Introduction to terms relevant to the discussion of mercury storage and disposal[1]

9th Draft

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[1] The title has been changed to 'Introduction' instead of 'glossary' in order to avoid overlapping with the list of definitions in the 'draft elements' paper (INC.2/3) and the glossary previously prepared by UNEP (INC.1/14).

Contents

1 Background and objective of this document

1.1 Introduction and overview

Mercury is a chemical of global concern owing to its long-range atmospheric transport, its persistence in the environment once anthropogenically introduced, its ability to bioaccumulate in ecosystems and its significant negative effects on human health and the environment[2].

In order to assist discussions within the Partnership on Supply and Storage, important terms with relevance to storage of elemental mercury and to storage and disposal of waste consisting of elemental mercury and waste containing or contaminated with mercury have been identified. These are presented in the format of a "Question and Answer" (Q & A) to provide a basic overview. This document:

- presents general descriptions of important terms
- refers to relevant definitions from chemical and waste conventions, notably the Basel Convention, where available and applicable
- provides background information on complex terms and issues
- groups synonymous terms.

This document is for information only. Descriptions and definitions presented for various terms are not intended to pre-empt any discussions or decisions to be undertaken at upcoming mercury Intergovernmental Negotiating Committee sessions. Nevertheless, the document may serve as a basis for starting discussions.

1.2 Methodology

As a first step, relevant UNEP documents were reviewed in order to identify terms in relation to storage and disposal of elemental mercury and mercury-containing waste, including:

- UNEP studies, reports and documents presented at or prepared for mercury OEWG 1, OEWG 2, PREP-INC, INC-1, INC-2, UNEP Governing Council 24th and 25th sessions

[2] UNEP Governing Council decision 25/5

- Basel and other Conventions
- Basel Technical Guidelines

Terms, where applicable, were combined into groups of synonymous or similar terms. For the first groups of terms discussed in Q & A format the following procedure was applied:

1. An introduction to the group of terms was developed to provide the reader with a context surrounding the terms and how they are used.
2. Descriptions and explanations of a term were given based on current practices or how the term is commonly used.
3. Synonymous or similar terms are briefly explained.

The list of considered terms is neither exhaustive nor conclusive, nor should all terms be regarded as recommended for further use, as many are synonymous, demonstrated to be unclear or may have different meanings to different users.

It is important to note that the description of terms under the Q & A section is not intended to provide a legal discussion of terminologies nor provide new definitions, but instead focuses on the practical and current usage of terms to provide a layman's perspective. However, when there are existing legal definitions they are referenced in the description to footnotes. It should also be noted that this present document is intended to concentrate on basic concepts rather than details. For example, there are no terms that qualify storage/disposal concepts (technical requirements and safety criteria) or procedures and technologies needed to implement one concept or another.

2 Introduction to terms and concepts

2.1 Mercury

Terms in this section:

- Mercury
- Elemental mercury
- Commodity mercury
- Mercury compounds
- Primary, secondary and by-product mercury
- Excess or surplus mercury
- Amalgams
- Mercury added products

Mercury is a chemical element, naturally occurring in nature in the form of elemental (native) mercury, mercury ores like cinnabar, but sometimes is also a minor component of other natural resources like metal ores (e.g. gold, zinc, copper) or natural gas. Mercury has been in use for over two thousand years, either as elemental mercury or as mercury compounds.

What is elemental mercury?

Mercury is the only metal that is liquid at ambient temperature (liquid from –38 to 356 °C). However, liquid mercury has a significant vapour pressure. The silver liquid found in some fever thermometers is a good example of elemental mercury. Elemental mercury has a valence of zero.

Other frequently used terms are Hg(0), liquid mercury, metallic mercury, quicksilver, liquid silver, hydrargyrum, colloidal mercury, azogue.

Fig. 1: Liquid elemental mercury

What is commodity mercury?

Elemental mercury which meets the specifications or quality parameters for use in a product or process is the normal form in which elemental mercury is traded on the open market. In some documents, such mercury is described as ‘commodity mercury’ or ‘mercury as a commodity’ to emphasize the difference from elemental mercury that is considered waste. Normally, commodity mercury is produced and stored for the purpose of later use in products and processes. In certain cases, the sale of governmental stocks of commodity mercury is no longer allowed. Today in many countries the use of mercury and its compounds is restricted or controlled, sometimes explicitly as a commodity or a waste. The distinction between commodity and waste is made by national legislation.

Fig. 2: Commodity mercury in flasks stacked on a pallet

Frequently, if elemental mercury is not declared waste, no qualifier is used, so that the simple term ‘mercury’ would mean that it is considered a commodity.

What are mercury compounds?

Fig. 3: Mercury (I) chloride (calomel), a mercury compound

Mercury compounds are chemical substances in which the mercury atoms have an oxidation state greater than zero. They are the product of a chemical reaction between mercury and other chemical elements or substances. Mercury compounds are typically manufactured for use in a product or process, but sometimes occur as a by-product of non-ferrous metal production (like mercury (I) chloride – calomel, Hg_2Cl_2 - in some zinc smelters). Examples are mercury sulphide (HgS), mercury oxide (HgO), and mercury chloride ($HgCl_2$). The chemical and physical properties of different compounds may vary significantly. For example, , some mercury compounds such as mercury (I) chloride can be easily transformed into elemental mercury, whereas such a conversion is more difficult for more stable compounds like mercury sulphide. A US EPA (2009) study evaluated which mercury compounds show a potential for export for regeneration of elemental mercury. The EU export ban includes some mercury compounds (EU 2008b).

What is cinnabar?

Fig. 4: Cinnabar, a naturally occurring mercury mineral

Cinnabar (or cinnabarite) is the name of a naturally occurring mineral composed of mercury and sulphur (mercury sulphide, HgS). It is generally found in a massive, granular or earthy form and is bright scarlet to brick-red in colour. Cinnabar and other more mercury minerals are sometimes found at small quantities (usually <1%) in other mineral ores such as gold, copper, lead and zinc. Another form of mercury sulphide is the black metacinnabarite which has the same chemical formula (HgS) but a different crystal structure. Both forms may be produced technically by mixing elemental mercury and sulphur.

What is an amalgam?

Amalgams are alloys made of mercury and one or more other metals. Amalgamation describes a physical process in which another metal dissolves in mercury or mercury dissolves in another metal to form a solid but often soft alloy (an ‘amalgam’). Mercury forms amalgams with most other metals. The most prominent exception is iron, so that mercury can be stored in iron con-

tainers. The process of amalgamation is reversible so that mercury can be released from these alloys by heating or through decomposition, emitting mercury into the biosphere. The most important applications of amalgams are dental fillings (alloy with silver and other metals) and compact fluorescent lamps (some brands). Amalgams are also formed when mercury is used during the extraction of gold and silver from ore in artisanal and small-scale gold and silver mining.

Fig. 5: Dental amalgam: a solid alloy of mercury, silver and other metals

In some documents the reaction of mercury with sulphur is also described as amalgamation (like in US CFR 2010). However, such an understanding is seldom found elsewhere.

What are the sources of mercury supply?

Mercury may be produced from several source materials. Often, certain terms are used to classify the mercury that comes from different sources types:

- **Primary mercury** – unused, 'virgin' mercury that has been produced as the main product of mining activities, e.g. the processing of the mercury ore cinnabar
- **Secondary mercury** – mercury that is generated through recycling of mercury-containing wastes, such as catalysts, products or mercury from decommissioned mercury cell chlor-alkali plants
- **By-product mercury** – mercury captured by air pollution control devices in the mining and processing of minerals other than mercury minerals (e.g. gold, zinc, lead), of crude oil and natural gas. In these processes mercury may be produced in elemental form or as mercury compounds such as mercury (I) chloride (calomel).

Independently of the source material, primary, secondary or by-product mercury is in fact elemental mercury and has the same physical, chemical, and toxic properties.

What is excess or surplus mercury?

Excess or surplus mercury is the amount of national (or regional) mercury supply that exceeds national (or regional) demand for use in products and processes. Surplus mercury includes mercury that is available, or might become available, on the market. It may be newly produced from mining and processing of metal ores (by-product mercury), made available from industries that have converted from mercury-using processes, or recovered from waste such as products

at the end of their life (secondary mercury). The US, the EU and several other countries have decided not to allow the selling of surplus mercury in the market but rather keep it in long-term storage (US) or to dispose it through permanent storage in underground mines (EU).

The alternative terms 'redundant mercury' and 'obsolete mercury' are synonymous but are rarely used and not widely accepted.

What are mercury-added products?

Mercury-added product means a product or product component that contains mercury or a mercury compound intentionally added to provide a specific characteristic, appearance or quality, to perform a specific function or for any other reason. The term 'product' also covers mixtures which are defined as: a mixture or solution composed of two or more substances in which they do not react (GHS). Mercury added products may further be distinguished into fabricated and formulated products (NEWMOA 2011):

1. A **fabricated** mercury-added product is a combination of individual components, one or more of which has mercury added, that combine to make a single unit.
2. A **formulated** mercury-added product is a chemical product, including but not limited to laboratory chemicals, cleaning products, cosmetics, pharmaceuticals, and coating materials that are sold as a consistent mixture of chemicals

The similar term 'mercury-containing products' is still in more widespread use but is not preferred because it is considered to have a wider meaning, such as products that unintentionally contain mercury in small concentrations.

What are the options for the management of commodity mercury, mercury added products and mercury waste?

The following graph gives an overview on the management options for commodity mercury, mercury added products, and mercury waste. The options are further explained in the following articles.

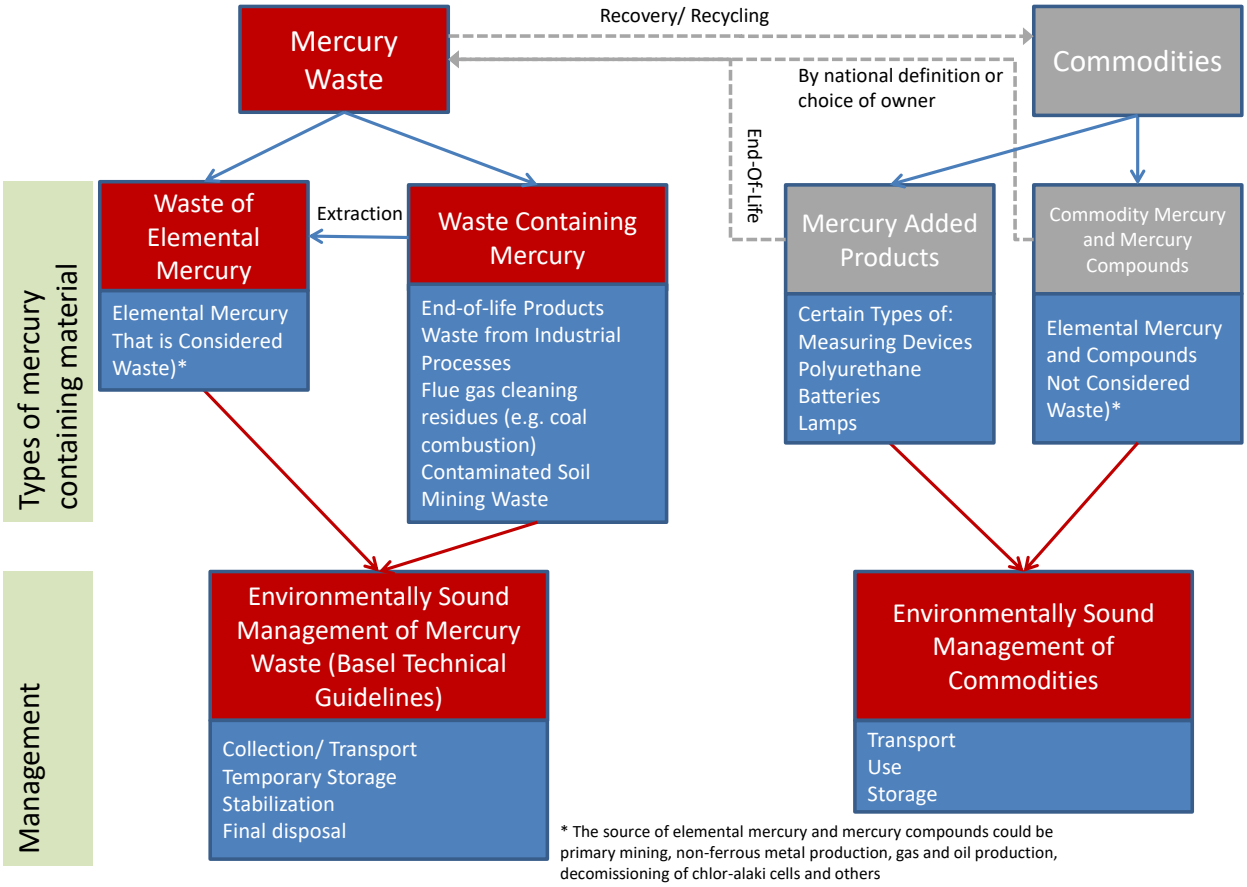

Fig. 6: Environmentally sound management of commodity mercury, mercury added products and mercury waste

2.2 Mercury waste

What is waste?

Terms in this section:

- Waste
- Hazardous waste
- Mercury wastes

In the layman's perspective 'waste' is often understood as trash, rubbish, litter, or any material that is unwanted or unusable. The term 'waste' is defined in the Basel Convention that relates 'waste' with the disposal of substances or objects[3]. Note that the definition of waste could vary depending on national law. Thus, in any discussion of the term waste it is important to bear in mind that variations of the term may be present.

What are hazardous wastes?

Hazardous wastes are characterized by chemical and physical properties such as, but not limited to, human and ecotoxicity, flammability, or corrosiveness. Like 'wastes' the term 'hazardous wastes' is defined in the Basel Convention[4]. Covered are all waste types that are 'hazardous' by definition of the Convention itself or by national legislation. Note that the definition of hazardous wastes could vary depending on national law. Thus, in any discussion of 'hazardous wastes' it is important to bear in mind that variation of this term may be present. Most often, mercury wastes are classified as hazardous wastes.

What are mercury wastes?

Mercury wastes may be categorized in three principal groups[5]:

A) **Wastes consisting of elemental mercury -** e.g., elemental mercury recovered from waste containing mercury and waste contaminated with mercury and surplus stock of el-

[3] "Wastes" are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law (BC Article 2-1)

[4] (a) Wastes that belong to any category contained in Annex I (of the Basel Convention), unless they do not possess any of the characteristics contained in Annex III (of the Basel Convention); and (b) Wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous wastes by the domestic legislation of the Party of export, import or transit. (BC Article 1-1)

[5] This categorization has been developed by the Basel Convention Open Ended Working Group, decision OEWG-VII/7 of May 2010.

emental mercury designated as waste. Examples are metallic mercury from the cells of decommissioned chlor-alkali plants or metallic mercury recovered or extracted from end-of-life mercury-added products such as thermometers or switches. Depending on national legislation elemental mercury from other sources (e.g. non-ferrous metal mining) may be regarded waste and thus fall under this category as well.

The term 'waste mercury' is also sometimes used to describe the same type of waste. It is not recommended for further use as it may be mistaken with mercury waste.

B) **Wastes containing mercury -** include wastes of mercury-added products that easily release mercury into the environment when they are broken (e.g., waste mercury thermometers, fluorescent lamps), wastes of other mercury-added products (e.g., batteries) and stabilized or solidified wastes containing mercury that result from the stabilization or solidification of wastes consisting of elemental mercury wastes.

C) **Wastes contaminated with mercury -** e.g., residues generated from mining processes, industrial processes, or waste treatment processes). Examples are debris and contaminated soil from decommissioned chlor-alkali plants, mercury loaded activated carbon from flue gas control facilities, or air pollution control sludges, tailings, and waste rock from mining and processing of minerals.

The Basel Convention already lists some types of mercury wastes[6]. Wastes contaminated with mercury' and 'wastes containing mercury' mainly differ in their origin, not necessarily in their mercury content. Normally, one would expect that waste containing mercury has a higher mercury concentration than waste contaminated with mercury. Counterexamples are end-of-life compact fluorescent lamps (mercury containing waste) that typically contain few milligrams of mercury within a product of 100 grams or more (<0.001 weight-%). On the other hand, contaminated soil or debris from decommissioned chlor-alkali plants (waste contaminated with mercury) may contain up to several weight-% of mercury.

[6] Basel Convention Annex VIII:
-A1010 Metal wastes and waste consisting of alloys of any of the following: [...]-mercury [...]
-A1030 Wastes having as constituents or contaminants any of the following [...] mercury; mercury compounds [...]
-A1180 Waste electrical and electronic assemblies or scrap containing components such as [...] mercury switches [...] or contaminated with Annex I constituents (e.g., [...] mercury [...])

2.3 Mercury waste management

The following section describes some important procedures of mercury waste management that have been raised or used in the discussion on mercury waste. In some cases, the treatment method could apply to both elemental mercury and mercury-containing waste. As noted above, elemental mercury may be declared a waste under some national laws and be removed from the marketplace.

Terms in this section:

- Waste management
- Environmentally sound management of waste
- Stabilization and solidification of wastes
- Stabilization of elemental mercury

What is waste management in general?

'Waste management' is generally understood to mean the collection, storage, treatment, transport and disposal of hazardous wastes or other wastes, including after-care of disposal sites (BC Article 2-2)

What is environmentally sound management of waste?

The phrase 'environmentally sound management' (ESM) has taken on a legal significance. In the Basel Convention the term 'ESM' means taking all practicable steps to ensure that human health and the environment are protected against the adverse effects that may result from such wastes[7]. ESM of hazardous wastes could include upstream interventions such as substitution of reduced mercury or mercury-free inputs and downstream interventions as well such as recycling these materials for reprocessing or reuse. Other ESM scenarios could include waste treatment to convert certain hazardous wastes into less hazardous or more stable waste forms. Storage and disposal of hazardous wastes are further elements of ESM.

What is stabilization and solidification of wastes?

Solidification/stabilization(S/S) processes are nondestructive methods to immobilize the hazardous constituents in a matrix while decreasing the waste surface area and permeability (US EPA 2011). Another definition says that stabilisation processes change the dangerousness of the constituents in the waste and thus transform hazardous waste into non-hazardous waste. Solidi-

[7] ESM of hazardous wastes or other wastes means taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes; BC, art. 2 – 8.

fication processes only change the physical state of the waste by using additives, (e.g. liquid into solid) without changing the chemical properties of the waste (European Commission 2000). Solidification and stabilization (S/S) is applied, for example, to waste consisting of elemental mercury and waste contaminated with mercury such as soil, sludge, ash, and liquid.

The three principal stabilization approaches may be distinguished:

1. Chemical stabilization: A chemical process that converts a chemical substance into another substance that is thermodynamically more stable, less soluble and less volatile. For mercury the most important chemical stabilization is conversion to mercury sulphide, sometimes called 'sulphur stabilization'

2. Microencapsulation: a process in which waste particles are embedded in the matrix of an inert material (like a polymer or concrete) with low permeability.

3. Macroencapsulation: a process in which the waste body as a whole is covered with a layer of impermeable material to reduce the surface exposure to leaching.

A typical example for stabilization is the mixing of slurry, sludge or waste water with Portland cement or lime/ pozzolans (e.g., fly ash and cement kiln dust) or combinations thereof to form a solid product (concrete). The process also includes a chemical reaction by which many waste constituents are chemically bound to the concrete matrix. Elemental mercury normally does not react and may be later released via evaporation. Therefore, some technologies include the addition of sulphur containing agents that chemically react with mercury and its compounds.

'Immobilization' and 'stabilization' are often used equivalently.

What is stabilization of elemental mercury?

One of the main reasons why management, storage and disposal of elemental mercury pose a serious risk to human health and the environment are its physical properties: it is a liquid and has a significant vapour pressure even at ambient temperature, making it very mobile in the environment. These properties could be removed or minimized if elemental mercury is stabilized; = that is converted into a solid substance with minimal vapour pressure. Several approaches exist, but conversion into mercury sulphide, the form in which mercury occurs in nature, is most frequently applied. In some applications the process is combined with microencapsulation in an

Fig. 7 Stabilized elemental mercury: red mercury sulphide (cinnabar)

inert matrix (GRS 2011). In recent years some technical processes have been developed that are now used (in the EU) or could be used in the near future (pending approval by national authorities) to bring elemental mercury into a form that could be more safely stored and disposed of. In the US, currently no stabilization technology has been approved for application although there is interest in reviewing recent developments.

Amalgamation of elemental mercury with a metal like zinc leaves the chemical state of mercury unchanged, thus it is normally not regarded as chemical stabilization but only as solidification.

2.4 Storage and disposal

What does removal from the market mean?

Removal from the market means that through the utilization of a policy or regulatory tool or a related measure, mercury is not allowed to be sold, used or reused and instead is placed into storage or otherwise managed so that it cannot be traded on the open market.

Disposal operations listed in Basel Convention Annex IV A lead to a permanent removal from the market in case later retrieval is excluded. In the US, it is understood that 'long term management and storage' of mercury means that the mercury is not intended to ever be used again or be placed on the market in one form or the other (US 2008), and this could therefore also be called 'removal from the market'.

Terms in this section:

- Removal from the market
- Disposal
- Storage
- Storage of waste
- Storage of commodity mercury
- Long-term management and storage
- Permanent storage of waste
- Storage of surplus mercury
- Aboveground storage
- Underground storage
- Specially engineered landfill
- Approved site or facility

Other terms describe a similar concept: The term 'sequestration' is originally used in law and biology. In the last years it has been applied to describe the concept of capturing and disposing ('storing') of CO_2 in deep geological formations, aquifers or caverns. UNFCCC (no year) defines 'carbon sequestration' as 'the process of removing carbon from the atmosphere and depositing it in a reservoir'. Like 'sequestration,' 'retirement' is rarely used and not widely accepted to describe mercury related activities.

What is disposal?

Disposal in the ordinary sense means discarding a material or waste so that this is not used in its initial form any longer. Disposal operations relate only to waste, not to commodities and products. However, the term 'disposal' has taken on a legal significance under the Basel Convention and in national laws, and its use will have very specific implications.[8]

Important disposal operations are physical-chemical treatment (stabilization), placement into a specially engineered landfill (see below), and permanent storage (e.g. disposal in underground mines).

In some documents the term 'final disposal' is used to describe disposal operations that lead to a final placement of waste in a waste disposal facility, like a specially engineered landfill or an underground mine. Final disposal of mercury waste is the permanent removal of mercury from the biosphere in a manner that conforms to each country's environmental requirements. In the US, there is currently no manner of disposing of wastes with a high concentration in elemental mercury. In the EU, waste containing or contaminated with mercury can be disposed of in underground waste disposal facilities. Currently in the EU, criteria and requirements for permanent storage (disposal) of wastes consisting of elemental mercury in underground mines are being developed.

In discussing final disposal of mercury waste, attention should be given to the various types of disposal operations that could be considered for different types/ physical characteristics of mercury waste which needs disposal. For example, it cannot be generally said that all types of mercury waste can just be landfilled, even in specially engineered landfills, since liquid elemental mercury is not an appropriate substance to be simply deposited in landfills for solid or hazardous wastes. Thus, care and attention should be given when attributing a specific disposal operation with regard to a specific type of mercury waste.

Depending on national waste acceptance requirements, some manufacturing processing wastes or discarded products could be disposed of in a landfill (specially engineered or not), or

[8] "Disposal" means any operation specified in Annex IV of the Basel Convention (BC Article 2-4). Disposal operations are grouped into two categories: the first (A) covers disposal operations in the narrower sense that lead to the waste's destruction, its placement into a landfill or release into the environment. The second category (B) covers recycling and recovery operations. Storage of waste prior to any of these operations is defined as a disposal operation as well. However, in the legislation of many countries, 'disposal operations' by definition do not include recycling/recovery operations.

could be further treated (e.g. stabilised) and then disposed of. In some countries, it is required that mercury is recovered from wastes (e.g. with a high mercury content) and disposed of separately.

What is storage?

In its ordinary meaning 'storage' signifies safekeeping of goods in a depository – like a warehouse where objects are placed in shelves or on palettes for future use. From a legal point of view storage of waste and storage of commodities and products have to be distinguished.

What is storage of waste?

The storage of waste is a waste management operation covered by the Basel Convention[9]. Storage covers:

1. Storage of by waste generators pending collection
2. Storage of waste pending a disposal operations (like landfilling, recycling or recovery)

The term 'storage of waste' may appear with qualifying adjectives which often imply a different meaning:

1. **'Temporary storage/ short term storage of waste' -** Normally, 'storage of waste' is understood as a temporary activity, restricted to a certain period (months up to a few years according to national law). This is why the term 'temporary storage' is sometimes used to stress the difference with disposal operations like permanent storage. However, it is noted that under the Basel Convention only the term 'storage' is used.

2. **'Preliminary storage' or 'interim storage' of waste** is the holding of waste at the location of the generator, owner or last user, e.g. collection of mercury-containing waste like broken thermometers in hospitals, before they are transported to a waste treatment or recycling facility. It should be noted that in some countries 'preliminary storage' is understood as 'tem-

[9] Storage covers:

a) Storage of waste pending any of the operations in Basel Convention Annex IV Section A (disposal operation D 15), e.g. at some waste collection point or near the place of the disposal site

b) Accumulation of material intended for any operation in Section B of Annex IV of the Basel Convention (Basel R 13: recycling and recovery operations), e.g. at a recycling facility before a batch is processed

porary storage, pending collection, on the site where the waste is produced' and is excluded from the definition of 'storage' (EU 2008a).

3. **'Permanent storage'** is a waste disposal operation listed in the Basel Convention (see below). It is often understood as disposal of waste in underground mines.

4. **'Long-term management and storage'** of elemental mercury refers to a US approach of storing elemental currently for a very long period (up to 40 years or more) in order to reduce its market availability (see below). This operation takes place in warehouses, thus it is often referred to as 'above-ground storage' or 'surface storage'. It must be noted that 'long-term management and storage' does not specifically refer to the storage of waste but may also be applied to commodity mercury.

What is storage of commodity mercury and mercury added products?

As long as there are accepted uses of elemental mercury, mercury compounds or mercury added products there is a necessity to store them along the chain of distribution (producer, wholesale dealer, retailer, end-user) for later sale or use. This includes all operations and processes that are necessary to temporarily hold and control stocks of mercury commodities and products during their life-cycle. In some documents, the term 'storage of commodity mercury' is used in order to underline the legal difference to storage of elemental mercury that is considered waste. The latter is a hazardous waste management operation that in many countries falls under a different legal regime.

Which are the concepts of storing surplus mercury?

Mercury that is no longer intended or needed for later use or is declared waste ('surplus mercury') has to be stored - for a certain period or indefinitely. For mercury, storage is packaging of mercury in secure containers and storing it in an ordered manner in a controlled facility.

From a technical point of view three principal types of mercury storage facilities can be identified:

- Storage of elemental mercury in above ground warehouses (including 'long term management and storage' as above)
- Permanent storage (disposal) of solid or solidified mercury waste in underground mines

- Forms of temporary storage like storage of mercury waste in waste collection centres, hospitals or at industrial sites; or the storage of elemental mercury at a commercial mercury recovery facility prior to mercury recovery.

Elemental mercury is often stored in specialized containers, for example 'mercury flasks'. The typical capacity of a mercury flask is 2.5 l = 34.5 kg[10]. The flask is also the standard unit for trading mercury. Other often used container types have a capacity of 1 metric ton.

Fig. 9: A flask (34.5 kg Hg)

Fig. 8: A 1 ton mercury container

The term "long-term storage" has been used in several documents to describe the concepts of above-ground storage in warehouses and permanent storage (disposal) in underground mines. Since both concepts are fundamentally different (both from a technical as well from a legal point of view), it's suggested that the term 'long-term storage' refers only to above ground storage in warehouses.

What are 'long-term management and storage' of mercury and above-ground storage facilities?

The US government has stored elemental mercury for over 50 years. The Mercury Export Ban Act (MEBA 2008) requires the US Department of Energy (DOE) to designate a facility or facilities for the purpose of long-term management and storage of elemental mercury generated in the United States and delivered to such facility(s) and deposited for a fee. The facility would operate under a waste disposal facility permit. Although planned for at least 40 years, the mercury in US storage facilities may be stored for a shorter or a longer period, or moved to another location, or further be managed if other waste management options become available that the US government is comfortable with, although this has yet to be determined. The MEBA refers to this as 'long-term management and storage' of mercury, but no time limit is provided in

Fig. 10:Warehouses used for above-ground storage of elemental mercury

[10] The mass of a flask (34.5 kg) is equal to three *Aarrobas Castellanas*, an old Spanish weight unit (UN 2003).

the Act; as a result for the US, 'long-term' could also mean 'indefinite', at least for the time being considering the above. Once a private facility makes the decision to send their mercury to the DOE facility(s) it will at this point be considered a waste. Section 3 of MEBA bans the sale, distribution or transfer of elemental mercury by federal agencies; thus, federal agencies cannot sell, distribute or transfer the elemental mercury stored at the DOE facility (or their own facilities) unless for the purpose of facilitating storage pursuant to MEBA.

'Long Term management and storage' takes place in a specially designed and operated above ground warehouse. However, as it was explained above, this storage could be considered as either time limited, or it could be considered as 'indefinite storage' i.e., the liquid mercury may stay indefinitely in the above ground warehouse provided that all relevant safety requirements are fulfilled[11].

'Long-term management and storage', 'aboveground storage' and 'warehouse storage' are synonymous terms.

What is permanent storage (disposal) of mercury waste in underground mines?

The term 'permanent storage' has been given legal significance under the Basel Convention and relates to disposal of solid or solidified waste not to storage of commodity mercury[12]. It is typically associated with the disposal of waste in underground mines[13]. It describes the operation of placing special containers (steel drums, plastic bags) with waste in an orderly manner in open cavities of former underground mines (at several 100 m depth) that are now licensed as underground waste disposal facilities. When full, they can be sealed so that the waste is isolated permanently from the biosphere. Examples are the underground

Fig. 11:Placing waste packages in an underground waste disposal facility

[11] See http://www.epa.gov/mercury/stocks/index.htm and http://www.mercurystorageeis.com/

[12] 'Permanent storage' is identified in Basel Convention Annex IV as Disposal Operation D12.

[13] Independent of its meaning in the Basel Convention, the term 'permanent storage' is sometimes used to describe the concept of long-term storage of mercury warehouses.'.

waste disposal facilities located in some former European salt mines. It should be noted that other geological formations like granite, clay or metal ores may be suitable as well, depending on the overall isolating performance of the geological system.

Permanent storage is considered as a final, irreversible disposal operation. It connotes a type of storage that continues as long as the geological structure the storage facility is built within persists (at least several millions of years). Permanent storage foresees that once mercury waste is placed in such a facility, the waste will not be used or retrieved again[14]. While the underground storage of solid hazardous waste including waste containing or contaminated with mercury is common practice in Europe, storage of liquid elemental mercury is currently not allowed. Because there are concerns about the specific risks of managing and storing elemental liquid mercury underground including its long-term behaviour, it is now discussed which additional requirements would have to be met in order to ensure the same level of environmental and occupational safety (BIPRO 2010, e.g. that the elemental mercury needs to be solidified). In principle, underground waste disposal facilities could also be used for the (temporary) storage of mercury waste, including waste consisting of elemental mercury, but until now these facilities have been used only for final disposal operations.

There are numerous alternative terms used to describe the same operation: indefinite storage, final storage, terminal storage, geological disposal, underground storage, underground disposal, deep storage. However, under the Basel Convention, only 'permanent storage' is used.

What is a specially engineered landfill?

These are sites selected for their containment properties, these being natural, augmented by, or provided directly by liners; the overall engineering being such as to ensure as far as possible the isolation of wastes from the environment. Such landfills are considered a final resort, only to be used after every effort has been made to reduce, mitigate or eliminate the hazards posed by such wastes (adapted from SBC, 1995)[15]. Specially engineered landfills are often regarded as disposal options for waste with low

Fig. 12:A specially engineered landfill

[14] Retrieval is technically feasible for a certain period of time, but not longer than the closure and sealing of the mine.

[15] Basel operation D5: e.g. placement into lined discrete cells which are capped and isolated from one another and the environment (BC Annex IV A)

mercury content, if the waste fulfils the national acceptance criteria (which often are met only after stabilization).

What is an approved site or facility?

An ‘approved site or facility’ means a site or facility for the disposal of hazardous wastes or other wastes which is authorized or permitted to operate for this purpose by a relevant authority of the State where the site or facility is located (BC article 2-5).

3 Abbreviations of references

Abbreviation	Reference
BC	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1989
BIPRO (2010)	BIPRO (2010) Requirements for facilities and acceptance criteria for the disposal of metallic mercury http://ec.europa.eu/environment/chemicals/mercury/pdf/bipro_study20100416.pdf
European Commission 2000	European Commission (2000): Commission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:226:0003:0024:EN:PDF
EU (2008a)	Directive 2008/98/EC Of The European Parliament And Of The Council of 19 November 2008 on waste and repealing certain Directiveshttp://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0003:EN:PDF
EU (2008b)	Regulation (EC) No 1102/2008 of the European Parliament and of the Council of 22 October 2008 on the banning of exports of metallic mercury and certain mercury compounds and mixtures and the safe storage of metallic mercury. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:304:0075:0079:EN:PDF
GHS	Globally Harmonized System of Classification and Labelling of Chemicals (GHS) Third revised edition (2009) http://www.unece.org/trans/danger/publi/ghs/ghs_rev03/03files_e.html
GRS (2011)	GRS (2011) Analysis of options for the environmentally sound management of surplus mercury in Asia and the Pacific. http://www.unep.org/hazardoussubstances/Portals/9/Mercury/Documents/supplystor-age/Analysis%20of%20options%20for%20the%20environmentally%20sound%20management%20of%20surplus%20Hg%20in%20AP%20R2.pdf
NEWMOA (2011)	NEWMOA (2011) State Mercury-Added Product Ban & Phase-out Guidance. http://www.newmoa.org/prevention/mercury/imerc/banphaseout.cfm
SBC (1995)	Basel Convention Technical Guidelines on Specially Engineered Landfill http://www.basel.int/meetings/sbc/workdoc/old%20docs/tech-d5.pdf
UN (2003)	Committee of experts on the transport of dangerous goods and on the globally harmonized system of classification and labelling of chemicals. Sub-Committee of Experts on the Transport of Dangerous Goods (Twenty-fourth session, 1-10 December 2003, agenda item 4 c) Packagings (including IBCs and large packagings) Miscellaneous proposals. Packing instruction P800Packing instruction P800. http://www.unece.org/trans/doc/2003/ac10c3/ST-SG-AC10-C3-2003-32e.doc
UNFCCC (no year)	UNFCCC (no year) Glossary of climate change acronyms http://unfccc.int/essential_background/glossary/items/3666.php
US (2008)	Mercury Export Ban Act of 2008. http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ414.110.pdf
US CFR (2010)	USA Code of Federal Regulations CFR (2010) Title 40: Protection of Environment. PART 268—Land disposal restrictions. Subpart D—Treatment Standards (current as of August 26, 2010). http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;rgn=div6;view=text;node=40%3A26.0.1.1.3.4;idno=40;sid=19bd3bfede9c96fc1859ae4d5b881dca;cc=ecfr
US EPA (2009)	Potential Export of Mercury Compounds from the United States for Conversion to Elemental Mercury. http://www.epa.gov/hg/pdfs/mercury-rpt-to-congress.pdf
US EPA (2011)	US EPA (2044): Mercury Treatment Technologies, http://www.clu-in.org/contaminantfocus/default.focus/sec/Mercury/cat/Treatment_Technologies