED replacement lamps for some types of metal halide lamps.</p> <p>One example is ProcureLED which offers a line of LED “Corn Lamps”, which are marketed as “Direct Replacement for Metal Halide” that can fit “many different fixtures to replace traditional lamps”, which are used to light factories, workshops, warehouses, shipyards, mining, gas stations, streets, etc.”¹⁶</p>
5.(i) Information on the technical feasibility of alternatives	<p>EU</p> <p>Replacement of Hg with Xenon in HPS lamps broadens the colour spectrum and therefore does not have the effect of a warm colour, and additionally requires very high pressures, which would hinder current ignition technology. Investigations into unsaturated vapour modes for lamps in which all sodium and mercury would be in vapour state in operation did not result in products with reduced Hg.</p> <p>LED luminaires are increasingly being made to replace HPS lamps and are expected to increase in this application. It has been demonstrated that these are suitable for Colour Rendering Index (CRI) at least up to 85 and as such are suitable to replace HPS in new installations for most applications, i.e. with the exception of those which require CRI >85. There are limitations to substitution of HPS with LED in existing installations due to different dimensions (Gensch et al., 2016).</p> <p>JLMA</p> <p>In general lighting, there are no lamps that can directly replace HID lamps. The reduction of mercury in HID lamps is being basically done by replacing them with LED fixtures.</p> <p>LightingEurope – HID lamps:</p> <p>Substitution by plug and play LED retrofit lamps is only limited possible:</p> <ul style="list-style-type: none"> - Lumen output for LED retrofit lamp is lower - Size and weight of LED lamps is much larger, so do not fit in most luminaires - Rewiring in the luminaire is needed - Environmental impacts of HID are lower Example of Street lighting: beam is important / regulated - Optical characteristics of the LED substitute lamps are completely different (glare, uniformity, minimum light on street) - The poles have to be replaced and the spacing changed - Life cycle cost of LED retrofit are higher due to lower total efficiency - Street luminaires are expensive: Weatherproof, resistant to vandalism, (250-500 €/per head). - Luminaire lifetime is more than 20 years.
5.(ii) Information on the economic feasibility of alternatives	<p>EU</p> <p>Industry has argued that there is an increase in fixed costs associated with substitution of mercury containing HPS lamps, loss of jobs from HPS manufacturing in Belgium and Hungary, and loss of application from different colour characteristics of Hg-free alternatives (Lighting Europe, 2015).</p>

¹⁶ ProcureLED LED Corn Lamps; March 2019, <https://procureled.com/wp-content/uploads/2019/03/Corn-Lamps-ProcureLED.pdf>

	<p>LEDs have larger upfront costs than HPS (Lighting Europe, 2015). However, LEDs have other economic benefits such as longer life and less energy usage. LED replacement lamps can use 50% less energy than HPS and last 50,000 hours compared to the 24,000 hour HID bulbs they replace (European Environment Bureau, 2015).</p> <p>JLMA response to question on Automotive headlamps</p> <p>Q. Is it economically feasible to substitute mercury containing headlamps globally?</p> <p>⇒ In order to replace mercury containing headlamps with mercury free headlamps, the headlamps themselves need to be newly manufactured and the entire HID lamp and lighting control circuit needs to be replaced, which is not economically feasible. HID lamps have high brightness and high efficiency. It is technically difficult to develop LED retrofit lamps of the same shape.</p> <p>LightingEurope</p> <p>Progress status of the LED (HID) transition in Europe in 2020:</p> <ul style="list-style-type: none"> • LED retrofit lamps have been developed for a limited number of existing HID luminaires, according to the EU consultants VHK & OEKO *) • For most existing installations and applications, LED retrofit lamps do not function properly or are not allowed. • Affordability is also a problem for HID retrofit lamps as these are very expensive (e.g. 200-300 \$) • Consider also the total socio-economic impact as exchanging all existing luminaires would result in huge investment costs for authorities and building owners (roads, tunnels, buildings, industry halls etc.).
<p>6. Information on environmental and health risks and benefits of alternatives</p>	<p>EU</p> <p>It has been estimated that there are 5-10 kg of mercury brought into the market in HPS lamps per annum in Europe (Lighting Europe, 2015). Reduced energy consumption from increased LED efficiency will result in lowered energy consumption and hence burning of fossil fuels. A total life-cycle assessment was conducted by Dale et al. (2011), finding that impacts of global warming potential, respiratory effects and ecotoxicity of LED lamps are 30% lower compared to high-pressure sodium and metal halide luminaires for street lighting and other outdoor applications (European Environment Bureau, 2015).</p> <p>If this is to be the case then replacement HPS bulbs will need to be available until luminaires are replaced.</p> <p>ZMWG</p> <p>The benefits of LEDs over HPS lamps are many:</p> <ul style="list-style-type: none"> • LED lamps are much more energy efficient than HPS lamps. • LEDs also have a longer rated life, which reduces their replacement and installation costs as well as their lifecycle environmental impacts. • LEDs emit a higher quality of light, which is white rather than the yellow light that is emitted from HPS lamps. • LED lamps do not cycle on and off. • LEDs are mercury-free unlike HPS lamps. <p>LEDs are increasingly being made to replace HPS lamps and are expected to increase for this application. A study cited by the International Energy Agency found [LED and induction lamp] impacts were about 30% lower in global warming potential,</p>

respiratory effects and ecotoxicity compared to high pressure sodium and metal halide luminaires [for street lighting and other outdoor lighting applications.”¹⁷

LightingEurope – HID:

Innovation progress on mercury reduction technology for lighting

- Mercury use for HID lighting accounts for far less than 1% of the total mercury release in the EU and in the world.
- Mercury use in lighting will further reduce the next years due to the natural LED transition in the market.

Conclusion: General lighting mercury lamps (HID lamps) are still needed as lamps for servicing existing luminaires due to issues with technical compatibility and complexity with existing luminaires and related investments, safety and affordability for new installations, the trend is to use LED luminaires.

Total mercury content from HID lamps for general lighting (HPS & MH)



Total EU Mercury by HID lamps (HPS & MH) (metric ton per year)	2020	2022	2026
Total Mercury put on the market	0.3	0.2	0.15
Total Mercury released in environment (non-recycled lamps)	0.16	0.12	0.08

Ratio HID lamps (HPS & MH) of total EU release (of all EU anthropogenic sources)	2020	2022	2026
Total Mercury put on the market	0.4%	0.3%	0.2%
Total Mercury released in environment (non-recycled lamps)	0.2%	0.15%	0.1%

- The mercury content released to the environment from HID lamps is <1% (0.3 tn in 2020) of the total EU mercury released to the environment of 77.2 tn
- The amount is decreasing further to 0.1 % in 2026 due to the natural LED transition in the market.

¹⁷ International Energy Agency, *Solid State Lighting Annex: Life Cycle Assessment of Solid State Lighting: Final Report*, 17 September 2014, http://ssl.iea-4e.org/files/otherfiles/0000/0068/IEA_4E_SSL_Report_on_LCA.pdf

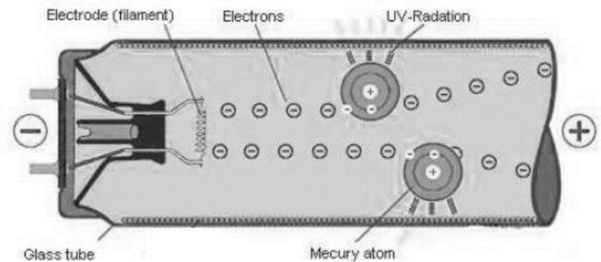
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	<p>EU</p> <p>High-pressure sodium lamps subject to restrictions under Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive):</p> <ul style="list-style-type: none"> • Mercury in High-Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner) in lamps with improved CRI Ra>60: <ul style="list-style-type: none"> ○ ≤ 155W: 30mg ○ >155W: 40mg • Mercury in other High-Pressure Sodium (vapour lamps) for general lighting purposes not exceeding (per burner): <ul style="list-style-type: none"> ○ ≤ 155W: 25mg ○ 155W-405W: 30mg ○ >405W: 40mg <p>High pressure sodium lamps <155W are still available on the market in the EU, however lamps >405W are no longer available. In the USA, the Interstate Mercury Education and Reduction Clearinghouse (IMERC) provides technical assistance to states that have enacted mercury education and reduction legislation. Some IMERC state members have enacted restrictions on the sale and distribution of mercury-containing lamps, such as in Connecticut (>100 mg) (IMERC, 2015). According to the EPA regulation the Universal Waste Rule (UWR), all mercury containing lamps must be managed as hazardous waste.</p> <p>A number of non EU countries have passed regulations which, like the EU RoHS directive, include the regulation of mercury-containing lamps. These include India, Russia and the Eurasian Economic Union, Japan, South Korea, Turkey and Vietnam (Chemical Watch, 2016).</p> <p>ZMWG</p> <p>Mercury containing lamps were brought under the ambit of E-waste management Rules in India in 2016¹⁸, which prescribes the mercury content for different kinds of lamps based on the rationale of ROHS limits for metals as prescribed by the EU. These limits have been in force since October 2016 and have been followed by all lighting companies registered in India. The allowed limits, listed below, are lower than the maximum mercury content limits set by Minamata Convention.</p>

¹⁸ Indian 2016 E-waste rules <http://cpcb.nic.in/displaypdf.php?id=UHVamVjdHMvRS1XYXN0ZS9FLVdhc3RlTV9SdWxlc18yMDE2LnBkZg==>

9. References

- Chemical Watch. (2016). RoHS around the world. Retrieved from <https://chemicalwatch.com/48769/rohs-around-the-world#overlay-strip>
- European Environment Bureau. (2015). Environmental NGOs Response to Stakeholder consultation 2015 #2 on mercury-containing lamps - Exemption 1-4 (Review of Annex to the RoHS directive). Retrieved from https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_1_a-e_/Ex_1-4_EEP-RPN-MPP_Comments_on_RoHS_Request-final_20151016.pdf
- Gensch et al. (2016). Assistance to the Commission on Technological Socio-Economic and Cost-Benefit Assessment Related to Exemptions from the Substance Restrictions in Electrical and Electronic Equipment. Retrieved from https://circabc.europa.eu/sd/a/eda9d68b-6ac9-4fb9-8667-5e561d8c957e/RoHS-Pack_9_Final_Full_report_Lamps_Alloys_Solders_June2016.pdf
- IMERC. (2015). IMERC Fact Sheet - Mercury Use in Lighting. Retrieved from http://www.newmoa.org/prevention/mercury/imerc/factsheets/lighting_2015.pdf
- Lighting Europe. (2015). Request to renew Exemption 4(b) under the RoHS Directive 2011/65/EU Mercury in High Pressure Sodium Lamps. Retrieved from https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_b_I-III_/4b_LE_RoHS_Exemption_Req_Final.pdf
- Lighting Europe. (2015). Response to Oko-Institut regarding the 1st Questionnaire Exemption No. 4c(I-III) (renewal request) Exemption for “Mercury in other High Pressure Sodium (vapour) lamps for general lighting purposes not exceeding (per burner):”. Retrieved from https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_b_I-III_/Ex_4b_I-II-III_LightingEurope_1st_Clarification-Questions_final.pdf
- Northeast Group. (2017). Global LED and Smart Street Lighting: Market forecast (2017-2027). Retrieved from <https://www.researchandmarkets.com/reports/4456402/global-led-and-smart-street-lighting-market>

Non-fluorescent low-pressure discharge lamps

1. Category of mercury-added product	Lamps
2. Further description of the product	Non-fluorescent low-pressure discharge lamps
3. Information on the use of the product	<p>EU</p> <p>Non-fluorescent low-pressure discharge lamps do not produce visible light and therefore, are not used for illumination purposes. Instead, these lamps are primarily used in germicidal applications, to reduce the spread of microorganisms. The use cases for these lamps include the ultraviolet germicidal disinfection of drinking water, waste water and beverages. In addition, these lamps are used for air disinfection units, aquaculture and fish farming applications, and the disinfection of surfaces (Gensch, et al., 2016). Germicidal effectiveness is primarily determined by wavelength, duration of exposure and the power intensity of UV light (Lux Review, 2017). In non-fluorescent low-pressure discharge lamps, a small amount of mercury is required to enable the lamp to function. As the electric current flows through the discharge tube between the electrodes, the electrons cause the mercury atoms to produce short-wave ultraviolet radiation. According to ISO Standard ISO-12348, these lamps enable transmission of light in the UVC region of 100 nm – 280 nm. Some UVC wavelengths are blocked by specific glass types. However, the use of synthetic quartz allows wavelengths as low as 185 nm to pass, as quartz is highly transparent to UVC radiation (Helios Quartz, 2016).</p> <p>Figure 2 – Non-fluorescent low pressure discharge lamp (Lighting Europe, 2015a)</p>  <p>The diagram illustrates the internal structure of a non-fluorescent low-pressure discharge lamp. It shows a horizontal glass tube with two electrodes (filaments) at each end, labeled 'Electrode (filament)'. The left electrode is connected to a negative terminal (-) and the right to a positive terminal (+). Inside the tube, a series of small circles represent 'Mercury atom'. Arrows indicate the flow of 'Electrons' from the negative electrode towards the positive electrode. At the positive end, 'UV-Radiation' is shown being emitted from the mercury atoms. The entire assembly is labeled 'Glass tube'.</p> <p>The use cases are highly specialised, resulting in a variety of sizes, power levels and end cap configurations depending on the specific application. In addition, the power ranges vary from 1 W to 1000 W and the operating temperature can range from 0°C to 100°C. In some cases, thermal control may be necessary (Gensch et al., 2016).</p> <p><u>Range of mercury content</u></p> <p>The average mercury content for lamps falling under exemption from the RoHS ‘mercury in other low-pressure discharge lamps’ is 4 mg – 15 mg (Gensch, et al., 2016). This upper limit of the range is largely linked to compliance with the RoHS, which places a 15 mg limit on non-fluorescent low-pressure discharge lamps. However, a number of manufacturers, which have operations outside Europe, also comply with the RoHS 15 mg limit (Van der Meer, et al., 2015).</p> <p>LightingEurope: Special purpose (non-fluorescent) lamps and luminaires are designed essentially for UV applications with specific features, e.g.:</p>

	<p>Where non-visible radiation has importance, for example:</p> <ul style="list-style-type: none"> • Medical/Therapy lamps • Disinfection lamps e.g. to inactivate bacteria and viruses (e.g. COVID) • Chemical and biological processes, e.g. Bio tech processes and monitoring equipment • Light sources for scientific instruments and/or the calibration of instruments
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>EU <u>Main alternatives: UVC LEDs</u> Despite the positive attributes of mercury UVCs (i.e. the ease of application, and lack of toxic by-products relative to chemical disinfection), these lamps are fragile, lack portability and in some cases, display a limited lifetime (University of Cambridge, 2019). Therefore, alternatives can address these drawbacks as well as bypassing the mercury contamination risk associated with disposal. The most promising alternative to mercury UVCs are UVC LEDs. In particular, UVC LEDs which use aluminium gallium nitride (AlGaIn), have become an effective alternative in recent years, due to their long lifetime, low voltage and relatively compact nature (Guo, et al., 2018). According to information provided by an industry group, there are also some developments in LED substitutes for small-scale applications, such as water bottle disinfection in homes and offices. Concerning sourcing a direct substitute to the use of mercury in non-fluorescent low-pressure discharge lamps, alternative substances to mercury are not currently available (Gensch, et al., 2016). Recent information provided by an industry group states that it is still the case that mercury cannot be substituted in low-pressure discharge lamps without fluorescent powder.</p> <p>ZMWG It has come to our attention that there are scientifically and technically practicable and reliable substitutes for certain mercury-based products currently covered by Exemption 4(a), for example for the use of low-pressure discharge lamps for disinfection and advanced oxidation treatment with UV light emitting equipment. More information can be received by Typhon Treatment Systems Ltd. www.typhontreatment.com</p> <p>JLMA There is no substitute for the lamps specified in 4(a) of the RoHS exemptions, which are used for measurement and analysis equipment using mercury emission lines. For example,</p> <ul style="list-style-type: none"> • As a light source for wavelength calibration. • As a light source for analysis in atomic absorption spectrophotometers. Wavelengths specific to mercury elements are required. • As a light source for water quality analyzer. UV light (254nm) and visible light (365, 402, 545nm, etc.) must be on the same optical path. • As a light source for oxidative decomposition. As a light source for oxidative decomposition, high brightness of 185nm is required. <p>Since there are no alternative light sources in these fields, industries are applying for exemption from RoHS. And, alternative light sources to low-pressure discharge lamps for sterilization and disinfection using UV light emitting devices have not been tested for</p>

	<p>effectiveness due to insufficient output. Low-pressure discharge lamps are necessary as a light source for UV sterilization and disinfection in response to the global spread of COVID-19.</p> <p>LightingEurope: Mercury-free LED substitutes are still in R&D development phase or entering the market for some very low power UV applications.</p>
5.(i) Information on the technical feasibility of alternatives	<p>EU A number of projects and studies are currently engaged in the development and application of UVC LEDs (Advanced-UV, 2019; University of Cambridge, 2019). The use cases for non-fluorescent low-pressure discharge lamps are highly specialised, requiring that alternatives can produce light in a specific range of the UVC spectrum. The germicidal range, which is important for the disinfection role of UVCs, is largely considered to be 200 nm – 300 nm (Lux Review, 2017). The spectral range of UVC LEDs varies depending on the source. Lux Review (2017) suggests that UVC LEDs have a wavelength of 200 nm – 280 nm and therefore appropriate for disinfection applications. UVC LEDs offer a long-life alternative to mercury lamps (Lux Review, 2017). An industry group stated that UV LEDs are a new field of research and development, and that certain applications of UV LED solutions are becoming available, including UVC LEDs, emitting in the critical range for germicidal applications. However, in disinfection applications, there are no retrofit solutions realistically possible, as UVC LED solutions require new equipment. Information provided by an industry group also states that the current efficiency of UVC LED technology is considerably lower (4% relative to 30% in UVC lamps), and that it is likely to be a minimum of five years before conventional lamps are no longer needed in new equipment.</p> <p>JLMA Special purpose lamps are available in a wide variety of sizes and with different requirements. Many of them require specific wavelengths, and it is technically impossible to replace them with LEDs.</p> <p>LightingEurope Special purpose UV lamps: Comparison of data for UV curing: The comparison must also take into account the desired properties of the end product, process-related requirements and the limitations of materials. When considering the substitution of mercury, the necessary and more reactive chemistry of UV LED inks should also be taken into account. A disposal problem certainly also arises from the use of LEDs.</p>

	Hg Low Pressure		Hg Medium Pressure		UVC LED	
	From	To	From	To	From	To
UVC Wall Plug Efficiency / %	30	35	5	17	1	5
Output Power per UVC source / W	40	1000	1000	35000	0,01	0,4
Life Expectancy at full power / h	12000	16000	2000	10000	2500	5000
Cost per source / \$	5	100	50	250	0,5	15
Cost per W UVC / \$/W	\$0,417	\$0,286	\$1,000	\$0,042	\$5.000,00	\$750,00
Cost per µJ UVC / \$/µJ	\$0,010	\$0,005	\$0,139	\$0,001	\$555,556	\$41,667

- Table source: http://www.rohs.biois.eu/Clarification_Questionnaire_VDMA_Answers_final.pdf

Comparison of data for disinfection (wave range 240-280 nm)

Both flash lamps and UV Hg gas discharge lamps have their use cases in the disinfection sector. Flash lamps have advantages, for example, in the sterilisation of cups for the food industry. UV LEDs are only used in a niche application (very low throughput) for disinfection and cannot be used industrially. The radiant efficacy of UVC LEDs is about 1-6% (see table). In comparison, low-pressure mercury lamps have an optical yield of over 30%-40%. To achieve a comparable optical yield with UV LEDs, the material effort would increase significantly and the electrical power requirement would rise fivefold due to the approx. 80% lower optical yield. From an ecological point of view, the current use of UVC LEDs on an industrial scale is therefore not sustainable and leads to increased energy and material consumption. NOTE: The optical yield indicates how much electrical power is converted into radiant power at the desired wavelength. For disinfection the characteristic wavelength for or Hg low-pressure lamps is 253.4 nm. With an electrical lamp power of 370 W, Hg low-pressure lamps have an optical yield > 30% and thus approx. 120 W radiant power. In addition, the service life of UVC LEDs for disinfection is much shorter than that of LEDs that emit in the visible range and is usually less than 5000 hours. Especially from the Covid-19 point of view, the further availability of UV Hg medium-pressure and low-pressure lamps for air and surface disinfection is essential because of their high efficiency. This development of Covid-19 was not foreseeable at the time of the preparation of the elongation request.

	<table><tr><td></td><td>UVC LEDs</td><td>low pressure Hg lamps</td><td>medium pressure Hg lamps</td><td>flash lamps</td></tr><tr><td>Wall Plug Efficiency for UVC / %</td><td>1-6</td><td>30-40</td><td>10-20 (undoped)</td><td>2-4</td></tr><tr><td>Electrical power / W</td><td>0,1-10</td><td>4-1000</td><td>150-36.000</td><td>100 – 3000</td></tr><tr><td>Power output / W</td><td>0,001-0,3^c</td><td>1,2-400</td><td>15-7.200</td><td>2 - 120</td></tr><tr><td>Life expectancy / h</td><td>< 5000</td><td>8000-16000</td><td>4000-8000</td><td>5 - 10 million flashes^d</td></tr><tr><td>Cost (only lamp, chip)/ \$</td><td>60 – 120 per Chip^a</td><td>5 - 100</td><td>50 - 250</td><td>180^b</td></tr><tr><td>Disinfection efficiency</td><td>not applicable^f</td><td>99,99 % log 4^e</td><td>99,99 % log 4^e</td><td>99,9999% log 6^e</td></tr><tr><td colspan="5">a System costs for a 1000 W UV power system are estimated to be 40 times higher compared to a state-of-the-art system with UV Hg low pressure lamps b Costs for Flash Systems are more than 5 times higher than systems with low pressure lamps c LED package d (corresponds to 1400 - 2800 hours at 1 Hz), 2-3 times shorter than low pressure lamps e Factor of the germ reduction, log 4 means reduction from 100,000,000 to 10,000 microorganisms, at log 6 to 100 f not effective enough and economical for industrial use</td></tr></table>		UVC LEDs	low pressure Hg lamps	medium pressure Hg lamps	flash lamps	Wall Plug Efficiency for UVC / %	1-6	30-40	10-20 (undoped)	2-4	Electrical power / W	0,1-10	4-1000	150-36.000	100 – 3000	Power output / W	0,001-0,3 ^c	1,2-400	15-7.200	2 - 120	Life expectancy / h	< 5000	8000-16000	4000-8000	5 - 10 million flashes ^d	Cost (only lamp, chip)/ \$	60 – 120 per Chip ^a	5 - 100	50 - 250	180 ^b	Disinfection efficiency	not applicable ^f	99,99 % log 4 ^e	99,99 % log 4 ^e	99,9999% log 6 ^e	a System costs for a 1000 W UV power system are estimated to be 40 times higher compared to a state-of-the-art system with UV Hg low pressure lamps b Costs for Flash Systems are more than 5 times higher than systems with low pressure lamps c LED package d (corresponds to 1400 - 2800 hours at 1 Hz), 2-3 times shorter than low pressure lamps e Factor of the germ reduction, log 4 means reduction from 100,000,000 to 10,000 microorganisms, at log 6 to 100 f not effective enough and economical for industrial use				
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Wall Plug Efficiency for UVC / %	1-6	30-40	10-20 (undoped)	2-4																																					
Electrical power / W	0,1-10	4-1000	150-36.000	100 – 3000																																					
Power output / W	0,001-0,3 ^c	1,2-400	15-7.200	2 - 120																																					
Life expectancy / h	< 5000	8000-16000	4000-8000	5 - 10 million flashes ^d																																					
Cost (only lamp, chip)/ \$	60 – 120 per Chip ^a	5 - 100	50 - 250	180 ^b																																					
Disinfection efficiency	not applicable ^f	99,99 % log 4 ^e	99,99 % log 4 ^e	99,9999% log 6 ^e																																					
a System costs for a 1000 W UV power system are estimated to be 40 times higher compared to a state-of-the-art system with UV Hg low pressure lamps b Costs for Flash Systems are more than 5 times higher than systems with low pressure lamps c LED package d (corresponds to 1400 - 2800 hours at 1 Hz), 2-3 times shorter than low pressure lamps e Factor of the germ reduction, log 4 means reduction from 100,000,000 to 10,000 microorganisms, at log 6 to 100 f not effective enough and economical for industrial use																																									
Table source: http://www.rohs.biois.eu/Clarification_Questionnaire_VDMA_Answers_final.pdf																																									
5.(ii) Information on the economic feasibility of alternatives	EU The upfront costs associated with UVC LEDs is higher than for UVC mercury lamps (€10 per unit for LEDs vs. €5 per unit in the case of UVC lamps in residential water purification process (Lighting Europe, 2015b)). Additionally, as previously mentioned, energy efficiency is lower in UVC LEDs. According to information provided by an industry group, there are however no UVC LED retrofit lamps available for current installations. An industry group also stated that UV-emitting units bear significant running costs relative to UV LED lamps. For example, UV lamps cost approximately \$0.5 per Watt, whilst UVC LEDs cost approximately \$400-500 per Watt. In large water purification systems in cities, systems can exceed 100 kW, resulting in significant costs under UVC LED application.																																								
6. Information on environmental and health risks and benefits of alternatives	EU UVC LEDs are mercury-free and have lower energy consumption than UVC lamps. However, due to the lower wall plug efficiency of current LED alternatives, they would report higher levels of energy consumption than mercury UVCs (Gensch, et al., 2016). Also, although UVC LEDs are mercury-free, there are some concerns over end-of-life management, due to the presence of potentially hazardous materials (Seong-Rim, et al., 2011).																																								

	LightingEurope: Mercury-free LED substitutes are still in R&D development phase or entering the market e.g. for some very low power UV applications.
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	EU In Europe, Directive 2011/65/EC (Restriction of Hazardous Substances (RoHS) Directive) governs the use of mercury in non-fluorescent low-pressure discharge lamps and associated alternatives. Under Article 4(1) of the RoHS Directive, Member States must ensure that electrical and electronic equipment does not contain mercury. Annex III outlines exemptions from Article 4(1), which includes a ≤ 15 mg limit on the mercury content of low-pressure discharge lamps (4(a)) (Gensch, et al., 2016). There is no direct national legislation on the use of mercury in non-fluorescent low-pressure discharge lamps in the US, Canada, China or Australia, although separate energy efficiency standards or other regulatory tools in those countries may act as preventative or restrictive measures on mercury content in a number of instances. However, an industry group stated that India, Thailand, Ukraine and the Eurasian Economic Community (EurAsEC) have implemented national legislation on the use of mercury in non-fluorescent low pressure discharge lamps. Further, Jordan, Turkey, UAE, Saudi Arabia, Vietnam and South Korea have adopted national legislation in line with the RoHS Directive. In addition, the Gulf regions and Brazil are preparing national legislation.

9. References

Advanced-UV, 2019. Advanced UV for Life. Available at: <https://www.advanced-uv.de/en/about/welcome/>.

EU, 2011. DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011L0065&from=EN>.

Gensch, C.-O. et al., 2016. Study to assess renewal requests for 29 RoHS 2 Annex III exemptions [no. 1(a to e -lighting purpose), no. 1(f - special purpose), no. 2(a), no. 2(b)(3), no. 2(b)(4), no. 3, no. 4(a), no. 4(b), no. 4(c), no. 4(e), no. 4(f), no. 5(b), no. 6(a), no. 6(b), no. 6(c), no. 7(a), no. 7(c) - I, no. 7(c) - II, no. 7(c) - IV, no. 8.

Guo, Y. et al., 2018. Enhancing the light extraction of AlGaIn-based ultraviolet light-emitting diodes in the nanoscale. *Journal of Nanophotonics*.

Helios Quartz, 2016. UV Lamp. Available at: https://www.heliosquartz.com/wp-content/uploads/2016/01/Helios-Quartz_UV-LAMPS_eng.pdf.

Lighting Europe, 2015a. Request to renew Exemption 4a under the RoHS Directive 2011/65/EU. Available at: https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_a/Lighting_Europe/4a_LE_RoHS_Exemption_Req_Final.pdf.

Lighting Europe, 2015b. Response to Oeko-Institut regarding the 1st Questionnaire Exemption No. 4a (renewal request); Exemption for “Mercury in other low pressure discharge lamps (per lamp) – 15 mg may be used per lamp after 31 December 2011” Date of submission: September 15, 20. Available at: http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_9/Exemption_4_a/Lighting_Europe/Ex_4a_LightingEurope_1st_Clarification-Questions_final.pdf.

Lux Review, 2017. How effective are UVC LEDs?. Available at: <https://luxreview.com/article/2017/09/how-effective-are-uvc-leds->.

Seong-Rim, L., Kang, D. & Ogunseitan, O. a. S. J., 2011. Potential Environmental Impacts of Light-Emitting Diodes (LEDs): Metallic Resources, Toxicity and Hazardous Waste Classification. *Environmental Science & Technology*, Volume 45, pp. 320-327.

University of Cambridge, 2019. UV LEDs. Available at: <https://www.gan.msm.cam.ac.uk/projects/uv>.

Van der Meer, M., van Lierop, F. & Sokolov, D., 2015. The analysis of modern low pressure amalgam lamp characteristics. Available at: <http://www.dafp.de/wp-content/uploads/2015/10/The-analysis-of-modern-low-pressure-amalgam-characteristics.pdf>.

IV. Non-electronic measuring devices

Information provided by Argentina, Montenegro, Uganda, the USA, and other stakeholders (ZMWG)

Thermometers

1. Category of mercury-added product	Non-electronic measuring devices
2. Further description of the product	Thermometers (including pyrometers))
3. Information on the use of the product	<p>Argentina In Argentina, FITE S.A. is the only company that produces thermometers. Types of thermometers.</p> <ul style="list-style-type: none"> • Precision thermometers • Temperature greater than 150 ° C • Standard chemical thermometers • Combined (with densimeters) <p>According to FITE S.A., different types of thermometers are used in Argentina, mainly in chemical industry, petroleum laboratories and pharmaceutical industry.</p> <p>Information from experts</p> <ul style="list-style-type: none"> • Glass mercury thermometer is a thermometer in which mercury is sealed as a temperature sensitive liquid inside a transparent glass tube. • The amount of mercury used depends on the required accuracy, and is about 4 to 20 g per thermometer. The finer the scale (minimum display that can be confirmed), the greater the amount of mercury used. • There is almost no residual mercury in the narrow tube, shows good reproducibility, is highly accurate, and the temperature of substances such as hydrochloric acid, sulfuric acid, and other highly corrosive substances can be measured. • In addition to being used alone, these are incorporated in hygrometers, floats for LPG measurement, diesel engines, medical equipment (gas sterilizers), pycnometers, and flash point testers. • Demand for glass mercury thermometers with a scale of 1 ° C or higher is declining. <p>Information from experts</p> <ul style="list-style-type: none"> • Pyrometers are a form of mercury dial thermometer used for high temperature measurements such as in foundry application for the measurement of the temperature of diesel exhaust (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011). • Infrared thermometers appear to have replaced mercury thermometers, and new pyrometers are not manufactured with mercury (NEWMOA, 2016). There are no significant environmental risks or technical feasibility limitations around mercury-free alternatives, however electronic infrared pyrometers are more expensive (while also providing increased functionality). • In pyrometers, radiation from the measured body is focused on a detector, equipped with a dial gauge and temperature-sensing stem (thermocouple) (NEWMOA, 2016). • Range of mercury content/ consumption per unit product: 5-10 g contained within the thermocouple (sensor) (NEWMOA, 2016).

4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Argentina</p> <ul style="list-style-type: none"> • Precision thermometers – They are exempt from the Convention. • Temperatures greater than 150 ° C – Without replacement, in search of alternative technological solutions • Standard chemical thermometers – They only have replacements in temperatures below 150 ° C • Combined (with densimeters) - These do have replacements <p>Information from experts</p> <ul style="list-style-type: none"> • Currently, thermometers and digital thermometers that use other specific type of liquid as the temperature sensitive liquid are available. <p>Information from experts</p> <ul style="list-style-type: none"> • Main alternatives to pyrometers: Infrared thermometer, pyrometers with nitrogen-containing stem • Infrared thermometers are non-contact temperature measurement devices. They consist of a lens to focus infrared energy on to a detector (thermocouple) which converts the energy to an electrical signal (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011).
5.(i) Information on the technical feasibility of alternatives	<p>Argentina</p> <ul style="list-style-type: none"> • The Argentine company, FITE S.A., has begun its activities to replace the thermometers with temperatures below 150 ° C and the standard chemical thermometers with temperatures below 150 ° C. The replacement material for many of the applications that previously used mercury is galinstan, a eutectic alloy of gallium, indium, and tin. • The work related to the technical specifications is being carried out jointly with the National Institute of Industrial Technology (INTI) and Physical Metrology sector. • The companies that supply the inputs for the manufacture of the instruments are foreign. FITE S.A. has already started making relevant contacts with the companies that produce galinstan and glass tubes. The supplier of the latter will a German company. • Once they have the technical specifications and the purchase of supplies, they will proceed to the corresponding tests for the replacement of mercury in the instruments. <p>Information from experts</p> <ul style="list-style-type: none"> • Due to performance issues, replacement with mercury-free thermometers is not possible for some applications. Specifically, replacement is not possible for the following: • The maximum temperature that can be measured is 300 ° C or less, and the scale is 0.5 ° C or less. • The maximum measurable temperature is over 300 ° C and less than 500 ° C, and the scale is 2 ° C or less. • Thermometers that can measure the temperature of hydrochloric acid, sulfuric acid and other highly corrosive chemicals, the maximum temperature that can be measured is more than 200 ° C and 500 ° C or less, and the scale is 2 ° C or less. • Replacement during the time of repair with replacement products is difficult mainly due to factors such as simple replacement not being possible due to size differences. • Glass mercury thermometer is specified in the Japanese petroleum test. With digital thermometers, dealing with total immersion is difficult and standard data used until now cannot be used any more. Hence, requests have been made to continue manufacturing glass mercury thermometers even after 2020. • In addition to the thermometers specified in the standard, there is a possibility of continuing the manufacture of a small number of custom-made products that cannot be replaced.


	<p>Information from experts</p> <ul style="list-style-type: none"> There are no technical feasibility barriers associated with infrared pyrometers, evidenced by their use having replaced mercury pyrometers in industry.
5.(ii) Information on the economic feasibility of alternatives	<p>Information from experts</p> <ul style="list-style-type: none"> A glass mercury thermometer costs around 1,000 yen, while a digital thermometer costs around 5,000 to 10,000 yen and is more expensive. Some digital thermometers have high accuracy. However, in order to increase accuracy, it is necessary to increase the accuracy of both the temperature sensing unit and the display unit, which can be very expensive. <p>Information from experts</p> <ul style="list-style-type: none"> Infrared thermometers and pyrometers are electrical and cost more than mercury thermometers, however, have additional features and so are not directly comparable. Mercury pyrometers are no longer manufactured in the USA and Europe and have been replaced by infrared pyrometers and so economic barriers do not appear to be a significant factor (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011) (NEWMOA, 2016).
6. Information on environmental and health risks and benefits of alternatives	<p>Information from experts</p> <ul style="list-style-type: none"> The human health and environmental risks related to electronic/ infrared thermometers (and pyrometers) is insignificant compared with potential emission and exposure associated with mercury thermometers/pyrometers (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011).
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	<p>Information from experts</p> <ul style="list-style-type: none"> There are 10 manufacturers in Japan. Glass mercury thermometer (excluding those listed below) will be regulated by the Act on Preventing Environmental Pollution of Mercury of Japan after the phase-out deadline of the Minamata Convention (end of 2020). Exemptions included in Annex A of the Minamata Convention ([Products for research, calibration of instruments, for use as reference products], [Measuring devices for which no feasible mercury-free alternative for replacement is available],[Measuring devices installed in large-scale equipment or those used for high precision measurement, where no suitable mercury-free alternative is available]) are also not subject to regulation under the Act on Preventing Environmental Pollution of Mercury of Japan (During the review process, the scope of exemption for products will be determined by the use mentioned above). Products for which the maximum temperature that can be measured is 300 ° C or less, and the scale is 0.5 ° C or less. Products for which the maximum measurable temperature is above 300 ° C and 500 ° C or less, and the scale is 2 ° C or less. Products that can measure the temperature of hydrochloric acid, sulfuric acid and other highly corrosive chemicals, the maximum temperature that can be measured is more than 200 ° C and 500 ° C or less, and the scale is 2 ° C or less. <p>Information from experts</p> <p>Examples of regional or national restrictions</p> <ul style="list-style-type: none"> US EPA promulgated a significant new use rule (SNUR), effective June 29, 2012, under the Toxic Substances Control Act (TSCA) for elemental mercury use in barometers, manometers, hygrometers, and psychrometers. This action would require persons who intend to manufacture (including import) or process elemental mercury for an activity that is designated as a significant new use by this final rule to notify EPA at least 90 days before commencing that activity. The required notification would provide EPA with the opportunity to evaluate the intended use and, if necessary, to prohibit or limit that activity before it occurs.

	<ul style="list-style-type: none"> • US EPA promulgated another SNUR (effective August 20, 2010) for elementary mercury use in flow meters, natural gas manometers, and pyrometers. • In the EU, mercury thermometers, including pyrometers and psychrometers are banned by the Mercury Regulation 2017/852 and the REACH regulation 1907/2006 except for use in scientific research and development. Also exempted are platinum resistance thermometers using the triple point of mercury. ECHA (2011) concluded that ‘for all known applications, there are technically feasible alternatives that can replace all mercury thermometers and other non-electrical thermometric devices using mercury, with the exception of - thermometers used for testing according to analysis standards (test methods) that prescribe mercury thermometers.’ However, standards are subject to regular revisions during which mercury-free thermometers of the same accuracy may be included, a process that is already underway. Alternatives include: <ul style="list-style-type: none"> - Mercury-free liquid-in-glass thermometers containing liquids such as alcohol or gallium alloys - Gas or liquid dial thermometers - Bi-metal dial thermometers - Electronic thermometers - Infrared thermometers • In Europe, the export, import and manufacturing in the Union of non-electronic thermometers and other non-electrical thermometric applications is prohibited by 31 December 2020 according to Regulation 2018/852 on mercury. According to the Regulation 1907/2007 on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), thermometers and other non-electrical thermometric applications intended for industrial and professional uses containing mercury shall not be placed on the market from 10 April 2014. • Some US states prohibit the sale of mercury-added pyrometers under the category of mercury-containing measuring devices (Minnesota, New Hampshire, New York, Vermont) (NEWMOA, 2016).
8. Other relevant information pursuant to Decision MC-3/1	
9. References	Information from experts Information was collected through interviews with a group of domestic manufacturers of glass measuring instruments. ECHA. (2011). Background document to the opinions on the Annex XV dossier proposing restrictions on Mercury in measuring devices


Barometers

1. Category of mercury-added product	Non-electronic measuring devices
2. Further description of the product	Barometers
3. Information on the use of the product	Information from experts <ul style="list-style-type: none"> • Liquid column type mercury barometer is a barometer that utilizes the principle that when a glass tube with one end closed is filled with mercury and placed in mercury contained in another container, the weight of the mercury in the glass tube balances with the pressure applied to the mercury surface in the container.

	<ul style="list-style-type: none"> Currently, there is not much demand for this product and almost no production. In the future, products that are able to get certification by the Japan Meteorological Agency will be used as reference standard products for research and calibration, and hence there is a demand of manufacture for these specific products.
4. Information on the availability of mercury-free (or less-mercury) alternatives	Information from experts <ul style="list-style-type: none"> Digital barometers are available.
5.(i) Information on the technical feasibility of alternatives	
5.(ii) Information on the economic feasibility of alternatives	
6. Information on environmental and health risks and benefits of alternatives	
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	Information from experts <ul style="list-style-type: none"> Liquid column type mercury barometers will be regulated by the Act on Preventing Environmental Pollution of Mercury of Japan after the phase-out deadline of the Minamata Convention (end of 2020). Exemptions included in Annex A of the Minamata Convention (Products for research, calibration of instruments, for use as reference products) are also not subject to regulation under the Act on Preventing Environmental Pollution of Mercury of Japan (During the review process, the scope of exemption for products will be determined by the use mentioned above). US EPA promulgated a significant new use rule (SNUR), effective June 29, 2012, under the Toxic Substances Control Act (TSCA) for elemental mercury use in barometers, manometers, hygrometers, and psychrometers. This action would require persons who intend to manufacture (including import) or process elemental mercury for an activity that is designated as a significant new use by this final rule to notify EPA at least 90 days before commencing that activity. The required notification would provide EPA with the opportunity to evaluate the intended use and, if necessary, to prohibit or limit that activity before it occurs. US EPA promulgated another SNUR (effective August 20, 2010) for elementary mercury use in flow meters, natural gas manometers, and pyrometers. In the EU, the REACH regulation 1907/2006 bans barometers with the exemption of use in scientific research and development.
8. Other relevant information pursuant to Decision MC-3/1	
9. References	Information from experts Information was collected through interviews with a group of domestic manufacturers of glass measuring instruments.

Devices using mercury to measure the density of liquids	
Name of the product use and/or process	Hydrometer (non-electric)
Alternative names	Areometer, densimeter For specific applications: urinometer (med.), lactometer, alcohol meter, battery condition indicator, anti-freeze tester, anti-freeze meter, thermohydrometer, saccharometer
Purpose of the product/process	<p>A hydrometer is an instrument used for measuring the relative density of liquids based on the concept of buoyancy. They are typically calibrated and graduated with one or more scales such as specific gravity, but typically they contain a scale that directly indicates the information of interest, e.g. the content of alcohol in a water/alcohol mixture (Lemon 2013).</p> <p>A hydrometer usually consists of a sealed hollow glass tube with a wider bottom portion for buoyancy, a ballast such as lead or mercury for stability, and a narrow stem with graduations for measuring.</p>  <p>The image shows four different types of hydrometers. From left to right: a lactometer with a long, narrow stem and a bulbous bottom; an antifreeze meter with a black rubber bulb at the top and a long stem; an alcohol meter with a long stem and a bulbous bottom; and a battery tester with a black rubber bulb at the top and a long stem. Each hydrometer has a scale on its stem for measurement.</p> <p>Figure 3: Examples of hydrometers: from left to right: lactometer, antifreeze meter, alcohol meter, battery tester (filled with mercury or other high-density materials: Food museums of the province of Parma 2019, Butch 2015b, Michel 2017, Butch 2015a)</p>
Field of application	Urinometer (for urine analysis), lactometer (testing of milk), alcohol meter (determining the alcoholic strength of liquids), battery tester (battery condition tester), anti-freeze meter (test of cool liquid in a car), thermohydrometer (hydrometer with thermometer for measuring the density of petroleum products, like fuel oils), saccharometer (determining the amount of sugar in a solution), soil analysis (particle size distribution in fine-grained soils)

Mercury content	Several grams, depending on the hydrometer type, measuring range and volume of the hydrometer.
Extent of use/ production (globally, regionally)	Mercury filled hydrometers could not be identified on the European or US markets except antique objects (Lassen and Maxson 2008, NEWMOA 2016b). No information on production and use outside the EU and the USA available
Environmental or health risk	<ul style="list-style-type: none"> • Risk of mercury spillage in case of breakage of the product • Risk of mercury release in case of inappropriate disposal of waste product
Available non-mercury alternatives	<ul style="list-style-type: none"> • Hydrometers filled with lead or other high-density materials, electric devices
Advantages of mercury compared to alternatives	None
Additional comments	Visual assessment of products offered on international trading platforms (Alibaba.com, Made-in-china.com, ExportersIndia.com), indicate that most offered hydrometers do not contain liquid mercury, but other materials. More information is needed to verify this assumption.
References and sources for further information	<p>Butch (2015a): Battery condition indicator indicates the amount of charge in the battery (around 1985). Available online at https://upload.wikimedia.org/wikipedia/commons/4/44/Battery_condition_indicator.jpg, checked on 9/24/2019.</p> <p>Butch (2015b): Device to measure to what temperature the coolant of a car is protected against freezing. Available online at https://upload.wikimedia.org/wikipedia/commons/9/9d/Coolant_indicator.jpg, checked on 9/24/2019.</p> <p>Food museums of the province of Parma (2019): Densimetro o galattometro con custodia. Available online at https://upload.wikimedia.org/wikipedia/commons/b/b8/Densimetro_o_galattometro_con_custodia_-_Musei_del_cibo_-_Parmigiano_-_314a.jpg, checked on 9/24/2019.</p> <p>Lassen, C.; Maxson, P. (2008): Options for reducing mercury use in products and applications, and the fate of mercury already circulating in the society. Final Report. Edited by COWI. Available online at https://ec.europa.eu/environment/chemicals/mercury/pdf/study_report2008.pdf, checked on 9/24/2019.</p> <p>Lemon, K. (2013): Hydrometers- A Guide to applications and usage. Cambridge, United Kingdom (Camlab). Available online at https://camlab.info/wp/index.php/hydrometers-a-guide-to-applications-and-usage/, updated on 2/8/2013, checked on 6/10/2019.</p> <p>Michel (2017): Hydrometer in a still. Available online at https://commons.wikimedia.org/wiki/File:Hydrometer_in_a_still_(cropped).jpg, checked on 9/24/2019.</p> <p>NEWMOA (Ed.) (2016): Hospital equipment. Available online at http://www.newmoa.org/prevention/mercury/projects/legacy/healthcare.cfm, checked on 9/24/2019.</p>

Devices using mercury to measure fluxes/flows (flow meter, non-electric)	
Name of the product use and/or process	Flow meters
Alternative names	Analogue flow meters, fluxmeter, flow sensor, flow measuring device, flow rate meter
Purpose of the product/process	<p>Flow meters are used in water and sewage treatment plants, power stations, and other industrial applications. They may also be used in public water supply facilities, including pumping stations, distribution systems, and treatment plants. Flow meters are custom-designed for specific applications. The design depends on the substance being measured (liquid or gas) and the flow rate needed (volumetric or mass).</p> <p>Flow meters measure the flow of gas, water, air, and steam. The mercury in a flow meter is typically encased in a manometer, which is attached to an assembly or pipe system. The mercury in this manometer rises and falls with changes in the rate of flow of the liquid or gas (Environmental Protection Agency 2010, NEWMOA 2016c).</p>  <p>Figure 4: Mercury flow meters (NEWMOA 2016c)</p>
Field of application	Measuring technology
Mercury content	A mercury flow meter can contain as much as 5 kg of elemental mercury.
Extent of use/ production (globally, regionally)	No production anymore, use unknown
Environmental or health risk	<ul style="list-style-type: none"> • Risk of mercury spillage/exposure in case of breakage of the product or leakage of mercury • Risk of mercury release in case of inappropriate disposal of waste product

Available non-mercury alternatives	<ul style="list-style-type: none"> Non-mercury alternatives include digital, optical, and ball-actuated flow meters.
Advantages of mercury compared to alternatives	None
Additional comments	<p>Mercury-containing flow meters were commonly used prior to the 1970s. Mercury is not used in the manufacture of new flow meters; however, older flow meters may still be in use.</p> <ul style="list-style-type: none"> US EPA promulgated a significant new use rule (SNUR), effective June 29, 2012, under the Toxic Substances Control Act (TSCA) for elemental mercury use in barometers, manometers, hygrometers, and psychrometers. This action would require persons who intend to manufacture (including import) or process elemental mercury for an activity that is designated as a significant new use by this final rule to notify EPA at least 90 days before commencing that activity. The required notification would provide EPA with the opportunity to evaluate the intended use and, if necessary, to prohibit or limit that activity before it occurs. US EPA promulgated another SNUR (effective August 20, 2010) for elementary mercury use in flow meters, natural gas manometers, and pyrometers.
References and sources for further information	<p>Environmental Protection Agency (EPA) (2010): Elemental Mercury Used in Flow Meters, Natural Gas Manometers, and Pyrometers; Significant New Use Rule. Available online at https://www.federalregister.gov/documents/2010/07/21/2010-17718/elemental-mercury-used-in-flow-meters-natural-gas-manometers-and-pyrometers-significant-new-use-rule, checked on 7/25/2019.</p> <p>NEWMOA (Ed.) (2016): Measuring Devices (Miscellaneous). Available online at http://www.newmoa.org/prevention/mercury/projects/legacy/measdev.cfm, updated on 12/30/2016, checked on 9/24/2019.</p>

Strain gauge

1. Category of mercury-added product	Non-electronic measuring devices
2. Further description of the product	Strain gauge
3. Information on the use of the product	<ul style="list-style-type: none"> Mercury is used in strain gauge plethysmography to measure blood flow and blood pressure. This is used to diagnose arteriosclerosis, a disease affecting arterial walls and resulting in reduced blood circulation. The mercury strain gauge consists of a fine rubber tube filled with mercury which is placed around the body in the area where blood pressure is to be measured. Mercury usage in plethysmography is low in comparison to some other medical applications such as sphygmomanometers. 1.25g elemental mercury is used per strain gauge (ECHA, 2011). Mercury-containing strain gauges are now rare. No mercury strain gauges have been sold in Europe since 2014 and according to NEWMOA, mercury-filled strain gauges are rarely used (NEWMOA, 2016). It is estimated that, for example, in Sweden only 200 strain gauges are used per year, and one major global producer of strain gauges consumed 946 grams of mercury in 2004 (ECHA, 2011). It is estimated that 0.014 t Hg was placed on the EU market in 2010.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p><u>Main alternatives:</u> <i>Strain gauges with indium-gallium, photo cell/laser-Doppler techniques</i></p> <p>There are technically and economically feasible mercury-free alternatives available (ECHA, 2011).</p> <ul style="list-style-type: none"> Indium-gallium strain gauges are the main alternative to mercury strain gauges.

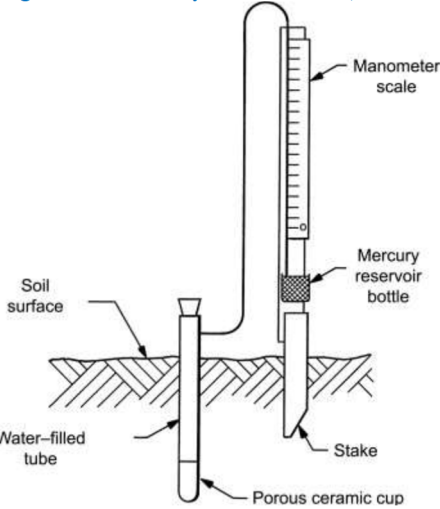
	<ul style="list-style-type: none"> • Photo cell and Doppler techniques are typically used for measurements in fingers and toes, for which indium-gallium gauges are not suitable (COWI, 2008). The photo cell technique registers changes in tissue colour at different pressures. The Doppler technique measures the velocity of red blood cells to determine blood flow. Ultrasonic devices are used for larger applications, and laser devices are used for measuring smaller volumes. • The world leading manufacturer is D.E. Hokanson, Inc., in the USA where both mercury and indium-gallium strain gauges are produced for export (COWI & ICF, 2017).
5.(i) Information on the technical feasibility of alternatives	<ul style="list-style-type: none"> • According to COWI (2008) photo cell and laser-Doppler technique or gallium/indium strain gauges are capable of identifying a variety of diagnosis offered by mercury-containing equipment. Indium-gallium strain gauges can be used with existing plethysmographs for the same application as mercury strain gauges (ECHA, 2011). • In the area of research, however, there is no alternative to mercury-containing plethysmographs where absolute blood flow in arms and legs is measured. This is due to the body of research and reference materials built up over decades of use. Indium-gallium gauges have a higher freezing point and lower resistance and so cannot be used for some applications, specifically Raynaud's disease or small digit tests, or cold water immersion studies (Hokanson, 2019) (COWI & ICF, 2017).
5.(ii) Information on the economic feasibility of alternatives	<p>The driving factor for ongoing use of mercury-containing strain gauges is economic as mercury-containing tubes are inexpensive. However, they are designed to work with complex electronic equipment costing in excess of EUR 20,000 and with life spans of 10-15 years. As such, clinics are hesitant to replace the complete system other than in the case of technical failure (COWI, 2008). It is possible to retrofit indium-gallium gauges with Hokanson plethysmographs with a few exceptions (COWI & ICF, 2017).</p> <p>The prices of indium-gallium strain gauges are approximately 40% higher than mercury gauges according to a major supplier (COWI & ICF, 2017). However, ECHA (2011) judged that indium-gallium gauges are economically feasible and estimated the cost of compliance in the EU for restrictions on mercury-containing strain gauges at EUR 2.6 million in the period of 2015-2034. A major producer of mercury strain gauge claimed that indium-gallium is also more difficult to handle during production, requiring more assembly time.</p>
6. Information on environmental and health risks and benefits of alternatives	<p>Gallium is reported to cause skin, eye and respiratory irritation and may cause bone marrow abnormalities with damage to blood forming tissues (ECHA, 2011). There is less information on the toxicological properties of indium. However, according to the submitter of the information, due to the clear evidence on the hazardous properties and risk of mercury, the usage of indium-gallium strain gauges is considered to reduce overall risk to environment and health.</p>
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	

8. Other relevant information pursuant to Decision MC-3/1	<p>The export, import and manufacturing of mercury-containing strain gauges to be used with plethysmographs are prohibited in the EU from 31 December 2020 by Regulation (EU) 2017/852 on Mercury.</p> <p>There are some exemptions to the restriction, notably:</p> <ul style="list-style-type: none"> • Non-electronic measuring devices installed in large-scale equipment or those used for high precision measurement where no suitable mercury-free alternative is available • Measuring devices more than 50 years old on 3 October 2007 • Measuring devices which are to be displayed in public exhibitions for cultural and historical purposes <p>Strain gauges to be used with plethysmographs intended for industrial and professional uses were restricted from being placed on the market from 10 April 2014. The restriction also applies to devices which are placed on the market empty if intended to be filled with mercury.</p> <p>In the USA, mercury strain-gauges are prohibited from sale in the states of Maine, Louisiana, Connecticut and Rhode Island.</p> <p>ZMWG</p> <p>In Serbia, strain gauges to be used with plethysmographs intended for industrial and professional uses have not been placed on the market since 1 October 2018.</p>
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9. References

- COWI & ICF. (2017). Support to assessing the impacts of certain amendments to the Proposal of the Commission for a Regulation on Mercury. Retrieved from http://ec.europa.eu/environment/chemicals/mercury/pdf/Final%20Report_KH0617141ENN.pdf
- COWI. (2008). Options for reducing mercury use in products and applications, and the fate of mercury already circulating in society. Retrieved from http://ec.europa.eu/environment/chemicals/mercury/pdf/EU_Mercury_Study2008.pdf
- ECHA. (2011). Background document to the opinions on the Annex XV dossier proposing restrictions on Mercury in measuring devices. Retrieved from <https://echa.europa.eu/documents/10162/20f4ee0a-6bcf-4ed0-a271-6674cd333710>
- Hokanson. (2019). Strain Gauges . Retrieved from <http://hokansonvascular.com/products/133386>
- NEWMOA. (2016). Hospital Equipment. Retrieved from <http://www.newmoa.org/prevention/mercury/projects/legacy/healthcare.cfm>
- Minamata Initial Assessment for Serbia, 2018, Available at https://www.researchgate.net/publication/330514455_Mercury_initial_assessment_for_the_Republic_of_Serbia

Tensiometer

1. Category of mercury-added product	Non-electronic measuring devices
2. Further description of the product	Tensiometer
3. Information on the use of the product	<p>Figure 1 – Mercury tensiometer (Kirkham, 2005)</p>  <p>Tensiometers measure the surface tension of liquids and are used in applications such as the determination of soil moisture tension, or for measuring tension in wire, fibres and beams (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011).</p> <p>The potentially mercury-containing component of a tensiometer is a manometer. It is linked via a capillary tubing to a water-filled tube with porous cup. If inserted into soil water from the tube may be sucked into the soil thus producing a vacuum that is measured by the manometer.</p> <p>Mercury manometers/tensiometers are shipped without mercury and filled with mercury by the user (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011). There may also be risk of release from breakage, but the highest risk of release is in the waste phase.</p> <p>70-140 g mercury is used per manometer.</p> <p>There was roughly 4 t of mercury estimated to have been accumulated in manometers in the EU in 2011, and 0.04-0.4 t Hg per year placed on the market (ECHA, 2010).</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p><u>Main alternatives:</u> Liquid filled in tube manometers, mechanical alternatives/elastic pressure sensors, electric manometers, other devices</p> <ul style="list-style-type: none"> • The mercury manometers used in tensiometers are usually replaced by elastic pressure sensors or electric manometers. • Elastic pressure sensors contain elements that are deformed or stretched when pressure is applied to them. The level of displacement is recorded. Common elastic pressure sensors include Bourdon tube manometers and pressure gauges with diaphragms. Bourdon tube manometers use a C-shape tube sealed at one end. Pressure is applied at the open end, causing pressure to be transferred to a gear and indicating needle. Pressure gauges with diaphragms can be mechanical or electric and contain a flexible two-sided membrane, with one side enclosed in a capsule containing a fluid such as air at a known pressure. Pressure is applied to the other side and the bending in the membrane is recorded. • Electric manometers use pressure transducers connected to an analogue to digital converter to transform the sensor response to an electrical signal.

	<ul style="list-style-type: none"> Liquid filled tube manometers can contain liquids other than mercury e.g. water or alcohol. There are also alternative methods to manometers to measure soil moisture. The gravimetric method determines the water content of soil by weighing it, drying it and measuring the difference in weight. <p>Information from experts</p> <ul style="list-style-type: none"> Alternatives are readily available for tensiometers for measuring soil moisture tension. If mercury tensionmeters are always accompanied by mercury manometers, are tensionmeters already effectively prohibited under the manometer ban in Annex A? This is an important issue that requires clarification, and for which the compilation is unclear.
5.(i) Information on the technical feasibility of alternatives	<ul style="list-style-type: none"> According to a European producer of mercury manometers, there was no application where mercury manometers cannot be replaced by other devices (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011). Bourdon tube manometers are more robust than mercury manometers and suitable for measuring higher pressures (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011). Pressure gauges with diaphragm are equally accurate as traditional mercury manometers. Electronic manometers are widely used and have advantages compared to mercury manometers such as requiring less maintenance and less expertise to use. The gravimetric method is time consuming and labour-intensive, however is accurate and low-cost.
5.(ii) Information on the economic feasibility of alternatives	<p>Alternatives to mercury manometers are usually cheaper (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011). Mercury manometers costed around €108 in 2006. Prices for bourdon tube manometers ranged from €4 to €122, and prices for pressure gauges with diaphragms ranged from €30 to €76.</p> <p>Electric manometers were the exception to this, costing 3-4 times more than mercury manometers for similar pressure ranges (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011).</p>
6. Information on environmental and health risks and benefits of alternatives	<p>Mercury manometers/tensiometers are shipped without mercury and filled with mercury by the user (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011). There may also be risk of release from breakage, but the highest risk of release is in the waste phase.</p> <p>There is no risk associated with the use of alternative liquids in manometers and the risks associated with electronic alternatives are not significant (Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011).</p>
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	

8. Other relevant information pursuant to Decision MC-3/1	<p>EU In Europe, tensiometers containing mercury intended for industrial and professional uses have been prohibited from being placed on the market from April 2014 according to the Regulation 1907/2007 on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). This restriction also applies to tensiometers supplied to the market empty with the intention of being filled with mercury. Electronic manometers also fall under restriction of the RoHS Directive which prohibits maximum mercury concentration over 0.1% in electrical and electronic equipment placed on the market.</p> <ul style="list-style-type: none"> • US EPA promulgated a significant new use rule (SNUR), effective June 29, 2012, under the Toxic Substances Control Act (TSCA) for elemental mercury use in barometers, manometers, hygrometers, and psychrometers. This action would require persons who intend to manufacture (including import) or process elemental mercury for an activity that is designated as a significant new use by this final rule to notify EPA at least 90 days before commencing that activity. The required notification would provide EPA with the opportunity to evaluate the intended use and, if necessary, to prohibit or limit that activity before it occurs. • US EPA promulgated another SNUR (effective August 20, 2010) for elementary mercury use in flow meters, natural gas manometers, and pyrometers. <p>ZMWG In Serbia, tensiometers intended for industrial and professional uses have not been placed on the market since 1 October 2018.</p>
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9. References

- Committee for Risk Assessment and Committee for Socio-economic Analysis, 2011. Background document to the opinions on the Annex XV dossier proposing restrictions on Mercury in measuring devices. [Online] Available at: <https://echa.europa.eu/documents/10162/20f4ee0a-6bcf-4ed0-a271-6674cd333710>
- COWI, 2008. Options for reducing mercury use in products and applications, and the fate of mercury already circulating in society. [Online] Available at: http://ec.europa.eu/environment/chemicals/mercury/pdf/EU_Mercury_Study2008.pdf
- ECHA, 2010. Annex XV Restriction Report: Proposal for a restriction. [Online] Available at: https://echa.europa.eu/documents/10162/13641/annex_xv_restriction_report_mercury_en.pdf/e6f7cce2-ecf4-49cc-ba4e-34bb2c60b4a5
- Kirkham, M., 2005. Tensiometers. [Online] Available at: <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/tensiometers>
- Minamata Initial Assessment for Serbia, 2018, Available at https://www.researchgate.net/publication/330514455_Mercury_initial_assessment_for_the_Republic_of_Serbia

Mercury column type pressure gauge

1. Category of mercury-added product	Non-electronic measuring devices
2. Further description of the product	Mercury column type pressure gauge
3. Information on the use of the product	<ul style="list-style-type: none"> • A pressure gauge that can accurately measure pressure using the density (specific gravity), height, and gravitational acceleration of mercury. • The average amount of mercury used is 1,500 g / piece. These are mainly used at research institutes and for calibration of pressure gauges, for purposes such as calibration of high-precision pressure gauges and inspection of aneroid sphygmomanometers. • Used for calibration purpose and not incorporated into other equipment.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<ul style="list-style-type: none"> • When using the certification system of the Measurement Law, a reference liquid column type pressure gauge is required. Hence, substitution with non-mercury alternative is difficult.
5.(i) Information on the technical feasibility of alternatives	<ul style="list-style-type: none"> • In order to achieve the same level of performance, no other liquid exists that can replace mercury and hence replacement is not possible. There is a request for continual manufacture according to the order.
5.(ii) Information on the economic feasibility of alternatives	
6. Information on environmental and health risks and benefits of alternatives	
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	<ul style="list-style-type: none"> • There are two manufacturers in Japan.
8. Other relevant information pursuant to Decision MC-3/1	<p>Mercury column type pressure gauges will be regulated by the Act on Preventing Environmental Pollution of Mercury of Japan after the phase-out deadline of the Minamata Convention (end of 2020). Exemptions included in Annex A of the Minamata Convention (Products for research, calibration of instruments, for use as reference products) are also not subject to regulation under the Act on Preventing Environmental Pollution of Mercury of Japan (During the review process, the scope of exemption for products will be determined by the use mentioned).</p> <p>Information from experts</p> <p>In the EU, all types of mercury-containing manometers are banned by Mercury Regulation and the REACH regulation except for applications in scientific research and development. Mercury-free alternatives are available and in use (ECHA 2011).</p> <p>ECHA. (2011). Background document to the opinions on the Annex XV dossier proposing restrictions on Mercury in measuring devices</p> <ul style="list-style-type: none"> • US EPA promulgated a significant new use rule (SNUR), effective June 29, 2012, under the Toxic Substances Control Act (TSCA) for elemental mercury use in barometers, manometers, hygrometers, and

	<p>psychrometers. This action would require persons who intend to manufacture (including import) or process elemental mercury for an activity that is designated as a significant new use by this final rule to notify EPA at least 90 days before commencing that activity. The required notification would provide EPA with the opportunity to evaluate the intended use and, if necessary, to prohibit or limit that activity before it occurs.</p> <ul style="list-style-type: none"> • US EPA promulgated another SNUR (effective August 20, 2010) for elementary mercury use in flow meters, natural gas manometers, and pyrometers.
9. References	<ul style="list-style-type: none"> • Information was collected through a questionnaire survey of domestic manufacturers of pressure gauges and thermometers.

High temperature diaphragm seal pressure gauge

1. Category of mercury-added product	Non-electronic measuring devices
2. Further description of the product (if any)	High temperature diaphragm seal pressure gauge
3. Information on the use of the product	<ul style="list-style-type: none"> • A measuring instrument that measures the pressure of a substance that is in a molten state under the harsh conditions of high temperature and high pressure. • The average amount of mercury used is 40 to 50 g / piece. Used as a part of chemical fiber / chemical resin machines and injection type resin molding machines.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<ul style="list-style-type: none"> • Pressure gauges used below 230 ° C have been replaced by alternative products (silicone oil).
5.(i) Information on the technical feasibility of alternatives	<ul style="list-style-type: none"> • There is no alternative for pressure measurements at or above 230 ° C and those used with a scale of 5 MPa or less.
5.(ii) Information on the economic feasibility of alternatives	<ul style="list-style-type: none"> • It is technically and economically difficult to develop alternative products for mercury for pressure measurement at 230 ° C or higher with a scale of 5 MPa or lower.
6. Information on environmental and health risks and benefits of alternatives	
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	<ul style="list-style-type: none"> • There are two manufacturers in Japan.
8. Other relevant information pursuant to Decision MC-3/1	<ul style="list-style-type: none"> • High-temperature diaphragm seal pressure gauges (pressure measurement at 230 ° C or higher, used at a scale of 5 MPa or lower) can be manufactured in Japan even after the phase-out deadline (end of 2020) of the Minamata Convention (not subject to the Enforcement Ordinance of the Act on Preventing Environmental Pollution of Mercury of Japan).
9. References	<ul style="list-style-type: none"> • Information was collected through a questionnaire survey of domestic manufacturers of pressure gauges and thermometers.

McLeod gauge

1. Category of mercury-added product	Non-electronic measuring devices
2. Further description of the product	McLeod gauge
3. Information on the use of the product	<ul style="list-style-type: none"> • A pressure gauge that can measure the degree of vacuum by compressing the residual gas in the capillary by rotating it and measuring the difference in the liquid column generated. • The measurement range is 0.1Pa to 1,300Pa (logarithmic scale). Mercury is used as a working fluid in a transparent glass gauge tube. • The amount of mercury used is about 135 g / unit. • These are used in chemical plants (vacuum distillation), steel mills (vacuum heat treatment), universities, etc. They may be placed in a vacuum for measurement, or may be connected with a rubber tube for measurement. • Embedded products are almost nonexistent.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<ul style="list-style-type: none"> • Heat conduction type vacuum gauge is under development as an alternative.
5.(i) Information on the technical feasibility of alternatives	<ul style="list-style-type: none"> • The alternative under development has the same measurement range as the McLeod gauge. However, the alternative is not explosion-proof because it requires an external power supply, as compared to the McLeod gauge, which does not require electricity. • In addition, durability of the sensor unit is of concern in certain cases (use in an environment where temperature changes and electric / magnetic fields are intense, where vibration is intense or where there are many droplets).
5.(ii) Information on the economic feasibility of alternatives	<ul style="list-style-type: none"> • Price difference is an issue because the price of the alternative is about 1.5 times that of the McLeod gauge.
6. Information on environmental and health risks and benefits of alternatives	
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	<ul style="list-style-type: none"> • There is only one manufacturer in Japan. <p>Information from experts</p> <ul style="list-style-type: none"> • In the EU, all types of mercury-containing manometers are banned by Mercury Regulation and the REACH regulation except for applications in scientific research and development. Mercury-free alternatives are available and in use (ECHA 2011). ECHA. (2011). Background document to the opinions on the Annex XV dossier proposing restrictions on Mercury in measuring devices • US EPA promulgated a significant new use rule (SNUR), effective June 29, 2012, under the Toxic Substances Control Act (TSCA) for elemental mercury use in barometers, manometers, hygrometers, and psychrometers. This action would require persons who intend to manufacture (including import) or process elemental mercury for an activity that is designated as a significant new use by this final rule to notify EPA

	<p>at least 90 days before commencing that activity. The required notification would provide EPA with the opportunity to evaluate the intended use and, if necessary, to prohibit or limit that activity before it occurs.</p> <ul style="list-style-type: none"> • US EPA promulgated another SNUR (effective August 20, 2010) for elementary mercury use in flow meters, natural gas manometers, and pyrometers.
8. Other relevant information pursuant to Decision MC-3/1	<ul style="list-style-type: none"> • McLeod gauges (maximum measurable pressure at 1,300 Pa or less, scale of 300 Pa or less) can possibly be manufactured in Japan even after the phase-out deadline (end of 2020) of the Minamata Convention (Not subject to enforcement ordinance regulations of the Act on Preventing Environmental Pollution of Mercury of Japan).
9. References	<ul style="list-style-type: none"> • Information was collected through interviews with groups of domestic manufacturers of scientific instruments.

U-shaped vacuum gauge

1. Category of mercury-added product	Non-electronic measuring devices
2. Further description of the product (if any)	U-shaped vacuum gauge These gauges are type of manometers.
3. Information on the use of the product	<ul style="list-style-type: none"> • A vacuum gauge (made of U-shaped glass with one side sealed) that can directly measure the pressure of gas using the difference in the height of the liquid column with a differential pressure that is evacuated to a vacuum and sealed. The measurement range is 200Pa to 28,000Pa. Scale 200Pa (equal spacing, scale spacing is about 1mm). • Mercury is used as a working fluid in a transparent glass gauge tube. • The amount of mercury used is about 50 g / unit. • These are used in chemical plants (vacuum distillation), steel mills (vacuum heat treatment), universities, etc. They may be placed in a vacuum, or connected with a rubber tube etc. for measurement. • Embedded products are almost nonexistent.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<ul style="list-style-type: none"> • Diaphragmatic pressure gauges have been on the market as an alternative since 2012 and many U-shaped pressure gauges have been replaced by this alternative product.
5.(i) Information on the technical feasibility of alternatives	<ul style="list-style-type: none"> • Measurement accuracy of the alternative is comparable to the U-shaped pressure gauge, but they are not explosion-proof.
5.(ii) Information on the economic feasibility of alternatives	<ul style="list-style-type: none"> • The price of the alternative product is more than three times that of the U-shaped pressure gauge and hence is an issue.
6. Information on environmental and health risks and benefits of alternatives	

7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	<ul style="list-style-type: none"> • There is only one manufacturer in Japan.
8. Other relevant information pursuant to Decision MC-3/1	<ul style="list-style-type: none"> • U-shaped pressure gauges (maximum measurable pressure of 66,000 Pa or less, scale of 200 Pa or less) can be manufactured in Japan even after the phase-out deadline (end of 2020) of the Minamata Convention (Not subject to enforcement ordinance regulations of the Act on Preventing Environmental Pollution of Mercury of Japan). <p>Information from experts</p> <ul style="list-style-type: none"> • In the EU, all types of mercury-containing manometers are banned by Mercury Regulation and the REACH regulation except for applications in scientific research and development. Mercury-free alternatives are available and in use (ECHA 2011). ECHA. (2011). Background document to the opinions on the Annex XV dossier proposing restrictions on Mercury in measuring devices • US EPA promulgated a significant new use rule (SNUR), effective June 29, 2012, under the Toxic Substances Control Act (TSCA) for elemental mercury use in barometers, manometers, hygrometers, and psychrometers. This action would require persons who intend to manufacture (including import) or process elemental mercury for an activity that is designated as a significant new use by this final rule to notify EPA at least 90 days before commencing that activity. The required notification would provide EPA with the opportunity to evaluate the intended use and, if necessary, to prohibit or limit that activity before it occurs. • US EPA promulgated another SNUR (effective August 20, 2010) for elementary mercury use in flow meters, natural gas manometers, and pyrometers.
9. References	<ul style="list-style-type: none"> • Information was collected through interviews with groups of domestic manufacturers of scientific instruments.

Non-electronic measuring devices to be phased out pursuant to Annex A

1. Category of mercury-added product	Non-electronic measuring devices
2. Further description of the product	
3. Information on the use of the product	<p>Uganda <u>Estimated Mercury input in the environment in Uganda (MIAs report, 2018)</u></p> <ul style="list-style-type: none"> At disposal phase, mercury containing thermometers contribute to 21 kg/Hg/Yr At disposal phase, Manometers and gauges contribute to 205kg/Hg/Yr <p><u>Information on use</u></p> <ul style="list-style-type: none"> In Uganda, measuring devices are extensively used in various sectors such as laboratory analysis, environmental monitoring, healthcare, academia, manufacturing, meteorology, agriculture, etc. Available mercury-free alternatives include alcohol (spirit) thermometers, electronic thermometers, oscillometric sphygmomanometers, etc. Many of these mercury-free measuring devices also conform to industry standards, calibration and other performance-related requirements. The replacement of mercury-added measuring devices by mercury-free devices has received worldwide attention in some sectors such as in healthcare. Accordingly, the World Health Organization (WHO) has been heavily involved in advocating the shift to mercury-free measuring devices in healthcare facilities. The WHO indeed published a document in 2015 outlining national strategies for phasing out mercury-added thermometers and sphygmomanometers.⁷ <p>Montenegro Montenegro has no production of the mercury added products. It has information on quantities of imported products, including non-electronic measuring devices, in 2019. However, most of these tariff numbers cover a wider range of product types which cannot be claimed with certainty to contain mercury. The country welcomes HS codes for mercury-added products.</p> <p>Information from experts (Thermometers) The most common mercury thermometers used in Indonesia is clinical thermometers. A clinical mercury thermometer mainly consists of a bulb, a stem or capillary connected to the bulb, a scale and a body. The bulb is filled with mercury which expands through the stem when the temperature of an object being measured rises. The bulb, the stem and the scale are contained in the body, usually a glass tube with a scale along the stem to indicate the temperature level units, both in Celsius and Fahrenheit degrees. Due to the fragility of the thermometer, the manufacturers usually provide a protective case along with the unit. Clinical thermometers are used to measure the temperature of a human body as well as an animal/pet in both households and health-care facilities. Based on the intermediate results of an on-going project in Indonesia and the Philippines funded by Japan-ASEAN Integration Fund, namely Development of Capacity for the Substitution and the Environmentally Sound Management (ESM) of Mercury-containing Medical Measuring Devices, the clinical thermometers used in the health sector in Indonesia are relatively distributed in sub-district public health center (71%), hospitals (18%), clinics (6.5%), and the rest are in private practices and others. The intermediate results of the project also reveals that about 84% of the mercury-containing thermometers has been substituted. The remaining ones are expected to be eliminated by the end of 2020.</p>

	<p>(Sphygmomanometers)</p> <p>Sphygmomanometers are used to measure the pressure of blood of a human body in both households and health-care facilities. Based on the intermediate results of an on-going project in Indonesia and the Philippines funded by Japan-ASEAN Integration Fund, namely Development of Capacity for the Substitution and the Environmentally Sound Management (ESM) of Mercury-containing Medical Measuring Devices, the sphygmomanometers used in the health sector in Indonesia are relatively distributed in sub-district public health center (71%), hospitals (18%), clinics (6.5%), and the rest are in private practices and others. The intermediate results of the project also reveals that currently Indonesia has achieved the phase-out levels of 76% of desk sphygmomanometers and 86% of standing sphygmomanometers. The remaining ones are expected to be eliminated by the end of 2020.</p>
<p>4. Information on the availability of mercury-free (or less-mercury) alternatives</p>	<p>Uganda</p> <p><u>Barometer products with no mercury</u></p> <ul style="list-style-type: none"> • <u>Aneroid</u> • <u>Digital</u> • <u>Fortin</u> <p><u>Manometer products with no mercury</u></p> <ul style="list-style-type: none"> • <u>Aneroid</u> • <u>Digital</u> <p><u>Hygrometer products with no mercury</u></p> <ul style="list-style-type: none"> • <u>Data loggers</u> <p><u>Thermometer products with no mercury</u></p> <ul style="list-style-type: none"> • <u>Digital</u> • <u>Alcohol / spirit</u> <p><i>Electronic and combined for special applications (e.g., data loggers, temperature/conductivity meter, etc.)</i></p> <p><i>Gallium-tin</i></p> <ul style="list-style-type: none"> • <i>Infra-red (laboratory)</i> • <i>Standard Platinum Resistance</i> • <i>Tympanic/temporal (clinical)</i> <p><u>Blood pressure measuring devices with no mercury</u></p> <ul style="list-style-type: none"> • <u>Aneroid</u> • <u>Digital</u> <p>Information submitted by WHO</p> <p>WHO Reference: https://apps.who.int/iris/handle/10665/331749</p> <ul style="list-style-type: none"> - Aneroid sphygmomanometer: A manual BPMD with a manometer, composed of an inflation bulb for controlling the air pressure within the cuff that is attached to the manometer by tubing. The manometer head contains mechanical parts that convert the cuff pressure into readings. - Automated BPMD: A device that estimates BP after automatic inflation and deflation of the cuff and displays the values on an electronic display. The semi-automated device requires manual inflation.

- Semi-automated BPMD: Device that operates by manual cuff inflation and electronic cuff deflation. BP is estimated as with other electronic devices. This device is energy-efficient because the cuff is inflated manually with a bulb.
- Sphygmomanometer: Medical device for measuring arterial BP comprised of a cuff, an inflation bulb with release valve and a manometer (typically either a mercury column or an aneroid dial).

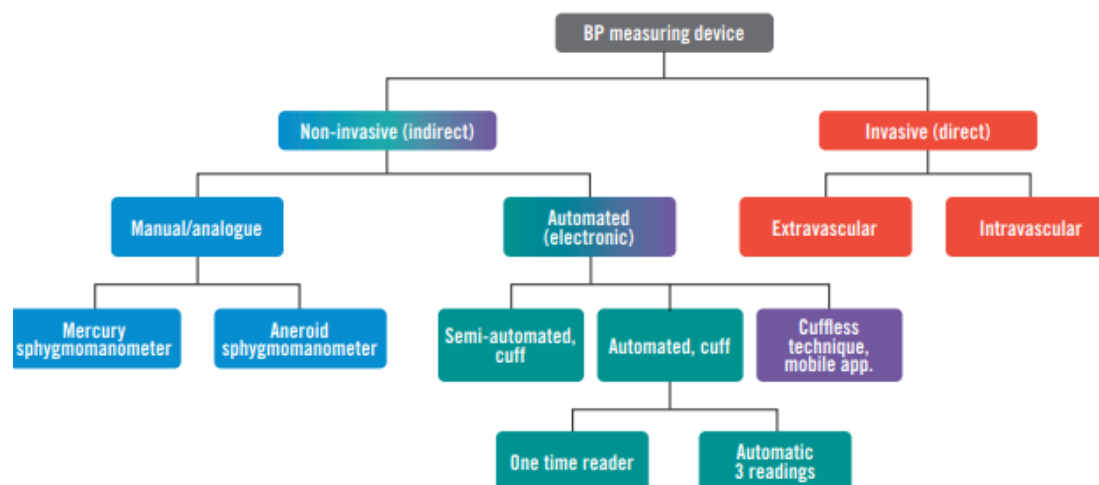


Fig. 2. Main means for measuring BP

WHO documents on medical measuring devices

WHO technical specifications for automated non-invasive blood pressure measuring devices with cuff (2020)

<https://apps.who.int/iris/handle/10665/331749>

This document contains detailed information, including the definitions of the different types of blood pressure measuring devices.

Technical guidance on replacement of mercury thermometers and sphygmomanometers (2011)

<https://apps.who.int/iris/handle/10665/44592>

WHO plans to develop a document on technical specifications for thermometers to complement the new 2020 document on blood-pressure measuring devices.

Developing national strategies for phasing out mercury-containing thermometers and sphygmomanometers in health care, including in the context of the Minamata Convention on Mercury: key considerations and step-by-step guidance

<https://apps.who.int/iris/handle/10665/259448>

	<ul style="list-style-type: none"> - (responding to a question) The battery life of the infrared thermometers will vary depending on the device. Usually, this is contained in the manufacturer's specifications normally available on the internet or on device packages.
5.(i) Information on the technical feasibility of alternatives	<p>Uganda</p> <ul style="list-style-type: none"> • There is limited knowledge by consumers in Uganda on existence of alternatives • There is limited policy restrictions on importation of listed Non-electronic measuring devices • There are no incentives on use/importation of alternatives • There is an institutional framework for promoting adoption of alternatives
5.(ii) Information on the economic feasibility of alternatives	<p>Uganda</p> <ul style="list-style-type: none"> • The alternatives usually cost higher than the more toxic ones • Alternatives are mainly imported, hence transferring taxation costs to the consumer
6. Information on environmental and health risks and benefits of alternatives	
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	
8. Other relevant information pursuant to Decision MC-3/1	<p>Montenegro</p> <ul style="list-style-type: none"> • In terms of waste management in Montenegro, the Decree on the procedure for establishing a system for collection and treatment of electrical and electronic waste ("OG of MNE", No. 24/12) prescribes pre-treatment of electrical and electronic waste and Rulebook on the limit values of the hazardous substances in electrical and electronic equipment ("OG of MNE", No. 067/18) prescribes the limit values for the presence of hazardous substances (mercury, among the others) in electrical and electronic products, the designation of the type of waste and the method of waste management arising from these products. <p>ZMWG</p> <p>In Serbia, the national legislation on Chemicals prescribes bans and restrictions of use, placing on the market and production of Mercury and Mercury compounds. The law established the legal basis for adoption of the Rulebook on Bans and Restrictions of Production ("Off. Gazette RS" No. 90/2013, 25/2015, 2/2016 and 44/2017), placing on the Market and Use of Chemicals which has been harmonized with Annex XVII of EU Regulation No. 1907/2006 (REACH).</p> <p>According to this rulebook, the following mercury-added products cannot be placed on the market:</p> <p>(a) in fever thermometers</p>

	<p>(b) in other measuring devices intended for sale to the general public (such as manometers, barometers, sphygmomanometers, thermometers other than fever thermometers).</p> <p>The restriction applies to measuring devices that were placed on the market after 5 July 2011.</p> <p>The following mercury-containing measuring devices intended for industrial and professional uses have not be placed on the market after 1 October 2018:</p> <ul style="list-style-type: none"> (a) barometers (b) hygrometers (c) manometers (d) sphygmomanometers (e) thermometers and other non-electrical thermometric applications. <p>The restriction also applies to measuring devices under points (a) to (e) which are placed on the market empty, if intended to be filled with mercury.</p>
9. References	<p>Uganda</p> <ul style="list-style-type: none"> • Developing National Strategies for Phasing Out Mercury Containing Thermometers and Sphygmomanometers in Health Care, Including in the Context of the Minamata Convention on Mercury, World Health Organization, 2015. Available at http://www.who.int/ipcs/assessment/public_health/WHOGuidanceReportonMercury2015.pdf?ua= • UNEP (2013): Minamata Convention on Mercury. Available at http://www.mercuryconvention.org • Minamata Initial Assessments report, 2018 • Mercury Learn - HS codes (2015); COMTRADE database <p>ZMWG</p> <p>Minamata Initial Assessment for Serbia, 2018, Available at https://www.researchgate.net/publication/330514455_Mercury_initial_assessment_for_the_Republic_of_Serbia</p>

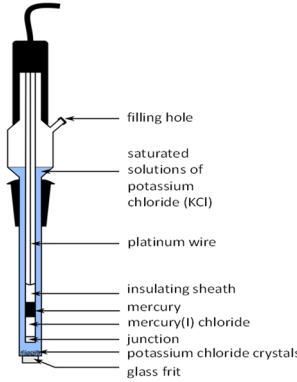
V. Other electronic devices

Information provided by **Canada**, **EU**, and other stakeholders (IPEN)

1. **Mercury slip rings**
2. **Reference electrodes for calibration of pH measuring devices**
3. **Infrared detectors**
4. **Melt pressure transducers, transmitters and sensors using a capillary system**
5. **Mercury vacuum pump (note that this includes non-electronic device)**
6. **Radiation light detectors**

1. Category of mercury-added product	Switches, relays and other electric devices
2. Further description of the product (if any)	1. Mercury slip rings
3. Information on the use of the product	A device that provides 360-degree rotations to transmit signal and power between stator (stationary) side and rotor side of different industrial equipment. This product uses mercury as a conductor to transfer current and signal as a liquid at normal temperatures.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Canada There are many manufacturers of mercury-free slip rings, which are widely available in all shapes and sizes.</p> <ul style="list-style-type: none"> • <u>Conductive block slip rings</u>: used mainly for lower technology applications involving transmitting power or simple signals. These use carbon or metal alloy brushes to transmit signals. • <u>Fiber brush slip rings</u>: suited for a wide variety of applications and come in many sizes. Brushes made of different metal fibers transmit power and signals from a rotating ring. Metal fiber brushes ensure a high contact quality and low wear due to their flexibility. Alloys of steel and other common metals are common for power transmission, whereas gold alloys are used for signal transmission since gold does not oxidize and therefore maintains quality over time. • <u>Wireless slip rings</u>: use the principle of capacitive or inductive coupling for power and signal transmission. • <u>Fiber optic slip rings (fiber optic rotary joints)</u>: the optical equivalent of a wireless slip ring. Light waves are synchronized between two ends using optic fibers. • <u>Liquid metal slip rings</u> using a gallium alloy instead of mercury are also available. <p>IPEN Alternatives are readily available for mercury slip rings for signal transmission between rotors and stators on industrial equipment.</p>
5.(i) Information on the technical feasibility of alternatives	<p>Canada</p> <ul style="list-style-type: none"> • Compared to mercury slip rings, conductive block slip rings have greater weight and volume for the same circuits, greater capacitance and crosstalk, are louder, do not last as long and require regular maintenance. Sparking may also occur if dust is present. Conductive block slip rings are low cost and are easily customized for mechanical assemblies in house since brushes and rings are available separately.¹ • Fiber brush slip rings have a large flexibility in use and can be used in a wide range of applications, from high power transmission to high frequency signal transmission. Fiber brush slip rings have an excellent volume to current ratio and are relatively maintenance free.¹ They also have a high frequency electric signal transmission and do not make a lot of noise. These are more costly than conductive block type slip rings but have comparable costs to mercury slip rings.

	<ul style="list-style-type: none"> • Wireless slip rings lack standard mechanical parts meaning they are more resilient in harsh operating environments and require less upkeep and maintenance. However, the amount of power that can be transmitted between coils is somewhat limited compared to mechanical-type slip rings. Wireless slip rings are generally less efficient than other slip rings and the loss of efficiency is proportional to the distance between the two components. One benefit of wireless slip rings is that there are many possible configurations for their placement. They are well suited for applications that need high rotational speeds and where there is poor access for maintenance.¹ Wireless slip rings are more costly than mechanical types of slip rings; however, slip ring manufacturers are investing most in developing and refining wireless slip ring technologies.² As this technology grows, costs will likely decline. • Fiber optic rotary joints enable continuous rotation of one or more optic fibres without affecting the signals transmitted along them. These are most beneficial for applications where a twist-free cable is needed. Single channel rotary joints are relatively simple and can be very compact while permitting high rotational speeds, good reliability, and little loss of performance over time. Multi-channel rotary joints can be very complex and need to be manually aligned when very high performance is required.¹ Often fiber optic joints are incorporated into other rotary components as the centre of the rotary assembly. These are quite costly, and costs are related to the overall size of the complete rotary joint assembly. • Mercury slip rings are limited by temperature since mercury solidifies as -40 C. The other types of slip rings do not have this limitation. <p>Japan Analytical Instruments Manufacturers' Association (JAIMA) The Hg based ERC(Electric Rotating Connector=slip ring) component within ACIST IVUS could not be replaced with a RoHS compliant component at present. This falls under RoHS exemption 42 (Mercury in electric rotating connectors used in intravascular ultrasound imaging systems capable of high operating frequency (> 50MHz) modes of operation.) (ref3). Some other slip rings are also using mercury for special purposes.</p>
5.(ii) Information on the economic feasibility of alternatives	NA
6. Information on environmental and health risks and benefits of alternatives	NA
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	NA
9. References	<p>1. Servotecnica. (2017) What is a slip ring. 2. Research and Markets. (2019). Global slip rings market 2019-2023.</p> <p>JAIMA Assistance to the Commission on Technological Socio-Economic and Cost-Benefit Assessment Related to Exemptions from the Substance Restrictions in Electrical and Electronic Equipment(RoHS Directive) Final Report – Pack P108 https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_16/Excerpt_Oeko-Institut_report_2014_AnnexIV_Ex_42.pdf</p>

1. Category of mercury-added product	Switches, relays and other electric devices
2. Further description of the product	2. Reference electrodes for potentiometric measurement including pH
3. Information on the use of the product	<p>An electrode with a stable and known electric potential that is used in electrochemical measurements. The reference electrode allows control of the potential of a working electrode or the measurement of an indicator electrode¹</p> <p>Mercury-containing reference electrodes include calomel (Hg/Hg₂Cl₂), mercurous sulphate (Hg/Hg₂SO₄) and mercuric oxide (Hg/HgO) electrodes. The calomel electrode was widely used for pH measurements, while mercurous sulphate is used for other potentiometric measurements e.g. for silver halides and chemical oxygen demand titrations.²</p> <p>Comments from experts</p> <p>A reference electrode maintains a virtually invariant potential under the conditions prevailing in an electrochemical measurement, and that serves to permit the observation, measurement, or control of the potential of the indicator (or test) or working electrode (definition by IUPAC¹⁴). They are typically used in combination with pH electrodes to measure the acidity of a fluid such as an aqueous solution, in a laboratory, in industrial processes, or in the field. Often, a reference electrode and a pH electrode are combined in one device. Other applications for reference electrodes include potentiometric determination of the oxidation potential (or redox potential) and specific ion concentrations (e.g. chloride).</p> <p>Several types of reference electrodes exist. The most important is the standard hydrogen electrode (SHE), whose potential is zero by definition. The potentials of all other electrodes are determined in relation to the SHE. The SHE itself is difficult to handle in practice due to the use of gaseous hydrogen. Much more common is the silver/ silver chloride reference electrode. There are at least three types of mercury-based reference electrodes commercially available:</p> <ul style="list-style-type: none"> • The (saturated) calomel electrode (SCE) (includes mercury(I)chloride or Hg₂Cl₂), also referred to as low chloride mercury chloride electrode. • The mercury oxide electrode (HgO) • The mercury (I) sulphate electrode (Hg₂SO₄, also referred to as mercury-mercurous sulphate electrode) <p>Historically, the calomel electrode was the most widely used reference electrode until it was replaced more and more by other types¹⁵</p>  <p>Figure 1: Principal components of a calomel electrode (source: Wikipedia.org)</p>

4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Canada The mercury-free alternatives are made of glass and contain potassium chloride (KCl) with silver/silver chloride (Ag/AgCl₂). 3, 4, 5, 4, 5, 6</p> <p>Uses of mercury-containing electrodes appear to have been largely phased out in Canada due to a movement away from this type of electrode, likely due to the human health risks, extra handling precautions, and disposal costs associated with mercury. Mercury-free electrodes are available from all major scientific equipment suppliers in Canada and some no longer have mercury-containing electrodes available.</p> <p>Japan Analytical Instruments Manufacturers' Association (JAIMA) Silver/silver chloride electrodes have replaced mercury chloride electrodes in most applications but cannot replace low chloride, mercury sulphate or mercury oxide. (ref5). It falls under RoHS exemption 1d (Mercury in reference electrodes: low chloride mercury chloride, mercury sulphate and mercury oxide.)</p>
5.(i) Information on the technical feasibility of alternatives	<p>Canada Mercury-containing electrodes show the most stable potential in the presence of potassium chloride; however, the reliable temperature range of mercury chloride is narrow. Above 60°C, it begins to degrade. Mercury-free electrodes can work in a wide range of temperatures (up to 140°C) and are therefore able to be heat-sterilized.⁷ Electrodes made of silver/silver chloride can be affected by sulphides and cannot directly be used as a reference electrode for chemical analysis of chloride or silver concentrations. However, a barrier can be put in place and allow the silver/silver chloride electrodes to be used in sulphide environments and environments with other metal ions. Mercury-free alternatives are generally marginally more expensive than mercury containing electrodes but come in a variety of body styles (where mercury-containing electrodes are limited) and are refillable.⁸ A newer iodine/iodide system has also been developed and is much less sensitive to temperature fluctuations.^{7, 12} The iodine/iodide system is free of silver and other heavy metals, which is useful when measuring Tris buffers and protein solutions, since reference electrodes using silver/silver chloride would require the use of barriers.^{7, 11} This system is considerably more expensive than other alternatives, but is one of the only options suitable for analyses with chloride ions and is more accurate and precise than silver/silver chloride reference electrodes.¹²</p> <p>Comments from experts: At least for the vast majority of fluids to be measured (pH 1-14, aqueous and non-aqueous, presence or absence of chloride), alternative reference electrodes allow reliable and traceable measurements of pH as well as other solution properties. The replacement of the calomel electrode by the silver chloride electrode is also recommended by the United States Pharmacopeial Convention (2017)¹⁶. Many leading electrode manufacturers no longer have mercury-containing electrodes in their program and recommend the use of silver chloride or proprietary reference electrode systems¹⁵. Mercury-containing reference electrodes may be needed for specific research activities where specific thermodynamic solution properties are investigated. The mercury oxide electrode is still advertised for the characterization of solutions with extreme pH (>14), such as in concentrated solutions of potassium hydroxide or sodium hydroxide in some battery electrolytes. According to industry information, monitoring of the concentration of extremely alkaline etching solutions (such as KOH) can</p>

	also be measured by conductivity, densitometry, or refractometry thus eliminating the need for potentiometric measurements. It needs to be verified if these mercury-free devices fully cover the application range of mercury oxide electrodes. The mercury (I) sulphate electrode (Hg/Hg ₂ SO ₄ , mercury-mercurous sulphate electrode was indicated in cases where contamination with chloride from the reference cell was not desirable. Since chloride-free reference electrodes (e.g. iodine/iodide) are now available and double junction electrodes may be sufficient to block the release of chloride from the Ag/AgCl reference electrodes, the continued need for Hg/Hg ₂ SO ₄ electrodes appears to be doubtful.
5.(ii) Information on the economic feasibility of alternatives	NA
6. Information on environmental and health risks and benefits of alternatives	<p>Canada</p> <p>Handling and disposal are less of an issue with silver/silver chloride systems since silver is non-toxic to humans. For example, the safety data sheet for mercury chloride electrodes list them as having acute toxicity due to inhalation risks, reproductive toxicity, and repeated exposure toxicity.⁹ Whereas silver/silver chloride solutions used in electrodes are listed only as causing skin and eye irritation.¹⁰</p> <p>Iodine/iodide systems would not be subject to strict handling or disposal procedures since iodine/iodide solution is not toxic to humans but could cause skin or respiratory tract irritation.¹³</p> <p>Comments from experts</p> <p>The use of mercury-containing reference electrode includes the following risks:</p> <ul style="list-style-type: none"> • Mercury spillage/contamination in case of damage to the product (inside or outside the human body) • Contamination of the measuring solution by slow diffusion of mercury-contaminated filling solution into the fluid that is being measured • Mercury spillage/contamination in case of inappropriate disposal of waste product/ contaminated filling solutions
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	NA

9. References

1. Kahlert, H. (2005). Reference electrodes. In: Scholz F. (eds) Electroanalytical Methods. Springer, Berlin, Heidelberg. Available from: https://link.springer.com/chapter/10.1007/978-3-662-04757-6_14
2. COWI (2008). Options for reducing mercury use in products and applications, and the fate of mercury already circulating in society. Final report for the European Commission prepared by Lassen, C., Holt Andersen, B., Maag, J & Maxson, P.
3. Fisher scientific. (2020). Fisherbrand accumet glass body Ag/AgCl reference electrodes – mercury-free. Available from: <https://www.fishersci.com/shop/products/fisher-scientific-accumet-glass-body-ag-agcl-reference-electrodes-mercury-free-4/p-2903565>
4. Sensorex. (2012). Product specification sheet: Sensorex new 'calomel free' epoxy and glass body pH and reference electrodes. Available from: <https://www.sensorex.com/docs/specs/SpecsCalomelFree.pdf>
5. Autolab electrochemical instruments. (N.D.) Autolab application note: reference electrodes and their usage. Available from: <http://www.autolabj.com/appl.files/appl%20note/Apl038.pdf>

6. Fisher scientific. (2020). Fisherbrand accumet epoxy body mercury-free reference electrode. Available from: <https://www.fishersci.com/shop/products/fisher-scientific-accumet-epoxy-body-mercury-free-reference-electrode/p-4950075#?keyword=mercury+sulphate+reference+electrode>
 7. YSI (2019). Anatomy of pH electrodes. Available from: <https://www.ysi.com/ysi-blog/water-blogged-blog/2019/02/anatomy-of-ph-electrodes>
 8. ThermoFisher Scientific. (N.D.) Essentials of pH measurement. Available from: http://www.ohiowea.org/docs/1500_pH_Seminar_Meiose.pdf
 9. Koslow Scientific. (2015). Kit product number: Saturated calomel electrode (SCE), Safety data sheet. Available from https://www.ameteksi.com/-/media/ameteksi/download_links/documentations/supportcenter/princetonappliedresearch/safety_data_sheets/g0115_saturated_calomel_electrode.pdf?la=en
 10. ThermoFisher Scientific. (2014). Safety data sheet, Filling solution: 4M KCL saturated with Ag Cl. Available from: <https://www.fishersci.com/shop/msdsproxy?productName=SP135500&productDescription=POTASSIUM+CHLORID+SOL+4M+500ML&catNo=SP135-500&vendorId=VN00033897&storeId=10652>
 11. Engineer Live. (2013). Innovative pH electrodes with iodine/iodide reference system. Available from: <https://www.engineerlive.com/content/innovative-ph-electrodes-iodineiodide-reference-system>
 12. Fisher scientific. (2020). Sartorius GoldLINE electrodes. Available from: <https://www.fishersci.ca/shop/products/goldline-electrodes/p-5295538>
 13. Home science Tools. (2018). Safety data sheet: iodine-potassium iodide solution. <https://www.homesciencetools.com/content/reference/CH-IODINE.pdf>
 14. International Union of Pure and Applied Chemistry (IUPAC) (2014) Gold book. <https://goldbook.iupac.org/terms/view/R05229>
 15. Metrohm (2011) Reference Electrodes and Their Usage. Autolab Application Note EC02. https://www.metrohm-autolab.com/download/Applicationnotes/Autolab_Application_Note_EC02.pdf
 16. United States Pharmacopeial Convention (2017) General Chapter Prospectus: <541> Titrimetry. <https://www.uspnf.com/notices/gcp-541-titrimetry>
- JAIMA
 Review of Directive 2002/95/EC (RoHS) Categories 8 and 9 Final report P61 and P175-177
https://ec.europa.eu/environment/pdf/waste/weee/era_study_final_report.pdf

1. Category of mercury-added product	Switches, relays and other electric devices
2. Further description of the product	3. Infrared detectors
3. Information on the use of the product	<p>Infrared detectors are detectors that react to infrared (IR) radiation. IR detector products can be highly specialized and have many uses in the military, scientific, security, medical, industrial and automotive areas. For example, IR detectors can be used in: rail safety, gas leak detection, flame detection, medical applications, petroleum exploration, space operations, temperature sensing, water and steel analysis, as well as motion detectors for alarm systems.</p> <p>There are two major types of IR detectors: thermal detectors and photon-sensitive detectors (photodiodes). Thermocouples, bolometers, thermistors, Golay cells, and pyroelectric devices such as those based on deuterated triglycine sulfate (DTGS) are examples of thermal detectors; while silicon photodiode, indium gallium arsenide (InGaAs), lead selenide (PbSe), mercury cadmium telluride (MCT), and indium antimonide (InSb) are examples of photon-sensitive semiconducting detectors.</p> <p>Comments from experts:</p> <p>An infrared detector is a device for the measurements of electromagnetic radiation (EMR) with wavelengths longer than those of visible light (700 nm to 1 mm). They are used in many civilian as well as military applications such as thermal efficiency analysis, remote temperature sensing, short-range wireless communication, moisture measurement, spectroscopy, astronomy, target acquisition, surveillance, night vision and many more.</p> <p>In principle, two measuring principles exist⁴</p> <ul style="list-style-type: none"> - Thermal detectors exploit the infrared energy as a source of heat that leads to a change of electrically measurable properties. They work independent of the radiation wavelength, need no cooling but have slow response times and low sensitivity. - Quantum or photodetectors are semiconductors whose electrical resistance decreases with increasing radiation. Photodetectors have a much lower response time and a higher sensitivity than thermal detectors but often need to be cooled to suppress thermal noise. Each photodetector system is applicable only in a narrow spectral bandwidth. <p>Infrared detectors are selected according to the specific requirements in a given application.</p> <p>Mercury-containing infrared detectors belong to the group of photodetectors. Among them, mercury cadmium telluride (MCT) is the commercially most important material type. It is a mixture of mercury telluride (HgTe) and cadmium telluride (CdTe). Changing the mixing ratio allows an optimization of the sensitivity at certain wavelengths. That is why MCT detectors, unlike other systems, can cover a quite broad spectral range (2 – 16 µm). That includes spectral ranges that are poorly covered by other semiconductor types, especially in the short wave and medium wave infrared spectrum⁵.</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Canada</p> <p>Depending on the detector and application, several other types of IR detectors are available including (but not limited to): InGaAs (indium gallium arsenide), InAs/GaInSb (indium arsenide/gallium antimonide), InSb (indium antimonide), SiAs (silicon arsenide), PbSe (lead selenide), InSb (indium antimonide) and SiSb (silicon antimonide), and SiGe (silicon germanium).¹ Detectors may also use a combination of the different types of technologies. New high-performance IR detectors are also using emerging technologies based on nanomaterials including graphene.²</p> <p>The alternative most suitable for the reported IR detector products will depend on the exact product type and the nature of the mercury-containing component.</p>

The 2018 report by ToxEcology indicated that although some MCT-based detectors were imported into Canada in 2016, other companies are using mercury-free alternatives. ¹ This indicates that in Canada, mercury-free alternatives are available.

Comments from experts

- The European regulation, namely Restriction of Hazardous Substances Directive (RoHS), has exemption system for infrared detectors. Mercury or cadmium in the infrared detectors is exempted under RoHS, but the EU Commission is currently investigating for which applications the exemption needs to be renewed. It is possible to look at the investigation results when they are available. The homepage of EU RoHS exemption renewal can be accessed at <https://rohs.biois.eu/requests.html>.
- An expert, in response to a query, responded that he was not certain about the actual content of mercury in the infrared detectors, but assumed that the absolute mercury content could be rather low, because only a small layer of mercury compound is needed to achieve the functioning of the infrared detectors. In addition, infrared detectors are typically a part of some sophisticated device used by the professionals in specialized circumstances. In other words, infrared detectors are less likely to end up as a general household waste, unless disposed improperly. On the other hand, it is worth noting that alternatives to mercury cadmium telluride (MCT) are other materials that also contain heavy metals. It is, therefore, necessary to fully assess the health and environmental risks and benefits of these alternatives.
- Japan Analytical Instruments Manufacturers' Association (JAIMA)
Mercury cadmium telluride(MCT) was first developed in the 1970's as an infra-red detector and no substitute has yet been found that has equal sensitivity and speed over the same wavelength range. Detectors are very small containing from 10 to 500 mg of MCT.
MCT is the only semiconductor that is sensitive to wavelength between 6 (the upper limit for InSb) and 20µm. Semiconductor detectors are very sensitive and also very fast which is particularly essential for Fourier transform infra-red(FTIR) spectrometers which are the most accurate and sensitive type of spectrometer on the market.(ref 5). It falls under RoHS exemption 1C (Lead, cadmium and mercury in infra-red light detectors)

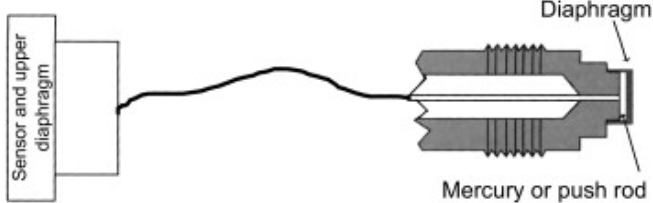


Figure 1: Example of a cooled infrared detector (source: Wikipedia.org)

5.(i) Information on the technical feasibility of alternatives	Canada The non-mercury alternatives can provide comparable performance to MCT-based detectors for all applications and are used by major IR detector manufacturers. ^{3, 4}
5.(ii) Information on the economic feasibility of alternatives	Comments from experts: According to available information, the global volume of the infrared detector market is in the order of 500 Mio. USD with a strong tendency for growth ⁶ . The share of MCT detectors is unknown
6. Information on environmental and health risks and benefits of alternatives	Canada Substitution of mercury with lead compounds would not be recommended from a human health or environmental perspective. Further investigation on the appropriateness of substituting mercury compounds with arsenic compounds may be needed to fully assess the health and environmental risks and benefits of these alternatives. Comments from experts: Several other IR detectors are available such as <ul style="list-style-type: none"> - Thermal detectors - photo detectors: indium gallium arsenide InGaAs, lead sulphide PbSe, lead selenide PbSe, indium arsenide InAs, indium antimonide InSb - They may replace MCT detectors in some but due to different characteristics not in all applications
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	NA

9. References

1. ToxEcology Environmental Consulting Ltd. (2018). Technical background study on products containing mercury in Canada with reference to the recently ratified Minamata Convention on Mercury.
 2. Tan, C.L & Mohseni, H. (2017). Emerging technologies for high performance infrared detectors. Nanophotonics, 7(1): 169-197: Available from : <https://www.degruyter.com/downloadpdf/j/nanoph.2018.7.issue-1/nanoph-2017-0061/nanoph-2017-0061.xml>
 3. Rogalski, A. (2012). History of Infrared detectors. Opto-Electron. Rev. 20, no.3. 279-308: DOI: 10.2478/s11772-012-0037-7 (e.g. see Table 3) <https://doi.org/10.1088/0034-4885/68/10/R01>;
 4. Hamamatsu Photonics. (2011). Infrared Detectors – Technical Information. Available from: https://www.hamamatsu.com/resources/pdf/ssd/infrared_kird9001e.pdf
 5. Lynred (2020) Understanding and using infrared technology. https://lynred.com/sites/default/files/2020-05/Livre%20Blanc-Sensibilisation_EN_compressed.pdf
 6. Markets and Markets (2020) Infrared Detector Market worth \$683 million by 2025 <https://www.marketsandmarkets.com/PressReleases/ir-detector.asp>
- JAIMA
Review of Directive 2002/95/EC (RoHS) Categories 8 and 9 Final report P169-170
https://ec.europa.eu/environment/pdf/waste/weee/era_study_final_report.pdf

1. Category of mercury-added product	Switches, relays and other electric devices
2. Further description of the product	4. Melt pressure transducers, transmitters and sensors using a capillary system
3. Information on the use of the product	<p>Melt pressure transducers, transmitters and sensors enable accurate pressure measurements to be made, enhancing product quality and limiting damage to equipment (Dynisco, 2016). In melt pressure transducers, pressure transmission occurs in a closed capillary system filled with a transmission medium (i.e. mercury). The system is designed to transfer the pressure exerted on the diaphragm, pictured in Figure 5, to the transduction feature (i.e. upper diaphragm with the strain gauge). The strain gauge then converts the physical pressure into an electric signal (Gefran, 2017). In cases of excess pressure during extrusion, this process enables transducers to ensure safety, by switching off extruder driving systems when defined pressure limits have been exceeded (Bagsik, 2019).</p> <p>In melt pressure transducers, mercury was traditionally used as the transmission medium, due to its capacity to transmit pressure readings at high temperatures. However, there is potential risk of mercury leakage during the manufacturing process. The EU through Directive 2011/65/EC (RoHS Directive) has required the use of inert mercury-free alternatives, such as silicon oil and sodium potassium alloy (NaK) (Industry Search, 2019). Despite the absence of regulation in other countries, many countries outside the EU also manufacture mercury-free alternatives, appealing to international customers.</p> <p>Figure 5 – Melt pressure transducer cross-section (Wagner, et al., 2014)</p>  <p>The mercury content in melt pressure transducers varies depending on the model. Dynisco states that their pressure transducer 420/460 model contains 7mm³ of mercury as the transmission medium. However, models released by other companies display a mercury filling volume of 30mm³ – 40mm³ (Gefran, 2014). In addition, Dynisco have provided another estimate of the mercury fill being approximately 0.003 cubic inches per transducer (~50mm³) (Dynisco, 2016).</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>EU</p> <p>Main alternatives: sodium-potassium alloy, silicon oil</p> <p>Although mercury devices are still on the market, a number of alternative transmission mediums exist. It is essential that alternatives meet certain requirements to ensure that they are suitable for extrusion processes. For example, products must be capable of withstanding high temperatures (up to 700°F) and high pressures (up to 30,000 psi), as well as being able to function in potentially corrosive settings (Dynisco, 2016). In addition, it is essential that the substances replacing mercury are capable of transferring pressure in a similar fashion.</p> <p>The two key alternatives to the use of mercury as a transmission medium are silicon oil and sodium-potassium alloy (NaK). The latter is capable of transferring pressure with comparable quality to mercury (Gräff, 2015). However, Gräff (2015) states that silicon oil is not always an appropriate alternative to mercury, due to the disparity in its capacity to transfer pressure in a</p>

	<p>comparable manner to mercury. However, the silicon oil substitute is commonly used in food and medical applications, where lower temperatures are required.</p> <p>Some companies have also developed sensors which do not require a transmission fluid. Instead, pressure is transferred to a silicon element through a diaphragm (Gefran, 2017).</p> <p>IPEN</p> <p>Hg free alternatives are available for melt pressure transducers, transmitters and sensors using mercury in a capillary system.</p>
5.(i) Information on the technical feasibility of alternatives	<p>EU</p> <p>Mercury-free alternatives are technically feasible and already commercially available. Through the use of advanced production processes, melt pressure products can be produced without the mercury filling and still provide an accurate reading (Müller, 2019). Sodium-potassium alloy is an alternative used by multiple manufacturers, due to its ability to mimic the characteristics of mercury. Sodium-potassium alloy alternatives can withstand temperatures of 400°C and according to Gräff (2015, p. 4), their mercury-free alternative is '100% market-compatible with all common manufacturers'. Due to its capacity to function under high temperatures, NaK is an ideal alternative for the plastics manufacturing industry (Industry Search, 2019).</p> <p>In addition, the majority of manufacturers also produce melt pressure transducers which use silicon oil as an alternative transmission medium. Although these products have limits on the temperature which they can withstand, their use is ideal in food, medical and pharmaceutical applications.</p>
5.(ii) Information on the economic feasibility of alternatives	<p>EU</p> <p>Due to increasing pressure from the US Food and Drug Administration (FDA) and the EU Restriction of Hazardous Substances (RoHS) Directive, several manufacturers already produce mercury-free alternatives (Gräff, 2015). As these alternatives are readily available on the market, manufacturers will not face the additional cost of having to invest in research and development to create mercury-free alternatives (Gefran, 2010). All European manufacturers comply with the RoHS Directive and manufacturers based in China already produce mercury-free alternatives.</p>
6. Information on environmental and health risks and benefits of alternatives	<p>EU</p> <p>The primary risk of mercury transducers, transmitters and sensors is the exposure to mercury during manufacturing processes. In addition, the use of mercury is particularly concerning in processes concerning food packaging, due to the direct link to human consumption (Dynisco, 2016). The silicon oil and NaK alternatives are considered safe by the US FDA, with neither of these alternatives containing hazardous substances. However, NaK is known to react strongly with water to produce highly-flammable hydrogen. NaK also reacts with CO₂ to produce methane (Chemwatch, 2009). However, the significance of this reactivity depends on the volume of NaK present. With the relatively low volume of transmission medium fill (7mm³-50mm³) for melt pressure transducers, the effect is likely to be minimal.</p>
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	NA

9. References

- AZO Materials, 2019. What are Mercury Fill Sensors?. Available at: <https://www.azom.com/article.aspx?ArticleID=17470>.
- Bagsik, 2019. Pressure Measurement. Available at: <http://www.bagsik.net/download.php?module=download&file=ZmlsZXNmZG93bmVvYWQvMTQ3Njk2MjAzMzE3NTNfZW5fcHJlc3N1cmUtbWVhc3VyZW1lbnQucGRm>.
- Chemwatch, 2009. Sodium-potassium alloy. Available at: <http://datasheets.scbt.com/sc-281150.pdf> [Accessed 25/06/2019].
- Dynisco, 2016. Melt Pressure Measurement: Environmental Effects. Available at: https://www.dynisco.com/userfiles/files/Datasheets/melt_pressure_measurement_environmental_effects.pdf.
- Gefran, 2010. Melt pressure transducers and transmitters. Available at: <https://gefran-online.com/products/pdf/1323.pdf>.
- Gefran, 2014. Pressure Sensors for High Temperature. Available at: <http://www.thermalsolutionsoftexas.com/pdfs/components/user-manuals/nak-fill.pdf>.
- Gefran, 2017. Melt Pressure Sensors. Available at: <https://www.gefran.com/en/download/3367/attachment/en>.
- Government of Canada, 2017. Terms and conditions for the approval of pressure transducers. Available: <https://www.ic.gc.ca/eic/site/mc-mc.nsf/eng/lm00123.html>.
- Gräff, 2015. Melt Pressure Sensors. Available at: http://www.graeff-gmbh.com/pdf/MASSED RUCK_EN_eigen.pdf.
- Industry Search, 2019. Highly Durable Melt Pressure Sensor by Gefran. Available at: <https://www.industrysearch.com.au/highly-durable-melt-pressure-sensor-by-gefran/p/65842>.
- METI, 2017. Overview of the National Implementation Plan for Preventing Environmental Pollution of Mercury. Available at: https://www.meti.go.jp/english/press/2017/pdf/1016_003a.pdf.
- Minister of Justice, 2019. Products Containing Mercury Regulations. Available at: <https://laws-lois.justice.gc.ca/PDF/SOR-2014-254.pdf> [Accessed 13/06/2019].
- MPI Melt Pressure, 2019. Oil Fill Melt Pressure Transducers & Transmitters. Available at: <https://www.mpipressure.com/melt-pressure/transmitters/oil-fill>.
- Müller, 2019. Melt pressure and melt temperature sensors. Available at: <https://mueller-ie.com/en/current-news/1112-melt-pressure-and-melt-temperature-sensors.html>.
- Wagner, J., Mount, E. & Giles, H., 2014. Extrusion. Available at: <https://www.sciencedirect.com/book/9781437734812/extrusion#book-info>.
- World Bank, 2019. Capacity Strengthening for Implementation of Minamata Convention on Mercury Project. Available at: <http://projects.worldbank.org/P151281?lang=en>.

1. Category of mercury-added product	Switches, relays and other electric devices
2. Further description of the product	5. Electric and non-electric mercury vacuum pump
3. Information on the use of the product	<p>Two types of mercury vacuum pumps exist:</p> <div> </div> <p>1. The Sprengel pump is a form of non-electric vacuum pump that uses drops of mercury falling through a small-bore capillary tube in order to trap air. Mercury is contained in the reservoir and flows into bulb B, where it forms drops which fall leaving air entrapped in bulb B. Mercury is collected and restored to the left reservoir. In this way almost all air can be removed from bulb B and by extension vessel R (Sella 2008).</p> <p>Figure 6 – Mercury-containing vacuum pump (Beach & Chandler, 1914)</p> <p>Range of mercury content: 3.4 kg-Hg (COWI, 2008)</p> <p>The same principle was used in the more efficient (electric) mercury rotation pump invented by Gaede in 1905. It contained 26 kg mercury. But both variants were soon replaced by the mercury diffusion pump (see below).</p> <p>2. Mercury diffusion pumps</p> <p>The mercury diffusion pump was invented by Gaede in 1913 and later improved by Langmuir. It was one of the first effective sources of high vacuum. It uses the principle that a jet of heavy gas vapour directs (lighter) gas molecules in the pump throat down into the bottom of the pump and out the exhaust (Sella 2009). The heavy gas is condensed on the walls and flows back to a heater section where it is vaporized again. Initially, mercury was used as a working fluid, but until the 1980ies it was almost completely replaced by different types of oils such as polyphenyl ether (Vac Aero 2014). Unlike other vacuum pumps, diffusion pumps have no moving parts and thus are robust and very durable. Older pumps using mercury as a working fluid may still be in use but there is no indication that mercury vacuum pumps are still produced on a commercial basis.</p>

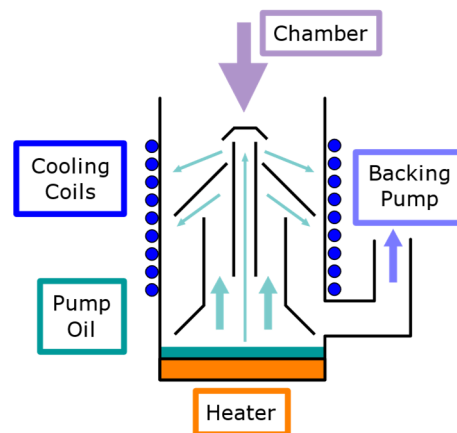


Figure 7: Diagram of an oil diffusion pump (source: wikipedia.org, mercury diffusion pumps use the same principle)

4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>EU Main alternatives: Positive displacement pumps, momentum transfer pump Positive displacement pumps use a mechanism to expand a cavity, causing gases to flow in from the chamber that is to be extracted, after which the chamber is sealed and gases are exhausted. This can be repeated indefinitely to create an increasing vacuum. Momentum transfer pumps (molecular pumps) use dense fluid or high speed blades to knock gas molecules out of the chamber.</p> <p>IPEN Hg free alternatives are available and are in common use for mercury vacuum pumps.</p>
5.(i) Information on the technical feasibility of alternatives	<p>EU There are technically feasible alternatives to mercury pumps available and widely used. Positive displacement pumps are most effective for the creation of low vacuums, while momentum transfer pumps are used to create high vacuums. The KALPUREX process for removing helium from exhaust gases in a planned fusion demonstration power plant (DEMO, potential successor of the ITER) employs two mercury vacuum pumps. Mercury is used as a working fluid because of its very good compatibility with radioactive tritium (Giegerich & Day, 2014). The concept was chosen as the most suitable option on the basis of a Strength, Weakness, Opportunity and Threat (SWOT) analysis (Giegerich & Day, 2014).</p>
5.(ii) Information on the economic feasibility of alternatives	<p>EU There are economically feasible alternatives to mercury using vacuum pumps, evidenced by the fact that no mercury using pumps were sold in the EU since before 2008 (COWI, 2008).</p>
6. Information on environmental and health risks and benefits of alternatives	<p>EU There are no known environmental downsides to mercury free alternatives to mercury containing vacuum pumps (COWI, 2008).</p>

7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	EU According to Directive 2011/65/EU, the RoHS Directive, Member States must ensure that all electrical and electronic equipment placed on the market shall not contain mercury beyond a maximum concentration of 0.1% by weight in homogenous material. There are however exemptions for medical devices and monitoring and control instruments, as well as research applications.

9. References

- Atta & Hablanian, 1991. "Vacuum and Vacuum Technology". In Rita G. Lerner; George L. Trigg (eds.) Encyclopedia of Physics (Second ed.). s.l.:VCH Publishers.
- Beach & Chandler, 1914. "Air Pump". The New Student's Reference Work. Chicago: F.E. Compton and Co..
- COWI, 2008. Options for reducing mercury use in products and applications, and the fate of mercury already circulating in society. [Online]
Available at: http://ec.europa.eu/environment/chemicals/mercury/pdf/EU_Mercury_Study2008.pdf
- Giegerich & Day, 2014. Development of Advanced Exhaust Pumping Technology for a DT Fusion Power Plant. [Online]
Available at: <https://ieeexplore.ieee.org/document/6762984>
- Giegerich & Day, 2014. The KALPUREX-process - A new vacuum pumping process for exhaust gases in fusion power plants. [Online]
Available at: https://inis.iaea.org/search/search.aspx?orig_q=RN:46087195
- Sella 2008. Classic Kit: Sprengel pump. Available at: <https://www.chemistryworld.com/opinion/classic-kit-sprengel-pump/3004941.article>
- Sella 2009. Classic Kit: Gaede's diffusion pump. Available at: <https://www.chemistryworld.com/opinion/classic-kit-gaede-diffusion-pump/3004912.article>
- Vac Aero International, 2014. Oil Diffusion Pump Controls. Available at <https://vacaero.com/information-resources/vacuum-pump-technology-education-and-training/966-oil-diffusion-pump-controls.html>

1. Category of mercury-added product	Switches, relays and other electric devices
2. Further description of the product	Radiation light detectors / detectors for ionizing radiation
3. Information on the use of the product	<p>Detectors for ionizing radiation are employed to measure ionizing radiation, especially gamma rays. They are used in medical and industrial instruments to see inside or through the human body or technical objects. Applications include computed tomography, bone densitometry, mammography, non-destructive testing, X-ray imaging, food inspection and security purposes.</p> <p>Three general measuring principles are employed:</p> <ul style="list-style-type: none"> - photographic film (now largely replaced by more sensitive electronic devices) - indirect detectors using scintillators that convert radiation into visible light - direct detectors using semiconductors <p>According to information by COCIR (2020) mercury(II) iodide (mercuric iodide, HgI_2) is one of several semiconductor materials considered for such detectors.</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Electronic detection of ionizing radiation often requires the use of heavy metals because lighter chemical elements such as silicon have a much lower sensitivity. Using lighter elements would have to be compensated by higher radiation which is not desirable and potentially harmful.</p> <p>Several semiconductor materials have been developed, but the following types are the most important on the market (JBCE 2020, COCIR 2020)</p> <ul style="list-style-type: none"> - silicon (Si) - selenium (α-Se) - germanium (Ge) - cadmium telluride (CdTe) - cadmium zinc telluride (CZT) - lead iodide (PbI_2) <p>According to (JBCE 2020), mercury iodide (HgI_2) is still in the development phase and not commercially available, so that existing applications using ionizing radiation are already covered by at least one of the above-mentioned materials.</p>
5.(i) Information on the technical feasibility of alternatives	Currently, two industrial groups applied for specific exemptions under the European RoHS directive regarding the use of cadmium and lead in detectors for ionizing radiation. But they did not include mercury compounds in their application. Therefore, it must be concluded that the use of mercury iodide or any other mercury compound is technically not necessary.
5.(ii) Information on the economic feasibility of alternatives	As there is currently no indication that semiconductors containing mercury iodide (HgI_2) are present on the market there seem to be no economic incentives to introduce it.
6. Information on environmental and health risks and benefits of alternatives	Many of the technical alternatives also contain heavy metals that may be harmful to human health and the environment if disposed of improperly.
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA

8. Other relevant information pursuant to Decision MC-3/1	NA
9. References	Japanese Business Council in Europe (JBCE) (2020) Exemption Request (RoHS, on cadmium in detectors for ionising radiation) https://rohs.biois.eu/Ex_1-IV_JBCE_Renewal-Request.pdf COCIR (2020) Exemption Request (RoHS, on cadmium and lead in detectors for ionising radiation) https://rohs.biois.eu/Ex_1-IV_COCIR%20_Renewal-Request.pdf

VI. Other non-electronic products

Information provided by **Canada** and other stakeholders (IPEN)

1. Photographic film/paper

2. Mercury-containing counter balancers (tire balancers/wheel weights)

1. Category of mercury-added product	Other non-electronic products
2. Further description of the product	1. Photographic film/paper
3. Information on the use of the product	<p>Film and photographic paper that contains mercury as part of the developing process</p> <p>Information from experts Specialized silver halide photographic papers and motion picture and X-ray films may contain trace amounts of mercury in order to reduce the formation of an unwanted background image during processing (Baldsiefen et al. 1951, NEWMOA 2017: IMERC database, specialized photographic products). According to information from one manufacturer and the IMERC database, mercury has now been replaced in silver halide photographic papers and films (Eastman Kodak Company 2015, NEWMOA 2017). Mercury content was 0 to 10 ppm, total annual use: 0.6 g (2004, one manufacturer, USA).</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Canada <u>Main alternatives:</u> i) <i>Digital cameras and prints;</i> ii) <i>Mercury-free film and photographic paper</i></p> <p>Alternatives are widely available and appear to have been available since the 1970s. Little information is available on the current use and availability of mercury containing film and photographic paper.</p>
5.(i) Information on the technical feasibility of alternatives	<p>Canada Mercury-free photo papers perform just as well if not better than mercury-added photo papers¹. Alternatives for mercury added photographic film and paper are most widely used and are therefore assumed to be economically and technically feasible.</p>
5.(ii) Information on the economic feasibility of alternatives	
6. Information on environmental and health risks and benefits of alternatives	<p>Canada Mercury-free photographic film and paper do not require special treatments for handling or disposal.</p>
7. Additional information	NA
8. Other relevant information pursuant to Decision MC-3/1	NA
9. References	<p>https://imaging.kodakalaris.com/sites/uat/files/wysiwyg/pro/Silver_Halide_White_Paper.pdf Baldsiefen, W. D.; Conrad, L. J., Linkhart, R. N. (1951): Silver halide emulsions. Patent no. 2,540,086. Eastman Kodak Company (Ed.) (2015): Silver Halide Photographic Paper. Available online at https://imaging.kodakalaris.com/sites/uat/files/wysiwyg/pro/Silver_Halide_White_Paper.pdf, checked on 7/29/2019. NEWMOA (Ed.) (2017): Mercury-Added Products Database. Available online at http://www.newmoa.org/prevention/mercury/imerc/notification/.</p>

1. Category of mercury-added product	Other non-electronic products
2. Further description of the product	2. Mercury-containing counter balancers (tire balancers/wheel weights)
3. Information on the use of the product	<ul style="list-style-type: none"> Mercury-containing counter balancers can be used in a variety of mechanical components including engines, drive shafts, and pumps. It is estimated that each mercury-containing balancer contains 99.2 g of mercury. Although these are now prohibited for use in Canada, previously they were used mostly on tires in various types of vehicles including trucks, cars, motorhomes, motorcycles, jet skis, and ultralites. Mercury-containing tire balancers consist of mercury filled tubes that are fitted to rotating mechanical parts. This type of tire balancer uses mercury in a continuous active balancing system that uses centrifugal force to position the liquid weight (mercury) in counterweight positions. This allows tires to rotate without causing vibrations. The purpose of a tire balancer is to eliminate uneven tire wear to extend the useful life of the tire. Manufacturers claim that using tire balancers results in a greater tire footprint and more control in adverse driving conditions. They also suggest that mercury-containing tire balancers increase fuel mileage by up to 5% and tire life by up to 50%.¹
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Canada</p> <ul style="list-style-type: none"> The most similar available products to mercury-tire balancers are bolt-on centrifugal liquid rings and internal liquids that are injected into the tire. Non-liquid types of tire-balancers (wheel weights) are also available alternatives and are typically made from tin, steel, or high-density polymer composites. These wheel weights can be coated or non-coated, and adhesive or clip-on. Clip-on or adhesive wheel weights made from lead are also alternatives; however, they may not be an appropriate substitute due to environmental and human health concerns. <p>IPEN Liquid alternatives to mercury containing counter-balancers (tire weights) are available.</p>
5.(i) Information on the technical feasibility of alternatives	<p>Canada</p> <ul style="list-style-type: none"> A study conducted for the Government of Canada found that for most manufacturers, wheel weights made of steel had no higher costs than wheel weights made of lead and performed similarly. The non-toxic tin, steel, and composite alternatives that have been developed meet the main technical requirements for tire balancing products. Mainly that they are: made of a dense material, corrosion resistant and function in a range of operating temperatures.
5.(ii) Information on the economic feasibility of alternatives	<p>Canada</p> <ul style="list-style-type: none"> Mercury-containing tire balancers are not produced in Canada, and there is little information comparing the costs and performance of them to mercury-free tire balancing products. However, anecdotal research suggests that mercury-containing tire balancing products have a higher up-front consumer cost compared to other tire balancing products.² The costs of metal wheel balancers fluctuate with the costs of the raw materials.³
6. Information on environmental and health risks and benefits of alternatives	<p>Canada Mercury-free tire balancing products contain internal compounds or liquids that are non-toxic; making their use and disposal safer for the environment and human health compared to mercury-containing tire balancing products.</p>

	<p>External wheel weights made of steel are also non-toxic to the environment or human health. One benefit of metal wheel weights is that they can be recycled. However, steel wheel weights made of recycled material may contain additives such as nickel and chromium, which could have a relatively small impact on human and/or environmental health.⁴ Coated steel weights are currently the most environmentally friendly solid wheel weight product.⁶</p> <p>Solid wheel weights are often mismanaged at the end of product life when taken out of service. Employees in the tire and wheel service industry who handle lead wheel weights, in particular, can be exposed and also bring contamination home with them.⁴</p> <p>Solid wheel weights fall off during normal use. Although lead is a toxic substance, it is still preferable to use lead wheel weights compared with mercury tire balancers because lead is less volatile than mercury and solid wheel weights are relatively easier to collect and contain than a liquid containing mercury.⁷</p>
7. Additional information	NA
8. Other relevant information pursuant to Decision MC-3/1	<p>Canada</p> <p>The manufacture and import of mercury wheel weights is prohibited under Canada's Products Containing Mercury Regulations which came into effect in 2014. New cars entering the Canadian market currently have mercury-free tire balancers installed. As a result, no mercury-containing tire balancers are expected to be available in Canada.</p> <p>Mercury-containing tire balancers have also been banned in some American states and in the European Union. There was little information on the availability of mercury-containing tire balancers and their alternatives in other regions.</p>
9. References	<ol style="list-style-type: none"> 1 For example: http://www.balancemasters.com/trucks/index.html 2 For example: http://forum.prevostownersgroup.com/archive/index.php/t-3485.html; https://www.turbodieselregister.com/threads/balance-master-vs-centramatics.238074/ 3 Toxecology Environmental Consulting Ltd. (2013). Background study and use pattern for lead wheel weights in Canada. 4 California Environmental Protection Agency (2011). Wheel weight alternatives assessment. Available from: https://dtsc.ca.gov/wp-content/uploads/sites/31/2017/05/AAWheelWeights.pdf 5 Minnesota Pollution Control Agency. (N.D.) Lead and mercury wheel weights. Available from: https://www.pca.state.mn.us/quick-links/lead-and-mercury-wheel-weights 6 State of Washington. (2008). Environmentally preferable purchasing fact sheet: wheel weights. Publication No. 13-07-008. Available from https://fortress.wa.gov/ecy/publications/documents/1307008.pdf 7 Government of Canada. (2007). Proposed risk management instrument for mercury-containing products. Available from: https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/proposed-risk-management-instruments-mercury-products.html#s2_7

VII. Cosmetics

Information provided by [EU](#), [Uganda](#), [the United States](#) and other stakeholders (IPEN)

Eye makeup, cleansing products and mascara containing thiomersal

1. Category of mercury-added product	Cosmetics
2. Further description of the product (if any)	Eye makeup, cleansing products and mascara containing thiomersal
3. Information on the use of the product	<ul style="list-style-type: none"> • Thiomersal is an organic compound, containing ethyl mercury, which is often used as a preservative in mascara, eye makeup and cleansing products (WHO, 2011). Thiomersal provides a useful role, extending the shelf life of cosmetics and limiting the risk of infection to cosmetic users. However, due to the risk of allergic reaction and the wider health impacts associated with exposure to mercury, the concentration of mercury in eye makeup products is restricted by legislation internationally. • The majority of purchased cosmetic products are stored at room temperature in households, in relatively moist conditions. These conditions, combined with repeated, regular use by consumers, leave cosmetic products susceptible to microorganism growth (ICCR, 2016). For eye makeup products, which have a high water content, such as mascara and liquid eyeliner, preservatives are required to limit microbial growth and extend the shelf life of these products. • Thiomersal is a key preservative used in eye makeup products, to prevent fungal and bacterial growth and limit the risk of infection for consumers. Although thiomersal serves reduces the spread of microorganisms, mercury compounds can cause skin irritation, neurotoxicity and kidney damage (EWG, 2019a). The North American Contact Dermatitis Group reported thiomersal as the fifth most common allergen, with 11% of patch-test patients experiencing allergic reactions, despite its low clinical relevance (Fonacier & Boguniewicz, 2016). In spite of these concerns, WHO scientist, Tempowski, states that ‘the risk-benefit analysis favours the use of these preservatives’, due to their ability to inhibit bacterial and fungal growth (Scientific American, 2013). • Mercury concentrations in eye makeup products vary depending on the product yet usually do not exceed 1 ppm. According to information provided by an industry group, thiomersal is no longer used by the European cosmetics industry, based on knowledge of the 2016 Cosmetics Europe Preservative Use Survey for the preservation of cosmetic products. This Survey was completed by 85 organisations in the sector, including multinational organisations and SMEs. In addition, over 60,000 product types were analysed, accounting for over 60,000 product formulations.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>Main alternatives: <i>Parabens, organic alternatives</i></p> <p>COWI (2008) suggests that, for the use of mercury as a preservative in cosmetics, ‘alternatives dominate the market, but new products with mercury also have significant market share’.</p> <p>Phenoxyethanol, methylisothiazolinone and parabens are mercury-free substitutes used to replace thiomersal in eye makeup products. However, these alternatives are also associated with detrimental health impacts, from allergic reactions to toxicity (Scientific American, 2013). Organic preservatives, such as benzoic acid and sorbic acid, as well as organic ingredients, such as honey and sea salt, are also used by some cosmetic companies. Dermosoft multifunctionals, which</p>

	<p>combine organic acids and chemical compounds, can also offer an alternative to thiomersal, effectively tackling microbial growth through combining multiple preservatives (Thiemann & Jänichen, 2014).</p> <p>Some companies also choose to use sterilisation as an alternative to preservatives, using the Ultra-High-Temperature process (UHT) to heat and sterilise the product, before quickly cooling it. In addition, as high water-content is one of the key causes of microbial growth, some brands are innovating to replace water with a gelled substitute, removing the need for preservatives altogether (EcoMundo, 2019).</p> <p>There are a number of mercury-free alternatives available, and according to the Environmental Working Group's (EWG) Skip Deep Cosmetics Database, there are no eye makeup products currently available in the US that contain thiomersal (EWG, 2019b).</p>
5.(i) Information on the technical feasibility of alternatives	<p>Several factors are considered when selecting the most suitable preservative to use in cosmetic products. This decision is linked to the expected performance of the product, consumer behaviour and the specific requirements of the product (ICCR, 2016). Alongside these key factors, preservatives must be determined as safe, and aim to use the minimum concentration of preservatives required to ensure the product does not spoil. A consideration of the interaction between preservatives and other product ingredients is essential, to ensure the preservative operates effectively. Therefore, the technical feasibility of alternatives is product-specific, as it depends on the interaction of substitute preservatives with other product ingredients.</p> <p>Organic preservatives, such as sorbic or benzoic acid, are effective against most fungi. However, they tend not to be particularly effective against bacterial growth (Microchem Laboratory, 2018). Multiple organic preservatives can be combined to achieve wider success in limiting microbial growth. However, these alternatives also precipitate in products with high water content, which diminishes their effectiveness (ibid). Phenoxyethanol is particularly stable and not pH dependent, unlike some organic preservatives, which require a pH range of 2-6. Parabens are most widely used, in both rinse-off products and makeup products used throughout the day, providing a suitable alternative to thiomersal (ibid). It can also be useful to combine preservatives, as is the case with dermosoft multifunctionals, to achieve a more cohesive antimicrobial effect (Thiemann & Jänichen, 2014). Therefore, there are a number of technically feasible alternatives that are already commercially available. However, it is important to also consider practical and health-related factors, to ensure the preservative is suitable for the product.</p>
5.(ii) Information on the economic feasibility of alternatives	<p>The cost of non-mercury alternatives varies depending on the preservative. The cost of cosmetic ingredients is an important consideration, as it greatly influences the marketing of products. Although consumers are moving towards more affordable cosmetics, the cost of antimicrobials is not necessarily negative, as consumers are generally willing to pay to avoid negative health outcomes (Halla, et al., 2018).</p>
6. Information on environmental and health risks and benefits of alternatives	<p>The health and environmental risks associated with non-mercury alternatives vary depending on the substitute. Parabens are often used in cleansing products. However, these preservatives are linked to a number of health concerns, including damage to skin cells, reproductive toxicity and</p>

	<p>endocrine disruption. Phenoxyethanol is also used as a preservative in cosmetic products, yet it has been linked to allergic reactions, including eczema and anaphylaxis. However, it is a viable alternative, if individuals are not allergic to the preservative.</p> <p>Methylisothiazolinone is another preservative used in mascara and cleansing products. However, it is linked to inhalation toxicity and allergic reactions (Breast Cancer Prevention Partners, 2019). In 2015, 75 000 metric tonnes of preservatives were used in cosmetic products globally.</p> <p>Therefore, organic alternatives, such as honey and sea salt, which naturally break down without causing harm to the environment, are preferable (LUSH, 2019).</p>
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	<p>In Europe, Regulation (EC) 1223/2009 is the primary piece of legislation governing the use of mercury in eye makeup, cleansing products and mascara. Under Article 14(1)(a), restrictions are placed on the use of certain substances in cosmetic products, listed under Annex II. Mercury and its compounds are banned, with the exception of special cases outlined in Annex V. The use of thiomersal in eye makeup products is one of the special cases identified by the Regulation, where a maximum concentration of 0,007 % of mercury is permitted in eye makeup, mascara and cleansing products. If thiomersal is combined with other mercury compounds permitted under Regulation (EC) 1223/2009, the maximum concentration of mercury in eye products remains the same (i.e. 0,007 %). Phenylmercuric salts (including borate) found in eye products are also subject to the same maximum concentration. In addition, through the introduction of a ‘date of minimum durability’ or a ‘period after opening’ date in Europe, consumers are more aware of the appropriate shelf life of cosmetic products (Cosmetics Europe, 2019).</p> <p>During the ad hoc group’s meeting, an expert confirmed that, to his knowledge, the European cosmetics industry no longer use mercury preservatives.</p> <p>In the US, the Food and Drug Administration (FDA) leads on legislative development for cosmetics. The concentration of mercury compounds in eye makeup products is limited to 0,0065 %, and is only permitted in the case that no mercury-free alternatives are available (US FDA, 2017). All other cosmetic products must have a mercury concentration of less than 1 mg per kg. Mercury is listed in 21 CFR. § 700.13 as a banned ingredient for cosmetic uses, with the exception of “<i>de minimis</i>” use as a preservative in eye-area cosmetics if no other alternatives are available. A search of FDA’s Voluntary Cosmetic Registration Program (VCRP, 21 CR 720) in October of 2020 found no cosmetic products containing either organic or inorganic Hg-containing ingredients currently registered.</p> <p>Skin bleaching products, generally, especially those containing ammoniated mercury are deemed unapproved over-the-counter (OTC) drug products and are unapproved new drugs in the United States.</p> <p>Cosmetic products containing Hg that do not comply with the above noted regulation would be deemed to be “adulterated” and the FDA has the authority to enjoin and criminally prosecute offenses relating to such products (see, 21 U.S.C. §§ 331(a), 332,</p>

	<p>333). FDA Import Alert # 53-18 (“Detention Without Physical Examination of Skin Whitening Creams Containing Mercury”; https://www.accessdata.fda.gov/cms_ia/importalert_137.html) is the basis for surveillance by inspectors at U.S. ports of entry for imported cosmetics that may contain Hg in violation of FDA regulations at 21 CFR 700.13. In the past few years, FDA and state health officials have discovered and analyzed some products marketed as skin lighteners that contain mercury; FDA’s internet website posted an article, “Skin Products Containing Mercury”, which presents the Hg content found in seven 2019 skin products along with the products names and images. (See, https://www.fda.gov/consumers/health-fraud-scams/skin-products-containing-mercury). All cosmetic products covered by the Convention are also subject to the labeling requirements of the Federal Food, Drug, and Cosmetic Act and, if marketed at retail for consumers, the Fair Packaging and Labeling Act. The ASEAN Cosmetic Directive reflects EU legislation, with thiomersal permitted as a preservative in eye makeup and cleansing products, as long as the concentration of mercury does not exceed 0,007 %. The maximum concentration of mercury remains 0,007 % if other mercury compounds are contained in the product (Health Sciences Authority, 2018). All 10 Member States³ were required to implement the Directive by January 2018.</p>
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9. References

- ASEAN, 2017. ASEAN guidelines on limits of contaminants for cosmetics. Available at: https://www.hsa.gov.sg/content/dam/HSA/HPRG/Cosmetic_Products/ASEAN%20Guidelines%20on%20Limits%20of%20Contaminants%20for%20Cosmetics.pdf.
- Breast Cancer Prevention Partners, 2019. Chemicals of Concern. Available at: <http://www.safecosmetics.org/get-the-facts/chem-of-concern/>.
- Cosmetics Europe, 2018. Socio-Economic Contribution of the European Cosmetics Industry. Available at: <https://www.cosmeticseurope.eu/download/NjVMWDNaVGJXcUJpZVhxM0lXN3BxUT09>.
- Cosmetics Europe, 2019. Preservatives: Protecting Consumers. Available at: https://www.cosmeticseurope.eu/files/6215/4296/8648/CE_Fact_sheet_preservatives.pdf.
- COWI, 2008. Options for reducing mercury use in products and applications, and the fate of mercury already circulating in the society. Final Report. Available at: http://ec.europa.eu/environment/chemicals/mercury/pdf/study_report2008.pdf.
- EcoMundo, 2019. Preservatives in cosmetic products. Available at: <https://www.ecomundo.eu/en/blog/preservatives-in-cosmetic-products>.
- EWG, 2019a. Thimerosal. Available at: <https://www.ewg.org/skindeep/ingredient/706528/THIMEROSAL/>.
- EWG, 2019b. Products containing THIMEROSAL. Available online: <https://www.ewg.org/skindeep/browse.php?old=1&containing=706528&>.
- Fonacier, L. & Boguniewicz, M., 2016. Contact Dermatitis. Pediatric Allergy: Principles and Practice (Third Edition).
- Global Market Insights, 2018. Cosmetic Preservatives Market size to exceed \$1.4 Bn by 2024. Available at: <https://www.gminsights.com/pressrelease/cosmetic-preservatives-market>.
- Halla, N. et al., 2018. Cosmetics Preservation: A Review on Present Strategies. Available at: <https://www.mdpi.com/1420-3049/23/7/1571/pdf>.
- Health Sciences Authority, 2018. Annexes of the ASEAN Cosmetic Directive. Available at: [https://www.hsa.gov.sg/content/dam/HSA/HPRG/Cosmetic_Products/Annexes%20of%20ACD%20\(after%2029th%20ACSB%20Meeting\).pdf](https://www.hsa.gov.sg/content/dam/HSA/HPRG/Cosmetic_Products/Annexes%20of%20ACD%20(after%2029th%20ACSB%20Meeting).pdf).
- ICCR, 2016. General and Technical Frequently Asked Questions. Available at: <https://ec.europa.eu/docsroom/documents/17203/attachments/1/translations/>.
- LUSH, 2019. The environmental cost of preservatives. Available at: <https://uk.lush.com/article/environmental-cost-preservatives>.
- Microchem Laboratory, 2018. Five Most Common Types of Preservatives Used in Cosmetics. Available at: <https://microchemlab.com/information/five-most-common-types-preservatives-usedcosmetics>.
- Ministry of Health, Labour and Welfare, 2000. Standards for Cosmetics. Available at: <https://www.mhlw.go.jp/file/06-Seisakujouhou-11120000-Iyakushokuhinkyoku/0000032704.pdf>.
- Orbis Research, 2018. Global Cosmetics Products Market-Analysis of Growth, Trends and Forecasts (2018-2023). Available at: <http://orbisresearch.com/reports/index/global-cosmetics-products-marketanalysis-of-growth-trends-and-forecasts-2018-2023>.

- Scientific American, 2013. In the Public Eye: Mascara Exempt from Mercury Treaty. Available at: <https://www.scientificamerican.com/article/in-the-public-eye-mascara-exempt-from-mercury-treaty/?redirect=1> [Accessed 28/05/2019].
- Thiemann, A. & Jänichen, K., 2014. The formulator's guide to safe cosmetic preservation. Available at: https://www.dr-straetmans.de/dl/media/filer_public/7a/ef/7aef7f01-c566-425c-9c7b-500334a96b2a/review_article_about_the_development_and_trends_in_preservative_legislation_and_safe_alternatives_for_the_future_verstatil_dermosoft.pdf.
- UNEP, 2013. Minamata Convention on Mercury.
- US FDA, 2017. Prohibited & Restricted Ingredients in Cosmetics. Available at: <https://www.fda.gov/cosmetics/cosmetics-laws-regulations/prohibited-restricted-ingredients-cosmetics#prohibited> [Accessed 28/05/2019].
- WHO, 2011. Thiomersal - questions and answers. Available at: https://www.who.int/immunization/newsroom/thiomersal_questions_and_answers/en/ [Accessed 28/05/2019].

Other cosmetics

1. Category of mercury-added product	Cosmetics
2. Further description of the product (if any)	Other cosmetics
3. Information on the use of the product	<p>Uganda</p> <p>There are mercury containing cosmetics and related products in use in Uganda as revealed in the National Minamata Initial Assessments report, 2018.</p> <p><u>Estimated Mercury input in the environment (MIAs report, 2018)</u></p> <ul style="list-style-type: none"> • At use and disposal phase fused together, cosmetics and related products contribute to 104 kg/Hg/Yr <p><u>Use of the product</u></p> <ul style="list-style-type: none"> • Available in various forms such as sprays, gels, lotions, creams, soaps, powders, etc., cosmetics cover a wide range of products intended for contact with the body. Of particular concern are skin-lightening (or fairness) creams and soaps exceeding that level.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p><u>Existing less-mercury products</u></p> <ul style="list-style-type: none"> • <i>Cosmetics with trace levels of mercury (< 1ppm)</i> • <i>Beauty soaps and creams without mercury, e.g., cosmetic products based on natural products, vegetable oils, or essential oil formulations</i> <p>Information from experts</p> <p>In Indonesia, mercury has been banned since 1998 for cosmetic products by MOH and 2011 by NADFC. Since mercury has been banned for many years, the cosmetics industry was able to replace mercury with other alternative ingredients.</p>
5.(i) Information on the technical feasibility of alternatives	<p>Uganda</p> <ul style="list-style-type: none"> • There is limited knowledge by consumers in Uganda on existence of alternatives • There is limited policy restrictions on importation of listed Non-electronic measuring devices • There are no incentives on use/importation of alternatives

	<p>IPEN Many manufacturers have now moved to formulations that are mercury free demonstrating that alternatives are available and accepted (COWI, 2008) by the cosmetics industry.</p>
5.(ii) Information on the economic feasibility of alternatives	<p>Uganda</p> <ul style="list-style-type: none"> • The alternatives usually cost higher than the more toxic ones. • Alternatives are mainly imported, hence transferring taxation costs to the consumer.
6. Information on environmental and health risks and benefits of alternatives	
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	
8. Other relevant information pursuant to Decision MC-3/1	
9. References	<ul style="list-style-type: none"> • Developing National Strategies for Phasing Out Mercury Containing Thermometers and Sphygmomanometers in Health Care, Including in the Context of the Minamata Convention on Mercury, World Health Organization, 2015. Available at http://www.who.int/ipcs/assessment/public_health/WHOGuidanceReportonMercury2015.pdf?ua= • UNEP (2013): Minamata Convention on Mercury. Available at http://www.mercuryconvention.org • Minamata Initial Assessments report, 2018 • Mercury Learn - HS codes (2015); COMTRADE database <p>Information from experts Peraturan Menteri Kesehatan Nomor 445/MENKES/Per/V/1998 tentang Pelarangan Penggunaan Merkuri dalam Sediaan Kosmetika; Badan Pengawas Obat dan Makanan Republik Indonesia Nomor HK.03.1.23.08.11.07517 Tahun 2011 tentang larangan penggunaan Merkuri dalam sediaan kosmetik; Peraturan Badan POM 23 Tahun 2019 Persyaratan Teknis Bahan Kosmetika. PERATURAN BADAN PENGAWAS OBAT DAN MAKANAN NOMOR 12 TAHUN 2019 TENTANG CEMARAN DALAM KOSMETIKA</p>

VIII. Pesticides, biocides and topical antiseptics

Information provided by **Uganda, USA**

1. Category of mercury-added product	Pesticides, biocides and topical antiseptics
2. Further description of the product	
3. Information on the use of the product	<ul style="list-style-type: none"> There are no mercury containing biocides and pesticides in use in Uganda as revealed in the National Minamata Initial Assessments report, 2018. There are no mercury containing pharmaceuticals for human and veterinary uses in Uganda as revealed in the National Minamata Initial Assessments report, 2018. Mercury is not registered in the United States for sale and distribution as a pesticide. By 1995, all U.S. registrations for mercury-containing pesticides, including for use as a preservative in paint (e.g., as a biocide), were cancelled. It is therefore unlawful to sell or distribute such a product in the United States. In addition, U.S. EPA's 2020 Mercury Inventory Report does not indicate any production, use, import, or export of mercury as a pesticide, which is also consistent with the outcome of the review of U.S. pesticide production reports for mercury pesticides being produced for export.
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p><u>Mercury free Biocides & Pesticides</u></p> <ul style="list-style-type: none"> Biocides & pesticides without mercury include carbamates, organophosphates, pyrethroids Biological pesticides <p><u>Mercury free topical antiseptics</u></p> <ul style="list-style-type: none"> Herbal and natural-product antiseptics Topical antiseptics with active ingredients** like alcohol, benzalkonium chloride, chloroxylonol, Polyvidone iodine, etc. (mercury-free) Medicated soaps and surface-active agents (mercury-free)
5.(i) Information on the technical feasibility of alternatives	Alternatives are already in use
5.(ii) Information on the economic feasibility of alternatives	<ul style="list-style-type: none"> The alternatives usually cost higher than the more toxic ones Alternatives are mainly imported, hence transferring taxation costs to the consumer
6. Information on environmental and health risks and benefits of alternatives	NA
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	NA

9. References

- Developing National Strategies for Phasing Out Mercury Containing Thermometers and Sphygmomanometers in Health Care, Including in the Context of the Minamata Convention on Mercury, World Health Organization, 2015. Available at http://www.who.int/ipcs/assessment/public_health/WHOGuidanceReportonMercury2015.pdf?ua=
- UNEP (2013): Minamata Convention on Mercury. Available at <http://www.mercuryconvention.org>
- Minamata Initial Assessments report, 2018
- Mercury Learn - HS codes (2015); COMTRADE database

IX. Satellite propulsion

Information provided by **Canada**, **EU**, **Norway**, and other stakeholders (IPEN and ZMWG)

1. Category of mercury-added product	Ion engines for satellites and spacecraft
2. Further description of the product	Alternative names: Ion thruster; mercury ion thruster; mercury bombardment ion thruster; Hall thruster
3. Information on the use of the product	<p>Canada</p> <ul style="list-style-type: none"> Canada has been made aware of potential uses of mercury in rocket propulsion systems in other jurisdictions¹. This is a concern to Canada because of the atmospheric fallout and distribution of mercury into the air. Most atmospheric mercury deposited in Canada comes from foreign sources, and the addition of rocket fuel to existing mercury sources would only exacerbate this issue. <p>EU</p> <ul style="list-style-type: none"> Ion thrusters are used for spacecraft propulsion and create thrust by accelerating ions using electricity. Ion thrusters ionize a propellant by adding or removing electrons to produce ions. This is mostly achieved through electron bombardment, where a high energy electron collides with a propellant atom to release electrons and create a positive ion. Mercury has been used as a propellant in the past, up to around 1980 (Fazio et al., 2018). Concerns related to mercury toxicity led to its abandonment. Manufacturers of mercury ion thrusters include Apollo Fusion (USA). Consumption: 20 kg of propellant for a representative configuration ideal for a low-orbit satellite (Bloomberg, 2019). According to information from the website of Apollo Fusion, the company intends to produce up to 500 thrusters between 2019 and 2023. This would result in a consumption of around 10 t mercury in five years (Apollo Fusion 2019). Plans for satellite constellations are expected to increase the number of satellites in Low Earth Orbit by a factor of 10 in the next 10-20 years (Fourie et al., 2019). It has been estimated that 2000 satellites would emit approximately 20 t of mercury per year over a 10-year lifetime which would largely be deposited in oceans. There is no manufacture/use in the EU. <p>Norway</p> <ul style="list-style-type: none"> At 20 Mg/yr., mercury emissions from satellites would represent about 1% of global anthropogenic mercury emissions. The vast majority of mercury emissions from satellites in Low Earth Orbit with Hall thruster propulsion will reach the turbopause (about 80 km altitude), and about 75% of the mercury reaching the turbopause is deposited in the oceans. (Fourie et al., 2019) <p>ZMWG</p> <p>According to the Apollo Fusion's website (accessed 27 April 2020), it expects to have its "first thruster in flight operation in 2020; over 100 thrusters in flight operation by the end of 2022; and over 500 thrusters in flight operation by the end of 2024."</p>

	<p>Information from experts</p> <ul style="list-style-type: none"> Mercury was used as a propellant back in the 60s, primarily because of its high storage density (a lot of kilograms of mercury can be stored in a very small volume) which is attractive for the spacecraft. There were, however, a great deal of technical difficulties with mercury and health and safety concerns, for which NASA, the primary developer, abandoned the use of mercury and started using non-mercury alternatives. Mercury will be expelled possibly in the low earth orbit, and according to the expert predictions, this exhausted mercury is likely to travel back to earth's atmosphere and eventually to the surface of the earth over several years. A NASA Review report "State-of-the-art small spacecraft technology" was released in October 2020. On page marked 76 it states that the Astro Digital Ignis Satellite will carry the Apollo Fusion ACE engine which carries 1.1 kg of "a proprietary high density propellant." The satellite launch date is given as 2020. An Astro Digital Ignis Satellite Orbital Debris Assessment report was filed with the US FCC in 2019 as a requirement to launch. On the page marked 7 it states, "the ACE propulsion system utilizes a high density proprietary inert propellant (see Proprietary Information Exhibit for details)." On the page marked 10 it states that "a rupture of the propellant tank would release gaseous nitrogen and up to 1.1 kg of liquid propellant....Droplets of propellant would be expected to leak out of vent holes in the spacecraft body, but would reenter quickly due to their high area to mass ratio."
<p>4. Information on the availability of mercury-free (or less-mercury) alternatives</p>	<p>Canada Alternatives to mercury-based propellants are available and have been used for many years.</p> <p>EU Non-mercury alternatives include Xenon (Xe), Krypton (Kr), Argon (Ar), Neon (Ne), Helium (He), Hydrogen (H₂), Iodine (I₂), Buckminsterfullerene (C₆₀), Adamantane (C₁₀H₁₆), and Air (nitrogen/oxygen).</p> <p>ZMWG Mercury-free alternatives have been available and almost universally used in recent decades (Kieckhafer and King, 2005)</p>
<p>5.(i) Information on the technical feasibility of alternatives</p>	<p>EU A heavy element, such as mercury and iodine, offers the best engine performance among the alternatives, as they allow a higher payload/propellant ratio than for example xenon.</p> <p>IPEN Non-hazardous alternatives are currently available and achieve high performance levels (xenon gas) and have been in commercial use for decades as a propellant for satellite thrusters.</p> <p>ZMWG Fazio et al. (2018) published a comparative overview of the properties of various propellants suitable for electric propulsion, comparing the physical properties and performance, and concluded that the only viable alternative would appear to be Krypton if all of the selected impacts are taken into consideration; however, Iodine and Mercury have the best performance but could be eliminated because of compatibility issues, especially in terms of spacecraft contamination and toxicity. Nevertheless, it should be noted that the former [Iodine] is current [sic] being actively pursued both in Europe and the USA</p>

	as an alternative propellant despite these issues and that the latter [Mercury] was in the past (up to around 1980) the preferred propellant choice, only being replaced by Xenon due to spacecraft interactions. Additionally, the low storage density of Krypton has important effects on the storage system, i.e. need for a bigger and/or heavier propellant tank system.
5.(ii) Information on the economic feasibility of alternatives	<p>Norway</p> <p>Fourie et al. published the study that characterizes the potential environmental impact of widespread mercury used as a satellite propellant. “Concerns related to toxicity led to the abandonment of mercury as a propellant in the 1980s in favor of noble gases, predominantly xenon (Rawlin 1982). However, the high price of xenon (\$2000/kg) coupled with burgeoning commercial space development has recently renewed interest in alternative, low-cost propellants such as mercury for electric propulsion (Kieckhafer and King 2007, Holste et al 2015, Saevets et al 2017, Elgin 2018).” The study concludes that “the environmental impact of mercury propellant is not worth the satellite cost savings of moving away from existing non-toxic propellants.”</p>
6. Information on environmental and health risks and benefits of alternatives	<p>EU</p> <ul style="list-style-type: none"> • Risk of spillage/ contamination on the ground. • Emission of mercury in orbit over the period of 5-7 years, at the height of 300 km to 1,200 km above the Earth. Due to the weight of mercury, it is expected to travel back to the surface of the Earth over several years. <p>Norway</p> <ul style="list-style-type: none"> • Satellite electric propulsion using mercury propellant, if launched, would be a major environmental concern. • The most common propellants, for example xenon, are NOT an environmental concern. <p>Information from experts</p> <ul style="list-style-type: none"> • There is a risk in launch vehicle accidents. The satellites full of mercury will get a ride into the orbit on top of a large launch vehicle, possibly 100 satellites on each vehicle. Launch vehicles, such as SpaceX Falcon 9, fail at a rate of approximately 2%, which means one in every 50 rockets will fail in some way, which could be an explosion on the launch pad or a mid-course abort that sends it down into the ocean somewhere. In those instances, thousands of kilograms of mercury would very directly be deposited on earth, around the launch-sites or in the oceans.
7. If any, additional information being submitted on mercury-added products pursuant to Article 4.4 of the Convention not addressed above (e.g. manufacture, general trade information, etc.)	NA
8. Other relevant information pursuant to Decision MC-3/1	NA

9. References

- 1 Bloomberg. (2019). This Silicon Valley Space Startup Could Lace the Atmosphere with Mercury. Available online at <https://www.bloomberg.com/news/articles/2018-11-19/this-space-startup-could-lace-the-atmospherewith-toxic-mercury>
- Apollo Fusion (2019): <http://apollofusion.com/>
- Bloomberg. (2019). This Silicon Valley Space Startup Could Lace the Atmosphere with Mercury. Available online at <https://www.bloomberg.com/news/articles/2018-11-19/this-space-startup-could-lace-the-atmosphere-with-toxic-mercury>
- Fazio et al. (2018). Alternative Propellants for Gridded Ion Engines. Available online at https://www.researchgate.net/publication/326571233_Alternative_propellants_for_gridded_ion_engines
- Fourie et al. (2019). Are mercury emissions from satellite electric propulsion an environmental concern? Published in Environmental Research Letters. Available online at <https://iopscience.iop.org/article/10.1088/1748-9326/ab4b75/pdf>
- Fourie et al. (2019). Are mercury emissions from satellite electric propulsion an environmental concern? Published in Environmental Research Letters. Available online at <https://iopscience.iop.org/article/10.1088/1748-9326/ab4b75/pdf>
- Kieckhafer and King (2005). A Kieckhafer and LB King, Energetics of Propellant Options for High-Power Hall Thrusters, Proceedings of the Space Nuclear Conference, San Diego, California, June 5-9, 2005, Paper 1092. Available online at http://aerospace.mtu.edu/__reports/Conference_Proceedings/2005_Kieckhafer_1.pdf
- Ames Research Center (2020). State-of-the-art: small spacecraft technology.
- Astro Digital US Inc. (2019) Astro Digital Ignis Orbital Debris Assessment Report (ODAR)

X. Manufacturing processes in which mercury or mercury compounds are used

Information provided by Argentina, Colombia, EU, Indonesia, Montenegro, Uganda, the USA, and other stakeholders (IPEN)

Chlor-alkali production

1. Category of manufacturing process in which mercury or mercury compounds are used	Chlor-alkali production
2. Further description of the process (if any)	
3. Information on the manufacturing activities using the process (incl. amount of mercury or mercury compounds used, production amount, etc.)	<p>The mercury cell process</p> <p>In Mercury Process, the cell consist of cell box, adjustable anode, decomposer, and mercury circulation pump. The feed brine (NaCl solution) is introduced to the cell box , where mercury is circulated by a special pump, from the decomposer and flows continuously at the bottom of cell box. The applied current is introduced through adjustable anode so then in the cell box, NaCl will be electrolyzed to the Na⁺ and Cl⁻. The ion Na⁺ will be bonded to mercury (where act as cathode) to form amalgam , Na(Hg)x and flows to decomposer. While the Cl⁻ will be oxidized at anode to form Cl² and leaves from top nozzle of cell box to go to chlorine handling unit.</p> <p>Entering to the decomposer, the amalgam, Na(Hg)x will react with de-mineralized water to form NaOH and Hydrogen gas, H₂. The generated NaOH then submitted to product NaOH handling where it will be cooled and filtered to minimized carry over of mercury in Caustic Soda product.</p> <p>The produced NaOH by decomposer having around 50 %wt of concentration, so that not necessary to be concentrated further and can be delivered to customers, directly.</p> $\text{NaCl} \xrightarrow{\text{H}_2\text{O} \ \& \ \text{Hg}} \text{Na (Hg)x} + \frac{1}{2} \text{Cl}_2 \quad (\text{in cell room / cell box})$ $\text{Na(Hg)x} + \text{H}_2\text{O} \longrightarrow \text{NaOH} + \text{H}_2 + \text{xHg} \quad (\text{in decomposer})$ <hr/> $\text{NaCl} + \text{H}_2\text{O} \xrightarrow{\text{H}_2\text{O} \ \& \ \text{Hg}} \text{NaOH} + \frac{1}{2} \text{Cl}_2 + \frac{1}{2} \text{H}_2$ <p>There are several disadvantages in Mercury Process :</p> <ul style="list-style-type: none"> ➔ It's easier any generated hydrogen in the cell box, due to dirty, higher concentration amalgam, un-even circulation and distribution mercury. The generated hydrogen will carry over in chlorine gas and in certain level will create an explosion. The generated hydrogen in the cell box also can happen with the presence of heavy metals such as Vanadium (V), molybdenum (Mo), and chromium (Cr), at the 0.01–0.1 ppm level ➔ Due to directly contact in generated of the products, the content mercury for each of product is very difficult to be avoided.

	<p>→ Another serious case with Mercury process is mercury emission to the environment, where needs hardest effort for protection this.</p> <p>Colombia Regarding the industries in Colombia, in 2016, the chlor-alkali industry, a single factory operating in Zipaquirá - Cundinamarca, eliminated the use of mercury in its production process. The use of mercury for processes in Colombia will be prohibited as of July 15, 2023.</p> <p>USA Chlor-alkali production (labelled as “Chlorine production”) is the only process in the Minamata listing that was identified as actively practiced in the United States in 2018. There is only one remaining facility using this process in the United States.</p>
<p>4. Information on the availability of mercury-free (or less-mercury) alternatives</p>	<p>(1) The diaphragm process</p> <p>In the diaphragm cell process, there are two compartments separated by an asbestos fibers where act as the permeable diaphragm. Brine is introduced into the anode compartment and flows into the cathode compartment. The chloride ions are oxidized at the anode to produce chlorine, and at the cathode, water is split into caustic soda and hydrogen. The diaphragm prevents the reaction of the caustic soda with the chlorine. A diluted caustic brine leaves the cell, then has to be concentrated to 50% by weight which consume around three tones of steam per tone of caustic soda.</p> <p>The disadvantage of this process is on usage of asbestos where well known harmful for human body and the environment</p> <p>(2) The cell membrane process</p> <p>In the membrane process, the cell is divided into two compartments, anolyte and catholyte compartment and separated by a thin activated selective membrane, which passes of sodium ion ion (Na^+) during electrolysis process.</p> <p>The anode is used an expanded metal coated by Titanium and for cathode normally using expanded metal coated by nickel, both coatings give less drop voltage and increase current efficiency.</p> <p>The saturated pure brine solution ($\text{NaCl} \pm 27\% \text{ wt}$) is circulated to anolyte compartment and lean caustic soda solution ($\text{NaOH} \pm 28\% \text{ wt}$) is circulated to the catholyte compartment, and the DC-current is introduced to electrolyze electrolyze NaCl to make ion Na^+ and ion Cl^- in anolyte compartment, and electrolyze water H_2O into ion H^+ and ion OH^- in catholyte compartment.</p> <p>The ion sodium (Na^+) will pass through the membrane and entering to catholyte compartment, meet with hydroxyl ion (OH^-) become to NaOH (Caustic Soda) and increase the concentration of lean NaOH to 32 – 34 %wt, and also, the ion hydrogen (H^+) will be reduced at the cathode to H_2 Gas. Then, the caustic soda solution and Hydrogen is separated in the separator for further handling.</p> <p>Leaves the separator, the caustic soda will be collected in the circulation tank, where some amount of it will be send to concentrator to increase the concentration to 50 %wt as the finish product, while the other amount of caustic soda will be re-diluted again by de-mineralized water to be re-circulated to the cell membrane.</p>

	<p>In the anolyte compartment, the ion chloride (Cl^-) will be oxidized at the anode to chlorine gas, where come out from the cell together with lean brine solution to be separated in the separator., for further treatment.</p> $\begin{array}{l} \text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^- \\ \text{Cl}^- \rightarrow \frac{1}{2} \text{Cl}_2 + \text{e}^- \quad (\text{at anode}) \end{array} \left. \vphantom{\begin{array}{l} \text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^- \\ \text{Cl}^- \rightarrow \frac{1}{2} \text{Cl}_2 + \text{e}^- \quad (\text{at anode}) \end{array}} \right\} \begin{array}{l} \text{(in anolyte compartment, where } \text{Na}^+ \text{ will pass through the membrane} \\ \text{to catholyte compartment)} \end{array}$ $\begin{array}{l} \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^- \\ \text{Na}^+ + \text{OH}^- \rightarrow \text{NaOH} \\ \text{H}^+ + \text{e}^- \rightarrow \frac{1}{2} \text{H}_2 \quad (\text{at cathode}) \end{array} \left. \vphantom{\begin{array}{l} \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^- \\ \text{Na}^+ + \text{OH}^- \rightarrow \text{NaOH} \\ \text{H}^+ + \text{e}^- \rightarrow \frac{1}{2} \text{H}_2 \quad (\text{at cathode}) \end{array}} \right\} \begin{array}{l} \text{(in catholyte compartment)} \end{array}$ <hr/> $\text{NaCl} + \text{H}_2\text{O} \xrightarrow{\text{DC Current}} \text{NaOH} + \frac{1}{2} \text{Cl}_2 + \frac{1}{2} \text{H}_2$ <p>The disadvantage of the membrane process is that the activity of membrane can be contaminated by such metal ion (mainly Ca^{2+}, and Mg^{2+}), so that requires a super purified brine, but this requirement can be fulfilled easily by using ion – exchange resin.</p> <p>Argentina Argentina has registered an exemption for the phase-out date on Chlor-alkali production, and the expiry date for the exemption is 2030. INDUPA, a caustic soda producer in Argentina, plans to convert its mercury cell process to ion exchange membrane technology during 2022-2025. The plan would be carried out in three stages, gradually replacing the mercury cell process with membranes.</p>
5.(i) Information on the technical feasibility of alternatives	<p>Indonesia In 1998, The 2nd large of Chlor Alkali Plant in Indonesia has successful in converting previous using Mercury Process into Cell Membranes Process . The plant capacity also increase more than two times (by expansion) to 215,000 DMTPA of Caustic Soda , instead previous capacity at 90,000 DMTPA. The success story of conversion also followed by continuously optimizations (by re-arrangement cell configurations, converting the conventional finite gap cell into zero gap cell, and some additional cell units), so that in few years, the capacity could be increased to 320,000 DMTPA, mostly with existing plant area and plant's facilities. Refer to his experience, seems that the converting Mercury Process to Cell Membrane Process is possible and relatively easy. Also, the optimization project to obtain higher productivity can be done, relatively easy.</p>
5.(ii) Information on the economic feasibility of alternatives	<p>Indonesia The main term of economic consideration in chlor alkali industry is unit consumption of power. Refer to the experience, by operate cell membrane, the unit consumption of power for rectifier is 2.2 – 2.4 MWH/DMT NaOH comparing by cell mercury, the unit consumption power is 2.7 – 2.9 MWH/DMT NaOH, means cell membrane giving less around 0.5 MWH/DMT of NaOH or any reduction for around 17%</p>

6. Information on the environmental and health risks and benefits of alternatives	<p>Indonesia</p> <p>It's already clear that among of proven process in the chlor alkali plant, the cell membrane process will give less impact to the environment, due to using non-hazardous material, comparing to usage mercury (in mercury cell process) and usage asbestos (in diaphragm process). Both Mercury and Asbestos are well known as heavy dangerous to the environment and human being. According safety risk, in the mercury cell, some factors such as un-even of distribution mercury, un-uniform distribution of current, higher concentration amalgam, disturbing mercury pump circulation, un-even bottom of cell box, are the factors that can boost an explosion in the cell box. On other hand, the potential of explosion just will happen if the membrane get big leaking during operation, so that some hydrogen can enter to anolyte compartment and meet with chlorine, to make explosion. For protect this, generally the cell membrane is equipped with interlocking system to stop operated cell whenever any indication big leaking of the membrane.</p> <p>Based on both explanations regarding with environment and safety risk, it's concluded that cell membranes process will be operated safely compared to Mercury cell and Diaphragm cell.</p>
7. Other relevant information pursuant to Decision MC-3/1	<p>EU</p> <p>Under Regulation (EU) 2017/852, the use of mercury as an electrode in chlor-alkali production is prohibited since 11 December 2017.</p>
8. References	<p>❖ EPA. 2020. Inventory of Mercury Supply, Use, and Trade in The United States – 2020 Report.</p>

Manufacturing processes using mercury as electrodes

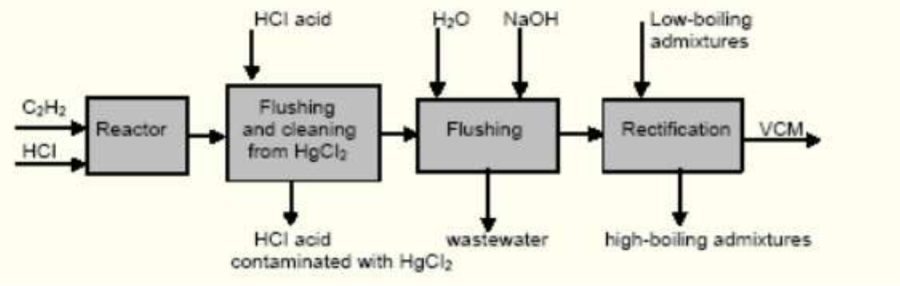
1. Category of manufacturing process in which mercury or mercury compounds are used	Manufacturing processes using mercury as electrodes, including sodium or potassium methylate or ethylate production
2. Further description of the process (if any)	
3. Information on the manufacturing activities using the process (incl. amount of mercury or mercury compounds used, production amount, etc.)	<p>EU</p> <p>Apart from chlor-alkali and alcoholates production, mercury electrodes are found to be used in the production of sodium dithionite and production of alkali metals.</p> <p>Sodium dithionite is a reducing agent, which is primarily used in vat dyeing and bleaching (Chavan, 2011). It is primarily supplied as a dry powder and is known to be effective for stripping colour and removal of multiple types of dyes.</p> <p>Alkali metals are a group of six reactive metals (lithium, sodium potassium, rubidium, caesium and francium). Due to their reactive nature, alkali metals tend to be found combined with other elements. Due to the distinct nature of these metals, their uses vary greatly, including the manufacture of fertilizers, construction of lightweight batteries and the reduction of organic compounds.</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>EU</p> <p>Suitable non-mercury alternatives are available for both sodium dithionite and alkali metal production processes, such as the zinc dust process for the production of sodium dithionite and the electrolysis of liquid sodium chloride.</p>
5.(i) Information on the technical feasibility of alternatives	EU

	<ul style="list-style-type: none"> In 2006, the mercury amalgam process accounted for only 15% of the global production capacity of sodium dithionite. The sodium borohydride process, zinc dust process and sodium formate process accounted for 10%, 35% and 40% respectively (OECD SIDS, 2006). Therefore, the mercury-free alternatives are already commercially available, and the zinc dust and sodium formate processes comprise the greatest capacity to produce sodium dithionite. In addition, Hagemann & Bischofer (2013) state that alongside the market share for the mercury cell process being relatively small, there are no specific product qualities which are associated with the mercury cell process that alternative processes cannot produce.
5.(ii) Information on the economic feasibility of alternatives	<p>EU</p> <ul style="list-style-type: none"> As mercury now comprises one of the least used catalysts for the production of sodium dithionite, this suggests that the alternative methods of production are economically feasible. Production of sodium metal using the amalgam process consumes approximately 40% less energy than the Downs process (Verband Der Chemischen Industrie e.V., 2005). However, about 99% of sodium metal is produced applying the Downs process and is accepted by the market.
6. Information on the environmental and health risks and benefits of alternatives	<p>EU</p> <ul style="list-style-type: none"> The health effects associated with the alternative processes used to manufacture sodium dithionite are not well documented (PubChem, 2019).
7. Other relevant information pursuant to Decision MC-3/1	<ul style="list-style-type: none"> In Montenegro, the Law on Industrial Emissions ("OG of MNE", No. 17/19) prohibits the use of mercury and mercury compounds and mixtures of mercury in plants, i.e., appropriate production processes. Exceptionally, the use of mercury and mercury compounds and mixtures of mercury in production processes is allowed in the production of sodium, or potassium methylates and ethylates. Furthermore, the Rulebook on the conditions of use and release of mercury and mercury compounds ("OG of MNE", No. 068/19) prescribes the conditions of use and release of mercury, mercury compounds and mixtures of mercury in the production processes of sodium or potassium methylates and ethylates. Under Regulation (EU) 2017/852, the use of mercury as an electrode in manufacturing processes is prohibited from January 2022.

8. References

- ❖ Chavan, R., 2011. Handbook of Textile and Industrial Dyeing. Available at: <https://www.sciencedirect.com/book/9781845696955/handbook-of-textile-and-industrial-dyeing>
- ❖ Hagemann, S. & Bischofer, B., 2013. Analyse der Effizienz von Maßnahmen und Entwicklung von Strategien zur Verbesserung der internationalen Chemikaliensicherheit hinsichtlich der Auswirkungen für Mensch und Umwelt. Available at: https://www.bmu.de/fileadmin/Daten_BMU/Pool/Forschungsdatenbank/fkz_3711_65_499_chemikaliensicherheit_bf.pdf
- ❖ OECD SIDS, 2006. Sodium dithionite. Available at: <http://www.inchem.org/documents/sids/sids/7775146.pdf>
- ❖ PubChem, 2019. Sodium dithionite. Available at: <https://pubchem.ncbi.nlm.nih.gov/compound/Sodium-dithionite#section=Formulations-Preparations>
- ❖ Verband Der Chemischen Industrie e.V., 2005. Positionen zur Chemie mit Chlor. [Online].

Vinyl chloride monomer production

1. Category of manufacturing process in which mercury or mercury compounds are used	Vinyl chloride monomer production
2. Further description of the process (if any)	<p>EU</p> <p>Vinyl chloride monomer (VCM) is an industrial chemical mainly used in the production of polyvinyl chloride (PVC), an important polymer used (>45 million tonnes/yr globally) as a building material and in household products (IPEN, 2015).</p> <p>Two synthesis routes are used for VCM production in an industrial scale: based on</p> <ol style="list-style-type: none"> 1 ethylene (produced from natural gas or crude oil; no mercury used; more prevalent now) 2 acetylene (coal and natural gas derived; mercury catalyst is utilized; largely phased-out for economic and environmental reasons)
3. Information on the manufacturing activities using the process (incl. amount of mercury or mercury compounds used, production amount, etc.)	<p>EU</p> <ul style="list-style-type: none"> • Mercury catalysts (in the acetylene process) are in large-scale commercial use in VCM production primarily in China (DCM Shriram, 2019), but also in India (ICIS, 2005) and Russia (UNEP, 2017). • The acetylene process is used in the EU by Fortischem AS (formerly Novacke Chemické Zavody AS) in the Slovak Republic, in parallel to the ethylene process. It is used for approximately 25% of the total VCM production at this facility. Approximately 20 t of catalyst containing 10% by weight of mercury chloride (2 t) is consumed annually in this plant. Under Annex III of Regulation (EU) 2017/852 on mercury, this manufacturing process will be phased out by 1 January 2022. • In acetylene process, coal-derived coke is heated with calcium carbonate to produce calcium carbide, which is then hydrolysed to create acetylene. Acetylene is then reacted with hydrogen chloride using mercury (II) chloride (HgCl_2) as a catalyst to produce vinyl chloride, which is then polymerized to create PVC. The catalyst is used with activated carbon as a support. When the support is installed, it contains between 8-12% mercury (II) chloride. Over time, the catalyst is depleted and once the content in the support drops below 5%, it will be replaced. However, since 2010 China promotes the use of low-mercury catalyst with an initial mercury content of about 4-5% (The GEF, 2018). <p>Figure 1 – Production of VCM using a mercury catalyst (Danish EPA, 2005)</p>  <pre> graph LR C2H2 --> Reactor HCl --> Reactor Reactor --> FlushingCleaning[Flushing and cleaning from HgCl2] HClAcid[HCl acid] --> FlushingCleaning FlushingCleaning --> Wastewater[HCl acid contaminated with HgCl2] FlushingCleaning --> Flushing H2O --> Flushing NaOH --> Flushing Flushing --> Wastewater2[wastewater] Flushing --> Rectification LowBoiling[Low-boiling admixtures] --> Rectification Rectification --> HighBoiling[high-boiling admixtures] Rectification --> VCM </pre> <ul style="list-style-type: none"> • Acetylene process of PVC synthesis was largely phased out in most of the world between 1960 and 2000 due to high energy consumption and waste, however in China this method is still pervasive due to the use of coal as a starting material (IPEN,

	<p>2015). China's VCM mercury consumption is the principal reason for continued mercury production from primary mercury mining in China, since it consumes the majority of China's mercury supply (The GEF, 2018).</p> <ul style="list-style-type: none"> • There were 14 million tonnes of VCM produced via the acetylene process in China in 2014, with a mercury consumption of 1,216 tonnes (UNEP, 2017). The amount of mercury per ton of VCM produced ranges from 97 g Hg/t VCM to 49 g/t as a result of the shift to a lower mercury catalyst (Lin et al., 2016). • The fate of mercury lost from the catalyst as it depletes is not well understood. The 2017 UNEP report on global supply, trade and demand of mercury reported that 30-50% of mercury remains in the spent catalyst and is mostly recycled while another 30-50% is caught in activated carbon filters that are also recycled. 4-6% of mercury ends up in waste products, meaning that there is approximately 30% of mercury that is lost in the process with unknown destination (UNEP, 2017). Catalyst recycling may result in significant mercury emissions due to "lack of effective mercury management and properly guided mercury recovery practices".¹⁹ • Global mercury consumption for VCM production was 1210-1240 tonnes in 2015 (UNEP, 2017). China accounted for 1217 tonnes of mercury consumption in this sector in 2014.²⁰ For calendar years 2017-2018, China reports mercury use in the range of 700-820 tonnes at 69 facilities.²¹ 520 tonnes of mercury were retrieved from recycling VCM catalysts in China in 2014 and estimates have been as high as 650 tonnes for 2015 figures (UNEP, 2017). The 2018 Global Mercury Assessment reported for the first time an estimate of emissions to air from VCM production at 58 tonnes in 2015 (UNEP, 2018). <p>Uganda and the United States/ Information from experts</p> <ul style="list-style-type: none"> • There is no vinyl chloride monomer production using mercury as a catalyst in Uganda and in the United States. <p>NRDC</p> <p>In China, notwithstanding the prohibition in the Convention against the construction of new mercury-using factories, the PVC sector is still growing, presumably through facility expansion. About 80% of China's PVC production is by the calcium carbide (mercury catalyst) process, and 20% is by the ethylene (non-mercury) process.</p> <p>Uzbekistan's largest PVC production project, undertaken as part of the "one belt and one road" initiative, was officially completed in the industrial city of Navoi, central Uzbekistan on December 28, 2019, according to People's Daily and Xinhua news agency¹. Cohesion (Beijing) Technology Co., Ltd. provided technical support for environmental protection of the project in Uzbekistan"² and refers to the use of mercury on its website.</p>
<p>4. Information on the availability of mercury-free (or less-mercury) alternatives</p>	<p>EU</p> <p><u>Main alternatives:</u> <i>Use of ethylene instead of acetylene; use alternatives to PVC.</i></p> <p>The production of VCM in most countries does not involve mercury catalysts as using ethylene as the hydrocarbon feedstock in VCM production is preferred to using acetylene. Ethylene is produced from petroleum or natural gas, while acetylene is produced mainly from coal (it can also be produced from natural gas), which is the primary reason for its continued usage in China, which has</p>

¹⁹ https://open.unido.org/api/documents/5974278/download/UNIDO%20GEF%206%20China%20VCM_CEO%20Endorsement%20%206921%20app.pdf, p. 53

²⁰ https://open.unido.org/api/documents/5974278/download/UNIDO%20GEF%206%20China%20VCM_CEO%20Endorsement%20%206921%20app.pdf, p. 38

²¹ http://www.mercuryconvention.org/Portals/11/documents/Notifications/China_Article5_5c.pdf

	<p>large coal reserves but must rely on imported petroleum which is subject to price fluctuations. Additionally, PVC plants are often located far from the sea and so use of local coal has been preferred to transporting ethylene long distances by land.</p> <p>Comments from experts</p> <ul style="list-style-type: none"> There is no easy conversion from an acetylene-based process to an ethylene-based process; virtually all legacy equipment from the acetylene process would have to be abandoned if a conversion was contemplated.
5.(i) Information on the technical feasibility of alternatives	<p>EU</p> <ul style="list-style-type: none"> As previously mentioned, it is possible to produce VCM from ethylene, rather than acetylene, using petroleum and gas as a feedstock. In China due to an abundance of coal resources and a lack of natural gas, it is likely that usage of acetylene will continue, especially in inland regions far from seaports. There is ongoing research into production of VCM using acetylene using alternative catalysts, most notably gold catalysts, which have been demonstrated to have comparable catalytic efficiency to commercial mercury catalysts (Chai et al., 2019). Other alternative catalysts include nitrogen-doped activated carbon, copper and ruthenium (Shen et al., 2018) (Li et al., 2018).
5.(ii) Information on the economic feasibility of alternatives	<p>EU</p> <ul style="list-style-type: none"> Most VCM production around the world uses ethylene as a feedstock derived from natural gas which does not make use of a mercury catalyst. This process is less energy-intensive than the mercury catalyst using acetylene process. According to an industry expert, there are economic costs related to the transportation and storage of ethylene as it is a liquid. There are also differences in investment costs of technical process equipment, with costs being higher for ethylene. Usage of mercury-free alternative catalysts, most notably gold catalysts, in the acetylene process are potentially limited by economic performance. However, (1) very low gold levels are needed as gold has a much higher activity than mercury, (2) gold catalysts have been proven to have a much longer life-time than mercury catalyst, (3) significantly less catalyst is needed due to a much lower catalyst density and (4) gold can be recovered very efficiently from spent catalyst so it can be used again to manufacture fresh catalyst. Hence it is estimated that the overall life cycle cost of gold catalyst will be in the same order as that of mercury catalyst even before including the cost of additional mercury containment measures to protect workers and the environment that may need to be implemented as long as the use and recycling of mercury catalyst continues, see for example (Johnston, P. et al , Davies C. J et al), The GEF-funded project, noted below, will be examining the economic feasibility of mercury-free catalysts.
6. Information on the environmental and health risks and benefits of alternatives	NA
7. Other relevant information pursuant to Decision MC-3/1	<ul style="list-style-type: none"> Mercury use in the production of VCM is prohibited in the EU from the 1 January 2022 according to Regulation (EU) 2017/852 on Mercury (Article 7(1) and Annex III (Part I)). There is a five-year Global Environment Facility (GEF) funded project underway with funding of over USD 16 million for the reduction and minimization of mercury in PVC production in China. This project is scheduled to be completed in 2022, and includes an expert panel established to review the mercury-free VCM production technologies, and at least two mercury-free VCM production technologies evaluated

	<ul style="list-style-type: none"> • In Japan, the Regulation on the use of mercury or mercury compounds in products and manufacturing processes prohibits the use of mercury in VCM production (Ministry of the Environment Japan, No date).
8. References	<ul style="list-style-type: none"> ❖ Chai et al. (2019). AuI as a cheap, nontoxic, and efficient alternate to commercial mercury catalyst for production of vinyl chloride monomer. Retrieved from https://www.sciencedirect.com/science/article/pii/S0926860X1830574X ❖ Danish EPA. (2005). Assessment of Mercury Releases from the Russian Federation - Intentional use of Mercury. Retrieved from https://www2.mst.dk/udgiv/publications/2005/87-7614-539-5/html/kap03_eng.htm ❖ DCM Shriram. (2019). Calcium Carbide. Retrieved from https://www.dcmshriram.com/calciumcarbide ❖ ICIS. (2005). India's DSCL expands Kota calcium carbide capacity 79%. Retrieved from https://www.icis.com/explore/resources/news/2005/07/25/2003669/india-s-dscl-expands-kota-calciumcarbide-capacity-79- ❖ IPEN. (2015). China chemical safety case study: Qihua PVC plant in Qiqihar, Heilongjiang Province. Retrieved from https://ipen.org/sites/default/files/documents/Case%20Study%20Report%20Qihua%202015r.pdf ❖ Li et al. (2018). Synthesis of Vinyl Chloride Monomer over Carbon-Supported Tris- (Triphenylphosphine) Ruthenium Dichloride Catalysts. Retrieved from https://www.mdpi.com/2073-4344/8/7/276/pdf ❖ Lin et al. (2016). Material flow for the intentional use of mercury in China. Retrieved from https://pubs.acs.org/doi/suppl/10.1021/acs.est.5b04998/suppl_file/es5b04998_si_001.pdf ❖ Ministry of the Environment Japan. (No date). Major points of measures to implement the Minamata Convention in Japan. Retrieved from https://www.env.go.jp/en/chemi/mercury/mcm/kokunaitaisaku.html ❖ Shen et al. (2018). Mercury-free nitrogen-doped activated carbon catalyst: an efficient catalyst for the catalytic coupling reaction of acetylene and ethylene dichloride to synthesize the vinyl chloride monomer. Retrieved from https://pubs.rsc.org/en/content/articlelanding/2018/re/c7re00201g#!divAbstract ❖ The GEF. (2018). Demonstration of Mercury Reduction and Minimization in the Production of Vinyl Chloride Monomer in China. Retrieved from https://www.thegef.org/project/demonstration-mercury-reduction-and-minimization-production-vinyl-chloride-monomer-china ❖ UNEP. (2017). Global mercury supply, trade and demand. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/21725/global_mercury.pdf?sequence=1&isAllowed=y ❖ UNEP. (2018). Global Mercury Assessment 2018. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/27579/GMA2018.pdf?sequence=1&isAllowed=y ❖ Johnston, Peter et al. "Discovery, Development, and Commercialization of Gold Catalysts for Acetylene Hydrochlorination", J. Am. Chem. Soc. 2015, 137, pages 14548–14557; doi.org/10.1021/jacs.5b07752 ❖ Davies, Catherine J. et al " Vinyl chloride monomer production catalysed by gold: A review", Chinese Journal of Catalysis, 37, (2016), pages 1600–1607; DOI: 10.1016/S1872-2067(16)62482-8 ❖ http://world.people.com.cn/n1/2019/1230/c1002-31527557.html ❖ https://www.sohu.com/a/329192637_503344

Production of polyurethane

1. Category of manufacturing process in which mercury or mercury compounds are used	Production of polyurethane using mercury containing catalysts
2. Further description of the process (if any)	
3. Information on the manufacturing activities using the process (incl. amount of mercury or mercury compounds used, production amount, etc.)	<ul style="list-style-type: none"> • Polyurethane is a polymer comprised of a series of organic units, which are linked by urethane (ChemEurope, 2019). • Polyurethane is available in a number of forms and densities, and is used in bedding, thermal insulation and in floorings (ibid). However, the primary use of mercury catalysts is in the production of polyurethane coatings, adhesives, sealants, and elastomers (referred to as CASE applications). • According to a major catalyst supplier, elastomers comprise approximately 90% of the mercury catalyst market (Norwegian Climate and Policy Agency, 2010). • In the formation of polyurethane, mercury catalysts are used in the reaction between a polyol and an isocyanate component. During the reaction, mercury catalysts enable a long induction period, followed by a rapid reaction for curing the product. The catalyst tends to be present in the polyol component. The mercury catalyst is integrated into the polymer and remains present in the final polyurethane product (Norwegian Climate and Policy Agency, 2010). • Organic mercury compounds provide the desired characteristics of catalysts for the majority of polyurethane applications. Mercury catalysts offer an initial induction period (pot life) where the reaction between polyurethane and the catalyst is slow or does not occur. This enables sufficient time for the mixture to be cast, following the addition of the catalyst. This provides the manufacturer with greater oversight of the polyurethane application (ibid). • Secondly, mercury catalysts engender a rapid reaction following the initial induction period, which enables the product to reach its final form and adopt the desired properties in relation to shape, density and malleability. In addition to allowing the product to take on its desired characteristics, the rapid reaction enables the production process to occur in a timely manner (COWI, 2008). • The mercury catalyst is typically added to the polyurethane systems at concentration levels of 0.2 % – 1 %. However, this depends on the specifications of the end product and the other components present (Norwegian Climate and Policy Agency, 2010). • Uses include the manufacturing of doming prints (or domed/ doming labels/stickers). They are produced by special (desktop) devices that add a liquid polyurethane on top of a printed label. The mixture is left standing to cure for a period of time and solidifies into a flexible and transparent thick resin / coating. Mercury containing catalysts were and possibly are often used to facilitate the polymerization process, leading to mercury emissions at the (indoor) place of the doming machine (ST Media Group International 2004). Following the EU ban on mercury use in PU production, many companies now offer mercury-free doming liquids that can be used with existing equipment (e.g. Stuart-Turner 2017ab). • In Uganda, at disposal phase, production of polyurethane using mercury containing catalysts contributes to 282.34 hg/kg/Yr (NEMA, 2018). <p>USA Rubberized polyurethane flooring that was installed in schools, hospitals, retirement homes, community centers, and other public spaces beginning in the 1960s and continuing into the 1990s was a historical use in the United States. A number of studies have been</p>

	<p>conducted over the years that indicate these floors, which often contain mercury in the finished product as a result of its use as a catalyst in the manufacturing process, can emit mercury vapors over the course of their lifetime, as well as when the flooring material is removed. The finished flooring typically contains 0.1 percent to 0.2 percent of mercury, usually phenyl mercuric acetate (PMA). This flooring material was previously manufactured in the United States and other countries; however, U.S. industry has indicated that no one has manufactured or offered this type of flooring for sale for many, many years, thus rendering it a legacy product. In addition, neither the 2017 Initial Mercury Inventory nor the 2020 Mercury Inventory Report indicates any production or use of polyurethane using mercury containing catalysts in the United States.</p> <p>Information from experts <i>Mercury-catalyzed polyurethane elastomers consist basically of cast PU elastomers and PU elastomer coatings. Like any catalyst used in PU elastomer systems, the mercury catalyst is incorporated into the polymer structure and remains in the final product. Over time – and accelerated by exposure to harsh environments, UV, abrasion, etc. – the polymer structure breaks down and mercury is released.</i> (COWI, 2008, 115)</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p><u>Main alternatives:</u> <i>bismuth and zinc carboxylates, tertiary amines, organotin compounds</i></p> <ul style="list-style-type: none"> • According to the European trade association for producers of diisocyanates and polyols (ISOPA) and the European Aliphatic Isocyanates Producers Association (ALIPA), using the polyurethane systems currently in place with a non-mercury catalyst does not enable the same level of performance as using these systems with mercury catalysts. Therefore, designing alternative polyurethane systems, which use alternative polyol or isocyanate components, with a non-mercury catalyst is preferable (ISOPA, 2009). • There is also the potential for the development of systems based on other polymers to replace mercury polyurethane systems. However, due to the wide range of applications required, finding suitable polymers is expected to be a complex task (Norwegian Climate and Policy Agency, 2010). • In contrast, non-mercury catalysts are available for the majority of applications and are used as catalysts in over 95% of polyurethane elastomer applications (ChemEurope, 2019). Several nonmercury catalysts with distinct properties have been developed for polyurethane elastomers, as a ‘one-size-fits-all’ approach is not applicable in the case of replacing mercury catalysts for multiple applications (Norwegian Climate and Policy Agency, 2010). • Bismuth and zinc carboxylates have been used as alternatives to mercury catalysts since the 1980s. Bismuth and zirconium systems are also available on the market as mercury catalyst alternatives. In addition, tertiary amines and organotin compounds have also been used as substitutes to mercury catalysts in a range of applications (ibid). <p>Information from experts <i>Perfectly viable substitutes to mercury catalysts are already in use for over 95% of PU elastomer systems and have been in use for many years. Tin and amine catalysts are alternatives to Hg catalysts for some PU elastomer applications, titanium and zirconium compounds have been introduced for others, while bismuth, zinc, platinum, palladium, hafnium, etc., compounds are marketed for still others.</i> (COWI, 2008, 117)</p>
5.(i) Information on the technical feasibility of alternatives	<ul style="list-style-type: none"> • Bismuth and zinc carboxylates have been adopted for many decades, and are designed to replace the use of mercury, lead and tin catalysts. These catalysts have displayed commercial success, despite their shortcomings relative to mercury (ChemEurope, 2019). For example, bismuth compounds require manufacturers to make adjustments to account for the differing reactivity of bismuth relative to mercury. In addition, bismuth compounds result in greater viscosity relative to mercury, as the reaction occurs. This produces polymers with different consistencies, relative to the polymers which a mercury catalyst produces. However, the use of a bismuth neodecanoate and zinc neodecanoate mixture enables users to

	<p>adjust the concentration of the two metals, and hence adjust the behaviour of the gel (Norwegian Climate and Policy Agency, 2010).</p> <ul style="list-style-type: none"> • Bismuth and zirconium systems are also used as mercury catalysts for the production of polyurethane elastomers. However, their sensitivity to moisture renders it difficult for these systems to act as catalysts in the presence of water. • Organotin compounds are not considered direct replacements for mercury catalysts, although they have been used to replace mercury in some applications. For example, organotin compounds are used in polyurethane systems to produce foams, coatings, adhesive and elastomers. However, these compounds cannot replace the use of mercury in all applications (ibid). • Tertiary amines have also been used as catalysts, producing a long pot life, followed by rapid reaction rate, two characteristics necessary for a suitable alternative to mercury catalysts. These can be used in adhesive, sealant and elastomer applications. However, the water content of polyurethane systems needs to be controlled, to ensure that foaming issues do not occur (ibid). • The aforementioned catalysts are all currently available on the market. <p>Information from experts <i>Known mercury-free catalysts could be used for nearly all elastomer applications, but some reduction in the key performance characteristics of activity, selectivity, catalyst lifetime, etc., may have to be accommodated until the best system is identified for a given application. (COWI, 2008, 117)</i></p>
<p>5.(ii) Information on the economic feasibility of alternatives</p>	<ul style="list-style-type: none"> • The cost of mercury-free catalysts is expected to be comparable with the cost of mercury catalysts. The cost of mercury catalysts has increased, and therefore, the price of alternatives is not expected to be a barrier (COWI, 2008). Broader research and development is expected to engender higher costs, as sourcing substitutes for a relatively simple polyurethane system is expected to require two months of research from one researcher (equivalent to €10,000 - €15,000). However, it is not expected that additional machinery costs will be incurred, as the same machinery can be used for both mercury and non-mercury systems (Norwegian Climate and Policy Agency, 2010). • Only non-mercury alternatives are used for manufacturing of polyurethane in the EU. <p>Information from experts <i>The cost of most mercury-free catalysts is quite competitive with the typical mercury catalyst cost, and even more so if one takes account of waste disposal costs, environmental and other customer concerns. (COWI, 2008, 117)</i></p>
<p>6. Information on the environmental and health risks and benefits of alternatives</p>	<ul style="list-style-type: none"> • All of the mercury catalyst used in polyurethane production remains in the product. This represents 0.2 to 1% of the polyurethane in products and several hundred tonnes of mercury catalyst globally. In most cases, polyurethane waste is subject to unspecific waste disposal and therefore represents significant risks of emissions and releases to the environment. • There are in some cases health concerns associated with non-mercury alternatives. For example, zinc neodecanoate is reported to cause potential irritation to skin and eyes. In addition, there are some adverse effects associated with ingestion of zinc and bismuth. However, bismuth and zirconium are not considered to be skin irritants (ibid). • One of the primary environmental concerns associated with the use of mercury in polyurethane elastomers is the contamination of municipal waste streams and waste incinerators. This contamination is likely to contribute towards atmospheric mercury releases (COWI, 2008), as well as being toxic to aquatic organisms (Norwegian Climate and Policy Agency, 2010). In contrast, mercury-free alternatives have minimal impact on the toxicity of aquatic organisms. • In relation to both health and environmental impacts, mercury-free alternatives have minimal impact relative to mercury.

<p>7. Other relevant information pursuant to Decision MC-3/1</p>	<ul style="list-style-type: none"> • USA: Rubberized polyurethane flooring that was installed in schools, hospitals, retirement homes, community centers, and other public spaces beginning in the 1960s and continuing into the 1990s was a historical use in the United States. A number of studies have been conducted over the years that indicate these floors, which often contain mercury in the finished product as a result of its use as a catalyst in the manufacturing process, can emit mercury vapors over the course of their lifetime, as well as when the flooring material is removed. The finished flooring typically contains 0.1 percent to 0.2 percent of mercury, usually phenyl mercuric acetate (PMA). This flooring material was previously manufactured in the United States and other countries; however, U.S. industry has indicated that no one has manufactured or offered this type of flooring for sale for many, many years, thus rendering it a legacy product. In addition, neither the 2017 Initial Mercury Inventory nor the 2020 Mercury Inventory Report indicates any production or use of polyurethane using mercury containing catalysts in the United States. • In the EU, Regulation (EC) No 2017/852 prohibits manufacturing processes in which mercury or mercury compounds are used as a catalyst from 1 January 2018. • Before Regulation (EC) No 2017/852 came into effect, national legislation in Norway exceeded EU-level restriction, prohibiting the production, use and sale of mercury compounds, which include polyurethane elastomers using mercury (COWI, 2008). • In 2017, Japan implemented the Mercury Pollution Prevention Act, which adopts measures in line with the Minamata Convention, as well as additional stricter measures. In the National Implementation plan, Japan states that ‘no manufacturing process using mercury catalysts has been found in the polyurethane production processes’ (Mercury Convention, 2017, p. 16). <p>ZMWG</p> <p>In Serbia, the national legislation on Chemicals prescribes bans and restrictions of use, placing on the market and production of Mercury and Mercury compounds. The law established the legal basis for adoption of the Rulebook on Bans and Restrictions of Production that introduces annex XVII of EU REACH Regulation and stipulates that five phenylmercury compounds are known to be used especially as catalysts in polyurethane systems shall not be produced, placed on the market or used as substances or in mixtures after 10 October 2017 if the concentration of mercury in the mixtures is equal to or greater than 0.01% by weight (Mihajlov et al., 2018).</p>
<p>8. References</p>	<ul style="list-style-type: none"> ❖ ChemEurope, 2019. Polyurethane. Available at: https://www.chemeuropa.com/en/encyclopedia/Polyurethane.html ❖ COWI, 2008. Options for reducing mercury use in products and applications, and the fate of mercury already circulating in society. [Online] Available at: http://ec.europa.eu/environment/chemicals/mercury/pdf/EU_Mercury_Study2008.pdf ❖ ISOPA, 2009. Personal communication with Wolfram Frank, ISOPA Secretary General/ALIPA Sector Manager. European Aliphatic Isocyanates Producers Association (ALIPA) and the European trade association for producers of diisocyanates and polyols (ISOPA). ❖ Mercury Convention, 2017. National Implementation Plan for Preventing Environmental Pollution of Mercury and Mercury Compounds. Available at: http://www.mercuryconvention.org/Portals/11/documents/NIP/Japan_NIP_EN.pdf ❖ Minister of Justice, 2019. Products Containing Mercury Regulation. Available at: https://lawslois.justice.gc.ca/PDF/SOR-2014-254.pdf ❖ Norwegian Climate and Policy Agency, 2010. Annex XV Restriction Report: Proposal for a Restriction. Available at: https://echa.europa.eu/documents/10162/13641/annex_xv_restriction_report_phenylmercury_compounds_en.pdf ❖ ST Media Group International (2004) Raising Product Appeal Through Doming. https://www.screenweb.com/content/raising-product-appeal-through-doming

	<ul style="list-style-type: none"> ❖ Stuart-Turner (2017a) Royal Adhesives shows mercury-free doming system at Fespa. https://www.printweek.com/product-news/article/royal-adhesives-shows-mercury-free-doming-system-at-fespa ❖ Stuart-Turner (2017b) Kimjaya shows mercury-free doming resins at Fespa,. https://www.printweek.com/product-news/article/kimjaya-shows-mercury-free-doming-resins-at-fespa ❖ US EPA, 2015. Petition to promulgate reporting rules for mercury manufacturing, processing, and importation under Section 8(a) of the Toxic Substances Control Act. Available at: https://www.epa.gov/sites/production/files/2015-09/documents/2015-06-24-tsca_hg_reporting_petition-final_0.pdf ❖ World Bank, 2019. Capacity Strengthening for Implementation of Minamata Convention on Mercury Project. Available at: http://projects.worldbank.org/P151281?lang=en ❖ NEMA. (2018). National Minamata Initial Assessment (MIA) Report. Available at http://www.mercuryconvention.org/Portals/11/documents/MIAs/Uganda-MIA-2018.pdf ❖ Mihajlov et al. 2018. Mercury Initial Assessment for the Republic of Serbia. Available at https://www.researchgate.net/publication/330514455_Mercury_initial_assessment_for_the_Republic_of_Serbia
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Other processes using mercury containing catalysts

1. Category of manufacturing process in which mercury or mercury compounds are used	Other processes using mercury containing catalysts
2. Further description of the process (if any)	<p>EU</p> <p>Apart from VCM and polyurethane production, mercury catalysts may also be used to promote a large range of polymer reactions in production processes (COWI, 2008), for example, in producing 1- aminoanthraquinone and anthraquinone derivatives, vinyl acetate and keto acids.</p>
3. Information on the manufacturing activities using the process (incl. amount of mercury or mercury compounds used, production amount, etc.)	<p>EU</p> <p>Vinyl acetate monomer is an important material used in the production of polymers, and is used in plastics, paints, varnishes, and glues (Kumar, et al., 2006). Similarly, keto acids are used in industry as solvents and in pharmaceuticals. 1- aminoanthraquinone is used for colorants and pigments in a number of products (PubChem, 2019a).</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>EU</p> <p>There are substitutes available to the use of mercury in polymer production processes, such as zinc and palladium. In addition, alternative processes can be used to synthesise some materials. The development of substitutes is still ongoing in some cases, in attempts to reduce the complex nature of separating by-products.</p>
5.(i) Information on the technical feasibility of alternatives	<p>EU</p> <ul style="list-style-type: none"> • The alternative process to produce 1-aminoanthraquinone does result in the production of multiple products, requiring hydrogenation. This results in the need for complex methods of separation to produce pure 1-aminoanthraquinone (IFI CLAIMS Patent Services, 2019a).

	<ul style="list-style-type: none"> • Zinc and palladium provide technically feasible substitutes for mercury and are currently used in polymer production processes (COWI, 2008). • Research into alternatives to the use of mercury in the synthesis of keto acids for polymer applications are still ongoing. Therefore, technically feasible alternatives are not currently available and further research developments are necessary (IFI CLAIMS Patent Services, 2019b).
5.(ii) Information on the economic feasibility of alternatives	<p>EU</p> <ul style="list-style-type: none"> • Regulation (EU) 2017/852 prohibits mercury use as a catalyst, which implies that it is economically feasible for EU industry to use mercury-free alternatives.
6. Information on the environmental and health risks and benefits of alternatives	<p>EU</p> <ul style="list-style-type: none"> • The phasing out of the use of mercury as a catalyst in the polymer industry will engender beneficial health and environmental effects. Alternatives such as zinc or iron chloride catalysts do not pose the same health threats linked to exposure or the environmental concerns associated with the release of mercury.
7. Other relevant information pursuant to Decision MC-3/1	<ul style="list-style-type: none"> • Under Regulation (EU) 2017/852, processes using mercury as a catalyst are prohibited. Little information exists on the use of these processes in the EU. However, the lack of protest during the negotiations of the Regulation implies that there is no significant use.

8. References

- ❖ COWI, 2008. Options for reducing mercury use in products and applications, and the fate of mercury already circulating in society. Available at: http://ec.europa.eu/environment/chemicals/mercury/pdf/EU_Mercury_Study2008.pdf
- ❖ IFI CLAIMS Patent Services, 2019a. Synthesis of 1-amino-anthraquinone. Available at: <https://patents.google.com/patent/EP0499451A1>
- ❖ IFI CLAIMS Patent Services, 2019b. Method for synthesis of keto acid or amino acid by hydration of acetylene compound. Available at: <https://patents.google.com/patent/EP1932824A1>
- ❖ Kumar, D., Han, Y.-F., Chen, M. & Goodman, D., 2006. Kinetic and spectroscopic studies of vinyl acetate synthesis over Pd(100). Catalysis Letters 106: 1-2
- ❖ PubChem, 2019a. 1-Aminoanthraquinone. Available at: <https://pubchem.ncbi.nlm.nih.gov/compound/1-aminoanthraquinone#section=Use-and-Manufacturing>

Gold plating

1. Category of manufacturing process in which mercury or mercury compounds are used	Gold plating
2. Further description of the process (if any)	Alternative names: fire gilding, mercury gilding
3. Information on the manufacturing activities using the process (incl. amount of mercury or mercury compounds used, production amount, etc.)	<p>IPEN</p> <p>Metal plating (gold plating) is a process in which gold lining/painting is conducted on metal objects (e.g. statues, sculptures) by mixing mercury and gold together in a hand held mortar and pestle for extended hours thus preparing paste of gold and mercury. The paste is applied over the metal statue and then heated with a blow torch to evaporate mercury with gold plating remaining on the statue.</p> <p>Gold plating (gold-mercury amalgam) is one of the traditional works primarily practiced by an ethnic community in Nepal and has a history of many centuries. According to Department of Archaeology (DOArc), a total of 190,212 items of gold-plated</p>

	<p>sculptures having a total weight of 1255.33 MT were exported in the year 2016/17 and this led to an estimation of 12,825 Kg of mercury used in preparing the above sculptures. The gold-plated sculptures are mainly exported to China, India, Sri Lanka, Thailand, Bhutan, including others.</p> <p>Information from experts: Fire gilding is sometimes used for the restoration of ancient artwork to provide a surface structure and color that resemble the original product. In that case, strict measures are mandated to ensure safe working conditions and to minimize mercury releases to the environment. However, many originally fire gilded objects are restored by electroplating (Darque-Ceretti and Aucouturier 2013).</p>
4. Information on the availability of mercury-free (or less-mercury) alternatives	<p>IPEN There is a strong belief among processors that gold plating carried out through this process lasts longer and is better quality than gold electroplating – the main industrial alternative. The latter methods does have some limitations with larger statues requiring a large bath and a lot of gold.</p> <p>Information from experts: Other methods for gilding objects include leaf gilding (by attaching very thin pieces of gold), depletion gilding and powder gilding (Darque-Ceretti and Aucouturier 2013).</p>
5.(i) Information on the technical feasibility of alternatives	NA
5.(ii) Information on the economic feasibility of alternatives	NA
6. Information on the environmental and health risks and benefits of alternatives	<p>IPEN As regards gold plating, it is estimated that about 95% of the used mercury is released to atmosphere while blow torching the sculptures with hot flame to remove the mercury; also, 3% of Hg may get into water used to wash the sculptures and only 2% might deposit into the soil in the immediate vicinity of gold plating activities. Gold plating (gold-mercury amalgam) is identified as the highest contributor in releasing mercury in Nepal.</p> <p>Studies of occupationally exposed workers in Iran confirm health impacts from gold plating using mercury (Vahabzadeh and Balali-Mood, 2016).</p>
7. Other relevant information pursuant to Decision MC-3/1	<p>IPEN Metal (gold) plating technique has been used for centuries to decorate religious statues, artworks, clocks, porcelain and furniture. The practice was made illegal in France in the 1830's due to the severe health impacts on artisans using the technique.</p>

8. References

- ❖ Vahabzadeh M, Balali-Mood M. (2016) Occupational metallic mercury poisoning in gilders. *Int J. Occup Environ Med* 2016: 7-122
- ❖ Ministry of Forests and Environment. 2019. Minamata Convention Initial Assessment (MIA) in Nepal. Available online at http://mercuryconvention.org/Portals/11/documents/MIAs/Nepal_MIA_2019.pdf
- ❖ Darque-Ceretti, E.; Aucouturier, M (2013) Gilding for matter decoration and sublimation. A brief history of the artisanal technical know-how. *Int. J. Conservat. Sci.* 4, 647-660. <http://ijcs.ro/public/IJCS-SI-Darque-Ceretti.pdf>

Other information

US EPA identified the following additional uses of mercury in manufacturing processes through the information submitted under the mercury inventory reporting rule:

- Bonding weld head (catalyst)
- Molecular beam epitaxy
- Quality analysis (density measurement of tungsten bars)
- Inactivation
- Quality control test (small arms ammunition case-mercury stress crack)

Information from experts

Welding is a process of joining two pieces of material (typically a metal) through the use of force or heat. In (resistance) seam welding workpieces are moved along a line between two rotating welding heads/ wheel electrodes. The heat caused by an electric current produces a continuous welding seam. In some welding machines, mercury is used as an electric contactor between the rotating welding heads and the arms that are holding them.

Mercury-free welding heads and welding machines are available on the market.
