國際化學品與汞2019
8/7~8/9 管理研討會
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Taiwan

The challenge and opportunity to implement the Minamata Convention: the global perspective of recycling and treatment of mercury waste

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1 Relevant provisions under the Minamata Convention

Article 11: Mercury wastes

- Necessary actions for each Party
  - Manage in an environmentally sound manner
  - Only recover, recycle, reclaim or directly re-use for a use allowed to a Party under this Convention or for environmentally sound disposal
  - Not transport across international boundaries except for the purpose of environmentally sound disposal and with the Basel Convention
- Necessary actions for Conference of the Parties (COP)
  - Define relevant thresholds for mercury wastes
  - Adopt requirements on the environmentally sound management of mercury wastes

Article 11: Mercury wastes

Target Mercury Wastes

Mercury* = Mercury or mercury compounds

Substances or objects

(a) Consisting of mercury*

- Excess mercury from the decommissioning of chlor-alkali facilities
- Mercury recovered from wastes containing/contaminated with mercury*
- Surplus stock of mercury* designated as waste

(b) Containing mercury*

- Wastes of mercury-added products
- Wastes containing mercury or mercury compounds that result from a treatment of mercury wastes

(c) Contaminated with mercury*

- Residues generated from mining processes, industrial processes, or waste treatment processes

in a quantity above the relevant thresholds defined by the COP

To specify wastes to be covered by Article 11 of the Minamata Convention

Note: this definition excludes overburden, waste rock and tailings from mining, except from primary mercury mining, unless they contain mercury or mercury compounds **above thresholds** defined by the COP.

Article 11: Mercury wastes

- Items to be considered for the environmentally sound management of mercury wastes

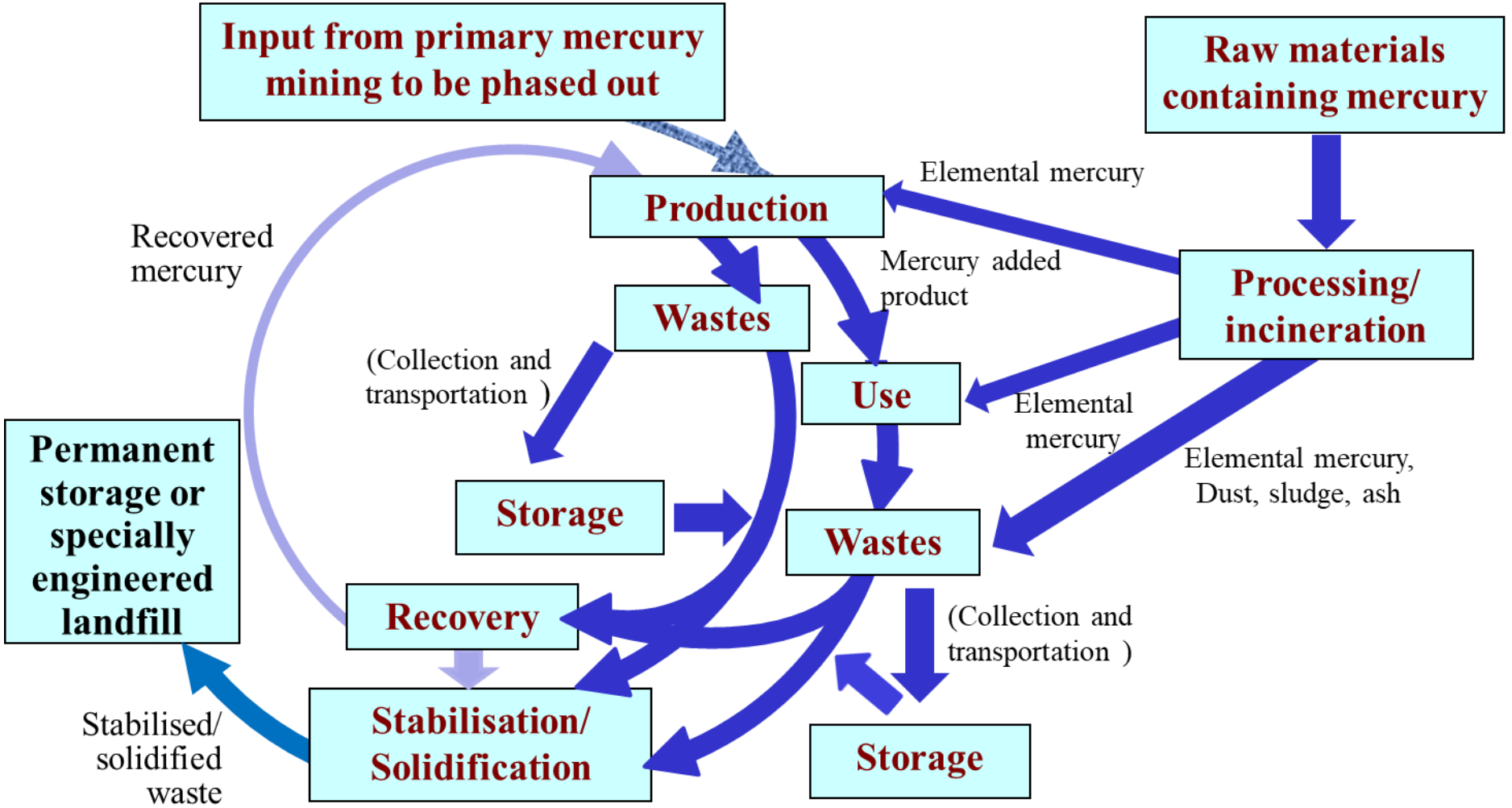
  - Guidelines developed under the Basel Convention
    - ✓ Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with mercury or mercury compounds

    (http://www.basel.int/Implementation/Publications/LatestTechnicalGuidelines/tabid/5875/Default.aspx)

  - Requirements that the COP shall adopt in an additional annex

Basel technical guidelines

- Basic concept of mercury management



Source: Basel technical guidelines for ESM of mercury wastes

Basel technical guidelines

- Environmentally sound disposal
  - Recovery operations
    - ✓ Pre-treatment
    - ✓ Recycling/reclamation of mercury or mercury compounds
      - Thermal treatment
      - Chemical oxidation
      - Chemical precipitation
      - Adsorption treatment
    - ✓ Distillation of mercury – purification
  - Operations not leading to recovery of mercury or mercury compounds
    - ✓ Physico-chemical treatment
      - Stabilization and solidification
      - Soil washing and acid extraction
    - ✓ Disposal in specially engineered landfills
    - ✓ Disposal in permanent storage (underground facilities)

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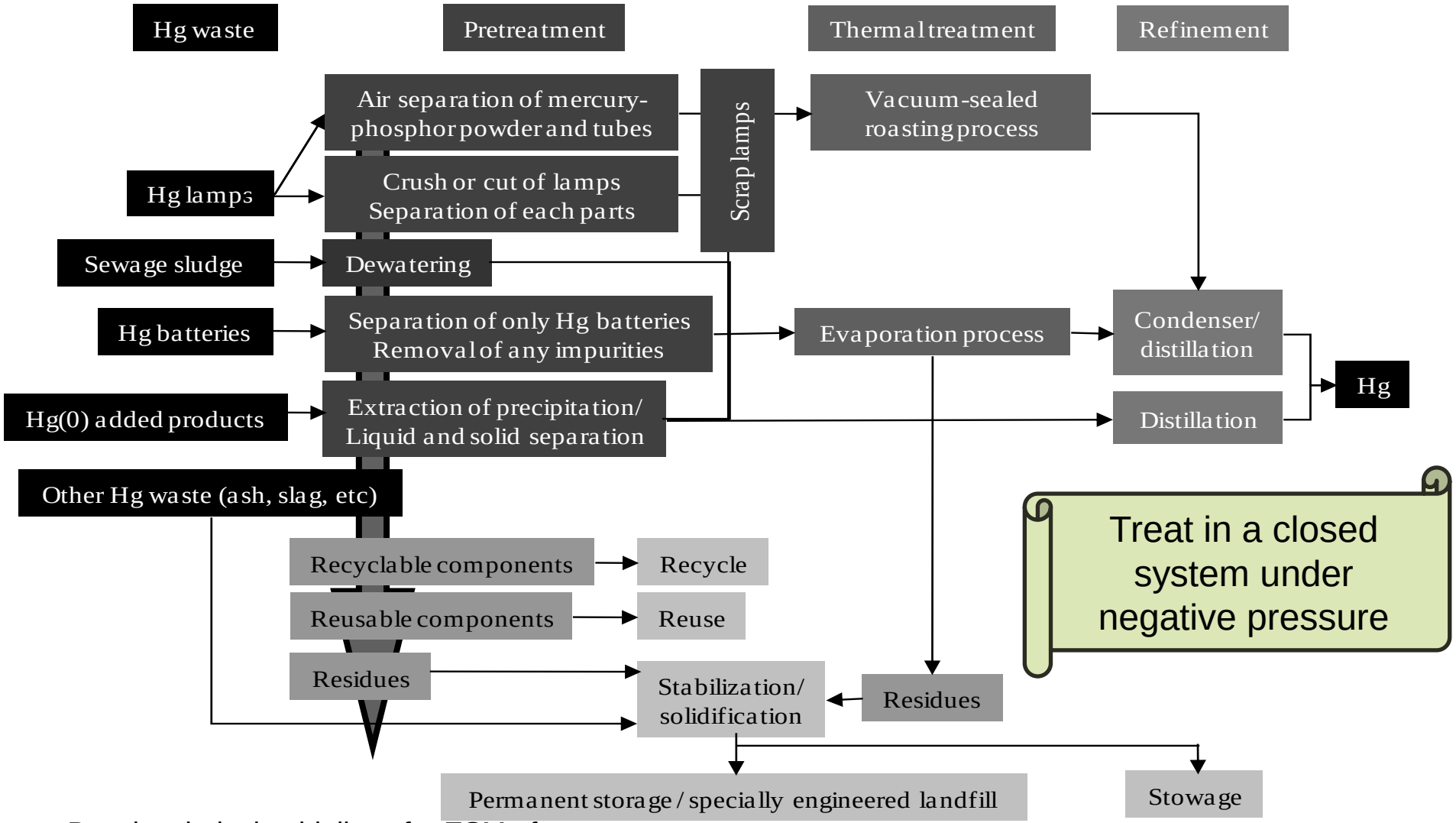
2 Recycling of mercury wastes

Basel technical guidelines

- Recovery operations
  - Flow of mercury recovery from solid waste



Source: Basel technical guidelines for ESM of mercury wastes

Basel technical guidelines

➢ Examples of pre-treatment operations

Fluorescent lamps	• Mechanical crushing: separate into glass, end-caps and mercury-phosphor powder mixtures • Air separation: Air is blown into the cut lamps to remove mercury-phosphor powder adsorbed on lamp glass
Mercury-added batteries	Removal of impurities, mechanical screening of the size of mercury-added batteries
Sewage sludge	Dewatering
Mercury-added products	Mercury extraction
Wastes containing mercury attached to devices	Dismantling (careful removal by hand): switches and relays from electronic devices, lamps from LCD screens of PCs and TVs

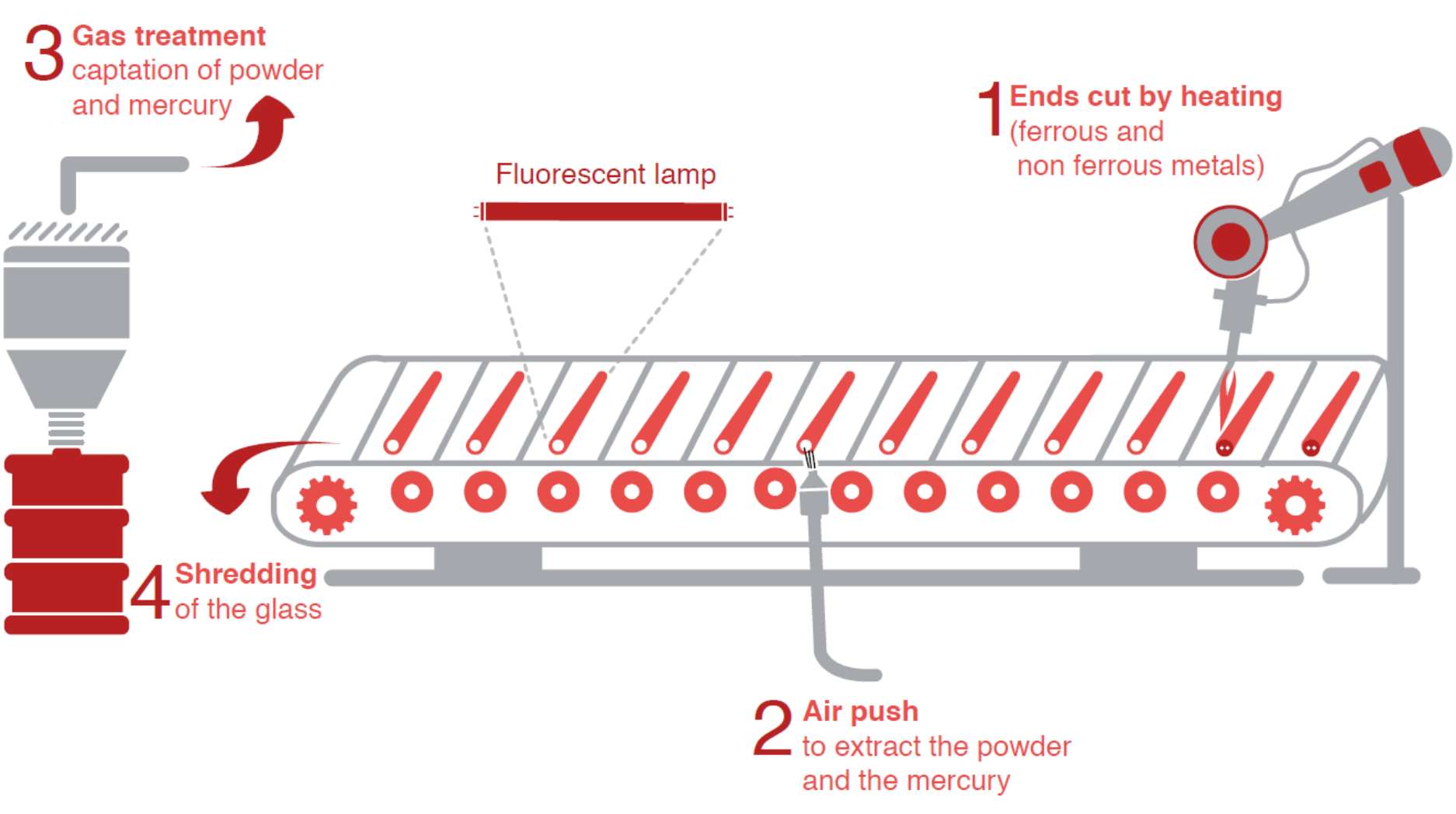
Metal pins of the end caps should be removed and treated separately

Extracted water will probably need to be managed as mercury waste

Should not be treated through shredding

Recycling practices

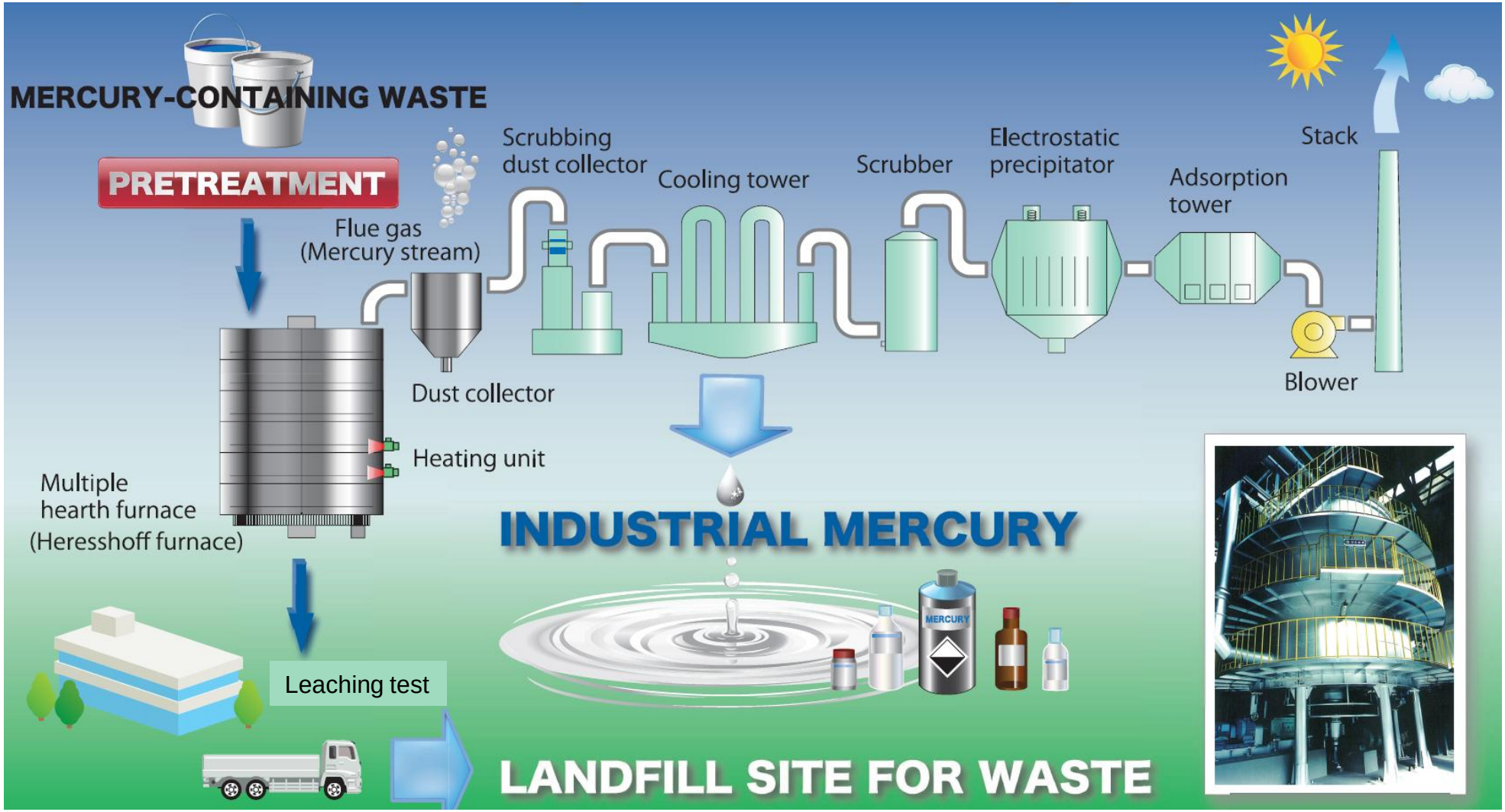
- Air separation of fluorescent lamps



Source: UNEP. (2015). Practical sourcebook on mercury waste storage and disposal.

Recycling practices

- Processing flow of mercury-containing waste



Source: Nomura Kohsan Co., Ltd. http://nkcl.jp/common/images/Processing-Flow_1.pdf

Recycling practices

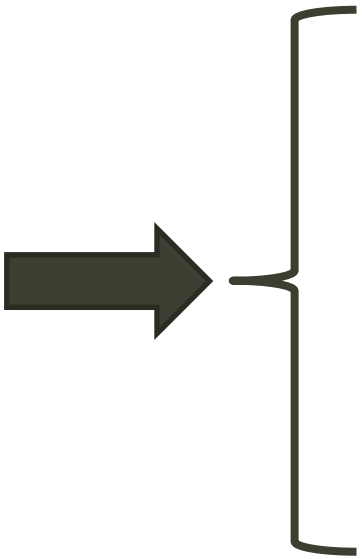
- Japan's case
  - Mercury recovery is required for
    - ✓ Wastes contaminated with mercury ≥1000mg/kg
    - ✓ Industrial wastes of mercury-added products

1. Switches/relays 2. Barometers 3. Hygrometers 4. Liquid manometers 5. Elastic manometers 6. Pressure transmitters 7. Vacuum gauges 8. Glass thermometers 9. Mercury-filled pressure thermometers 10. Mercury clinical thermometers 11. Mercury sphygmomanometers 12. Rotating lens assembly of a lighthouse 13. Mercury trim and heel adjusting devices	14. Discharge tubes (excluding discharge lamps including fluorescent/HID lamps) 15. Differential pressure flowmeters 16. Float type densitometers 17. Clinometers 18. Elapsed time indicators 19. Volume type power meters 20. Strain gauge sensors 21. Dropping mercury electrode 22. Coulometers 23. gyrocompasses 24. Grip dynamometers

Supply and demand for mercury

Supply

- Mercury from primary mining — **Zero 15 years after entry into force**
- Excess mercury from decommissioning of chlor alkali facilities — **after entry into force**
- Mercury recovered from mercury wastes
- Stockpiles of mercury



Demand

- Mercury-added products to be phased out — **By 2020**
- Manufacturing processes to be phase out — **By 2025 or 2018**
- Mercury-added products allowed
- Manufacturing processes allowed
- Other mercury uses allowed

Prohibited uses under the Convention

➢ Mercury-added products

Product	Exemption
Batteries	• Button zinc silver oxide batteries with Hg < 2% • Button zinc air batteries with Hg < 2%
Switches and relays	• 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
Compact fluorescent lamps	• Those not for general lighting purposes • Those that are > 30 watts • Those with a mercury content not exceeding 5 mg per lamp burner
Linear fluorescent lamps (LFLs)	• Those not for general lighting purposes • Triband phosphor: those that are ≥ 60 watts or those with a mercury content not exceeding 5 mg per lamp • Halophosphate phosphor: those that are > 40 watts or those with a mercury content exceeding 10 mg per lamp

Prohibited uses under the Convention

Mercury-added products

Product	Exemption
High pressure mercury vapor lamps (HPMV)	• Those not for general lighting purposes
Cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL)	• Those not for electronic displays • short length (≤ 500 mm) with mercury content not exceeding 3.5 mg per lamp • medium length (> 500 mm and ≤ 1 500 mm) with mercury content not exceeding 5 mg per lamp • long length (> 1 500 mm) with mercury content not exceeding 13 mg per lamp
Cosmetics, including skin lightening soaps and creams	• Those with mercury content ≤ 1ppm • Eye area cosmetics where mercury is used as a preservative and no effective and safe substitute preservatives are available
Pesticides, biocides and topical antiseptics	

Prohibited uses under the Convention

➢ Mercury-added products

Product	Exemption
Non-electronic measuring devices: (a) barometers (b) hygrometers (c) manometers (d) thermometers (e) sphygmomanometers	• Non-electronic measuring devices installed in large-scale equipment or those used for high precision measurement, where no suitable mercury-free alternative is available

General exemptions

(a) Products essential for civil protection and military uses
(b) Products for research, calibration of instrumentation, for use as reference standard
(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
(d) Products used in traditional or religious practices
(e) Vaccines containing thiomersal as preservatives

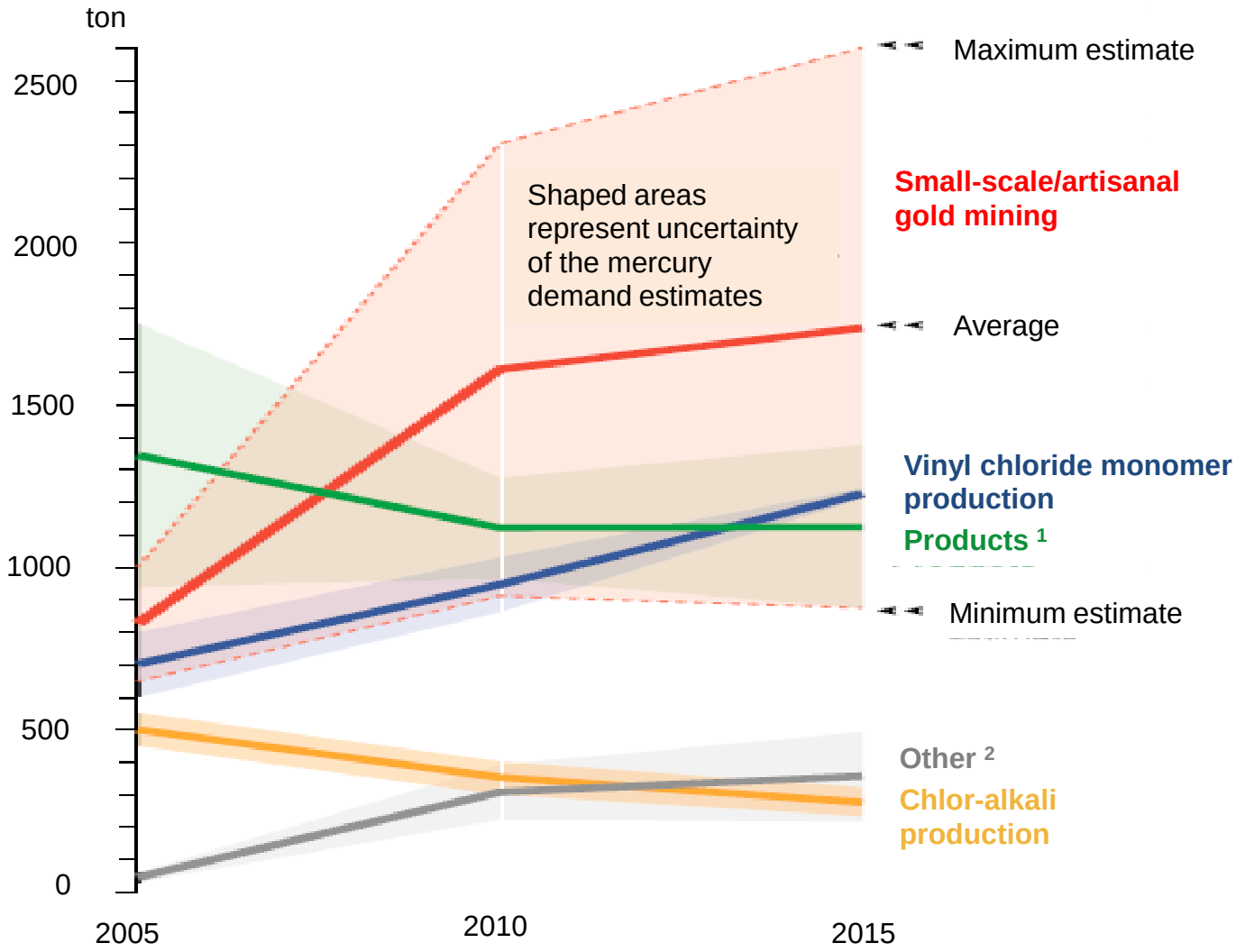
Prohibited uses under the Convention

- Manufacturing processes in which mercury or mercury compounds are used
  - Chlor-alkali production
  - Acetaldehyde production in which mercury or mercury compounds are used as a catalyst

Reduction of mercury use is required but not prohibited

- Vinyl chloride monomer production
- Sodium or potassium methylate or ethylate
- Production of polyurethane using mercury containing catalysts

Global mercury demand



1. Batteries, dental application, measuring and control devices, lamps, electrical and electronic devices
2. Paints, laboratory, pharmaceutical, cultural/traditional uses, etc.

Source: UNEP. (2017). Global mercury supply, trade and demand.

3 Treatment of mercury wastes (with focus on wastes consisting of mercury)

Wastes consisting of mercury*

- Examples of wastes consisting of mercury or mercury compounds

Type	Example
Consisting of mercury	• Mercury recovered from wastes containing or contaminated with mercury or mercury compounds from waste treatment facilities • Mercury electrode from production facilities for the production of chlor-alkali, alcoholates, dithionite and ultrapure potassium hydroxide solution • Mercury used in a porosimeter from laboratories/research institutions • Mercury in the mercury bearing to float and revolve the lens apparatus from light houses • Reagents and reference standard from laboratories
Consisting of mercury compounds	• Mercuric chloride (HgCl2) catalyst from VCM production facilities • Mercury sulphate (HgSO4) catalyst from acetaldehyde production facilities

Basel technical guidelines

- Transportation
  - Mercury in bulk form must be carefully packaged in appropriate containers before shipping to designated storage or disposal facilities.
  - Mercury wastes should be transported in an environmentally sound manner in order to avoid accidental spills; they should also be tracked during transport until they have reached their final destination.
  - Prior to transportation, contingency plans should be prepared in order to minimize environmental impacts associated with spills, fires and other potential emergencies.
  - Companies transporting wastes within their own countries should be certified as carriers of hazardous materials and wastes, and their personnel should be qualified and certified as handlers of hazardous materials and wastes

Basel technical guidelines

- Storage pending disposal operations
  - Storage facilities should not be built in sensitive locations whenever possible.
  - Storage facilities should be kept locked to avoid theft or unauthorized access.
  - Site-specific procedures should be developed to implement safety requirements identified for the storage of mercury wastes.
  - Containers should meet the following requirements:
    - ✓ they should not be damaged from any materials previously stored in them or have contained materials that could adversely react with mercury
    - ✓ their structural integrity should be intact
    - ✓ they should not be excessively corroded
    - ✓ they should have a protective coating (paint) to prevent against corrosion

Basel technical guidelines

- Storage pending disposal operations
  - Containers for wastes consisting of mercury or mercury compounds should be stored upright on pallets off the ground.
  - Aisles in storage areas should be wide enough to allow the passage of inspection teams, loading machinery and emergency equipment.
  - The floors of storage facilities should be coated with an epoxy coating and be light in colour to allow the detection of mercury droplets.
  - The floor and floor coating should be inspected frequently to ensure that the floor has no cracks and the coating is intact.
  - The floor should not be penetrated by any drains or plumbing, and sloped floors and open flow gutters with rounded-down edges (to avoid mercury trapping under gutter covers) could be used to facilitate the collection of spills.
  - The mercury content should be as pure as possible in order to avoid chemical reactions and the degradation of containers.

Basel technical guidelines

- Disposal
  - Wastes consisting of mercury or mercury compounds should be stabilized and/or solidified before final disposal and final disposal should be carried out in accordance with national and local laws and regulations.
    - ✓ Example of stabilization: conversion of mercury into mercury sulfide
    - ✓ Example of solidification: solidification of mercury sulfide with modified sulfur
  - Final disposal
    - ✓ Specially engineered landfills
    - ✓ Underground permanent storage

Disposal practices

- EU's case
  - ✓ New regulation (EU) 2017/852 on mercury requires mercury waste (metallic mercury that qualifies as waste) to undergo:
    - Conversion if permanently disposed of in underground facilities
    - Conversion and solidification if permanently disposed of in above-ground facilities

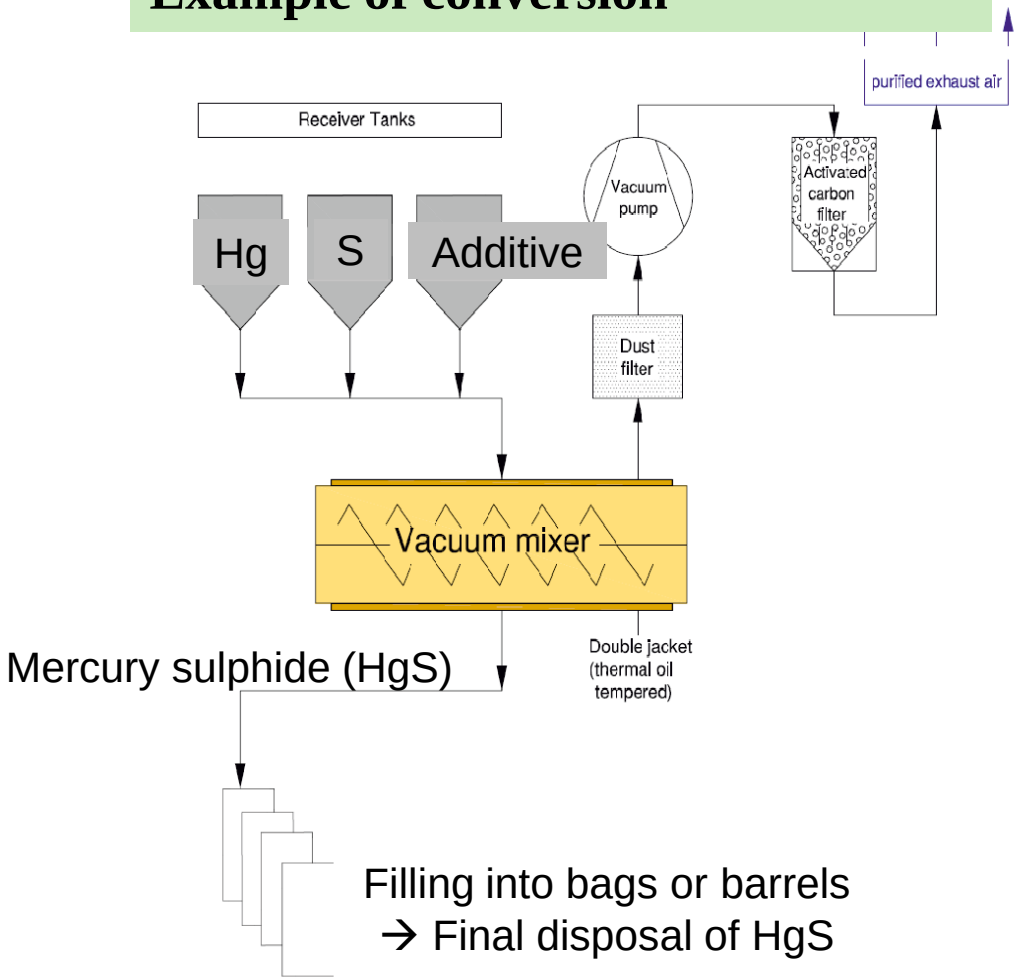
Conversion: the chemical transformation of the physical state of mercury from a liquid state to

- mercury sulfide or
- a comparable chemical compound that is equally or more stable and equally or less soluble in water and that presents no greater environmental or health hazard than mercury sulfide.

Disposal practices

➢ EU's case

Example of conversion



Source: Eurochlor website. https://www.eurochlor.org/wp-content/uploads/2019/04/2016-remondis_stabilisation_process_description.pdf

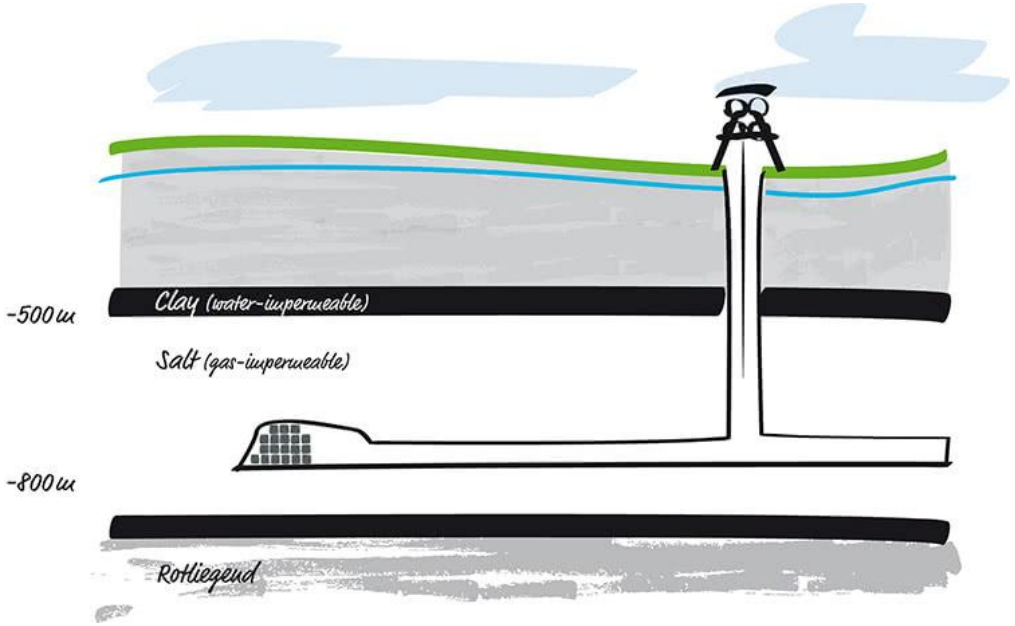
Disposal practices

- EU's case
  - ✓ Mercury waste that underwent conversion and, if applicable, solidification shall only be permanently disposed of in the following permanent storage facilities licensed for disposal of hazardous waste:
    - Salt mines that are adapted for the permanent storage of mercury waste that underwent conversion, or deep underground hard rock formations providing a level of safety and confinement equivalent to or higher than that of such salt mines
    - Above-ground facilities dedicated to and equipped for the permanent storage of mercury waste that underwent conversion and solidification and that provide a level of safety and confinement equivalent to or higher than that of the facilities referred to in point

Disposal practices

➢ EU's case

Underground facility for disposal

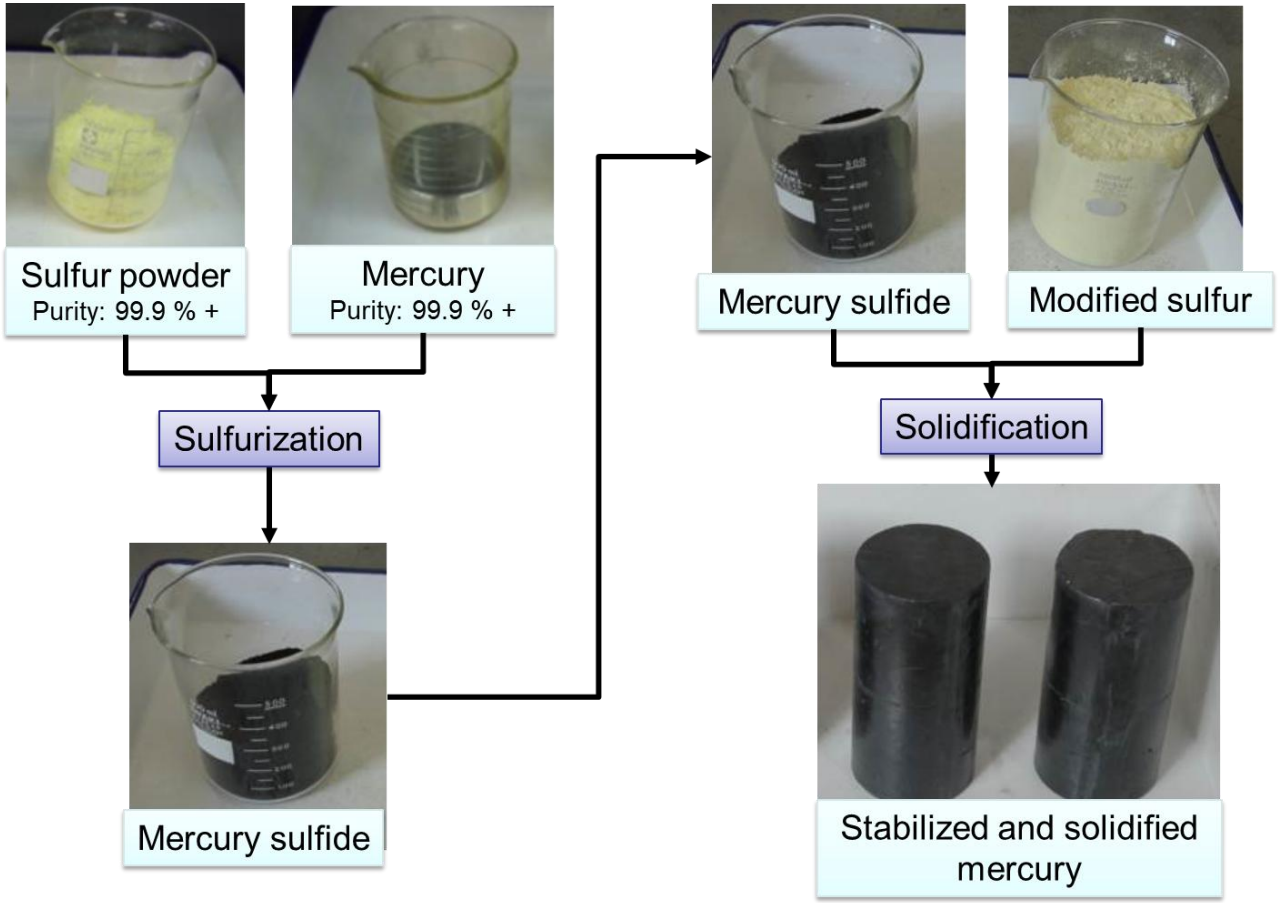


- Harmful substances are deposited into decommissioned sections of potash mines.
- People and the environment are protected well into the future as waste is embedded in thick salt layers well below the groundwater level.

Source: K + S website. http://www.ks-entsorgung.com/en/geschaeftsfelder/deponie/

Disposal practices

- Japan's case
  - ✓ Amend the existing regulations to require sulfurization and solidification of wastes consisting of mercury* before final disposal

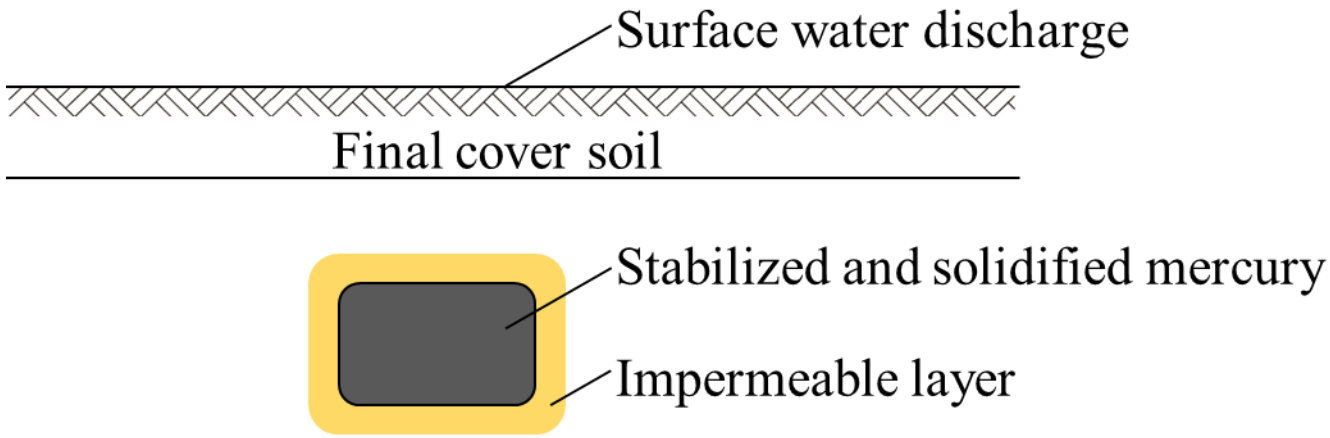


Source: Ministry of the Environment, Japan. (2017). Presentation on amendment of waste management regulations (in Japanese)

Disposal practices

- Japan's case
  - ✓ Amend the existing regulations to require additional measures to accept sulfurized and solidified of wastes consisting of mercury* to leachate-control type landfills

Image of disposing of stabilized and solidified mercury in a leachate-controlled type landfill

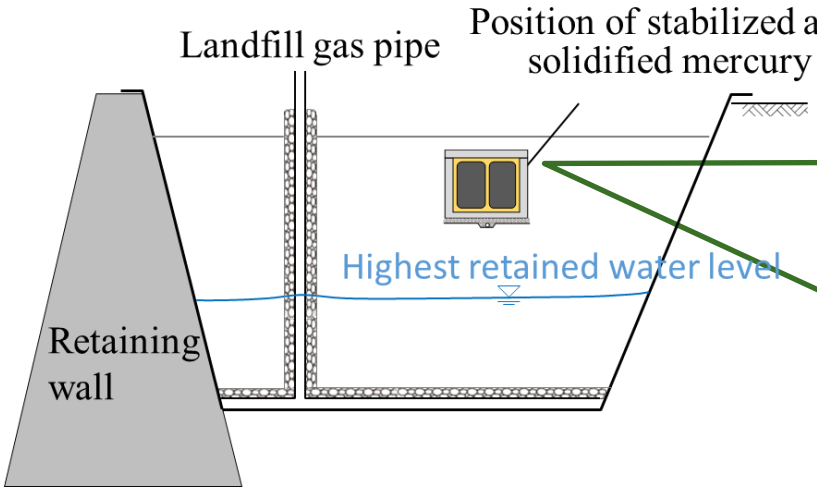


Source: Ministry of the Environment, Japan. (2019). Mercury waste guidelines (in Japanese)

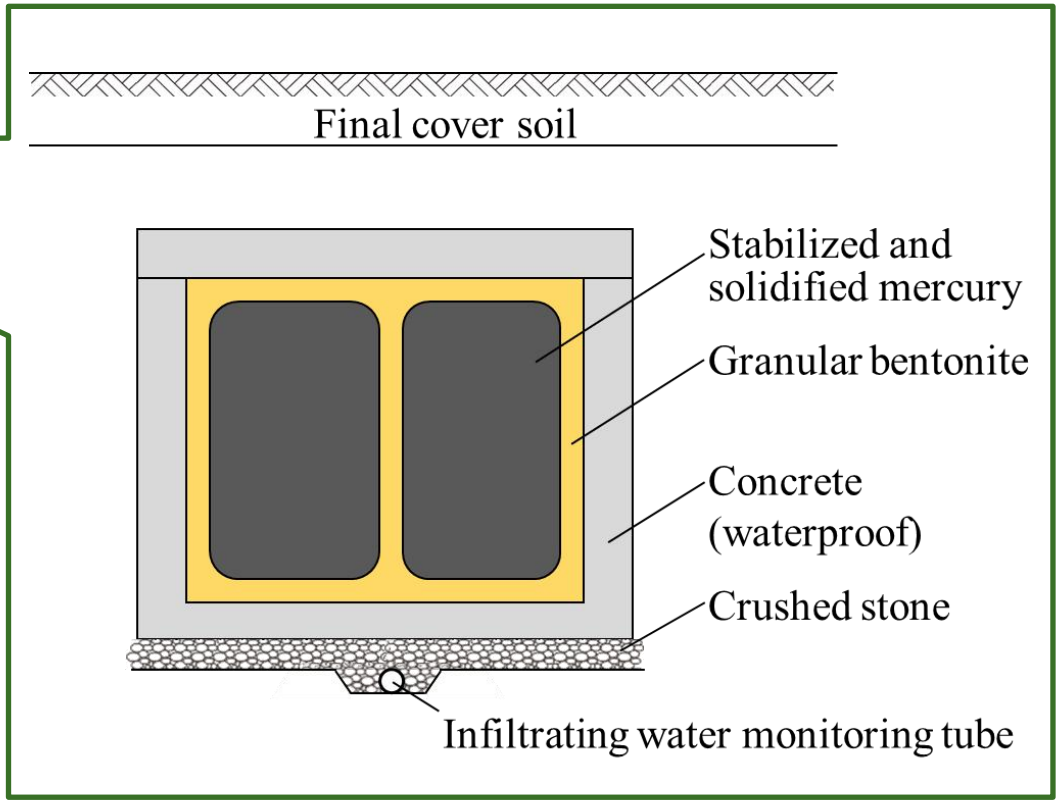
Disposal practices

➢ Japan's case

Example of the position of stabilized and solidified mercury in a landfill



Example of landfilling method of stabilized and solidified mercury



Source: Ministry of the Environment, Japan. (2019). Mercury waste guidelines (in Japanese)

Challenges and opportunities

- Stabilization and solidification of wastes consisting of mercury*
  - Need to stabilize and, if necessary, solidify wastes consisting of mercury for disposal
    - ✓ Purification, sulfurization, solidification of mercury
      - Technology
      - Facility and operator
      - Legal system for
        - requiring environmentally sound treatment
        - setting standards
        - issuing permits
        - monitoring treatment practices

Challenges and opportunities

- Stabilization and solidification of wastes consisting of mercury*
  - Challenges
    - ✓ Increased storage/disposal costs due to additional treatment and waste volume should be considered
    - ✓ Measures to prevent decomposition of stabilized mercury wastes in the long term should be identified
    - ✓ Completeness of the reaction between mercury and treatment chemicals should be established
    - ✓ Further research and steps towards large-scale commercialization needed
  - Opportunities
    - ✓ Reduces vapor pressure, solubility and mobility, enhances physical strength
    - ✓ Enhances safeguards against illegal use
    - ✓ Stabilized/solidified mercury wastes are relatively easy and safe to handle
    - ✓ Allows safe storage and disposal in SELs or permanent storage underground

Source: UNEP. (2015). Practical sourcebook on mercury waste storage and disposal.

Challenges and opportunities

- Final disposal of treated wastes consisting of mercury*
  - Need to find ways to safely dispose of treated wastes consisting of mercury
    - ✓ Export to the countries where treated wastes can be disposed of
      - Legal system for exporting wastes
      - Entities to handle such wastes
    - ✓ Establish a disposal system within the country
      - Facility and operator
      - Legal system for
        - setting standards
        - issuing permits
        - monitoring disposal practices

Challenges and opportunities

- Final disposal of wastes consisting of mercury* in specially engineered landfills (SELs)
  - Challenges
    - ✓ Long-term stability of treated mercury wastes in SELs should be examined, and methods to evaluate such long-term stability should be established.
    - ✓ SELs where treated mercury wastes are disposed of should be continuously managed and monitored to prevent mercury releases to the environment.
  - Opportunities
    - ✓ Well established concept in many countries; experience with other hazardous wastes
    - ✓ Relatively low investment costs
    - ✓ Mercury wastes are isolated for a defined period of time
    - ✓ SELs could be a solution to countries that do not have natural underground facilities/options

Source: UNEP. (2015). Practical sourcebook on mercury waste storage and disposal.

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