Guidance on mercury releases to land and water under article 9 of the Minamata Convention on Mercury
Compilation of comments as of 24 Feb 2023

Comments received from:

- Argentina
- EU and its member states
- Thailand
- US (email text from the expert group member)
- Association of Lighting and Mercury Recyclers (ALMR)
- International Council on Mining and Metals (ICMM)
- International Dental Manufacturers Association (IDM)
- IPEN
- Alfa Laval Technologies AB
- Atium
- OASIS

General comments

Submitter	Comments
Argentina	Chapter 3. It would be clarifying to introduce this chapter on control releases describing mercury speciation (as described in line 350), and refer to the concern regarding methylation and bioaccumulation of mercury that occurs in the aquatic environment; which is avoidable if inorganic mercury is not released in the first place.
Argentina	Chapter 3. Techniques could be introduced making an analysis considering best efficiencies were found combining them. As they often consist on a pretreatment (removal of uncontaminated solid particles), treatment (reduction/oxidation in order to obtain mercury specie susceptible to treatment, precipitation, etc) and physical removal (filtration, coalescence, adsorption, etc.); techniques could be regrouped in those categories.
Argentina	Chapter 3.3 Ion exchange: Analysis on utility and situations in which this technology is convenient are missing. This method has advantages such as the possibility of performing a pre-concentration of mercury for low concentration samples, in order to reduce concentrations of releases to even lower limits; and may prove to be applicable as a rapid screening method for mercury speciation in environmental samples (potential for monitoring's source in the last comment section). In addition, a comment on negative aspects could be included, as mentioned before, regarding useful life and resin replacement.
Argentina	Chapter 3.4 Adsorption on activated carbon: Desorption process is missing; and 3.5 Biological treatment: Sludge disposition or post treatment as well. General comments addressing the need for a post treatment or disposal that may involve capacity building should be taken into account in order to make an informed decision when choosing a technique.
Argentina	APPENDIX: Emerging and innovative techniques. Aminopyrrolidine dithiocarbamic acid (APDC) or diphenylthiocarbazon (dithizon) coprecipitation of the trace metal with a thiol-containing organic complexing agent seem promising. Specificity for the removal of heavy metals as an alternative to sulfide, interesting when there are ambient chelators in industrial effluents.
EU	The adding of a prefixed subchapter "*Chemical forms of mercury in water and land*" in Chapter I '*Introduction*' would be helpful for the reader's understanding and to prevent unnecessary duplications in further chapters of the Guidance.

	This will mirror what has been done regarding the Guidance on best available techniques and best environmental practices taking into account any difference between new and existing sources and the need to minimize cross-media effects, adopted at COP1 (UNEP/MC/COP.1/7), in accordance with Article 8, paragraph 8, of the Minamata Convention (see section 1.3 '*Chemical forms of mercury*')
Atium	We are a university spinoff startup developing a research-based electrochemical technology for selective removal of mercury from industrial wastewater and from acids. While not able to compete for BAT-status yet, we have seen significant competitive advantages compared to conventional solutions. These are mainly a high removal efficiency (reaching below the ppb-range), very low waste generation, corrosion resistance and selectivity towards mercury ions. During 2023 and 2024 we will be scaling up and piloting with industrial users, to demonstrate the benefits. As I wrote, we are not a commercially available solution yet, but will be in 2-3 years. If there is any room in the report relating to the future outlook, current R&D-projects or similarly, we would love to contribute. Please reference our website www.atium.se or contact me, as well as the research of Dr. Björn Wickman at Chalmers University of Technology in Göteborg, Sweden.
Alfa Laval Technologies (PW)	The draft has taken good amount of information on technologies that can be used for mercury removal for waste treatment. However, the coverage on technologies and process description are limited to merely downstream treatment of mercury contaminated wastewater. It is strongly recommended to include more information on upstream treatment of mercury removal from sources, especially from hydrocarbons in oil and gas industries. Substantial efforts have been paid by companies in this industrial sector, including Shell, Chevron, Schlumberger, and Alfa Laval, over the past few decades in developing sustainable technique to reduce mercury emission to the environment. It has been suggested by industrial process engineers and technologists to adopt self-cleaning filtration technique, either as self-cleaning membrane filtration unit (den Boestert et al., 2021) or self-cleaning centrifugal separator (Manelius & Aguedach 2018), to be used as pre-treatment facility in highly contaminated waste flow before sending effluent to downstream polishing for mercury removal. Using finer adsorption material (powder), for example, granulate in the size range 5-10 µm, can be effective with a filter/separator system. This use of finer granule structure can significantly increase adsorption surface area compares to fluid adsorption beds or adsorption pellets. In addition, by dosing the fine adsorption material in combination with continuous filtration (frequent removal of the filter cake), the system is less prone to adsorbent fouling effects. Continuous separation equipment like Alfa Laval disc stack centrifuges with self-ejecting (discharge) solid removal function, are ideal to be used for removal of condensates at micron level. Such technology of using Alfa Laval PX separators has been successfully applied to mercury removal from crude oil streams (Manelius & Aguedach 2018). Self-cleaning filtration for mercury during decontamination where mercury is present in solids (mercury sulphide) has been applied at the Den Helder gas and condensate receiving plant in the Netherlands (den Boestert et al., 2008).
Alfa Laval Technologies (MT)	On a general level, the document misses out to recognize centrifugal separation as one method to remove mercury contaminants from crude oil streams. This has been used previously in Oil & Gas and still in use with excellent results. The comments proposed in this review address this in the relevant sections of the document.
ALMR	Of all the sources of mercury discussed in the draft guidance document, throughout the reference materials, as well as Article 11 paragraph 2, mercury lighting is not specifically called out. We have had numerous discussions about recycling mercury lighting at the COP meetings, the intercessional meetings and the GMP Waste Management Webex zoom conferences, yet there is no guidance to specifically inform countries that the only fail-safe method to prevent uncontrolled mercury releases from lighting is to prevent uncontrolled handling. It is guaranteed that uncontrolled handing causes breakage, releasing mercury.
ALMR	Lighting is the most ubiquitous source of mercury that is released into the environment. While lighting contains less mercury per unit than many other sources, the fact that lighting is used by most humans on earth means that releases from 10s of billions of mercury lights occurs annually directly into air, water and on the land. And these releases occur in billions of locations. The chemical and biological fate of this mercury is well understood.
ALMR	Many developed countries have established end-of-life management systems for mercury lighting, including collection and safe processing to prevent mercury releases. Most developing countries and SIDS do not have this. Moreover, even in developed countries with infrastructure, policy exemptions and low enforcement contribute to low recycling rates. Some of the GMP partners have described lighting recovery systems, mercury removal techniques

	and reuse of the materials that comprise lighting. This information has been provided to the GMP in the WMA Catalogue, Source and reference materials and Success Stories. We suggest that references to these materials, or excerpts from these materials be included in the Guidance documents here.
ALMR	In all countries there are low risk methods to minimize or prevent uncontrolled breakage leading to mercury releases. Where population is high there are government and private collection events followed by legal recycling. Where population is lower, or where capital investment can't be supported, there are low-cost collection programs and pre-treatment options that lead to the lighting being sent to other countries for complete recycling.
ALMR	There is an established industry, with members including both Parties and Stakeholders of the Convention, that can set up or assist with any program to divert mercury lighting from uncontrolled breakage. We believe that this approach is under-utilized due to intense pressure to prioritize the sale of lighting where no end-of-life management exists. More recently, pressure to sell LED lighting to replace mercury lighting, combined with regulatory/statutory policies to ban mercury lighting are upstaging the platform to recycle. To the degree that this disparity exists we can expect many years or decades of uncontrolled releases.
ALMR	Unlike many of the sources of mercury releases that come from corporate or institutional activities, lighting is used by individuals, households, small businesses, and consumers in general. Empowering people everywhere to divert lighting from the trash helps each person take personal responsibility. We think this is hugely rewarding and will also help people embrace the other elements of the Guidance.
ICMM	Experts in industrial wastewater treatment from ICMM member companies are concerned over the provision of ranges of achievable concentrations in the draft Guidance document without more information on the design basis, aqueous matrix, unit operations and reagents utilized, operating conditions (especially pH), equipment utilized, residuals management, etc that give rise to those values. Such an approach is not appropriate or helpful in informing users of the guidance on BAT/BEP measures to be taken. Experts are also concerned that the suite of technologies included in the document is not comprehensive as several control applicable technologies are not described; the control technologies included seem to be focused on those used in the chloralkali sector. We have briefly reviewed the information provided in the technical Annex and find that it does not describe the full range of conditions that can exist. Consequently, the technical Annex neither justifies the cited performance levels, nor justifies their generic read-across to all scenarios. To ensure that the BAT/BEP Guidance remains generically applicable, it is recommended to avoid accidentally misleading users of the guidance by speculating about general relevance of concentrations achieved in an incomplete set of circumstances. Generally, many of the techniques described in Section 4 are applicable across several different potential sources – so not really "for specific sources". This raises the question of whether it is advisable to keep Chapter 4, or whether all gathered information should instead be presented in Chapter 3.
ICMM	The following references might also be helpful for improving the other sections of the BAT/BEP draft guidance: • [EPRI] Electric Power Research Institute. 2015. Flue Gas Desulfurization (FGD) Wastewater Chemical Precipitation Bench-Scale Treatability Study. 3002004893. Technical Update. August 2015. • [EPRI] Electric Power Research Institute. 2013. Case Studies to Evaluate FGD Wastewater Physical/Chemical Treatment Performance. 3002001202. Technical Update. December 2013. • [EPRI] Electric Power Research Institute. 2010. Evaluation of Technologies Implemented for Treatment of Mercury from Flue Gas Desulfurization Wastewater. 1019873. Technical Update. December 2010. • [US EPA] United States Environmental Protection Agency. 2015. Technical Development Document for the Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category. EPA/821/R-15/007. September 2015. • [US EPA] United States Environmental Protection Agency. 2013. Technical Development Document for the Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category. EPA/821/R-13/002. April 2013.

	• [US EPA] United States Environmental Protection Agency. 2007. Treatment Technologies for Mercury in Soil, Waste, and Water. August 2007. • • [US EPA] United States Environmental Protection Agency. 1997. Capsule Report: Aqueous Mercury Treatment. EPA/625/R-97/004. July 1997.
IDM	BAT/BAP for dental amalgam Amalgam Separators that meet the ISO 11143 Dentistry – Amalgam Separator standard are currently the BAT for capture of amalgam waste. These separators are placed in line after the suction system, separating the water and solid particles that come from the patient's mouth after either placement of dental amalgam or removal of old amalgams. This prevents amalgam waste discharge to waterways. The particles range in size from 1mm to 1 micron and have a very high mass to surface ratio. It is important to note that blood, tissue and saliva are also captured and when the amalgam container is full, the contents should be covered with a non-chlorine disinfectant to kill the bacteria and virus's present. There are 4 classifications of Amalgam separators Type 1: centrifugal system Type 2: sedimentation system Type 3: filter system Type 4: any combination of types 1, 2 and 3 The filled catchment container must be collected/sent to an authorized recycler for recycling and the retrieved mercury be sequestered or used again for permitted purposes. BAP for dental amalgam is to collect the larger amalgam waste particles (contact waste amalgam) that are captured in the filter in the dental chair and store these in a suitable container, again covered with a non-chlorine disinfectant for recycling. Any teeth that are removed with amalgam still present should be placed in this container. Amalgam that has been mixed and not used on the patient (non-contact amalgam) should be placed in a separate container or in the same contact waste amalgam container for recycling.
IPEN	The BAT BEP draft guidance is a good start but more detail is needed in some sections such as releases from chlor-alkali facilities and how to control/eliminate them. Similarly the pulp and paper section would benefit from more detail. Key issues are what sources within the industry sectors should be identified. If it is certain chemicals that are used e.g. slimicides in pulp mills – BAT BEP could require substitution of those chemicals for non-mercury alternatives rather than end of pipe filtrations systems that cannot fully eliminate releases.
OASIS	The report should be focused to the significant sources of mercury compound emissions that can reach the air, soil and water. This primarily refers to anthropogenic sources of pollution such as mines (gold mining), coal mining, waste (nuclear waste, medical, battery disposal mine tailings, fluorescent lamps etc), mine tailings. The text included sources that sporadically emit mercury compounds in very low concentrations (ppb or ppm) or in some case even wrongly reports that some sources do contain mercury compounds (Oil and gas). It is also important to distinguish natural and anthropogenic sources of emission of Hg (to add not more than one paragraph). Mercury and its compounds can be found in nature, and its existence in nature cannot be eliminated such as volcano eruptions or ore deposits or in soil that is formed on the rock and minerals that contain mercury. With an average share of 0.083 ppm in the Earth's crust, mercury ranks 65th in terms of abundance among chemical elements in nature.

	However, cinnabarite (HgS) is an ore with high concentration of Hg. For instance, there is a HgS deposit, located in the vicinity of Belgrade (Avala mountain), which is no longer exploited, but for sure a certain hydro-geo-chemical environment can enable further dissemination of mercury compounds into the water and soil even though the exploitation is closed. In that respect, management of the closed mine and its tailings is very important for the mercury pollution control. Special attention has to be paid to the coal combustion in power plants that are significant sources of emission of mercury into the air. In particular a special attention has to be paid to air quality monitoring from the qualitative and quantitative point of view such as PM 2.5 and PM 10 that are associated with mercury emitted from coal mines. Parties should to be therefore oriented towards the comprehensive monitoring of air, water and soil as well as the elimination of mercury compounds from the technological process and waste disposa, mine tailings, while not paying to much attention to the small concentrations of mercury from the natural source of emission (volcano, geological settings etc). The report should include the explanation of the level of toxicity for humans of each mercury compound. The toxicity of mercury depends on its chemical form and the type of exposure. Compounds containing mercury in oxidation state +I are less toxic than compounds of mercury in oxidation state +II because they are less soluble (it is important to compare analogous compounds, for example HgCl2 and Hg2 Cl2). On the other side, organic mercury compounds (methyl mercury and dimethyl mercury) are more toxic than inorganic ones. Methylmercury can be primarily found in fish in the aquatic environment. Fish and fish products are the main source of methylmercury. In terms of the best environmental practices, I would kindly suggest you to take into consideration natural products – minerals such are clays and zeolites that are in use for the prevention and protection of soil pollution with mercury under section 3.3 Ion-exchange . Citation: Gordana Grujic, 2015, UNCCD 3rd Scientific Conference, Mexico: There are many cases of heavy metal dissemination occurred, and mostly it is demonstrated that the clay fractions exert a major control on pollution retention and mobilization. Clay minerals are essential constituent of soil at the interface of the major environmental mediums, between air and solid earth, surface water and groundwater, that occurred in most pathways of geological settings and in rocks itself and hence are important to the transfer of potential pollutants in different waste disposal, from very communal to mining ones. Based on their mineralogical peculiarities, clays can be used in barriers for waste disposal to prevent percolation in the geological-geochemical environment. Clays are characterized by a specific grain size and peculiar properties such as low permeability and excellent adsorption capabilities for cations molecules, due to its high rate of cation exchange capacity (CEC), depending on their mineral composition and structural layers disorder. The highest rate of CEC from 2.0 – 0.6 (meq/g) are specific to clay minerals including Vermiculite, Saponite and Montmorillonite, while the lowest rate of 0.02 – 0.5 (meq/g) show Kaolinite, Illite, Glauconite On the other side, zeolites have the higher CEC than clays. The selectivity of the zeolites towards the cations examined differs in the order: Pb+2> Cd+2> Cs+> Cu+2> Co+2> Cr+3 >Zn+2> Ni+2> Hg+2. This depends on the fact that adsorption phenomena are influenced by charge density as well as by hydration energy and ionic radius of the cations.
OASIS	Additional clarification related to the chemical composition of the crude oil. There are scientific manuscripts related to the presence of mercury in crude oil, but in most cases the conc. of mercury is very small and probably the origin of mercury is sedimentary rocks around the crude oil deposit. Crude oil doesn't contain mercury compounds based on the literature I learned and data I have obtained in some projects. I have been working for the national oil company in particular on the organic geochemical research of crude oil, and I have never seen a result of the crude oil with mercury even in a trace conc..

	Of course, the composition of crude oil depends on the geological settings, so in that respect in some parts of the world maybe there are cases with small conc of mercury detected. I made my comments base on the research I have been involved.

Specific comments

Submitter	Line	Comment
OASIS	11	To add air: reducing releases of mercury and mercury compounds to air, land and water from relevant sources identified by the Party
IPEN	12	Is it premature to state this guidance has been adopted?
ICMM	19	We noted at the informal meeting of experts on 19/December 2022, that experts agreed to insert the following paragraph to clearly define 'relevant source': "*A "relevant source" is any significant anthropogenic point source of release as identified by a party that is not addressed in other provisions of the Convention. Paragraph 3 of article 9 provides that each party identify the relevant point source categories.*"
OASIS	22	To add air: Minamata Convention addresses mercury releases to air, land and water
IPEN	24&25	Selected sources are included but others should be added including pulp and paper mills and alumina production residue from the Bayer process such as 'red mud'. Also residues from any industries using the acetylene (C2H2) hydration process to produce acetaldehyde. Residues from this process contain considerable leachable mercury compounds.
ALMR	45	The reference to Article 9 paragraphs 4 and 5 states that "A Party with relevant sources shall take measures…". All Parties do have and use lighting but do not "take measures to control…". This reference clearly includes mercury lighting, yet subsequent text does not discuss controls for lighting waste.
ALMR	62 Table 1.	It is not clear whether lighting is considered a relevant point source. Some would argue that it is not a point source in the traditional sense of point sources, and others would argue that billions of discarded mercury lights annually are billions of small point sources. Either way, we recommend that a reference to lighting be included in section 5.5.1-5.5.9 with Manufactured products with intentional use of mercury.
IPEN	Table 1	More information required on the cement industry residues such as CKD and how they are managed, disposed or stockpiled. The recent webinar on Mercury Releases from the Cement industry Area Meeting (mercury partnership) should provide more detail that could be used.
IPEN	Table 1	5.3.2 more information required on the use of mercury based slimicides in process waters and their subsequent releases
IPEN	Table 1	5.3.4 Releases from mercury based pesticides should be included. In Australia the herbicide Shirtan (used on sugar cane) released 5000 kg Hg annually into waterways. Release is presumed to be ongoing despite deregistration of the product.
IPEN	Table 1	There is no mention of releases from Hg contaminated sites or methods to control them in this table. Does the Minamata Contaminated sites guidance address releases directly? If not it should be addressed here.
IPEN	Table 1	5.7.3? Numbering incomplete. The issue of mercury releases from shipbreaking is significant especially breaking FSOs, FPSOs, decommissioned pipeline infrastructure etc. where mercury is bonded via amalgamation to steel hulls and cut up or subject to 'flame cleaning' with blow torches on beaches releasing mercury to air, soil, sediment and ocean water. This should require detail in chapter 4.
IPEN	Table 1	5.8.1 should this read 'releases from air pollution control system *residues'?*
OASIS	Table 1	To add air: Releases to air, land and water from coal storage, coal washing and air-pollution-control systems.
ALMR	64 and throughout	We recommend that these sections specifically include methods to avoid releases from lighting in the discussions of BEP and common techniques for control of releases.

	Chapter II and Chapter III	
Argentina	70 -71	Costs for application, equipment maintenance and capacity building of such technology.
Argentina	73	For general steps an example of each one would be useful. Maybe the example could be included at the end of chapter III once techniques are explained.
ICMM	94-101	With reference to our general comment (above), we recommend that Section 2.2 and information about performance levels in Chapters 3 and 4 be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
Argentina	105	In accordance with our previous comment, also considerations related to technical skills training/capacity building costs required.
ICMM	119-124	We noted at the informal meeting of experts of 19/December 2022, that experts agreed to delete these lines of text as they are not directly related to control of mercury releases.
US	132-158	I am late to realizing how much the different versions of draft guidance have changed, but notice with concern the new sections on cross-media effects. Specifically, the discussion of air pollution control (cross media effects) without any reference to Article 8 is contrary to the previously understood implementation of the Convention.
IPEN	141 - 142	It is not clear how *effluent sedimentation reduces mercury concentrations.* While inorganic mercury may partition to the sediment it will increase mercury concentrations in the sediment. Organic mercury compounds and specifically methyl mercury may increase in the liquid fraction during sedimentation due to bacterial action during thee process. What sort of lining is required in the sedimentation pond to prevent mercury releases to groundwater? More detail and references required.
IPEN	150 - 151	More detail on release prevention from final disposal of sludges required. Specifically leachate collection and treatment to prevent groundwater contamination.
Argentina	152-158	It is referring to a technique not described before and not explained. "There are techniques that may be used to control the releases of a range of pollutants, such as heavy metals. ~~Consideration should be given to the advantages of using techniques capable of controlling several pollutants simultaneously to deliver mercury co-benefits.~~ For instance, the treatment effectiveness concentrations used for chemical precipitation and sedimentation technology are based on optimized treatment for concomitant multiple metals removal, for example, coprecipitation of heavy metals in presence of Iron (a metal with the following characteristics: natural coagulation, adsorption of heavy metals onto iron solids). Thus, even though metals have somewhat different theoretical solubilities, they will be removed at very nearly the same rate in a chemical precipitation and sedimentation treatment system operated for multiple metals removal. Consideration should be given to the advantages of using techniques capable of controlling several pollutants simultaneously to deliver mercury co-benefits."
ICMM	152	In light of the absence of an agreed criterion-based definition for a 'heavy metal' ", please delete the word "heavy" from this sentence.
IPEN	154 - 155	Sentence is unclear
EU	161 - 162	• These are general information of the forms of mercury which could occur in the environment. As highlighted in the General comment, this information should be addressed in a prefixed subchapter in Chapter I '*Introduction*'.
Argentina	170 -1	Since there are different species of mercury, oxidation and reduction steps are important to ensure that all mercury present is converted to the specie that is susceptible to the elected treatment.
EU	177	• It would be appropriate to add the expression '*e.g.*' after '*Suitable separation or clarification techniques include*' to make clear that the list of those techniques is not exhaustive.
Alfa Laval Technologies	179	In the bullet list under section 3.1, the technology "*centrifugal separation*" is missing. The most logic place would be at line 179 as it is a sedimentation technique using significantly higher g-forces from rotation to greatly increase the sedimentation speed.

EU	179	• It would be appropriate to specify/define what is meant by 'clarification'.
Argentina	183	Clogging and blockage is an important issue to consider always in filtrating steps, maintenance associated too. First 4 physical techniques have the advantage of not having this issue, but filtration could be useful after them as a polishing technique, in order to preserve ion exchange membranes or other technology as described in this parragraph.
Alfa Laval Technologies	186	In the text, between "…prevent plugging." and "Solid-free…", the following description of centrifugal separation would be relevant: *Industrial centrifugal separators, like disc stack centrifuges utilizing high g-forces and short settling distance between discs, are able to continuously remove suspended particles all the way down to very small particle sizes 1-10 µm, typically for mercury contaminants. What's more, disc stack centrifuges can tolerate large variation of particle concentration in feed, making it a feasible technique in situations with changing solid contents*.
Argentina	196	Hydrogen sulfide presence is related to pH shifts.
ICMM	197-198	For accuracy, please change to "*harmful effects to occupational health, may be generated during* ~~***the***~~ *metal sulfide precipitation (MEE, 2012[47]).The* ***simplified*** *chemical reaction is illustrated below*"
Argentina	202	pH controlling step is missing.
Argentina	204	managed ~~as solid waste~~ and disposed of in an environmentally sound manner.
ICMM	205-212	With reference to our general comment (above), we recommend that these lines be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
Argentina	209-212	The technology used is missing, according to the guidance reference: "However, some of the processes used multiple precipitation steps and additional treatment with other technologies such as activated carbon to reach this level."
Argentina	213	Most used but usually complemented with other techniques to achieve a better or more specific target. The best performances found consist on combinations of precipitation with filtration, co-precipitation, and adsorption.
ICMM	218-224	Ion exchange is not commonly used for mercury treatment, as it is more likely to be affected by characteristics of the media and contaminants other than mercury, than co-precipitation and sulfide precipitation (US EPA 2007). As such, adsorption and ion exchange are more appropriate for applications where mercury is the only contaminant to be treated, for smaller capacity systems, and for polishing of pre-treated effluent.
ICMM	225-226	With reference to our previous comment and our general comment (above), we recommend that these lines be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
ICMM	228-242	Experts in industrial wastewater treatment from ICMM member companies recommend also mentioning other commonly used adsorbents such as sulfur-impregnated activated carbon, functionalized activated alumina, and self-assembled monolayers on mesoporous supports).
Argentina	236	It is the first time that "removal by coalescence and recovery of metallic mercury" is addressed, it may be adequate to discuss it in the precipitation/physical separation techniques section.
Argentina	238-242	In the technique analysis, activated carbon's need to be periodically replaced should be mentioned.
ICMM	247	If reference 76 is the report that we are familiar with (Treatment Technologies for Mercury in Soil, Waste, and Water (clu-in.org), biological treatment is only presented as having been evaluated at the pilot-scale. Fate and transport of assimilated mercury associated with this technique (e.g., potential methylation) should be of concern. This description should therefore be removed from Guidance.
IPEN	262-264	More information required on managing chlor-alkali residues.
Argentina	266	More details are needed. What mercury source was addressed at pilot scales? Why is it effective?
IPEN	269	Use of biomass for remedial absorption of mercury should contain disclaimers warning about the end use of the biomass. E.g. not for consumption, animal feed, firewood, composting etc to prevent further contamination/exposure. Must be regarded as waste for ESM.
ICMM	271-295	As Section 3.5 appears to deal with a variety of solid/liquid separation processes, and not just membrane filtration (i.e., separation of dissolved solutes), it is recommended to edit its title. Reverse osmosis is also a relevant process that could be described here.

ICMM	291	With reference to our general comment (above), we recommend that this line be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally. Membrane filtration performance is defined by removal efficiency (rejection). Achievable concentrations depend on influent concentrations and rejection.
ALMR	301-501	Most of these sections discuss technology and hardware systems for control. We recommend that actions taken by humans at any point in the life of lighting be added throughout. Technology does not break lighting and release mercury; humans do. It is important to stress how education, awareness, and some simple actions humans can take will result in billions of lighting devices not being broken and releasing mercury into the environment.
ICMM	314-322	With reference to our general comment (above), we recommend that these lines be shifted to Chapter 3, as they describe common techniques that are applied across several potential sources of release.
ICMM	317-318	With reference to our general comment (above), we recommend that the last sentence of this paragraph be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
ICMM	320-322	With reference to our general comment (above), we recommend that the last sentence of this paragraph be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
Argentina	333	Coal cleaning process is not described.
ICMM	339-341	With reference to our general comment (above), we recommend that these lines be shifted to Chapter 3, as they describe common techniques that are applied across several potential sources of release.
ICMM	342-344	With reference to our general comment (above), we recommend that this paragraph be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
EU	343	• It would be appropriate to replace “ng/L” by “ng/l”, for sake of consistency.
Thailand		Each party should have individual authority to determine the BAT mercury limitation for residues from oil and gas exploration and production (offshore drilling fluid and drill cuttings, etc) based on their background data and risk assessments.
OASIS	348, 349, 350, 351	To delete. This is incorrect information. In addition to hydrocarbons, the composition of oil includes S (0.5-6%), N (0.1-2.0%), O2 (0.05-1.5%) and metals such as Ni, V, Fe, Co. NO MERCURY OR ITS COMPOUNDS.
EU	350 - 351	• It would be appropriate to move the information on the three forms of mercury in above-mentioned prefixed chapter (see general comment)
Alfa Laval Technologies	353	Insufficient description of presence of mercury in crude oil fluids than in natural gas production. Following paragraph is proposed: *In Natural gas production the gas stream may contain gas condensate. In mercury rich wells, the condensate stream will the also contain mercury in similar concentrations as seen I crude oil. Condensate may typically be stored in periods offshore in e.g., a Floating storage and offload unit (FSO) where particles including Mercury sediment and accumulate to high concentrations. Reported mercury levels in crude/condensate samples range from 0.5 to50,000 µg/kg (ppb) (Bloom 2020). Production platforms using glycol injection to avoid hydrates may find significant portions of the mercury contaminants present in the glycol stream in the downstream processing.*
Alfa Laval Technologies	357	Crude oil and condensate treatment description is missing. At row 357 the following is proposed. *Removal of mercury from crude oil prior to use, reduces the mercury in emissions from fossil fuel./ Removal of mercury from crude oil at the extraction stage, reduces mercury emissions in further refining and use of petroleum. For crude/condensate or glycol process streams, there could be a need to process condensate or glycol at the offshore installation, depending on geochemical background of mercury deposits in oilfields (Gallup 2014, Boschee 2015). Removal of mercury contaminant in a closed system may allow reinjection of contaminants to the formation. Mercury in crude oil is typically found adsorbed on very small particles residing in a narrow particle size range, 1-10 µm. Disc stack centrifuges in offshore operation have been proven to perform significant condensate mercury removal that continuously reduced mercury*

		contaminants from levels of 8000 - 12000 ppb down to below 850 ppb (Manelius & Aguedach 2018). Traditionally the mercury removal has often been made with filtration, however filter handling is not only requiring more space, but also posing exposure hazards to maintenance personnel. Centrifugal separation of mercury contaminants from crude oil has proved to offer an enclosed continuous operation with a capability of removing micron level mercury contaminants at production scale.
IPEN	357	More information required on ESM for drilling muds and 'produced water' from extraction. Decommissioned gas/oil pipelines have very high mercury contamination levels and ESM should be suggested for these to prevent releases.
ICMM	368-371	With reference to our general comment (above), we recommend that these lines be shifted to Chapter 3, as they describe common techniques that are applied across several potential sources of release.
ICMM	371-377	With reference to our general comment (above), we recommend that these lines be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
EU	375	• It would be appropriate to delete the word 'database' as it appears consecutively twice.
ICMM	379-380	Suitable references for drafting of this section may include: – US Electric Power Research Institute, US EPA, and US DOE references/resources https://doi.org/10.1016/S0048-9697(00)00541-6 – Journal article on impacts of Chinese mercury mining https://doi.org/10.1002/9781119009115.ch9 – Control techniques for Hg-emissions from extraction https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9100EJD5.txt – Brady, George S., Henry R. Clauser, and John A. Vaccari. Materials Handbook, 14th Edition. McGraw-Hill, 1997 – https://www.britannica.com/technology/mercury-processing – http://www.madehow.com/Volume-4/Mercury.html
ICMM	384-386	For accuracy, please change "***Creation of w****aste rock and tailings during* ***mining and beneficiation can lead to*** *exposure of* ***mercury-bearing minerals*** *to oxygen and water,* ***and*** *leaching processes, which can result in* ***mercury*** *releases to water systems or* ~~***in which result in mercury release***~~ *to soil.*"
ICMM	387-394	For increased relevance, please change to: "*Metals commonly exist in nature as oxides, sulfides, or carbonates and the smelting process requires a chemical reaction in the presence of a reducing agent to liberate the metal (UNEP 2019b). At high temperatures mercury becomes highly volatile and is released to the gas phase, or may condense on fine particles produced in the processing (United Nations Environment Programme (2021).* ***Therefore****, thermal processing (such as smelting, roasting and other high temperature operations) of metallurgical raw materials have the potential to release mercury to the atmosphere,* ***and appropriate air-pollution control techniques capture it in various liquid or solid forms. Such waste needs to be treated and/or disposed of in an environmentally sound manner to prevent releases of mercury to land or to water.*** *(UNEP Global Mercury Partnership Study report on mercury from non-ferrous metals mining and smelting, Geneva).*"
ICMM	403-404	For increased suitability, please change to: "***N****on-recyclable or non-reusable water* ***can*** *be treated in order to minimise the concentration of pollutants such as metals, acidic substances and solid particles in the final effluents discharged to the aquatic environment*."
ICMM	406-408	For accuracy, please change to: "*These techniques* ***may be*** *used together* ***in series or in parallel depending on the water management plan of the site****,* ***and*** *opportunities can also be taken to settle solids and/or precipitate metals before the process stream is mixed with other effluents.*"
ICMM	409-433	With reference to our general comment (above), we recommend that these references to achieved reductions be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
Argentina	417	This is an example of the iron coprecipitation referred to previously.
EU	417	• It may be appropriate to replace 'iron' by 'Fe'.

ICMM	438-465	With reference to our general comment (above), we recommend that these references to US effluent limitations be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
IPEN	484	There is no discussion on releases of mercury from secondary use of incineration bottom ash for construction material, soil amendment or other agricultural applications. This should be included.
ICMM	489-490	The suggested achieved concentration in these lines contradicts the information presented in Section 3. With reference to our general comment (above), we recommend that all references to achieved reductions be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.
ICMM	494-498	The suggested achieved concentrations in these lines contradict the information presented in Section 3. With reference to our general comment (above), we recommend that all references to achieved reductions be removed from the Guidance itself, as the incomplete set of specific circumstances described is not helpful in general guidance to be applied globally.

Input to reference documents and other input

Submitter	Page	Comment
Argentina	2.5	Fulfilment of EPA Discharge Requirements for ARD Using Co-Precipitation Iron Process at Neutral PH. report
Argentina	3.3	Ion Exchange. Houserová P, Kubán P, Kubán V. Ion exchange preconcentration and separation of mercury species by CE with indirect contactless conductometric detection. Electrophoresis. 2006 Nov;27(22):4508-15. doi: 10.1002/elps.200600274. PMID: 17066384.
Argentina	Appendix	Removal of Mercury and Other Heavy Metals of Industrial and Contaminated Site Waste Waters by Organic Chelation, Coprecipitation, and High-Efficiency Particulate Removal. link. final report.
EU		**Part I: Common Techniques:** It may be appropriate to include in the introduction of Part I a general reminder of the techniques for removal solid content to ensure a parallelism with Chapter 3.1 of the Guidance document
EU		**Part II: Techniques for specific sources of releases:** It would be appropriate to align the Guidance document and the Technical reference document in respect of the order of appearance of the different techniques.
EU		**Appendix 'Emerging techniques':** It would be appropriate to rename the title of this Appendix as follows: 'Emerging and innovative techniques', to ensure consistency with the Guidance document
Alfa Laval Technologies		References Manelius T., Aguedach I., 2018. Efficient condensate mercury removal offshore, Paper presented at the Offshore Technology Conference, Houston, Texas, USA. OTC- 28743-MS, DOI: 10.4043/28743-MS Boschee, P. 2015. Advancements in the removal of mercury from crude oil, Oil and Gas Facilities, DOI: 10.2118/0413-0012-OGF Gallup, DL. 2014. Removal of mercury from water in the petroleum industry. IPEC 2014 – Second International Petroleum Environmental Conference

		Bloom, N. 2000. Analysis and stability of mercury speciation in petroleum hydrocarbons. Fresenius J Anal Chem 366, 438–443. DOI: 10.1007/s002160050089 den Boestert, J.L., Nijmeijer, A. and van den Enk, L. 2021. Development in sustainable separation methods for condensates. Shell TechXplorer Digest den Boestert, J.L., Nijmeijer, A. and Smit, C.J. 2008. Method for reducing the mercury content of natural gas condensate and natural gas processing plant. WIPO (PCT): WO2008116864A1
ALMR	Part I-pages 1-23	Part 1 discusses TECHNIQUES AND BEST ENVIRONMENTAL PRACTICES TO CONTROL MERCURY RELEASES TO LAND AND WATER FROM RELEVANT SOURCES. As discussed above, mercury lighting breakage and uncontrolled management presents the same problems as the other sources. The science, chemistry, and stoichiometry of mercury interactions with water, air and soil are the same from lighting as any of the other sources. Lighting is much more widespread, and the earth is impacted every day from millions of sources.
ALMR		We request lighting be added to the list items in Part 1 and that statements reference our comments above, or some variation that explains the consequences of uncontrolled management.
ALMR	Part II thru end of document	Again, all the environmental benefits, cross media effects and many of the technical considerations discussed in this Part also apply to mercury from lamps. Lighting presents a larger problem, yet the solutions are not as complex. Keeping lighting out of the environment is the only way to address this pollution. Technology and systems exist and are in place in many countries.
ALMR		We urge you to incorporate lighting into the discussions and simply encourage countries and populations to nearly eliminate this problem by setting up simple systems with infrastructure to avoid uncontrolled breakage and the havoc that ensues. It all starts with avoiding throwing them in the trash.
ICMM	all	The technical Annex summarizing reference documents still incorrectly describes only two forms of mercury in the environment: mercury dissolved in water and mercury adsorbed to particles. If the technical Annex is retained, reference should be made throughout the Annex, as is now done in the draft guidance document, to mercury that is neither dissolved, nor adsorbed, but rather present within the mineral matrix of particles.
ICMM	17-21	The section on Biological Treatment includes “Aqueous Biocyanide Process”, (page 19), and a general description of an aerobic bioprocess and apparently a citation to a report from the US EPA – perhaps “Treatment technologies for mercury in soil, waste, and water,” US EPA, August 2007. Concerns about the fate and transport of assimilated mercury associated with this technique (e.g., potential methylation), should at least be mentioned in the reference document. Such techniques should consequently not be mentioned in the Guidance itself.
ICMM	47-69	This discussion of BAT should also mention techniques related to the use of retorts in the gold-mining sector.
ICMM	64-69	The US EPA Effluent Limitations Guidelines in Table 18 are difficult to interpret without more information on their relation to achievable performance levels, which are in turn dependent on design basis, aqueous matrix, unit operations and reagents utilized, operating conditions (especially pH), equipment utilized, residuals management, etc. Such limitations are not necessarily helpful for informing users of the guidance on BAT/BEP measures to be taken in their own local circumstances.
IDM		Ref ISO 11143 : 2008 Dentistry – Amalgam separators This Standard was last reviewed and confirmed in 2022. Therefore this version remains current. (ISO website January 2023)
IDM		Ref International Dental Journal February 2022 Amalgam (Part 1) : Safe Management of Waste and Mercury