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環境省
Ministry of the Environment

Good Practices
for
Management of Mercury Releases from Waste (First Draft)

Sponsored and Contributed by the Ministry of the Environment, Japan

For

Waste Management Partnership Area
UNEP Global Mercury Partnership

October 2010

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Acronyms and Abbreviations (to be completed)

BAT	Best available techniques
BEP	Best environmental practices
EU	European Union
GC	Governing Council
Hg	Mercury
UNEP	United Nations Environment Programme
USA	United State of America
USEPA	United States Environmental Protection Agency
SEATEC	Society of Environmental Toxicology and Chemistry

1 Introduction

1.1 Background

1. United Nations Environmental Programme (UNEP) Governing Council (GC) Decision 23/9 called for mercury partnerships between governments and other stakeholders as one approach to reducing risks to human health and the environment from the release of mercury and its compounds to the environment. The decision encouraged Governments, the private sector and international organizations to take immediate actions to reduce the risks to human health and the environment posed on a global scale by mercury in products and production processes. In response to the Decision 23/9, the following five partnership areas were identified

- Mercury Management in Artisanal and Small-Scale Gold Mining
- Mercury Control from Coal Combustion
- Mercury Reduction in the Chlor-alkali Sector
- Mercury Reduction in Products
- Mercury Air Transport and Fate Research

2. At its 24th regular session in February 2007, GC recognised that efforts to reduce risks from mercury were not sufficient to address the global challenges posed by mercury and concluded that further long term international action is required. UNEP GC Decision 24/3 requests the Executive Director, working in consultation with Governments and other stakeholders, to strengthen the United Nations Environment Programme mercury programme partnerships by specific action including the expansion of the number and scope of partnerships to include new, growing or related sectors such as vinyl chloride monomer production, non-ferrous metals mining and cement production and waste combustion.

3. In 2008, Waste Management Partnership Area was initiated with the lead of the Government of Japan. The objective of the partnership area is to minimize and, where feasible, eliminate unintentional mercury releases to air, water, and land from waste containing mercury and mercury compounds by following a life cycle management approach. Part of the overall approach to achieve the objective is to strengthen the capacity of developing countries and countries with economies in transition to effectively deal with mercury waste. The partnership area has the following priority actions:

- Identify environmentally sound collection, treatment and disposal techniques for mercury waste following a lifecycle management approach
- Assess environmental impacts of current waste management practices and processes, including providing support to countries to assess their national situation and needs
- Promote awareness and education regarding mercury waste

4. One of the projects in the Waste Management Partnership Area is to develop a document for implementation of an important part of the Basel Convention Technical Guidelines on Environmentally Sound Management of Waste Consisting of Elemental Mercury and Waste Containing or Contaminated with Mercury (hereinafter referred to as “Basel TG”). The project aims to review available information on existing BAT/BEP for relevant sources, and to develop specific mercury technical document for implementation of several parts of the Basel TG.

5. The Basel TG have been drafted and covers a wide range of topics: basic knowledge about mercury, types and sources of mercury waste, prevention and minimization of mercury waste, environmentally sound handling, collection, storage and disposal of mercury waste, and the like. The fifth draft was discussed at the 7th Session of the Open-Ended Working Group held in May 2010, and the sixth draft will be submitted to the Basel Convention Secretariat by the end of October 2010.

6. This document provides practical information when readers of the Basel TG would like to implement principles described in the Basel TG. Some of the information formally included in the Basel TG, such as cases considered as good practices that realize the principles of the Basel TG, has been incorporated into this document in order to clarify characteristics of the both documents; the Basel TG provides principles while this document provides information about practical cases.

1.2 Objective of This Document

7. Objective of this document is to provide information that supports the implementation of good practices contributing to the reduction of mercury releases from waste following a life cycle management approach (see 1.4.1). This document is mainly composed of practical cases that realise the principles of the ESM of mercury waste in the Basel TG. These cases include, but not limited to, social systems (laws/regulations and voluntary agreement), institutional arrangement, and technical/cost information. These cases may not be directly applied to some cities/countries depending on the economic, technical, and political conditions that they face; readers of this document are expected to modify factors introduced in the cases in this document so as to fit their conditions.

8. This document is prepared based on the information available during 2009 and 2010. Better practices and more information will be available as we increase our experiences and new technologies are developed. This document is expected to be updated periodically to be more useful document to the readers. Those who know cases that implement the principles of the Basel TG or that are more advanced are strongly requested to provide information to the Ministry of the Environment, Japan (contact information will be indicated) and UNEP Chemicals (contact information will be indicated) for improving this document.

9. This document intends to provide the intergovernmental negotiating committee (INC) for global legally binding instruments for mercury control with useful information about possible actions to be taken by countries in order to reduce mercury releases from waste. (Background of starting (INC) and schedule of INC).

1.3 Definition of Mercury Waste

10. This document uses the same terminology as the Basel TG, which employs the following categorization of mercury waste:

A. Waste consisting of elemental mercury
   A-1 Waste elemental mercury (e.g. elemental mercury recovered from waste containing mercury and waste contaminated with mercury, spent catalyst, surplus stockpile of elemental mercury designated as waste)
   A-2 Stabilized or solidified waste elemental mercury
B. Waste containing mercury (e.g. waste of mercury added products)
   B-1 Waste products containing mercury that easily releases mercury into the environment when they are broken (e.g. waste mercury thermometer, fluorescent lamps)
   B-2 Waste products containing mercury other than B-1 (e.g. batteries)
C. Waste contaminated with mercury (e.g. residues generated from mining processes, industrial processes, or waste treatment processes)

1.4 Outline of This Document

1.4.1 Scope of This Document - Lifecycle Management Approach

11. A life cycle management (LCM) is a framework to analyse and manage the sustainability performance of goods and services (UNEP/SETAC, 2009). When it is applied to waste management, in the narrow sense, lifecycle of waste management covers waste separation at source, collection, treatment, and disposal, and in the broad sense, lifecycle of waste management covers material procurement, production, product use, and waste collection, treatment, and disposal.

12. When industrial processes do not use mercury in processes or products intentionally, waste contaminated with mercury generated from such industrial process and waste containing mercury as discarded products will be minimized. When products containing mercury are discarded by consumers, they are either 1) separated and collected for mercury recovery and recycling of other materials, 2) mixed with other municipal waste and combusted in waste incinerators, or 3) landfilled with other municipal waste or dumped in uncontrolled areas. From the collected waste products containing mercury, mercury is recovered and either permanently stored as final disposal or used for production of products for which mercury-free alternatives do not exist, are not available or take a long-term to replace. Combustion of waste containing or contaminated with mercury disperses the mercury into mainly flue gas and fly ash. Residues generated from a flue gas treatment process (collected and sludge from treatment of wastewater from wet scrubber). Depending on concentration of mercury in such residues, mercury is either recovered or stabilized/solidified, and the latter is landfilled. Dust, ash and sludge from coal/oil burning,

natural gas cleaning, non-ferrous smelting and industrial processes using mercury follow the same path as the waste treatment residues.

13. Following a life cycle approach, this document covers life cycle of products from production to disposal as indicated in Figure 1.4.1.

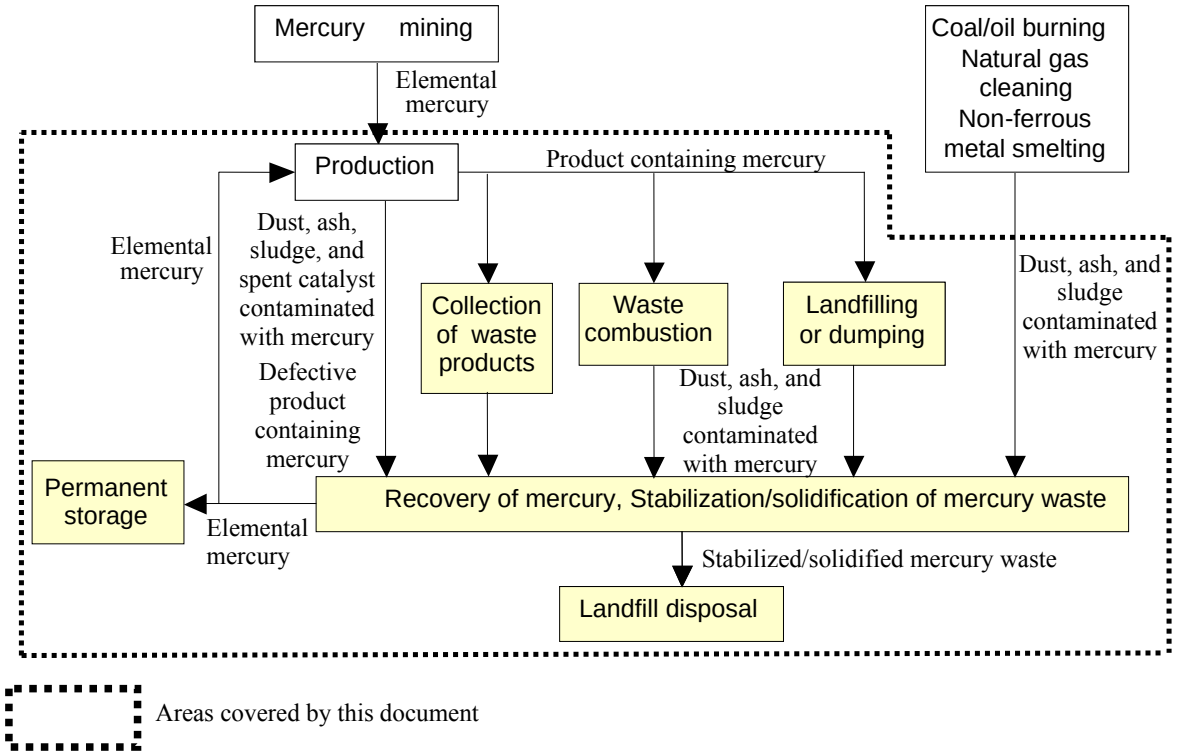


Figure 1.4.1 Scope of This Document

1.4.2 Contents of This Document

14. There are several areas of actions to reduce mercury releases from waste: reduction of mercury use in industrial processes and products, management of waste containing mercury, management of mercury in waste combustion, treatment of waste contaminated with mercury, disposal of mercury waste, and remediation of sites contaminated by waste containing or contaminated with mercury. Therefore, this document focuses on providing the following information:

- Identification of mercury waste: regulations on identifying hazardous waste based on mercury concentration level, examples of products containing mercury and their mercury contents, analysis methods of mercury in waste
- Reduction of mercury demands in industrial processes and products: regulations on mercury use in products, mercury-free alternatives, methods to reduce mercury use in industrial processes and products
- Collection of and mercury recovery of waste containing mercury: cases of legal systems and voluntary actions to implement collection and recycling of waste containing mercury (measuring equipment, fluorescent lamps, electrical and electronic equipment, dental amalgam, and batteries), their outcomes, challenges, and implementation scheme, mercury recovery technologies, and relevant awareness-raising activities
- Management of mercury during waste combustion: regulations on mercury concentrations in flue gas from waste incinerators, flue gas treatment technologies, wastewater treatment technologies, cases of managing mercury during waste combustion

- Disposal of mercury waste: regulations on waste acceptance criteria, solidification and stabilization technology, cases of disposal of waste contaminated mercury, regulations on temporal and permanent storage of waste elemental mercury
- Remediation of sites contaminated by mercury containing wastes: steps to clean-up contaminated sites, remedial techniques, cases of remediation of contaminated sites

1.5 Target Readers

15. Target readers of this document are mainly those who are in charge of formulating and implementing policies and projects to improve management of wastes containing mercury, and companies, engineers, and researchers who are developing technologies and plans relevant to BAT/BEP for waste management.

16. A trace level of mercury is included in municipal solid waste such as waste paper, cloth, garbage, wood, bamboo, straw, vinyl chloride, and synthetic resins other than waste batteries, fluorescent lamps, and dental amalgam that are recognized as waste products containing mercury (Takaoka, 2001). Even if mercury is eliminated in products, municipal solid waste may contain trace mercury. Therefore, readers should consider background mercury level when performance of actions is evaluated by the observed level of mercury in wastes.

1.6 Steps to Manage Mercury Releases from Waste (possible goals and steps will be added)

1.7 Relationship with the Related Documents and Activities

1.7.1 Basel Convention Technical Guidelines on Environmentally Sound Management of Waste Consisting of, Containing or Contaminated with Mercury

17. Development of the Basel TG was a part of the programme to support the implementation of the Strategic Plan focus area: B9 mercury waste adopted by the 8th Conference of the Parties (COP). The Basel TG focuses on mercury waste (Y29 Mercury; mercury compounds in Annex I of the Basel Convention). The first draft was prepared in July 2007, and the final draft will be prepared before the 10th COP in 2011.

18. While the Basel TG provide basic knowledge and expertise on the environmentally sound management of mercury waste and give comprehensive information about mercury waste, including the chemistry and toxicology of mercury, this document provides practical information to readers when they would like to implement the framework, technologies and practices in the Basel TG. This document tries to collect information about good practice options reflecting the principles in the Basel TG. In relation to the Basel TG, this document supplements the information in the sections of the 6th Draft Basel TG (see Table 1.7.1).

19. Since good practice cases provide information about relevant legal frameworks and awareness raising activities, Chapters 4, 5, and 6 covers the Basel TG sections of "3.2 Legislative and Regulatory Framework" and "3.12 Public Awareness and Participation". Chapter 2 also provides information about legal basis that provide mercury concentration levels for determination of hazardous wastes.

Table 1.7.1 Relationship between This Document and the Basel TG

Chapter of This Document	Relevant Sections in the Basel TG
1. Introduction	2. Relevant Provisions of the Basel Convention and Works under the UNEP 3. Guidance on the environmentally sound management (ESM) of Mercury Waste 3.1 General Introduction
2. Identification of Mercury Waste	3.2 Legislative and Regulatory Framework 3.3 Identification and Inventory
3. Reduction of Mercury Demands in Industrial Processes and Products	3.2 Legislative and Regulatory Framework 3.4 Mercury Waste Prevention and Minimization
4. Collection of and Mercury Recovery from Waste Containing Mercury	3.2 Legislative and Regulatory Framework 3.4 Mercury Waste Prevention and Minimization 3.6 Handling, Collection, Packaging, Labelling, Interim Storage and Transportation of Mercury Waste 3.7 Treatment of Mercury Waste and Recovery of Mercury 3.12 Public Awareness and Participation
5. Management of Mercury during	3.2 Legislative and Regulatory Framework

Chapter of This Document	Relevant Sections in the Basel TG
Waste Combustion	3.5 Reduction of Releases of Mercury from Waste Incineration and Disposal Site 3.7 Treatment of Mercury Waste and Recovery of Mercury 3.12 Public Awareness and Participation
6. Disposal of Mercury Waste	3.2 Legislative and Regulatory Framework 3.5 Reduction of Releases of Mercury from Waste Incineration and Disposal Site 3.7 Treatment of Mercury Waste and Recovery of Mercury 3.8 Temporal and Permanent Storage and Landfilling of Mercury Waste 3.12 Public Awareness and Participation
7. Remediation of Sites Contaminated with Mercury	3.9 Remediation of Contaminated Sites

1.7.2 UNEP Global Mercury Partnership Relevant Partnership Areas

20. (Outline of activities under the Product Partnership, Supply and Storage, Coal Combustion Partnership)

21. (Possible Collaboration areas between Waste Management Partnership and Other Partnerships)

1.8 Relevant Sections by Type of Waste Management

22. If you are interested in specific waste products or specific waste treatment methods, please refer to corresponding sections in this document as well as the Basel TG (see Table 1.8.1).

Table 1.8.1 Type of Waste Management and Corresponding Section (to be completed)

Type of Waste Management		Relevant Section in This Document	Relevant Section in Basel TG
Waste identification		2	3.3 Identification and Inventory
Reduction of mercury use in products and processes		3	3.4 Mercury Waste prevention and Minimization
Management of waste product	Measuring equipment	4.2	3.4.4 Products Containing Mercury 3.6 Handling, Collection, Packaging, Labelling, Temporal Storage, and Transportation of Mercury Waste 3.7 Treatment of Mercury Waste and Recovery of Mercury
	Fluorescent lamps	4.3	
	Electrical and electronic equipment (personal computer)	4.4	
	Dental Amalgam	4.5	
	Batteries	4.6	
Management of mercury during waste combustion	Treatment of flue gas from waste incineration	5.1, 5.3	3.5.1 Reduction of Mercury Releases from Waste Incineration
	Treatment of wastewater from wet scrubbers	5.2, 5.3	
Disposal of mercury waste	Prevention of landfill fire	(if information is collected)	3.5.2 Reduction of Mercury Releases from Disposal Sites 3.7 Treatment of Mercury Waste and Recovery of Mercury 3.8 Disposal of Mercury Waste
	Treatment of leachate from landfills	5.3.5	
	Treatment of sludge, fly ash	6.1	
	Disposal of waste consisting of elemental mercury	6.2	
Remediation of sites contaminated by waste containing mercury		7	3.9 Remediation of Contaminated Sites

23. Chapters 4, 5, and 6 of this document include good practice cases for corresponding issues. Good Practice cases try to provide information about the following items:

<u>Collection and recycling of waste containing mercury</u>

- General information

  - Target product (name, annual sales volume, weight of Hg in the product)
  - Target area
  - Started year
  - Background
  - Steps to introduce the system
  - Major outcome
  - Major challenges
  - Remaining issues to be solved
- Information about the collection system
  - Outline of collection system
  - Responsibility of stakeholders
  - Necessary costs for the collection and recovery system
  - Transport and storage methods for collected waste products
- Information about mercury recovery system
  - Outline of technology
  - Process flow
  - Ways to handle materials other than mercury
  - Description of pollution control measures
- Awareness raising
  - Target population
  - Activity period/frequency
  - Media used for awareness raising and message delivered
  - Responsibility of stakeholders
  - Cost sharing of stakeholders

<u>Waste treatment processes (flue gas, wastewater, residue/waste treatment)</u>

- General information (same as waste containing mercury)
- Information about legal/voluntary system
  - Legal basis or basis for voluntary system
  - Standard on mercury concentration
  - Rationale for standard value
  - Steps to introduce the standard
  - Enforcement scheme
- Technical information
  - Name and outline of technology to meet standard
  - Process flow
  - Mercury removal efficiency
  - Other environmental benefits
  - Further treatment needs (incl. amount of ashes and sludge generated through the treatment)
  - Initial and running costs (incl. Facility capacity)
- Awareness raising (same as waste products)

2 Identification of Mercury Waste

2.1 Criteria for Identifying Hazardous Waste based on Mercury Concentration Level

24. Many countries set judgment criteria so that the wastes that contain mercury above a certain level can be identified as hazardous waste and be managed properly. Although the basis of judgment criteria vary among countries, many countries take into account issues such as the impact of mercury to on human health, and economic feasibility to manage the identified hazardous wastes, availability of analysis methods, and the like.

25. For instance, in Japan, the estimated risk on human health from mercury intake through sea food consumption became the basis for setting the environmental water quality standards for mercury[1], and those standards became the basis for setting the effluent standards and the judgment criteria for identifying hazardous wastes. The Japanese Government set the environmental water quality standards for total mercury as equal to or below 0.0005mg/l, considering that if mercury concentration in environmental water is between 0.0005mg/l and 0.001mg/l, mercury concentration of sea food remains well below the interim regulation value (total mercury: 0.4 ppm, methyl mercury: 0.3ppm) of sea food and that background mercury concentration of environment is around 0.0001mg/l. The effluent standards for mercury (0.005mg/l) are set as ten times the value of the environmental water quality standards. Judgment criteria for hazardous waste in Japan are set based on the waste acceptance criteria for landfills for domestic and industrial wastes (leachate-controlled type). Since the waste acceptance criteria were also used for disposal of waste in ocean, the waste acceptance criteria were set as the same value of the effluent standards. Because the social, environmental and economic situations differ greatly among countries and regions, these judgment criteria should be set in a manner that is adapt to the situation of each country or region.

2.1.1 Examples of Criteria for Identifying Hazardous Waste based on Mercury Concentration Level

26. Table 2.1.1 and Table 2.1.2 summarize criteria for identifying hazardous waste based on mercury concentration in OECD and non-OECD countries respectively.

Table 2.1.1 Criteria for Identifying Hazardous Waste Containing Mercury in OECD Countries

Country	Target Waste Characteristics	Criteria for Identifying Hazardous Wastes based on Mercury Concentration Level	Legal Basis
Canada	Materials treated by one of the following operations R 1: Use as a fuel in an energy recovery system R 2: Recovery or regeneration of substances that have been used as solvents. R 3: Recovery of organic substances that have not been used as solvents. R 4: Recovery of metals and metal compounds. R 5: Recovery of inorganic materials other than metals or metal compounds. R 6: Regeneration of acids or bases. R 7: Recovery of components used for pollution abatement. R 8: Recovery of components from catalysts. R 9: Re-refining or reuse of used oil, other than by operation R1. R10: Land treatment resulting in	• Mercury: ≥0.10mg/l (TCLP, Test Method 1311)	Criteria for identifying hazardous waste (Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations)

[1] "Basis of Setting Environmental Standards (in Japanese)", Reference No. 5 from the Meeting of Experts on Environmental Standards under the Experts Committee on Water Environment of the Central Environment Council of Japan, http://www.env.go.jp/council/09water/y095-05/mat05.pdf

Country	Target Waste Characteristics	Criteria for Identifying Hazardous Wastes based on Mercury Concentration Level	Legal Basis
	agricultural or ecological improvement. R11: Use of residual materials obtained by any of operations R1 to R10 or R14. R12: Exchange of a recyclable material for another recyclable material prior to recycling by any of operations R1 to R11 or R14. R13: Accumulation prior to recycling by any of operations R1 to R11 orR14. R14: Recovery or regeneration of a substance or use or reuse of a recyclable material, other than by any of operations R1 to R10. R15: Testing of a new technology to recycle a hazardous recyclable material. R16: Interim storage prior to any of operations from R1 to R11 or R14.		
Germany	Wastes that indicate the following characteristics:		Criteria for identifying hazardous waste (Waste Catalogue Ordinance) NOTE *: Other than mercury(II) sulphide and those expressly listed in this Annex **: Other than those expressly listed in this Annex ***: Characteristics H1 to H12 are as follows: H1: explosive H2: oxidising H3-A: highly flammable H3-B: flammable H7: carcinogenic H9: infectious H10: teratogenic H11: mutagenic H12: substances and preparations which release toxic or very toxic gases in contact with water, air or an acid;
	H4: irritant (non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation; includes the substance R36/37/38 (irritates eyes, respiratory system and skin))	• Mercurous chloride: Concentration limit: 20% (Element/Substance content factor: 1.18)	
	H5: harmful (substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks; includes the substance R22 (harmful if swallowed))	• Mercurous chloride: Concentration limit: 25 % (Element/Substance content factor: 1.18)	
	H6: toxic (substances and preparations (including very toxic substances and preparations) which, if they are inhaled or ingested or if they penetrate the skin, may involve serious, acute or chronic health risks and even death; includes the substance R26/27/28 (harmful if inhaled, touches skin or swallowed))	• Mercury: Concentration limit: 3% • Inorganic mercury compounds: Concentration limit: 0.1 % * • Organic mercury compounds: Concentration limit: 0.1% ** • Mercury dichloride: Concentration limit: 0.1% (Element/Substance content factor: 1.35)	
	H8: corrosive (substances and preparations which may destroy living tissue on contact; includes the substance R34 (cause burns))	• Mercury dichloride: Concentration limit: 5% (Element/Substance content factor: 1.35)	

Country	Target Waste Characteristics	Criteria for Identifying Hazardous Wastes based on Mercury Concentration Level	Legal Basis
	H13: substances and preparations capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristics listed from H1 to H12***;	• Mercury: > 0.02mg/l (Leaching test DIN EN 1483)	
	H14: ecotoxic (substances and preparations which present or may present immediate or delayed risks for one or more sectors of the environment)	• Mercury: Concentration limit: 0.25% • Organic mercury compound: Concentration limit: 0.25% * • Inorganic mercury compound: Concentration limit: 0.25% ** • Mercurous chloride: Concentration limit: 0.25% (Element/Substance content factor: 1.18) • Mercury dichloride: Concentration limit: 0.25% (Element/Substance content factor: 1.35) • Mercurous chloride: Concentration limit: 0.25% (Element/Substance content factor: 1.18) • Mercury dichloride: Concentration limit: 0.25% (Element/Substance content factor: 1.35)	
	The following wastes • Single-use cameras using mercury-containing batteries • Electrical and electronic equipment that include mercury switches	No criteria (i.e. all of these wastes are automatically identified as hazardous wastes	
Japan	• Combustion residue • Soot and dust • Slag • Sludge • Treated combustion residue, soot/dust, slag and sludge for disposal that are not waste acid or waste alkali	• Alkyl mercury: Not detected • Mercury: > 0.005mg/l (Leaching test)	Criteria for determining specially controlled industrial waste (Ordinance on Judgment Criteria regarding Industrial Wastes containing Metals and other Substances under the Waste Management and Public Cleansing Law)
	• Waste acid or waste alkali • Treated waste acid or waste alkali that are waste acid or waste alkali	• Mercury: > 0.05mg/l (Concentration level in waste acid or waste	

Country	Target Waste Characteristics	Criteria for Identifying Hazardous Wastes based on Mercury Concentration Level	Legal Basis
	• Treated combustion residue, soot/dust, slag and sludge that are waste acid or waste alkali	alkali)	
Korea	Commercial wastes specified by Presidential Decree as harmful substances	• Mercury: > 0.005mg/l (Testing Method of Waste Leaching Procedure)	Criteria for identifying controlled waste (Presidential Decree concerning the Waste Control Act)
United States	Solid waste (except manufactured gas plant waste)	• Mercury: ≥ 0.2mg/l (TCLP, Test Method 1311)	Criteria for identifying hazardous waste (Resource Conservation and Recovery Act (40 CFR 261.24))
	Wastes from the following specific sources: • Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used (K071) • Wastewater treatment sludge from the mercury cell process in chlorine production (K106) • Wastewater treatment sludges from the production of vinyl chloride monomer using mercuric chloride catalyst in an acetylene-based process (K175) * Numbers in parentheses indicate hazardous waste numbers	No criteria (i.e. all of these wastes are automatically identified as hazardous wastes)	Criteria for identifying hazardous waste (Resource Conservation and Recovery Act (40 CFR 261.30～261.33))
	The following discarded commercial chemical products: • Fulminic acid, mercury(2+) salt (R,T) (P065) • Mercury, (acetato-O)phenyl- (P092) • Mercury (U151)	No criteria (i.e. all of these wastes are automatically identified as hazardous wastes)	

NOTE: In the US, wastes containing less than 260 mg/kg of total mercury are considered as "low mercury waste", and wastes containing more than 260 mg/kg total mercury are considered as "high mercury wastes". It is obligatory to recover mercury from the high mercury wastes. The high mercury wastes that contain organic mercury (which include organics and are not burnt residuals) may be incinerated.

Table 2.1.2 Criteria for Identifying Hazardous Waste Containing Mercury in non-OECD Countries

Country	Target Waste Characteristics	Criteria for Identifying Hazardous Wastes based on Mercury Concentration Level	Legal Basis
China	Solid wastes	• Methyl mercury: 10ng/l • Ethyl mercury: 20ng/l • Total mercury: 0.1mg/l (Leaching test)	Criteria for identifying hazardous waste (Identification standard for hazardous wastes – Identification for extraction procedure toxicity (GB5085.3-2007))
India	Wastes listed in List of	• Mercury and mercury	Criteria for identifying hazardous

Country	Target Waste Characteristics	Criteria for Identifying Hazardous Wastes based on Mercury Concentration Level	Legal Basis
	Hazardous Waste	compounds: ≥ 50mg/kg	waste (The Hazardous Waste (Management and Handling) Amendment Rules, 2003)
Indonesia	Wastes from non-specific sources, from specific sources and from overdue chemicals that are expired, spilled package residue or off-specific action products as defined by Governmental Regulation Number 85/1999 regarding Hazardous Waste Management	• Mercury: 0.2mg/l (TCLP)	Criteria for identifying hazardous waste (Governmental Regulation Number 85/1999 regarding Hazardous Waste Management Annex II)
Philippines	By-products, side-products, process residues, spent reaction media, contaminated plant or equipment or other substances from manufacturing operations and as consumer discards of manufactured products which present unreasonable risk and/or injury to health and safety and to the environment.	• Mercury: > 0.2mg/l (TCLP, Test Method 1311)	Criteria for identifying hazardous waste (DAO2004-36 (Procedural manual Title III of DAO 92-29 "Hazardous Waste Management")
Thailand	Wastes from industrial activities (including wastes)	• Mercury and/or mercury compounds: ≥0.2mg/l (Leaching test specified by the Notification) • Mercury and/or mercury compounds: ≥ 20mg/kg (Total analysis specified in the Notification)	Criteria for identifying hazardous waste (Notification of the Ministry of Industry Re: Industrial Waste Disposal B.E. 2548 (2005))
Vietnam	Solid, liquid or gas that is emitted from production processes, business operations, services, daily life and other activities.	• Mercury: 0.2mg/l (TCLP, Test Method 1311) • Mercury: 4ppm	Criteria for identifying hazardous waste (National Technical Regulation on Hazardous Waste Threshold (QCVN07: 2009/BTNMT))

2.1.2 Analysis Methods to Determine Concentration of Mercury in Waste

27. To determine concentration of mercury in waste, there are several analysis methods. Example methods are summarized in Table 2.1.3.

Table 2.1.3 Analysis Methods of Mercury in Waste

Target	Method
To determine the mobility of mercury in waste	Leaching Test Method - The Japanese Standardized Leaching Test No. 13 (JLT-13) (Ministry of the Environment Notification No. 13) (Ministry of the Environment, Japan 1973);
	US EPA Method 1311: TCLP, Toxicity Characteristic Leaching Procedure (US EPA 1992)
	EN 12457-1 to 4: Characterization of waste - Leaching - Compliance test for leaching of granular waste materials and sludges (European Committee for Standardization 2002)

Target	Method
	EN 12920: Characterization of waste - Methodology for the determination of the leaching behaviour of waste under specified conditions (European Committee for Standardization 2006)
	EN 13656: Characterization of waste - Microwave assisted digestion with hydrofluoric (HF), nitric (HNO_3) and hydrochloric (HCl) acid mixture for subsequent determination of elements in waste (European Committee for Standardization 2002)
	EN 13657: Characterization of waste - Digestion for subsequent determination of aqua regia soluble portion of elements in waste (European Committee for Standardization 2002)
	TS 14405: Characterization of waste - Leaching behaviour test - Up-flow percolation test (European Committee for Standardization 2004)
To determine concentrations of mercury in waste	Standard Methods for the Examination of Wastewater, Japan Sewage Works Association (in Japanese) (Japan Sewage Works Association 1997)
	US EPA Method 7471B: Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique) (US EPA 2007c)
	US EPA Method 7473: Mercury in Solids and Solutions by Thermal Decomposition, Amalgamation, and Atomic Absorption Spectrophotometry (US EPA 2007d)
	US EPA Method 7470 A: Mercury in Liquid Waste (Manual Cold-Vapor Technique) (US EPA 1994)
	EN 13370: Characterization of waste - Analysis of eluates - Determination of Ammonium, AOX, conductivity, Hg, phenol index, TOC, easy liberatable CN-, F- (European Committee for Standardization 2003)
	EN 15309: Characterization of waste and soil - Determination of elemental composition by X-ray fluorescence (European Committee for Standardization 2007)

2.2 Industrial Process Residues Contaminated with Mercury

28. (If information about mercury contents of industrial process residues contaminated with mercury is available, it will be summarized in Table 2.2.1.)

Table 2.2.1 Examples of Industrial Process Residues Contaminated with Mercury (to be completed)

Process	Waste Type	Mercury Content	Region	Source

2.3 Products Containing Mercury

29. This section provides information about examples of products containing mercury that will become waste containing mercury and their mercury contents.

2.3.1 Examples of Products Having Parts Containing Mercury

30. Products containing mercury include, but not limited to, thermometers and other measuring equipment, mercury switches/relays, fluorescent lamps, batteries, biocides, pesticides, paints, pigments, pharmaceuticals, cosmetics, dental amalgams, and laboratory chemicals. Among those, mercury switches/relays, lamps, mercury-containing batteries and are difficult to recognize when they are built onto devices such as toys and electrical and electronic equipment. Table 2.3.1 shows examples of products having parts containing mercury and location of the parts. Examples of mercury content and its form in the products are also shown in Table 2.3.2.

Table 2.3.1 Examples of Products Having Parts Containing Mercury (to be completed)

Product	Location of Parts Containing Mercury in Product	Photo (if available)

Product	Location of Parts Containing Mercury in Product	Photo (if available)

2.3.2 Available Information about Mercury Content in Products

31. Since the mercury content of the product varies by producer and product type, it is difficult to provide comprehensive information about mercury content of the product. However, examples of mercury content of products may be useful to estimate mercury to be contained in waste. Table 2.3.2 shows available information about mercury content of products and its form or location.

Table 2.3.2 Available Information about Mercury Content of Products

Product Type [parts consisting of/containing mercury]	Name	Mercury Content	Region	Source (Source in parentheses indicate original source)
Lamps [Mercury is found in form of vapour in glass tubes/bulbs.]	Fluorescent (double end)	10-22 mg/unit	USA	NJ MTF 2002
		23-46 mg/unit	Canada	Environment Canada 2003
		50 mg/unit (mid 1970s) 7 mg/unit (2007)	Japan	Japan Electric Lamp Manufactures Association 2008
		3-4 mg/unit	Global	Lowest content on the market
	Compact fluorescent (CFL, single end)	10 mg/unit	Canada	Environment Canada 2003
		Less than 5mg/unit	Japan	Japan Electric Lamp Manufactures Association 2008a
	High pressure mercury vapour	75 mg/unit (1993) 39 mg/unit (1997) 30 mg/unit (2002)	European Union	European Commission 2008 (Floyd *et al.* 2002)
		Appx. 10 mg for 50g lamp Appx. 25 mg for 280g lamp Appx. 70 mg for 550g lamp	Japan	Japan Electric Lamp Manufactures Association 2008b
	High-pressure sodium	20 mg/unit (1993) 25 mg/unit (1997) 30 mg/unit (2002)	European Union	European Commission 2008 (Floyd *et al.* 2002)
		Appx. 20 mg for 100g lamp Appx. 25 mg for 280g lamp Appx. 25 mg for 550g lamp	Japan	Japan Electric Lamp Manufactures Association 2008b
	Metal halide	60 mg/unit (1993) 30 mg/unit (1997) 25 mg/unit (2002)	European Union	European Commission 2008 (Floyd *et al.* 2002)
		Appx. 20 mg for 100g lamp Appx. 60 mg for 280g lamp Appx. 100 mg for 550g lamp	Japan	Japan Electric Lamp Manufactures Association 2008b
Mercury lamps in electronic devices [Mercury is found in form of vapour in glass tubes/bulbs.]	Multi-media monitor	Range: 75 mg/unit	European Union	European Commission 2008 (AEA 2007)
	LCD display monitor	Range: 2.5 - 30.0 mg/unit		
	LCD TV flat panel	Range 2.5 - 30.0 mg/unit		

Product Type [parts consisting of/containing mercury]	Name	Mercury Content	Region	Source (Source in parentheses indicate original source)
	Digital picture frame	Range: 2.5 mg/unit		
	LCD projector	Range: 75.0 mg/unit		
	Laptop/notebook	Range: 2.5 - 30.0 mg/unit		
	Fax/copier/printer	Range: 2.5 - 30.0 mg/unit		
	Fax	Range: 2.5 mg/unit		
	Scanner	Range: 2.5 - 30.0 mg/unit		
	Copier	Range: 2.5 - 7.5 mg/unit		
	Camcorder/camera	Range: 2.5 mg/unit		
	Audio equipment	Range: 2.5 mg/unit		
	DVD/VCR players	Range: 2.5 mg/unit		
Batteries [Mercury may be found in the insulating paper surrounding the battery or be mixed in the anode.]	Button cell (Lithium manganese dioxide) typically for photographic devices, auto garage door openers, electronics	0 % Hg	European Union	European Commission 2008
	Button cell (Silver oxide) typically for watches	0.2-1.0 % Hg		
	Button cell (Alkaline manganese dioxide) typically for calculators, small electronic devices, remote controls	0.1-0.9 % Hg		
	Button cell (Zinc air) typically for hearing aids, pagers	0.3-2.0 % Hg		
	Cylindrical or rectangular batteries (Alkaline manganese)	previously contained an average of 0.5 % mercury to control the zinc reaction, then 25 mg Hg, and now 0.0005 % Hg		
Thermometers	Medical thermometers	0.5-1.0 g/unit	European Union	European Commission 2008 (Floyd *et al.* 2002)
[Column of mercury is found inside thin glass tubes.]	Non-fever, basal	Less than 0.005 to 5 g/unit	USA	USEPA 2008 (Lowell Center for Sustainable Production (2003), Environment Canada (2002))
	Non-fever, industrial/commercial	Less than 0.005 to 1 g/unit	USA	USEPA 2008 (Lowell Center for Sustainable Production (2003), Environment Canada (2002))
	Thermometers used for laboratories and in industry [Mercury is found	1-20 g/unit (average 3-4 g/unit)	European Union	European Commission 2008

Product Type [parts consisting of/containing mercury]	Name	Mercury Content	Region	Source (Source in parentheses indicate original source)
	inside thin glass tubes which provide the temperature readout.]			
Manometers [Columns of mercury are found inside glass/plastic tubes.]	Manometers used for laboratories and in industry	70-40 g/unit	European Union	European Commission 2008
	Manometers	28-74 g/unit	USA	USEPA 2008 (Lowell Center for Sustainable Production (2003))
	Manometers	100-500 g/unit	USA	USEPA 2008 (Environment Canada (date not available))
Barometers [Mercury-filled reservoir is found at the end of a glass tube.]	Barometer for private households	60-75 g/unit	European Union	European Commission 2008
	Barometer for laboratories	Up to 1.1 kg/unit	European Union	European Commission 2008
	Barometers	300-622 g/unit	USA	USEPA 2008 (Lowell Center for Sustainable Production (2003), Environment Canada (date not available))
Sphygmomanometers [Column of mercury is found inside thin glass tubes.]	Sphygmomanometers	85-100 g/unit	European Union	European Commission 2008
		20-60 g/unit	USA	(Environment Canada (date not available))
		70-90 g/unit	USA	USEPA 2008 (USEPA (2002))
Psychrometers/ Hygrometers [Column of mercury is found inside thin glass tubes.]	Hygrometers	0.01-6 g/unit	USA	USEPA 2008 (Environment Canada (date not available))
	Psychrometers/	~7 g/unit	USA	USEPA 2008 (Environment Canada (date not available))
Thermostats [Mercury is found in the mercury switch, which consists of a glass	Thermostats (residential)	0.01- 4 g/unit	USA	USEPA 2008 (Lowell Center for Sustainable Production (2003))

Product Type [parts consisting of/containing mercury]	Name	Mercury Content	Region	Source (Source in parentheses indicate original source)
bulb filled with an inert gas and a small pool of mercury.]				
		3-18 g/unit	USA	USEPA 2008 (Environment Canada (date not available))
	Thermostats (industrial/commercial)	0.001-1g/unit	USA	USEPA 2008 (Lowell Center for Sustainable Production (2003))
		3-18 g/unit	USA	USEPA 2008 (Environment Canada (date not available))
Tensiometers [Column of mercury is found inside glass/plastic tubes.]	Tensiometers mainly used for research applications	Up to 0.5 kg/unit	European Union	European Commission 2008
Switches, relays [Mercury switches and relays are consisted of glass bulbs filled with an inert gas and a small pool of mercury.]	Mercury float switches	0.1-67 g/unit	USA	USEPA (2008) (NWMOA(2005))
	Mercury tilt switches	0.5-10 g/unit	European Union	European Commission 2008
		0.05-1 g/unit	USA	USEPA (2008) (NWMOA (2005))
	Mercury pressure switches	1-20 g/unit	USA	USEPA 2008 (Environment Canada (date not available))
	Mercury temperature switches	1-10 g/unit	USA	USEPA 2008 (Environment Canada (date not available))
	Mercury reed switches	HG switch (3 g Hg) HGW switch (0.32 g) HGX switch (0.071 g) MH4 switch (0.041 g) MH5 switch (0.0095)	European Union	European Commission 2008 (Comus 2008)
	Relays/contacts	0.001-153 g/unit		USEPA (2008) (NWMOA (2005))

3 Reduction of Mercury Demands in Industrial Processes and Products

3.1 Introduction

32. The ideal way to minimize mercury use in industrial processes and products is to plan mercury minimization in those processes and products as a life cycle approach. Mercury used in those processes and products eventually become waste and needs to be treated in the environmentally sound way. In order to undertake a lifecycle approach for mercury minimization, it is important to fully understand current use of mercury for processes and in products at national and/regional level, and of mercury accumulated in society in products, at production facilities, on the grounds of contaminated sites and within other stocks and inventories. Current available technologies to treat mercury in the environmentally sound way should be identified. Once all those information is collected and analyzed, a life-cycle approach to minimize mercury should be conducted to identify how minimization of mercury uses can be achieved. The European Commission produced a comprehensive study in "Options for reducing mercury use in products and applications and the fate of mercury already circulating in society" which is recommended as one of the references on a life-cycle approach to minimize mercury uses (European Commission 2008).

33. Awareness and action regarding the environmental and health effects of mercury are more and more common in both developed and developing countries around the world. In developed countries, much of the activity revolves around installing better engineering controls on coal-fired power plants and identifying and managing mercury-containing products already in the stream of commerce. As examples, Figure 3.1.1 and Figure 3.1.2 show the steady decline of mercury demand in Japan and USA, respectively. With a few exceptions like energy efficient lighting, legislation and public awareness have significantly reduced the entry of new mercury-containing products into the market. The developing world still suffers the effects of mercury emissions from industrial process using older technologies (e.g., chlor-alkali chlorine plants) and uncontrolled use of mercury emitting techniques (e.g., mercury amalgamation of gold in artisanal and small scale mining).

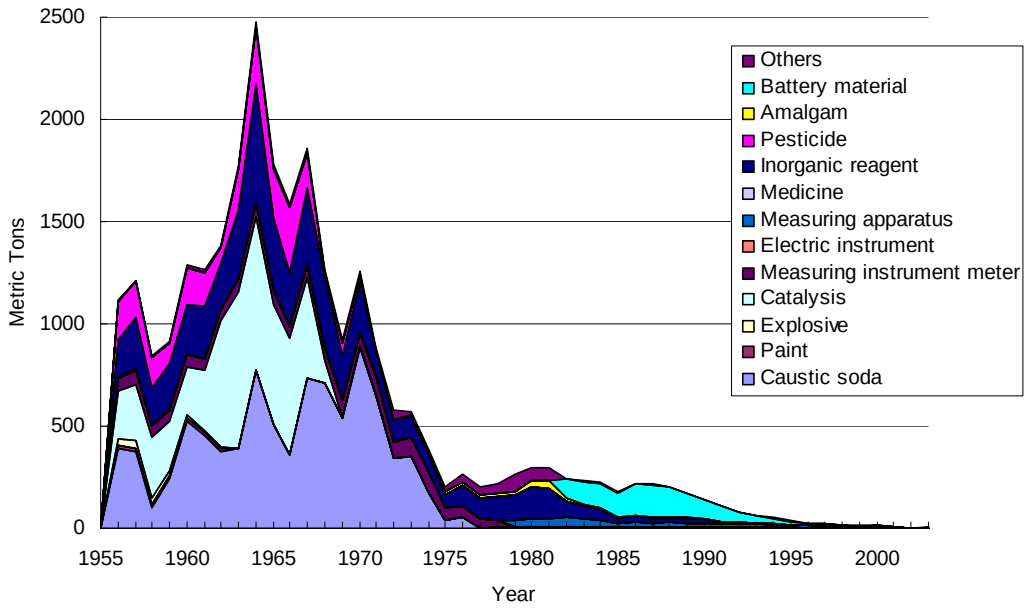


Figure 3.1.1 Japanese industrial mercury demand in the period 1956-2003 (Ministry of International Trade and Industry 1956-1974; 1995-2003)

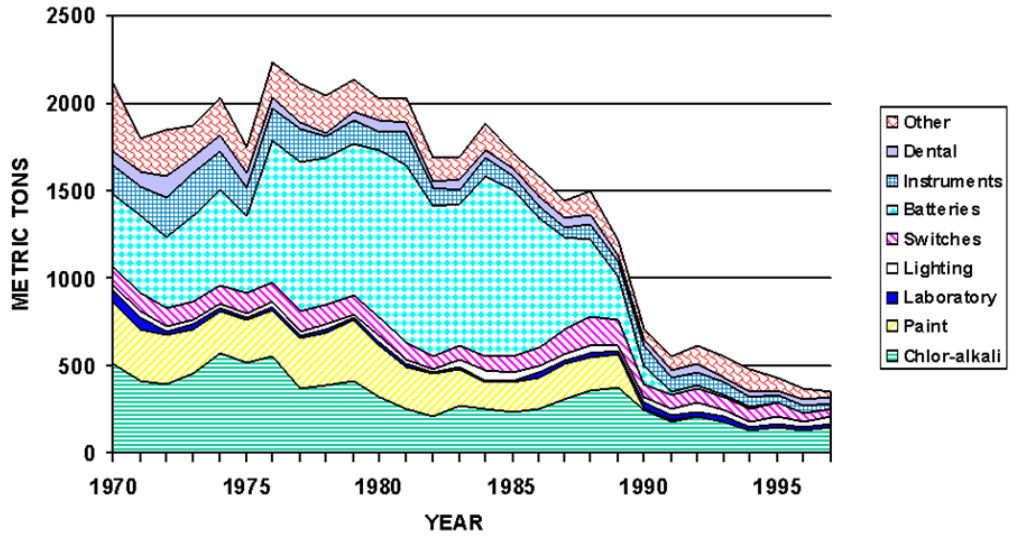


Figure 3.1.2 US industrial reported consumption of mercury in the period 1970-1997, distributed among industrial sectors (Sznopek 2000)

3.2 Industrial Processes

3.2.1 Artisanal and Small-Scale Gold Mining (ASGM)

3.2.1.1 Mercury-free ASGM

34. Studies and literature identify a variety of approaches for reducing mercury emissions from ASGM; unfortunately, most, like those using cyanide are more technical or require additional equipment, are less effective than using mercury amalgamation, or economically infeasible for widespread implementation. As a result, the most commonly cited alternative, processing gold using cyanide, is only typically successful with a local cooperative or collective organization (many miners pooling resources to minimize processing and handling cost) that is typically subsidized entirely or in large part by a government or NGO. Nonetheless, researchers correctly continue to pursue alternatives to mercury amalgamation as summarized in Table 3.2.1; in cases where organized alternatives are unavailable, the best interim solution is to promote the best management practices (BMP) summarized in the following subsection 3.2.1.2.

35. Although cyanide processing is also used to extract gold from ore or to leach mercury-contained tailings for further collecting gold, this process leads to an additional problem. Cyanide is highly toxic and at high concentrations would kill fish, birds and mammals (including humans). In addition, cyanide reacted with mercury to produce soluble chemical compounds is easily transported with water. Furthermore, it converts the mercury to a form in which it more easily enters the food chain and becomes more harmful when cyanide reacts with mercury. Thus, cyanide processing requires much more skill and technical control than amalgamation and not usually within the reach of individual or dispersed artisanal miners (GMP 2006). Having in mind the cyanide-catastrophe of the Hungarian river Tisza in January 2000 the cyanide processing cannot be regarded as BAT or BEP.

36. One example of a mercury- and cyanide-free gold mining is the Colombian Green Gold Programme (see http://www.greengold-oroverde.org/ingles/ov_impacto_ing.html).

Table 3.2.1 ASGM – Mercury-free techniques (GMP 2006)

Technique	Comments
Gravimetric Methods (CleanGold®)	▪ Uses magnetism in a simple sluice to create riffles with ferromagnetic components of the ore; ▪ In case the ore does not contain ferromagnetic components, the surface of the sluice can be charged with inexpensive, recyclable magnetic materials, such as black sand containing magnetite or iron grains from manmade sources (e.g. iron lost from welding and grinding);

Technique	Comments
	▪ Claimed gold capture efficiency of 90% after two passes performed over 5 minutes; further field studies unpublished; and ▪ Equipment is simple, but more than 75-150 USD per miner.
Mintek – Minataur Process (MMSD Project 2002)	▪ Experimental process; not implementable on a wide scale; ▪ Ore is treated with hydrochloric acid in the presence of sodium hypochlorite; ▪ Precipitate the gold out of the concentrate using sodium metabisulphate or oxalic acid; and ▪ Resulting concentrate is 99.5% fine gold powder.
Centre for Mineral Technology (CETEM) 1. Electrolytic process to leach gold mixed with sodium chloride (1 mol/L); 2. Mixture is transformed by electrolysis into a mixture of sodium hypochoritechlorate; 3. >95% of the gold dissolves within 4 hours and is collected on a graphite cathode.	▪ Treatment solution is recycled minimizing effluent discharge; ▪ The NaCl and energy consumptions are 100 kg/tonne of ore and 170 kWh/kg of gold respectively; ▪ Relatively uncomplicated process using plastic leaching tanks; and ▪ Trained personnel are required to control operating variables (pH, current density, etc).
Combining Non-Mercury Methods	Recent studies show that the types of ore and gold particles (e.g., oxidation, physical structure) affect the recovery rates of mining techniques. One study on gold-bearing ore from the Philippines (Hylander et al., 2007) showed that in removing gold mercury, amalgamation was less efficient than cyanide processing and that in an effort to increase recovery, miners were combining both methods. But the study data revealed the highest recovery rates for the particular ore-gold combination was a gravimetric method followed by cyanide processing. While the analytical resources used in the study would not be available to most ASM operations, simple experimentation with combined methodologies could yield higher recovery rates and – as in the study case described above – eliminate mercury amalgamation processing entirely as inefficient.

3.2.1.2 Waste Minimization in ASGM

37. Studies of ASM in developing countries have consistently concluded that mercury amalgamation will likely persist because: (a) mercury is inexpensive and widely available; (b) the technique is simple and the required equipment is rudimentary and inexpensive; and (c) the miners, their families, and the community are not aware of the health and environmental consequences. As a result, Table 3.2.2 summarizes techniques for using mercury more efficiently in ASGM.

Table 3.2.2 ASGM – BMP mercury techniques (GMP 2006)

Technique	Comments
Centralized Processing Centres Miners bring gravity concentrates to a centralized facility for amalgamation by trained personnel and under controlled conditions.	▪ Must be coupled with extensive education and promotion campaign to establish trust and understanding with miners; ▪ Requires 5 trained staff to operate the equipment; ▪ Increased security staff required to prevent raids of concentrated gold; ▪ Large initial expense from equipment, training, and construction; ▪ Reduces mercury exposure to miners to insignificant levels; ▪ Gold recovery from gravity concentrates is improved; ▪ Cost reduction in the processing plant; ▪ Better price of gold sold to banks or dealers (gold is already melted in the Centres);

Technique	Comments
	▪ Mercury vapour exposure is greatly reduced, but still present at 5 mg Hg/m^3 in air 5 to 15 m downwind of the centres (Oliveira 2004); and ▪ Miners do not need to buy mercury illegally.
BMP using Mercury	▪ Cover mercury with water inside closed containers to reduce mercury vapours formation; ▪ Do not use mercury in riffles: it DOES NOT increase gold recovery; ▪ Use gravity concentrates whenever possible to reduce the mercury required for amalgamation; o Mix for at least 15 minutes, but never longer than 2 hours (to avoid flouring); and o Use a few grams of soda or soap to clean natural fats or grease (1g/kg concentrate). ▪ Amalgamate away from watercourses. Use water boxes, or amalgamation ponds, and carefully dispose of tailings; ▪ Maximize amalgamation efficiency; ensure mercury contact by: o Clean or activate the surface of the mercury by putting it in salty water and connecting a radio or car battery: the positive wire to the water and the negative wire to the mercury for 10-20 minutes; use this mercury within 1 hour. ▪ Excess mercury can be removed from amalgam by centrifuges or presses; ▪ Use retorts to capture mercury vapour and recover and reuse up to 95% of mercury o Remove the condensing tube from the water before removing from the heat to avoid sucking water into the crucible and exploding the retort. ▪ Use a torch when using retorts, or a campfire with a blower to speed the retorting.

3.2.2 Chlor-alkali Production

3.2.2.1 Mercury-free Chlor-alkali Production

38. Diaphragm cell and membrane cell process are considered as mercury-free chlor-alkali production processes. Table 3.2.3 summarises advantages and disadvantages of these mercury-free and mercury cell chlor-alkali production processes.

Table 3.2.3 Comparison of mercury and mercury-free cell chlor-alkali processes

Process	Comments
1. Mercury Cell	**Advantages:** ▪ Produces high-quality caustic soda. **Disadvantages:** ▪ Less efficient process – requires more energy than membrane cell (3,560 kilowatt-hours per metric ton of chlorine [kWh/t chlorine] as the adjusted total energy use); and ▪ Produces mercury emissions and associated environmental liability and attention.
2. Diaphragm Cell	**Disadvantages:** ▪ Less efficient process – requires more energy than membrane cell (3,580 kWh/t chlorine as the adjusted total energy use); and ▪ Uses asbestos in cells with the potential for release into the air and the associated environmental liability and attention.
3. Membrane Cell	**Advantages:** ▪ More energy efficient process – 2,970 (kWh/t chlorine as the adjusted total energy use); and ▪ No mercury or asbestos emissions.

Process	Comments
	Disadvantages: ▪ Requires complete overhaul of older processes and associated capital costs.

3.2.2.2 Waste Minimization in Chlor-alkali Production

39. Best management practices in mercury cell chlor-alkali production can been found in "Chlor-Alkali Chlorine and Caustic Soda Manufacturing" in the Basel TG.

3.3 Products

3.3.1 Prohibition of Mercury Use in Products and Examples of Mercury-free Alternatives

40. This section provides information about prohibition of mercury use in products and examples of mercury-free alternatives. Table 3.3.1 outlines prohibition of mercury use in products, and Table 3.3.2 explains more on general ban on mercury and mercury-containing products including exemptions.

Table 3.3.1 Examples of Prohibition on Mercury-Containing Products

Type	Prohibition on Mercury-Containing Products	Region	Legal Basis
Mercury-containing products in general	General ban on mercury and mercury-containing products (Details including exemptions can be found in Table 3.3.1)	Denmark	Statutory Order no 627 of 01.07.2003 on Prohibition of Import, Sale and Export of Mercury and Mercury Compounds
		Sweden	Chemical Products (Handling, Import, and. Export Prohibitions) Ordinance (1998:944) as amended by Ordinance 2009:14
		Switzerland	Ordinance on the reduction of risks related to the use of particularly dangerous substances, preparations and objects (Ordinance on the reduction of risks related to chemicals, ORRChim) of 18 May 2005
	General ban on mercury-containing products (Details including exemptions can be found in Table 3.3.1)	Netherlands	Bulletin of Acts and Decrees of the Kingdom of the Netherlands No. 553 Decree of 9 September 1998, comprising regulations regarding products containing mercury
Thermometers and other measuring devices with mercury	Ban on mercury thermometers	10 states in USA[2]	(Different regulations exist for each state)
Batteries	Ban on the sale of button cell batteries	Maine, USA	Public Laws of the State of Maine, Chapter 509, S.P. 375-L.D. 1058-An Act to Regulate Batteries Containing Mercury (effective 23 August 2006)
		Connecticut, USA	Section 22a-616 of the Connecticut General Statutes (CGS), as amended in 2006
Others	Prohibition to place on the market or use plant protection products	European Union	Council Directive 79.117/EEC of 21 December 1978 amended by

[2] Healthcare without Harm Website, http://www.hcwh.org/us_canada/issues/toxins/mercury/laws.php

Type	Prohibition on Mercury-Containing Products	Region	Legal Basis
	containing certain mercury compounds		91/188/EEC (pesticides)
	Ban on mercury in cosmetics	Minnesota, USA	Minnesota Statutes § 116.92 Mercury Emissions Reduction

Table 3.3.2 Contents of General Ban on Mercury (and Mercury-Containing) Products and Exemptions

Country	Contents of General Ban and Exemptions
Denmark	Contents of General Ban The import, sale or export of mercury or products containing mercury is banned. Mercury means the element mercury, both in its metallic form and in chemical compounds. Exemptions: 1. Tooth fillings in permanent molars subject to wear (but not milk teeth) 2. Mercury-wetted reed circuit breakers and relays for special applications 3. Thermometers for two specific applications 4. Special lighting 5. Electrical contacts for a specific railway application 6. Manometers for a specific application 7. Barometers for a specific application 8. Electrodes for three specific applications 9. Mercury-containing chemicals for special applications 10. Research 11. Education 12. Essential applications in aeroplanes 13. Repair to existing mercury-containing equipment *Some products are not covered by the regulations, but must comply with other regulations relating to mercury. This is the case for batteries, cosmetics, medical equipment, paint, lacquer, packaging, waste products, and electrical and electronic equipment. The disinfection of walls, wood and textiles is also covered by another regulation. (Source: The Danish EPA- Fact Sheet No. 12: Mercury, http://www.mst.dk/English/Chemicals/Legislation/Fact_sheets/Fact_Sheet_No_12_Mercury.htm)
Sweden	Contents of General Ban Mercury may not be placed on the Swedish market, used in or professionally exported from Sweden, and goods containing mercury may not be placed on the Swedish market or professionally exported from Sweden. Exemptions 1. Mercury that occurs naturally in coal, ore or ore concentrate 2. Batteries that are covered by the provisions of Section 11 c, 3. Packaging and packaging components that are covered by the provisions of Sections 12 and 14, 4. Motor vehicles and trailers for these vehicles that are covered by the provisions on type approval in the Vehicles Ordinance (2002:925), 5. Light goods vehicles and passenger cars other than European Community type-approved passenger cars that are covered by the Ordinance (2003:208) Prohibiting Certain Metals in Vehicles, 6. Products for in-vitro diagnostics that are not covered by the Medical Devices Act (1993:584), 7. Medicinal products for human and veterinary use that are covered by the Medicinal Products Act (1992:859) and by the Regulation of the European Parliament and of the Council (EC) No 726/2004 laying down Community procedures for the authorisation and supervision of medicinal products for human and veterinary use and establishing a European Medicines Agency, 8. The uses referred to in Annex XVII (18) of the Regulation of the European Parliament and of the Council (EC) No 1907/2006 of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals

Country	Contents of General Ban and Exemptions
	Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EEC and 2000/21/EC, where use in research and development or for analytical purposes or placing on the market for such use is concerned, or 9. Professional exporting or importing of a) goods in connection with repair or calibration abroad, b) military equipment in connection with exercises, training or international activity, or c) spare parts and other components for repair and maintenance of equipment for a specific military purpose, or 10. Waste containing mercury exported from Sweden for recycling or disposal. Ordinance (2009:654). (Source: Chemical Products (Handling, Import, and. Export Prohibitions) Ordinance (1998:944) as amended by Ordinance 2009:14, http://www.kemi.se/upload/Forfattningar/docs_eng/F98_944.pdf)
Switzerland	Contents of General Ban The following is prohibited: a) The placing of preparations and articles containing mercury on the market by the manufacturer; b) The use of elemental mercury, mercury compounds and preparations containing mercury. <u>Exemptions under a):</u> 1. The prohibition in accordance with Number 2 letter a does not apply to: a. medicinal products; b. antiques; c. cosmetics in which mercury is permitted by the DHA pursuant to Art. 35 paragraph 4 letter a of the Ordinance of 23 November 200535 on Foodstuffs and Utility Articles. 2. If the state of the art is such that mercury-free substitution is not possible and if the quantity of mercury used does not exceed the quantity required for the intended use, the prohibition in accordance with Number 2 letter a does not apply to: a. electrical or electronic equipment in accordance with Art. 3 letter a of Directive 2002/95/EC of the European Parliament and of the Council of 27 January 200336 on the restriction of the use of certain hazardous substances in electrical and electronic equipment covered by categories 8 (medical devices) and 9 (monitoring and control instruments) in Annex IA of Directive 2002/96/EC of the European Parliament and of the Council of 27 January 200337 on waste electrical and electronic equipment, and components for such electrical and electronic equipment; b. appliances intended for laboratories and components for such appliances; c. electric lighting; d. artists' paints intended for restorations; e. medical devices for professional use; f. preparations intended for laboratories; g. auxiliary substances intended for manufacturing processes. 3. The prohibition in accordance with Number 2 letter a does not apply to the import of preparations and articles containing mercury which only undergo finishing or repackaging in Switzerland and are then re-exported in their entirety. 4. The placing on the market of mercury batteries and accumulators is governed by Annex 2.15. <u>Exemptions under b):</u> 1. The prohibition in accordance with Number 2 letter b does not apply to: a. the use of mercury in laboratories; b. the use of mercury for research purposes; c. the use of mercury for the manufacture of preparations and articles containing mercury, the placing on the market of which is authorised in accordance with Number 3.1; d. the use of preparations containing mercury, the placing on the market of which is authorised in accordance with Number 3.1. 2. If the state of the art is such that mercury-free substitution is not possible and if the quantity of

Country	Contents of General Ban and Exemptions
	mercury used does not exceed the quantity required, mercury may be used: a. for medical devices for professional use; b. as an auxiliary substance in manufacturing processes if it is not present in the final product. (Source: Ordinance on the reduction of risks related to the use of particularly dangerous substances, preparations and objects (Ordinance on the reduction of risks related to chemicals, ORRChim) of 18 May 2005, http://www.admin.ch/ch/e/rs/8/814.81.en.pdf)
Netherlands	Contents of General Ban It is prohibited to manufacture a product containing mercury or to import it into the Netherlands (effective as of 1 January 2000). <u>Exemptions</u> a. a pycnometer or porosimeter for measuring the air space volume of soil or other porous solids; b. sampling equipment designed to measure particles in liquids; c. a calibration instrument meant for low flow-rate flow meters; d. a cuvette, meant for determining the chemical oxygen demand; e. a McLeod compression manometer, meant for measuring absolute pressures lower than 20 kPa; f. a submersible pump; g. a roll-spot welding head, meant for seam welding; h. a slip ring; i. a semiconductor test system, as well as a mercury relay of which the maximu m mercury content per component does not exceed 0.15 gram and which is exclusively meant for use in semiconductor test systems; j. a mercury thermometer exclusively intended to perform specific analytical tests according to established k. standards; l. equipment for the calibration of platinum resistance thermometers using the triple point of mercury; m. a gas discharge lamp, with the exception of: 1. a fluorescent lamp for purposes of lighting with an integrated means of starting when it contains more 2. than 10 mg of mercury; 3. a non-circular fluorescent lamp for purposes of lighting with a single lamp -cap terminal connection 4. when it contains more than 10 mg of mercury; 5. a straight fluorescent lamp for purposes of lighting with two lamp -cap terminal connections when it 6. contains more than 20 mg of mercury; 7. a product for use in shipping in which the use of mercury is prescribed by or under law, equipment directly related to shipping in which the use of mercury is deemed to be necessary by the Minister of Transport and Public Works and ships' equipment to which Directive no. 96/98/EC of the Council of the European Union of 20 December 1996 on marine equipment (OJEC 1997 L 46) applies; n. a product for use in aviation for which the use of mercury is prescribed by or under the Aviation Act, and equally any product directly related to aviation purposes in which the use of mercury is deemed to be essential by the Minister of Transport and Public Works; o. equipment in use by the Armed Forces, in which the use of mercury is prescribed by or under law, or equipment necessary to the operational responsibilities of the Armed Forces in which the use of mercury is deemed to be essential by the Minister of Defence; o. a photographic film, a photographic plate and photographic paper, in as far as the film, plate or paper do not contain more than 0.3 mg of mercury per kg of product. (Source: Bulletin of Acts and Decrees of the Kingdom of the Netherlands No. 553 Decree of 9 September 1998, comprising regulations regarding products containing mercury)

41. More mercury-free alternatives become available as technology development advances and demands for such alternatives increase. Table 3.3.3 summarise available information about mercury-free alternatives.

Table 3.3.3 Mercury-free Alternatives to Mercury-containing Products (to be completed)

Type	Mercury-containing products and cost	Mercury-free alternatives and cost	Comments
Measuring and control devices with mercury	**Mercury thermometers** − USD 1.5-17.03* − USD 10-710 (non-fever, basal) ** − USD 10-60 (non-fever, industrial/commercial)** − 13 Euro (for laboratory uses)*** − 156 Euro (tested and certified)***	**Liquid** − USD 1.5-5.38* − USD <15 (non-fever, basal) ** − USD 2-60 (non-fever, industrial/commercial)**	
		Dial/Bi-metal − USD 4.9-19* − USD 6-138 (non-fever, basal) ** − 53 Euro or 2-4 times the price of a similar product containing mercury***	
		Digital/Electronic − USD 5.62-11.99* − USD ~12 (non-fever, basal) ** − USD 14-260 (non-fever, industrial/commercial)** − About 10 times the price of similar mercury thermometers (for platinum resistance machine and laboratory use)*** − Similar price of similar mercury thermometers (tested and certified thermometers)***	
		Infrared − USD 92-270 (non-fever, industrial/commercial)**	
	Mercury thermostats − USD 20.50-24.99* − USD 18-87 (residential)** − USD 65-350 (industrial/commercial)**	**Digital /Electronic** − USD 21-295 (residential)** − USD 65-350 (industrial/commercial)**	
		Mechanical switch − USD 11.79-23.00*	
	Mercury sphygmomanometers − USD 59.95-281* − USD 111-299** − 133 Euro (Europe-made)*** − 60 Euro (German-made)***	**Aneroid** − USD 20.93-117.98* − USD 59-264** − 50 Euro (German-made)*** − 63-214 Euro (in UK market)***	
		Electronic/Oscillometric − USD 89.95-99.95* − USD 645-995**	
	Mercury Manometers − USD 20-375** −	**Digital/Electronic** − USD 33-139.95* − USD 100-700** − About 3-4 times the price of a similar mercury manometer***	

Type	Mercury-containing products and cost	Mercury-free alternatives and cost	Comments
		Needle/Bourdon − USD 40-250**	
Electrical and electronic switches, contacts and relays with mercury	**Mercury tilt/vibration switches** − USD 4-12* − USD 2-300**	**Potentiometer** − USD 1-35* − USD 0.25-300**	
		Metallic ball − USD 1-11**	
		Electrolytic − USD 5-50**	
		Mechanical − USD 5-11* − USD 100-350**	
		Solid-state − USD 100-250**	
		Capacitive USD 80-250**	
	Mercury float switches − USD 90-95* − USD 15-150**	**Mechanical** − USD 66* − USD 10-150**	
		Magnetic dry reed − USD 18-66* − USD 6-400**	
		Optical − USD 70* − USD 120-400**	
		Conductivity − USD 345* − USD 40-800**	
		Sonic/Ultrasonic − USD 150-600**	
		Pressure Transmitter − USD 825**	
		Alloy − (cost not available)	
		Thermal − USD 87**	
		Capacitance − USD 150-500**	
	Mercury temperature switches − USD 345* − USD 150-250**	**Mechanical** − USD 345* − USD 8-600**	
		Solid-state − USD 350-600**	
	Mercury pressure switches − USD 212* − USD 150-170**	**Mechanical** − USD 57-315* − USD 40-600**	
		Solid-state − USD 362-460* − USD 200-350**	
	Mercury relays − USD 34-362 (mercury displacement relays)*	**Dry magnetic reed** − USD 2-35* − USD 2-15**	

Type	Mercury-containing products and cost	Mercury-free alternatives and cost	Comments
		Other electro-mechanical/electro-magnetic − USD 7-46* − USD 1-35**	
		Solid-state − USD 3-155* − USD 1-150**	
		Hybrid (Electro-mechanical and solid-state) − USD 47* − USD 40-140**	
		Silicon controlled − USD 30-150**	
Light sources with mercury	**Linear fluorescent lamps** − USD 3.49-5.69*	**Linear LED lamps** − USD 149*	
	Compact fluorescent lamps − USD 5.49-21.22*	**Incandescent lamps**	
		LED lamps − USD11.95-119.95*	
		LED downlight lamps − USD 92.99*	
	High-intensity discharge lamps − USD 15.35-44.62*		
	High-intensity discharge automobile headlamps − USD 129.99-359.95*	**Mercury-free HID headlamps**	
		Halogen headlamps − USD 14.99-41.99*	
		LED headlamps	
	Backlight units for LCD displays − USD 1,249-2,799*	**LED backlight units** − USD 1,399-2,899*	
Miniature batteries containing mercury	**Silver oxide miniature batteries** − USD 0.60-3.06*	**Mercury-free silver oxide miniature batteries** − USD 2.95*	
	Zinc air miniature batteries − USD 0.92-1.38*	**Mercury-free zinc air miniature batteries**	
	Alkaline miniature batteries − 1.08-3.59*	**Mercury-free alkaline miniature batteries**	
	Mercuric oxide miniature batteries	None	
Biocides and pesticides containing mercury			
Paints containing mercury			

Type	Mercury-containing products and cost	Mercury-free alternatives and cost	Comments
Pharmaceuticals for human and veterinary uses containing mercury			
Cosmetics and related products containing mercury			

Source:
* UNEP (2008): UNEP (DTIE)/Hg/OEWG.2/7/Add.1 - Report on the major mercury-containing products and processes, their substitutes and experience in switching to mercury-free products and processes, http://www.unep.org/hazardoussubstances/Portals/9/Mercury/Documents/OEWG2/2_7_add_1.pdf http://www.basel.int/techmatters/mercury/comments/240707hsweden-2.pdf
** USEPA (2008): Analysis of Mercury-Added Products and Substitutes, http://www.epa.gov/hpvis/rbp/RBP%20Support_Analysis%20of%20Mercury-Added%20Products%20and%20Substitutes_10.31.2008_FINAL.pdf
*** European Commission (2008): Options for Reducing Mercury Use in Products and Applications, and the Fate of Mercury already Circulating in Society, http://ec.europa.eu/environment/chemicals/mercury/pdf/study_report2008.pdf .

3.3.2 Regulations on Mercury Content in Products

42. When mercury-free alternatives are not available or take time to replace mercury containing products, regulating mercury content in products is a possible tool to reduce mercury releases from waste. Table 3.3.4 shows examples of regulations on mercury content in products.

Table 3.3.4 Example of Regulations on Mercury Content in Products

Type	Name	Regulated Mercury Content	Region	Legal Basis
Fluorescent lamps	Double end	− ≤ 10 mg/unit	China	Technical Requirement for Environmental Labeling Products: Energy-saving Low-mercury Double-capped Fluorescent Lamps (HJBZ 15.2-1997)
		− ≤ 10mg/unit (average)	Japan	Basic Policy for the Promotion of Procurement of Eco-Friendly Goods and Services
		− ≤ 20 mg in a straight fluorescent lamp with two lamp-cap terminal connections	Netherlands	Bulleting of Acts and Decrees of the Kingdom of the Netherlands No. 553: Decree of 9 September 1998, Comprising Regulations Regarding Products Containing Mercury, as Amended
	Double end (Tri-band phosphor with normal lifetime)	− ≤ 5 mg in a lamp with a tube diameter > 9 mm (≤ 4 mg/lamp after 31 December 2011) − ≤ 9 mg in a lamp with a tube diameter ≥ 9 mm and	European Union	European Parliament and the Council of 27 January 2003 on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (Directive 2002/95/EC), amended by 2010/571/EU of 24 September

Type	Name	Regulated Mercury Content	Region	Legal Basis
		≤ 17 mm (≤ 3 mg/lamp after 31 December 2011) – ≤ 5 mg in a lamp with a tube diameter ≥ 17 mm and ≤ 28 mm (≤ 3.5 mg/lamp after 31 December 2011) – ≤ 5 mg in a lamp with a tube diameter > 28 mm (≤ 3.5 mg/lamp after 31 December 2012)		2010
	Double end (Tri-band phosphor with long lifetime (≥ 25 000 h))	– ≤ 8 mg in lamp (5 mg/lamp after 31 December 2011)		
	Single-end, compact fluorescent lamps (CFL) and others	– ≤ 10 mg/unit	China	The Technical Requirement for Environmental Labeling Products: Energy-saving Fluorescent Lamps (HJBZ 15.1－1997)
	(For general lighting purposes)	– ≤ 5mg/burner in a lamp < 30 W (≤ 3.5 mg/burner until 31 December 2011; and ≤ 2.5mg/burner after 31 December 2012) – ≤ 5mg/burner in a lamp ≥ 30 W and < 50 W (≤ 3.5 mg/burner after 31 December 2011) – ≤ 5mg/burner in a lamp ≥ 50 W and ≤ 150 W – ≤ 15 mg/burner in a lamp ≥ 150 W NOTE: Although there are no restrictions for lamps with circular or square structural shape and tube diameter < 17 mm, restriction of ≤ 7mg/burner will apply after 31 December 2011	European Union	European Parliament and the Council of 27 January 2003 on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (Directive 2002/95/EC) , amended by 2010/571/EU of 24 September 2010
	(For special purposes)	– ≤ 5mg/burner		
Batteries	Button-shaped batteries	– ≤ 20 mg/g in a alkaline manganese or a zinc-air batteries	China	Primary Batteries, The Second Part: Shape Size and Technical Requirement (GB 8897.2-2005)
		– ≤ 2 % by weight	European	Directive 2006/66/EC of 6

Type	Name	Regulated Mercury Content	Region	Legal Basis
			Union	September 2006 on Batteries and Accumulators and Waste Batteries and Accumulators
		− ≤ 25 mg/unit	USA	Mercury-Containing and Rechargeable Battery Management Act
	Batteries other than button cells	− ≤ 0.0001 % by weight in alkaline zinc-manganese batteries	China	Technical Requirement for Environmental Labeling Products: Hg-free Dry Cells and Batteries (HJ/T 239－2006)
		− ≤ 1 ug/g in zinc-manganese batteries − ≤ 20 mg/g in zinc-silver oxide batteries	China	Primary Batteries, The Second Part: Shape Size and Technical Requirement（GB 8897.2-2005）
		− ≤ 0.0005 % by weight in batteries and accumulators (excluding button-shape batteries)	European Union	Directive 2006/66/EC of 6 September 2006 on Batteries and Accumulators and Waste Batteries and Accumulators
		− < 0.1 mg/kg	Korea	Quality Management & Safety Control of Industrial Products Act
Others	Toys	− ≤ 7.5 mg/kg in dry, brittle, powder-like or pliable toy material − ≤ 1.9 mg/kg in liquid or sticky toy material − ≤ 94 mg/kg in scraped-off toy material	European Union	Directive 2009/48/EC of 18 June 2009 on the Safety of Toys
	Cosmetics	− < 0.007% of weight	European Union	Directive 76/768/EEC of July 1976
	Antiseptics in pharmaceuticals	− < 0.0065 % of weight, calculated as elemental mercury	Thailand	Notification of the Ministry of Public Health, No. 21 B.E. 2538 (1995)
	Pigment and dyes	− ≤ 60 mg/kg	China	Indoor Decorating and Refurbishing Materials - Limit of Harmful Substances of Interior Architectural Coatings (GB18582-2008)
	Sludge fertilizer and product recycled from sludge	− ≤ 0.005 mg/l as total mercury − Non-detectable level of alkyl mercury (by leaching test)	Japan	Official Specification under the Law on Fertilizer Control

4 Collection of and Mercury Recovery from Waste Containing Mercury

4.1 Existing collection programme

43. Table 4.1.1 summarizes the mercury-containing products typically subject of collection programmes and includes resources required for planning and implementation.

Table 4.1.1 Mercury-containing product collection

Mercury-containing Product	Resources
Vehicle Switches and Sensors	Products include automatic braking sensors and tilt switches used for trunks and doors. ▪ US EPA Program: www.epa.gov/mercury/switch.htm ▪ Mercury Removal Instructions: www.elvsolutions.org/Elvs%20Brochure%20v11.pdf ▪ List of vehicles and the mercury added sensors and switches they contain: www.elvsolutions.org/educational.html
Mercury-Containing Medical Devices	Healthcare facilities typically contain large amounts of mercury-containing devices (sphygmomanometers, bougie tubes, etc.) that are still in use, but that can be replaced at end-of-life or proactively. ▪ Comprehensive guides to locating mercury-containing products in healthcare facilities: www.dtsc.ca.gov/PollutionPrevention/upload/guide-to-mercury-assessment-in-healthcare-facilities.pdf and http://sustainableproduction.org/downloads/ ▪ Vendor exchange of mercury-containing products like sphygmomanometers are often available through manufacturers (e.g. www.adctoday.com/support/mercuryexh.php); collection and mercury reclamation can be made part of the procurement of new mercury-free products ▪ US EPA Factsheet on Mercury-Containing Medical Devices in Hospitals www.epa.gov/region09/waste/p2/projects/hospital/mercury.pdf
Patient Thermometers	Many US municipalities and hospitals conduct mercury thermometer collection and exchange programs; the programs are typically sponsored by the local environmental agencies and solid waste contractors. ▪ US EPA Program lists of State and Local Mercury Collection Programs: www.epa.gov/osw/hazard/tsd/mercury/collect.htm ▪ Planning and Holding a Mercury Thermometer Exchange (Healthcare for a Healthy Environment): www.noharm.org/us/mercury/exchange
Batteries and High Efficiency Lights	Generators of these mercury-containing products are typically allowed to dispose of them in solid waste or household hazardous waste programmes or through an organized segregation programme sponsored by municipalities and typically operated as part of the solid waste management programme.

44. This section provides information about practical cases in which used products containing mercury are collected and treated or stored. Table 4.1.2 summarises feature of the practices introduced in this document and relevant sections. As information become available, more cases will be added in the revised version of this document.

Table 4.1.2 Summary of Good Practice Cases Managing Waste Containing Mercury

Product	Features of Practices	Country	Relevant

	Basis	Type of Practice		
Measuring equipment	Voluntary	Take back projects for thermometers	Canada, Austria	4.2.1
	Legal	Gradual phase out of mercury in health care facilities	The Republic of the Philippines	4.2.2
Fluorescent lamps	Voluntary	Leasing systems	Japan	4.3.1
	Legal	Take-back program	Republic of Korea	4.3.2
	Voluntary	Collection campaign	Kingdom of Thailand	4.3.3
Electrical and electronic equipment	Legal	Take-back program	Japan	4.4.1
Dental Amalgam	Legal	Installation of ISO 11143 certified amalgam separators	Canada	4.5.1
	Legal	Dental amalgam/mercury recycling certification program	Massachusetts (USA)*	4.5.2
Batteries	Voluntary	Elimination of mercury in major batteries	Japan	4.6.1
	Voluntary	Collection campaign	Panama	4.6.2
	Legal	Take-back program	Sweden	4.6.3

* Current document does not include these cases yet.

4.2 Measuring Equipment

4.2.1 Take-back Projects for Thermometers

Mercury Fever Thermometers in Canada

45. A good example of a take-back pilot project includes the voluntary collection of mercury fever thermometers in Ontario, Canada, in 2002. Residents in the participating cities could return their unbroken mercury fever thermometers in their original carrying cases or in a shatterproof container to participating retailers. Consumers were asked not to throw mercury products like fever thermometers directly into household garbage. If a broken fever thermometer was found in the home, consult the local poison information centre and household hazardous waste depot to determine a safe clean-up and disposal method (Environment Canada 2002b).

Mercury Fever Thermometers in Austria

46. The voluntary take back action for thermometers containing mercury was based on the Federal Waste Management Plan 2006 and carried out in close cooperation between the Austrian Chamber of Pharmacists (Österreichische Apothekerkammer), the Federal Ministry of Environment, a private waste disposer, a producer of electronic thermometers and a pharmaceutical distributor.

47. The disposal company supplied each pharmacy (approximately 1,200) with a collection bin and covered the disposal costs of the collected waste. The pharmaceutical distributor carried the logistic costs for the distribution of the thermometers. The pharmacies accepted a refund of only 0.50 Euro per thermometer for handling (which is far below their normal margin). The supplier provided the thermometer at a reduced price. The Federal Ministry supported each sold thermometer (covering about 30% of the direct project costs) and provided for the advertisement of the project. During the collection period consumers could bring in a mercury-containing thermometer and buy an electronic thermometer for a supported price of 1.00 Euro.

48. Between October 2007 and January 2008 about 465,000 electronic thermometers were sold and about one million thermometers containing mercury (containing approximately 1 tonne of metallic mercury) were collected (Austrian Federal Ministry of Agriculture, Foresting, Environment and Water Management 2009).

4.2.2 Gradual phase out of mercury in health care facilities in the Philippines

General information	Target product	Name	Mercury containing products in the healthcare system

		Annual sales volume in the target area	(Please indicate year for the annual sales volume) Year Unit
		Weight/volume of mercury included in the product	
	Target area (province, country, or region)		Philippine (all nation covered)
	Year started		2008
	Background (problems identified before the introduction of the system)		Mercury is highly toxic, especially when metabolized into methyl mercury. It may be fatal if inhaled and harmful if absorbed through skin. Around 80% of inhaled mercury vapor is absorbed in the blood through the lungs. It may cause harmful effects to the nervous, digestive, respiratory, immune systems and to the kidneys, besides causing lung damage. Adverse health effects from mercury exposure can be: tremors, impaired vision and hearing, paralysis, insomnia, emotional instability, developmental deficits during fetal development, and attention deficit and developmental delays during childhood.
	Steps to introduce the system (incl. legal basis)		• On July 30, 2008, the Department of Health issued Administrative Order No. 2008-0021 on Gradual Phase-out of Mercury in all Philippines Health Care Facilities and Institutions.
	Major outcomes of collection/recovery		
	Major challenges faced in implementing the system and ways to overcome those challenges		
	Remaining issues to be solved		
Information about the collection system	Description of the collection system		
	Responsibility of relevant stakeholders		
	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders		
	Transport and storage methods for collected used products		
	Ways to handle collected used products where a mercury recovery facility is not located in the target area (e.g. storage, export to the countries with mercury recovery facilities, etc.)		Presently, the collected measuring devices and other mercury-containing wastes are stored in the hospital's designated temporary storage area. Collected busted fluorescent lamps (BFLs) can be disposed through EMB-DENR registered Treatment, Storage and Disposal (TSD) facilities.
Information about the recovery system	Description of technology to recover mercury		There is still no facility in the Philippine that recovers mercury from mercury-containing wastes. For BFLs, there are EMB-registered TSD facilities that use the bulb-eater in crushing lamps in a controlled manner that prevents the release of mercury. Some TSD facilities collect and consolidate BFLs for export to other countries with mercury recovery facilities.

	Process flow to recover mercury from used products	
	Ways to handle materials other than mercury	
	Description of pollution control measures	
Awareness raising	Target population	Employees of healthcare facilities
	Activity period/frequency	24 months from the effectively of this order
	Media used for awareness raising and messages delivered	Media: Official Gazette, major newspaper, a facility-wide information campaign, personnel training program/employee education program, information materials Message:
	Responsibility of relevant stakeholders	All health care facilities: • Conduct a facility-wide information campaign and employee education on the consequences of continued mercury-use. Personnel training on preventing and proper handling of mercury spills should also be accomplished. • Display and/or be available information materials on mercury-use are in their facility for the benefit of their patients and the general public.
	Cost sharing of relevant stakeholders	
Remarks (if any)		
References and interviewees		Administrative Order No. 2008-21 from Republic of the Philippines Department of Health (http://www.doh.gov.ph/files/ao2008-0021.pdf).
Graphs or photos that can be used for the Good Practices		No

4.3 Fluorescent Lamps

4.3.1 Fluorescent lamp leasing system in Japan

General information	Target product	Name	Fluorescent lamps
		Annual sales volume in the target area	Adopted by about 1200 businesses and 6,800 business places (*) (Data for February 2010) (*) Business places：The number of facilities adopting the "AKARI ANSIN service"
		Weight/volume of mercury included in the product	The amount of mercury enclosed in one 40 W straight tube fluorescent lamp is about 7 mg (Figure for 2007, Japan Electric Lamp manufacturers association)
	Target area (province, country, or region)		Japan (all nation covered)
	Year started		April 2002

	Background (problems identified before the introduction of the system)	Used fluorescent lamp used to be disposed as industrial waste by individual waste generator and they were either recycled or disposed at the company's own responsibility. There always was a risk that collected used fluorescent lamps might be illegally dumped or treated in environmentally detrimental manner by the contracted waste collector or waste treatment facility. This service was thus introduced to prevent such environmental risks and to ensure that collected lamps are fully recycled in environmentally sound manner.
	Steps to introduce the system (incl. legal basis)	A business can sign a contract to lease the fluorescent lamp to be used from a service provider company (agents of Panasonic Electric Works Co. Ltd) in return for a usage fee, which will indicate the start of the service.
	Major outcomes of collection/recovery	The used fluorescent lamps are dismantled and segregated to parts and eventually recycled in environmentally sound manner. At present (February 2010), there are about 6800 facilities (about 1200 businesses) that are in use of this service. Although the total number of fluorescent lamps being used is not available, it is estimated (based on assumption that 250,000 of 40W lamps are being used) that the amount of mercury collected amounts to about 18kg <u>Understanding of the traceability</u> Traceability: the system was introduced to enable service user company, intermediate waste treatment facility, Panasonic Electric Works Co. Ltd, and service providing company to trace where the collected fluorescent lamps are treated at anytime through internet access. Through this system, waste treatment facility and service proving company can confirm the information provided. The system also has provisions for businesses requiring the service to view the contents.
	Major challenges faced in implementing the system and ways to overcome those challenges	Not applicable
	Remaining issues to be solved	Not applicable

Information about the collection system	Description of the collection system	This service provides fluorescent lamps to the companies that contract with service providing company (agents of Panasonic Electric Works Co. Ltd) on a lease. Upon being contacted by the businesses using the lamps, the service user companies collect the used fluorescent lamps and through intermediate waste treatment companies recycle them in environmentally sound manner. The service provider companies replace the collected lamps. This service was started by Panasonic Electric Works Co., Ltd in April 2002. At present (February 2010) about 6800 facilities (factories, offices, theme parks etc) belonging to about 1200 businesses are using this service. Used fluorescent lamps are collected without crushing through this service. The fluorescence substance, metal piece and mercury substance in the collected lamps are recycled to cover materials, aluminium and inorganic chemicals respectively. The glass part becomes cullet and used to be recycled to glass wool, tiles and lightweight aggregate etc before November, 2007. With the newly introduced specifically designed fluorescent lamps glass-melting furnace in Nov, 2007, recycling used fluorescent lamp to new fluorescent lamp has became possible.
	Responsibility of relevant stakeholders	<u>Service user company</u> After the contract is signed, service user company leases the fluorescent lamps from the service providing company. A usage fee per fluorescent lamp leased is payable. There are two options of the service fee payment, by either fixed charge (based on the assumed number of lamps to be used during the contract period) or metered charge. <u>Service providing company</u> Leases fluorescent lamps to service user company and replaces the used fluorescent lamps with new lamps when requested by the service user company. <u>Intermediate waste treatment facility and recycling facility</u> Accepts used fluorescent lamps and provides such pre-treatment as dismantling, segregation, and crushing on each parts in order to be recycled to cover material, aluminium and inorganic chemicals etc.
	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders	<u>Client</u> Signs a contract with the service provider company <u>Service Provider company</u> Becomes the responsible entity for the used fluorescent lamps. Signs contracts with the collection and transportation company and the intermediate treatment company and also prepares the manifest required. <u>Intermediate treatment company</u> Receives treatment fee from the Service Provider company and sells the valuables recovered after treatment.
	Transport and storage methods for collected used products	The collection method varies according to the Service Provider company Generally, a representative of the Service Provider company puts

		the lamps in cardboard boxes that were used originally for bringing in the lamps, which are then transported. At times, the old lamps are replaced by new ones at the time of transportation.
Information about the recovery system	Description of technology to recover mercury	The Service Provider company has signed contract with a few intermediate treatment companies. They have their own evaluation standard when signing the contracts. The treatment method differs according to the company involved in treatment. For example, a treatment company located in Kanto region cuts the cap of the lamps and uses its specialized process to extract fluorescent powder and mercury and the mercury is eventually collected through distillation.
	Process flow to recover mercury from used products	Figure 1 The process flow for collecting mercury from fluorescent lamps is shown in figure 1.
	Ways to handle materials other than mercury	Fluorescent powder： For example,, separation from mercury and collection. The collected matter is recycled for as road coverings or fluorescent powder. Iron, Aluminium, plastic：For example, these materials used in the cap of fluorescent lamps are separated, cleaned, dried and recycled as a resource. Glass ：For example, after carrying our acid cleaning and drying, they are recycled as glass wool or insulation materials.
	Description of pollution control measures	As an example, the waste liquid obtained from the acid cleaning process is treated within the premises and recycled.
Awareness raising	Target population	Businesses and a few local governments are using this service. For the target customers, the Service Provider company, during the sale of fluorescent lamps, proposes the option of using this service. This service is also being advertised in the company's homepage.
	Activity period/frequency	During the business related with sale of fluorescent lamps
	Media used for awareness raising and messages delivered	Websites, pamphlets etc
	Responsibility of relevant stakeholders	Not applicable in this case
	Cost sharing of relevant stakeholders	Not applicable in this case
Remarks (if any)		This service is currently only available in Japan.
References and interviewees		・The information given here is gathered by telephone interview with the Front Office of Marketing for the Electric Materials, Panasonic Electric Works Co., Ltd. (Tel No. +81-6-6908-1812) Used data etc., is based on the performance referring at the time of Feb. 2010. ・JFE HP Home page of JFE Kankyo Corporation (http://www.jfe-kankyo.co.jp/nkc01/fnkc01.html) ・Japan Electric lamp manufacturers association Q&A regarding fluorescent lamps and used fluorescent lamps http://www.jelma.or.jp/07kankyou/pdf/environment05.pdf
Graphs or photos that can be used for the Good Practices		Yes (see below)

Flow Chart of the Recycling of Fluorescent Glasses

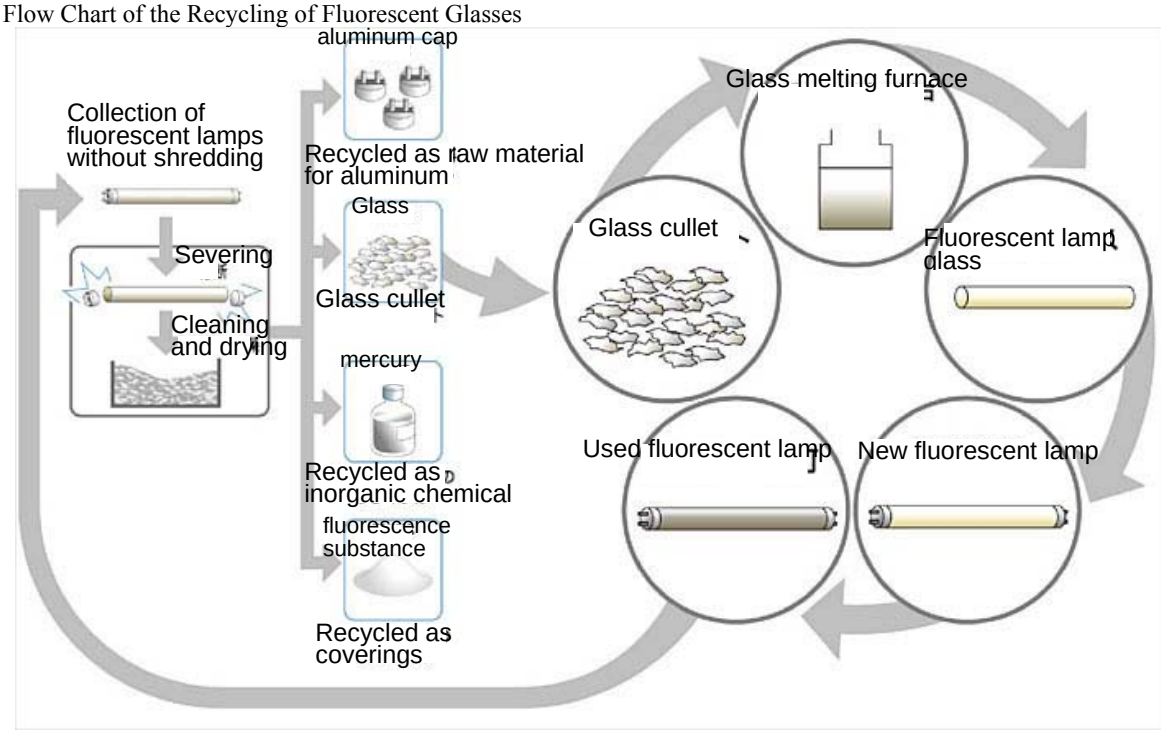


Figure 4.3.1 Recycled new fluorescent lamp from the used one
(This fluorescent lamp is specially designed model for recycling of this service.)

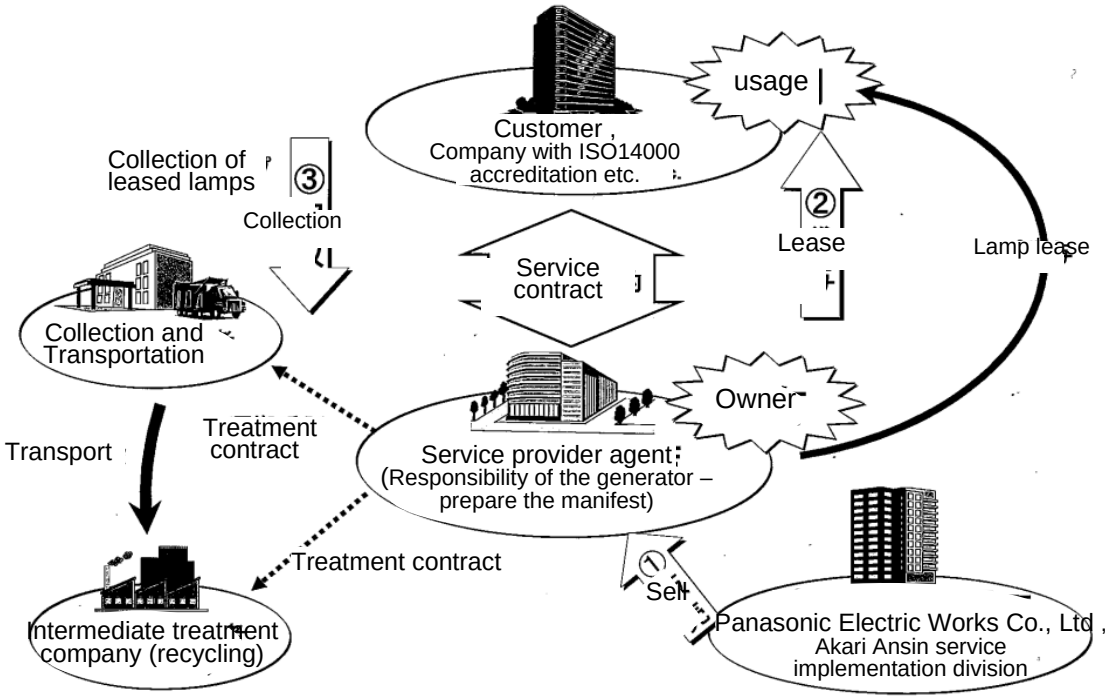


Figure 4.3.2 Scheme of the Akari Ansin Service

4.3.2 Collection and recovery systems of waste fluorescent lamps in the Republic of Korea

(Information from Korea will be provided in the near future.)

<table>
<tr><td rowspan="5">General information</td><td rowspan="5">Target product</td><td>Name</td><td>Fluorescent lamps</td></tr>
<tr><td>Annual sales volume in the target area</td><td>(Please indicate year for the annual sales volume)
Year Unit</td></tr>
<tr><td>Weight/volume of mercury included in the product</td><td>(Please include the unit such as “mg/unit” and “wt%”)
<table>
<tr><td></td><td colspan="2">Straight type</td><td>Round type</td></tr>
<tr><td>Watt</td><td colspan="2">40W</td><td>20W</td><td>30W</td></tr>
<tr><td>Glass tube</td><td colspan="2">230g</td><td>110g</td><td>160 – 170g</td></tr>
<tr><td>Fluorescent powder</td><td colspan="2">5-7g</td><td>2.5 – 3.5 g</td><td>2-3g</td></tr>
<tr><td>Electrode</td><td colspan="3">6-7g</td></tr>
<tr><td>Filled gas</td><td colspan="2">5-8mg</td><td>2.5-4mg</td><td>2-3.5mg</td></tr>
<tr><td>Mercury</td><td colspan="3">10-50mg (average 25mg~30mg)</td></tr>
<tr><td>Metal parts</td><td colspan="2">5-6g</td><td>15g</td></tr>
<tr><td>Adhesives on metal</td><td colspan="2">4-5g</td><td>-</td></tr>
<tr><td>Weight per unit</td><td colspan="2">255g</td><td>130g</td><td>190g</td></tr>
<tr><td rowspan="2"></td><td>diameter</td><td>32.5mm</td><td>32.5mm</td><td>32mm</td></tr>
<tr><td>length</td><td>1,198mm</td><td>580mm</td><td>230mm</td></tr>
</table></td></tr>
<tr><td colspan="2">Target area (province, country, or region)</td><td>The Republic of Korea (all nation covered)</td></tr>
<tr><td colspan="2">Year started</td><td>2004[3]</td></tr>
<tr><td colspan="2">Background (problems identified before the introduction of the system)</td><td>In 1990s, Korean governments paid attention to the importance of reducing waste volume before it is generated. Korean government realized that expanding waste treatment facilities could not meet the ever increasing demands for waste treatment with the soaring waste collection and disposal cost and the difficulty to secure sites for waste treatment facilities due to the nationwide NIMBY syndrome. Controlling the demand by achieving waste reduction in the prior phase of disposal seemed to be unavoidable in order to cope with the ever-increasing waste volume problem effectively. So the emphasis of waste policies was given on how to reduce waste volume and how to maximize reuse and recycling of solid waste and policy goals were set in achieving ideally zero waste society where waste volume is minimized and no waste are disposed without being reused or recycled. Various policy tools were introduced to implement this goal. They include volume based waste collection fee system, enforced recycling through deposit system or EPR, and assistance programs to recycling industries.

(Please describe the background that the EPR system was applied to waste fluorescent lamps.)</td></tr>
</table>

[3] EPR started in 2003, and fluorescent lamps were added as EPR item in 2004.

	Steps to introduce the system (incl. legal basis)	<EPR system> (Please describe how the society agreed to introduce the EPR system including the establishment of "Act on the Promotion of Saving and Recycling of Resources".) <Addition of fluorescent lamps to the EPR items> (Please describe how the society agreed to apply the EPR system to fluorescent lamps such as consultation with the industry associations and public hearings.)
	Major outcomes of collection/recovery	Overall of the EPR system (including fluorescent lamps): • Product recycling has been continuously increased. The amount of the EPR items for 2007 increased by 32.3% compared to the period before the EPR system was implemented. • It is estimated that 1 trillion 700 billion won of economic benefit and 3200 new jobs have been created in the 4 years (2003～2006). Fluorescent lamps: In 2005, 4,000 tons of fluorescent lamps were recycled (19% of the production (21,000 tons)). (Are there latest/historical statistics on how much of metal mercury or synthetic mercury was recovered?)
	Major challenges faced in implementing the system and ways to overcome those challenges	
	Remaining issues to be solved	
Information about the collection system	Description of the collection system	<Administrative aspect> *Step1:* Each year before the end of September, the Ministry of Environment (MOE) announces total recycling obligations per EPR item that were set by taking into consideration amount in the market, the amount of recycling collection, and the previous recycling records, as well as the given capacity for recycling, for each product or packaging material. *Step2:* Producers under the EPR system each receive specific mandatory recycling obligations according to the proportion of each producer's share in the market and submit their annual recycling plan by the end of November to the Minister of Environment for approval. *Step3:* Once their recycling plan is approved, producers must fulfil their recycling obligations during that particular year. *Step4:* Producers must then submit their progress report with the outcomes by the end of March of the following year and receive confirmation that they met their recycling obligations from the Minister of Environment by the end of May. *Step5:* The Minister of Environment imposes a charge of less than 130% of the actual recycling cost on producers that fail to meet their recycling obligations by June 15. <Physical aspect> (Please describe how the producers and importers of fluorescent lamps collect used products. Do they hire professional transporters or they have own collection vehicles?)

	Responsibility of relevant stakeholders	Ministry of Environment (MOE): • Set the amount of waste fluorescent lamps that must be recycled by each manufacturer, after taking into account the collection of recyclable resources and other recycling conditions. Producers and Importers[4]: • Reach their recycling target[5]. • Collect and recycle their products (fluorescent lamps) after consumers use and discard them, or pay for the full cost needed for recycling. • Submit annual recycling plans in November and annual progress report in March. • If fail to meet their full mandatory recycling quantity, they must pay recycling dues[6] to the MOE. Consumers: • Pay part of the recycling costs that producers reflect in the price of the products (fluorescent lamps). • Contribute to wastes fluorescent lamps being easily collected by separating and sorting wastes. (Any responsibility of local governments?) Local Governments: • Expand separate collection box for households. • Collection and transportation of fluorescent lamps from household. • Restrict fluorescent lamps going to incineration plant or landfill site. • Supervision and inspection of business site. • Record and inspection report to minister of ministry of environment annually. • Announce record of local released/recycled amount to press.
	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders	Necessary costs: Cost sharing: • Producers and importers directly cover the necessary costs. Consumers pay the costs through product prices.
	Transport and storage methods for collected used products	(Please see the attached figure)
Information about the recovery system	Description of technology to recover mercury	(According to the existing information, mercury should be collected in the form of metal or synthetic mercury. How mercury is recovered as metal mercury or synthetic mercury from waste fluorescent lamps?)
	Process flow to recover mercury from used products	(Please see the attached Figure)

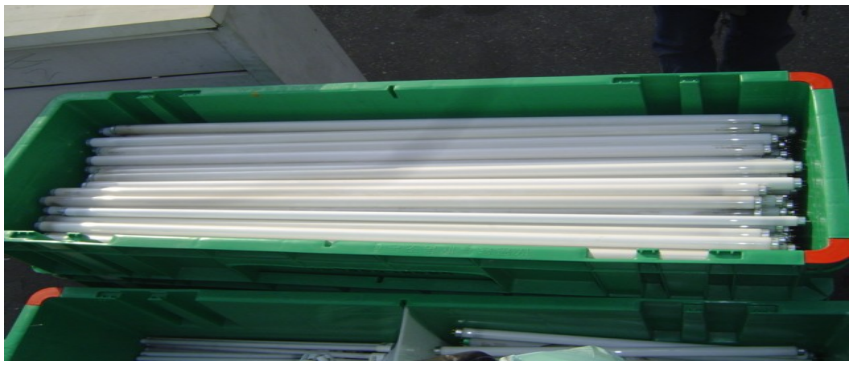
[4] Producers with an annual sale of less than $ 1 billion won (approx. US$ 870K) and importers with an annual import of less than $ 300K won (approx. US$260K) are exempted from the EPR.
[5] The total mandatory recycling amount of a recyclable item is multiplied by the ratio of a business in the total production of the item to produce the mandatory recycling amounts by business.
[6] The recycling dues reflect the actual cost of recycling the unmet portion plus a 30% surcharge. A 5% penalty is added if the recycling dues are not paid within 30 days of notice.

	Ways to handle materials other than mercury	Glass should be used to manufacture the material for glass products. (How about other materials such as aluminium?)
	Description of pollution control measures	
Awareness raising	Target population	(Please describe activities to increase awareness of the public about fluorescent lamps collection and recycling.)
	Activity period/frequency	
	Media used for awareness raising and messages delivered	
	Responsibility of relevant stakeholders	
	Cost sharing of relevant stakeholders	
Remarks (if any)		
References and interviewees		Ministry of Environment, Republic of Korea: http://eng.me.go.kr/content.do?method=moveContent&menuCode=pol_rec_pol_rec_sys_responsibility http://eng.me.go.kr/board.do?method=view&bbsCode=new_photo&docSeq=7979 http://eng.me.go.kr/board.do?method=view&docSeq=195&bbsCode=res_mat_policy Institute for Global Environmental Strategies: http://www.iges.or.jp/en/ltp/pdf/activity09/1_2_won.pdf Thai RoHS. Organization : http://www.thairohs.org/index.php?option=com_docman&task=doc_view&gid=25 RSJ Technical Consulting: http://www.rsjtechnical.com/WhatisKoreaEPR.htm
Graphs or photos that can be used for the Good Practices		Yes (see below)

Flow of fluorescent lamp recycling

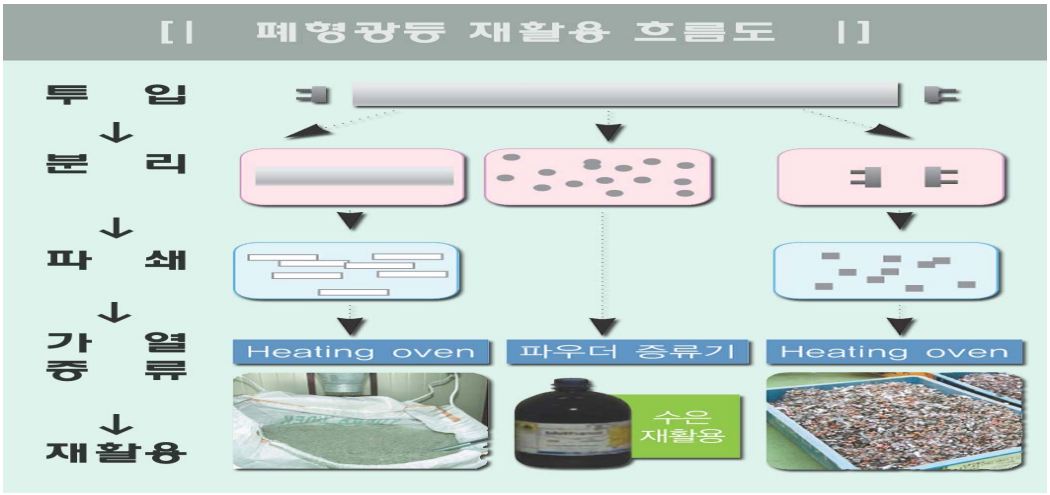
1. Disposal: collection box (household and business site)

2. Collection and transportation: local government



3. Recycling: recycling company

Process recycling



Fluorescent lamp recycling facility

1. Capital area

name	capital area branch
construction	site 3,636m², building 1,322m²
equipment	straight type 2 line HID type 1 line
capacity	straight type: 5,000/h HID type: 2,500/h

2. Yeongnam area

name	Yeongnam area branch
construction	site 3,107m²
equipment	straight and other type 1 line
capacity	straight and other type : 5,000/h

3. Honam area

name	Honam area branch
construction	factory 5,180m²
equipment	straight and other type 1 line
capacity	straight and other type : 5,000/h

4.3.3 Collection and recycling by the cooperation of municipalities, manufactures, and national government in the Kingdom of Thailand

General information	Target product	Name	Fluorescent lamps
		Annual sales volume in the target area	Year 2008. Tube: 37.5 million units, Circular: 3.5 million units, CFL: 8.9 million units
		Weight/volume of mercury included in the product	New model: 3 mg/unit (55%) Old model: 8 mg/unit (45%)
	Target area (province, country, or region)		About 23 large municipalities around Thailand including Bangkok Metropolitan Administration
	Year started		2006

	Background (problems identified before the introduction of the system)	• Fully aware of the danger of mercury, Pollution Control Department (PCD), with cooperation of the Japanese government and JETRO, established a pilot project on fluorescent lamp recycling in Thailand. The objectives of the project are to survey data and information of current amount and management system of waste fluorescent lamp, and to analyze the feasibility study of the fluorescent lamp recycling business in Thailand. Data and information received from the study were used by PCD to lay out a guideline to promote a collection of waste fluorescent lamps from household and business establishments for further recycle or proper disposal. At that time Thailand did not have any specific laws and authorities that clearly control a management of municipal hazardous waste. • The study of the project showed that in 2004 amount of waste fluorescent lamp in Thailand was about 41 million lamps, of which 70% is straight lamp and the others are circular and compact lamps. In the studied areas, covering Bangkok Metropolitan Administration (BMA) and vicinities such as Nonthaburi, Pathumthani, Nakornpathom, Samutprakarn and Samutsakorn municiapalities, it was found that about 14 millions of waste fluorescent lamps were straight lamps or about 50% of waste straight lamp of the country. • PCD then initiated the pilot partnership program with Toshiba and Phillips who have their own recycling facilities to collect and recycle waste FL from about 100 project partners including government offices, academic institutions, business offices, retailers, hotels and hospitals in Bangkok and vicinity area. A simple guideline of the program on waste fluorescent lamps recycling was developed. The MOU of the pilot project lasted for about 16 months from September 2006 to December 2007. • In the pilot program, PCD asked for cooperation with BMA and municipalities around Bangkok to collect waste fluorescent lamp from program partners, and negotiated with lamp manufacturers to expand their recycling or disposal services to cover those lamps generated from households.
	Steps to introduce the system (incl. legal basis)	• In 2007, the Public Health Act was amended. The Act authorizes local governments to collect and manage household hazardous waste such as fluorescent lamps, dry-cell batteries, etc. • At the same time, PCD developed a new household hazardous waste management scheme and disseminate the concept to as well as support financially and technically large-sized municipalities. The goal is to have all 23 large-sized municipalities capable of household hazardous waste collection and storage by 2011. As of 2009, about 16 large municipalities have implemented the scheme. • In this scheme, the municipalities collect the waste FL from households or from the designated points and transfer to the storage facility. The municipalities negotiated with FL recyclers or contract out waste processors. The municipalities are responsible for the costs. • In the long run, economic tool is needed to support the system. Therefore, PCD, in cooperation with the Ministry of Finance, have been drafting the new law to authorize agencies in the Ministry of Finance to impose product fee on the manufacturers and importers. FL is one of the target products to be charged. The fee will be deposited in the new fund and it will be used for the buy-back, collection, transportation, recycling and disposal of waste FL. The new law will be in effect in 2011 or later.

	Major outcomes of collection/recovery	• The collected amount in 2006 and 2007 was about 40,000 lamps and 60,000 lamps, respectively. • The collected amount in 2008 and 2009 increased significantly to about 600,000 and more than 700,000 lamps, respectively. • In 2009, it can be estimated that about 4-5 kg of mercury were not thrown in municipal landfills.
	Major challenges faced in implementing the system and ways to overcome those challenges	• The collection system depends very much on the awareness of both the public and the municipal garbage collectors. • The lack of collected waste FL storage area • Existing FL recycling facilities do not have enough capacity for the waste FL generated from the whole country. • Locations of FL recycling facilities are not well distributed.
	Remaining issues to be solved	• More investment in establishing FL recycling facilities. • Recovery of mercury instead of disposal.
Information about the collection system	Description of the collection system	Depending on the preferences of each municipality, municipalities collect fluorescent lamps from individual houses or designated sites. Some business establishments have direct contact with FL manufacturer to collect waste FL free of charge as an exchange when buying new lamps.
	Responsibility of relevant stakeholders	<u>Pollution Control Department (PCD)</u>: • Meet with municipal mayors or high-level management team of municipalities to introduce the new household hazardous waste management scheme; • Provide trainings for staff and communities; • Provide educational media such as pamphlet, poster, handbook, DVD; • Provide containers and specifications for truck modification. <u>Municipalities</u>: • Convene community leaders, teachers, etc to participate in the training; • Organize special event to raise awareness and to allow residents to bring waste FL to the event for lucky draw; • Collect waste fluorescent lamps from the household and buildings and store them to have enough amount before sending them to lamp manufacturers or proper waste disposers. <u>Fluorescent lamp manufactures</u>: Continue supporting municipalities that had participated in the pilot program since the beginning, despite the termination of the MOU.
	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders	<u>Necessary costs</u>: • The cost for the container is about $400 for every 1,000 residents; • Recycling cost – about $0.12-0.2 / tube; • Transportation cost – depending on the distance <u>Cost sharing</u>: • PCD: costs for educational material, training cost, sample containers; • Municipalities: costs for collection, storage, recycling and disposal; • Manufacturer/recycler: cost for recycling
	Transport and storage methods for collected used products	Municipalities use modified garbage trucks to collect waste FL from households and transfer to storage facility established by municipalities. Transportation to recycling facilities is done by professional waste transporter.

Information about the recovery system	Description of technology to recover mercury	No recovery
	Process flow to recover mercury from used products	No recovery
	Ways to handle materials other than mercury	Glass and aluminium cap can be recycled. Residual materials are sent to secure landfill.
	Description of pollution control measures	Sulfur-coated activated carbon is used to capture mercury and phosphor powder. Cyclone separator is also used for dust removal.
Awareness raising	Target population	• During the training workshops, PCD explains about the scheme and options for the collection. Usually, the community leaders participate in the training and they will disseminate their knowledge and inform other residents about the agreed drop-off sites or the agreed pick-up date. • Sometimes, municipalities convene separate community meeting to inform about the details. • Sometimes, municipalities organize a fair-like event with concert, performance, etc to inform the public and provide incentives for the separation of household hazardous waste.
	Activity period/frequency	About 1-3 times a year, depending on each municipality.
	Media used for awareness raising and messages delivered	• Canvas bags, notepads, pamphlets, handbook, DVD, roll-up poster, quiz games, etc • Messages: examples of household hazardous waste, its impact on human health and environment, how to avoid the generation, how to reduce this waste and how to deal with unavoidable hazardous waste.
	Responsibility of relevant stakeholders	PCD compiles information and write the text for the printed materials and drafted the script for the DVD and design the mascot for the scheme.
	Cost sharing of relevant stakeholders	PCD produces the original batch of media for municipalities to reproduce and modify to suit the local context.
Remarks (if any)		
References and interviewees		Pollution Control Department, Ministry of Natural Resources and Environment, Thailand. "Guideline of Fluorescent Lamp Management in Thailand" http://www.pcd.go.th/info_serv/en_haz_lamp.htm#s2
Graphs or photos that can be used for the Good Practices		Yes (see below)

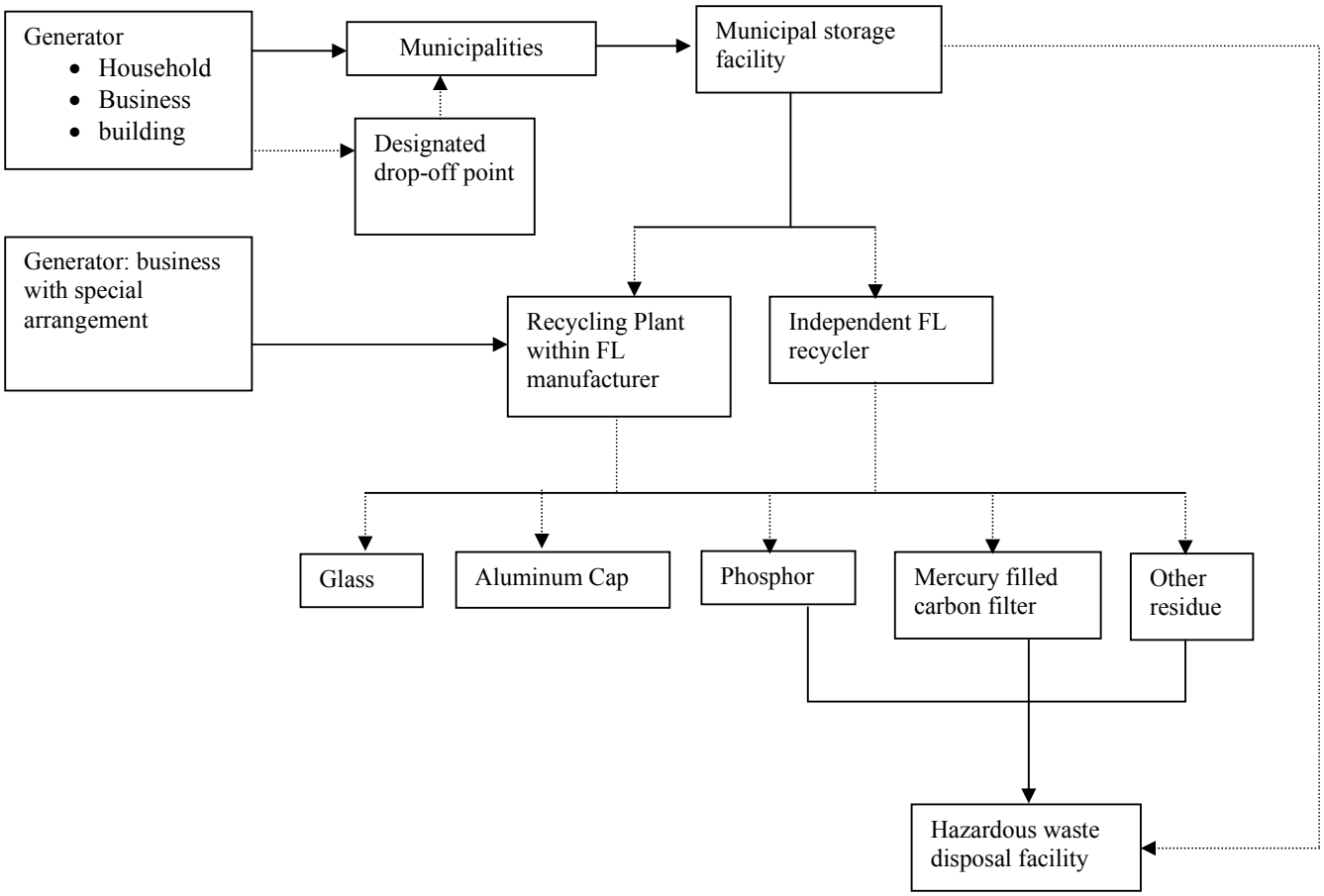


Figure 4.3.3 Diagram of Fluorescent Lamp Management in Thailand

4.4 Electrical and Electronic Equipment

4.4.1 PC Recycling based on EPR (including mercury recovery) in Japan

General information	Target product	Name	Electrical and Electronic appliances（PC）
		Annual sales volume in the target area	-
		Weight/volume of mercury included in the product	Depends on the product. However PC green labelling system defines one of the parameters of PC green label standard as “the light source for the liquid crystal backlight should be either a cold cathode tube with mercury amount less than 5mg or should not contain mercury.” http://www.pc3r.jp/greenlabel/point.html
	Target area (province, country, or region)		Japan (the whole nation is covered)
	Year started		Year 2001（PC for business use） Year 2003（PC for personal use）

	Background (problems identified before the introduction of the system)	• In Japan, types of domestic waste with large generation amount is targeted by specific recycling laws like "Act on the Promotion of Sorted Collection and Recycling of Containers and Packaging". However, products not covered by the individual acts are covered by the "Act on the Promotion of Effective Utilization of Resources" where they are required to have 3R measures during manufacture stage, consider 3R during design, have appropriate labelling for segregation and collection and have businesses setup a scheme for voluntary collection and recycling system. • Presently (January 2010) 69 products and 10 business types are covered by the law. Regarding PC, initially only PC from businesses were covered by the law, but with the recent increase in the usage of household PC, they have also been covered since 2003. • Mercury containing fluorescent tubes are used in the backlight of liquid crystal panels of PCs and in the recycle process mercury is also being recycled.
	Steps to introduce the system (incl. legal basis)	<u>December 2000</u> In the joint meeting of the industrial structure council (environment department waste recycle group , PC 3R subgroup) and Ministry of health and welfare`s (presently Ministry of Environment) investigative commission on recycle of computers , a joint report indicating the direction of collection and recycling of PCs used by businesses that covered about 80% of used PC was published. Further discussion was planned for PCs used in households. <u>April 2001</u> In accordance with "Act on the Promotion of Effective Utilization of Resources", the collection and recycling of PC from businesses was started. <u>July 2001</u> In the joint meeting of the industrial structure council (environment department waste recycle group, PC 3R subgroup) and Ministry of Environment's investigative commission on recycle of computers, discussion on collection and recycling of household computers was started. <u>February 2002</u> A draft report was prepared on the 6th meeting of the abovementioned joint meeting. <u>May 2002</u> After considering public comments, the final report was prepared. <u>October 2003</u> Collection and recycling of household PCs was started.

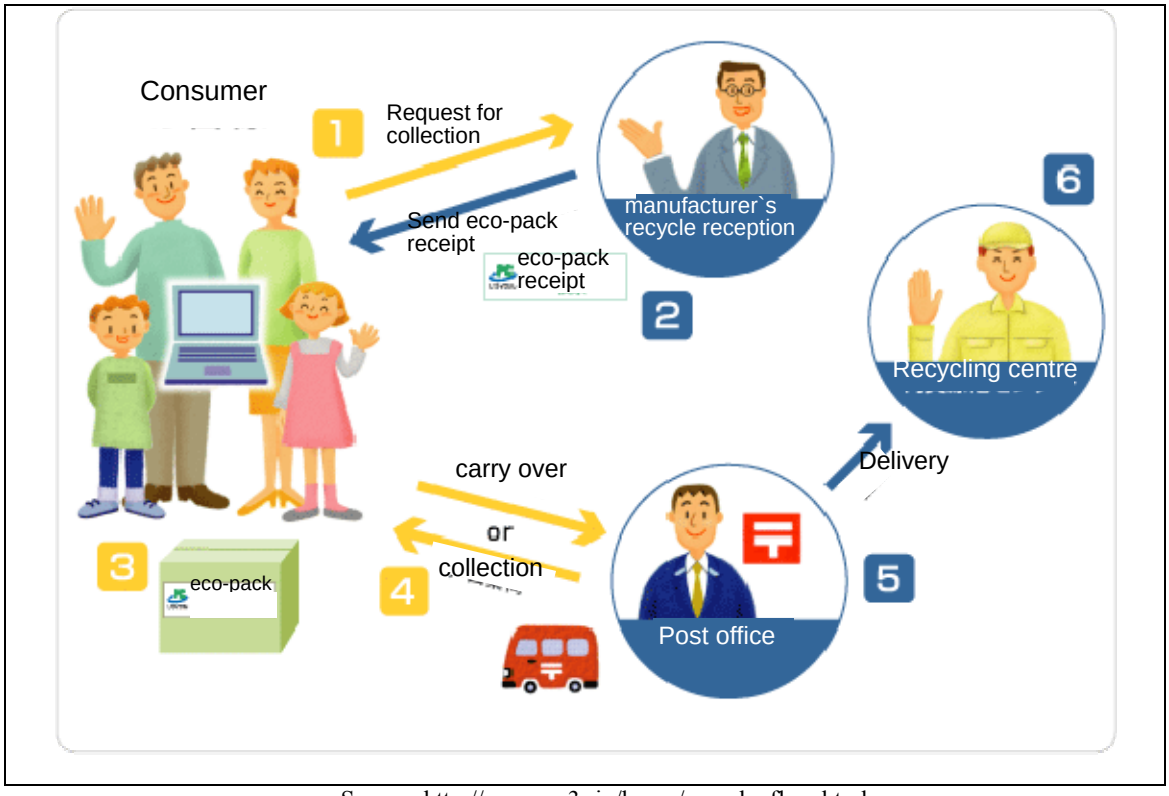
	Major outcomes of collection/recovery	The results for FY2008 are shown below. （http://www.pc3r.jp/association/recycle_result.html） - household PC: 358,145 - PC for businesses: 513,866 Among those, -Notebook computers: about 210,000 -LCD: about 170,000 The numbers above include collection and recycling from common collection system and also items bought for reuse purposes. *The amount of mercury collected from PCs is not available.
	Remaining issues to be solved	collection rate to be increased
Information about the collection system	Description of the collection system	Collection system for household PCs ➔ see Figure 4.4.1 Collection system for PCs for businesses ➔ see Figure 4.4.2 Mercury collection system from collected PC • Mainly fluorescent tubes in backlights of liquid crystals contain mercury • The handling methods for fluorescent tubes differ according to the manufacturer. However generally the tubes are extracted manually and the treatment is contracted out to treatment companies. These companies collect mercury which is recycled by smelting company.

	Responsibility of relevant stakeholders	The roles of various stakeholders in the collection and recycling of PC are as follows Role of the manufacturers ・Engage in voluntary collection and recycling in order to achieve the recycling target set by the government ・Consider and implement a collection and recycling system that is convenient to the consumers and is effective. ・Promote the usage of reused parts and recycled resources as well as rationalize the usage of raw materials. ・Make effort to decrease the recycle cost and improve the recycle ratio Role of the local government ・Make effort to promote the effective usage of resources considering the region's economic and social conditions. Further carry out information dissemination and notifications aimed at the public. Role of the National government ・Set the standard for recycling target in accordance with "Act on the Promotion of Effective Utilization of Resources" ・Strive to get the understanding of the public in the promotion of the effective usage of resources through educational and promotional activities and get the cooperation of the public in its implementation. Role of the consumer ・Make effort to promote usage of reused and recycled goods and use products for a longer period, cooperate in segregation and collection being carried out by vendors and also in activities being carried out by the national government, the local governments and businesses. From the viewpoint of recycling of mercury, it is required for the manufactures involved in recycling of PCs, recycling companies, treatment companies to carry out recycling of mercury contained in PCs in a manner that does not pose harm to the environment.

	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders	・The recycle cost is to be set by the various PC manufacturers by considering cost for collection, intermediate treatment, reuse, recycle and final disposal to landfill. It also includes cost for recycling of mercury containing parts like fluorescent tubes. <u>Collection and recycling cost for household PC</u> ・It is added to the selling price during the sale of PCs. When the used PC is carried to the designated collection places of the manufacturers, the manufacturers buy back the PCs and recycle them. Recycle cost has not been added to the selling price of the PCs sold before the implementation of the system and hence the consumers need to pay the manufacturers the recycling cost before having their PC taken back. <u>Recycle and collection cost for PCs used by businesses</u> ・The manufacturers are setting the price according the number and generation place of used PCs and collecting the recycle cost before taking back.。 <u>Treatment cost of parts containing mercury</u> ・For parts or products that contain mercury (e.g. fluorescent lights) the PC recycling companies (companies that are contracted by PC manufacturers to carry out recycling of the PCs) pay the intermediate treatment companies and recycling companies for treatment. They also pay for the transportation cost.
	Transport and storage methods for collected used products	<u>Transportation of PCs</u> ・"Act on the Promotion of Effective Utilization of Resources" requires the manufacturers to specify a "designated collection place" and take back PC brought there by customers. ・In actual practice, the manufacturers have specified post offices located in about 20,000 places in Japan as the designated collection place and have utilized the YUPACK (express delivery system of the post office) to collect PCs from households. <u>Transportation of parts containing mercury</u> ・The transportation and intermediate treatment of mercury containing products/parts differs according to the company carry out the intermediate treatment, a few examples of which are shown below →The intermediate treatment company uses a special container where the fluorescent tube is transferred and is transported by a truck. →The parts associated with fluorescent tubes are put into a drum and sealed and is transported to the treatment facility by trucks or trains.

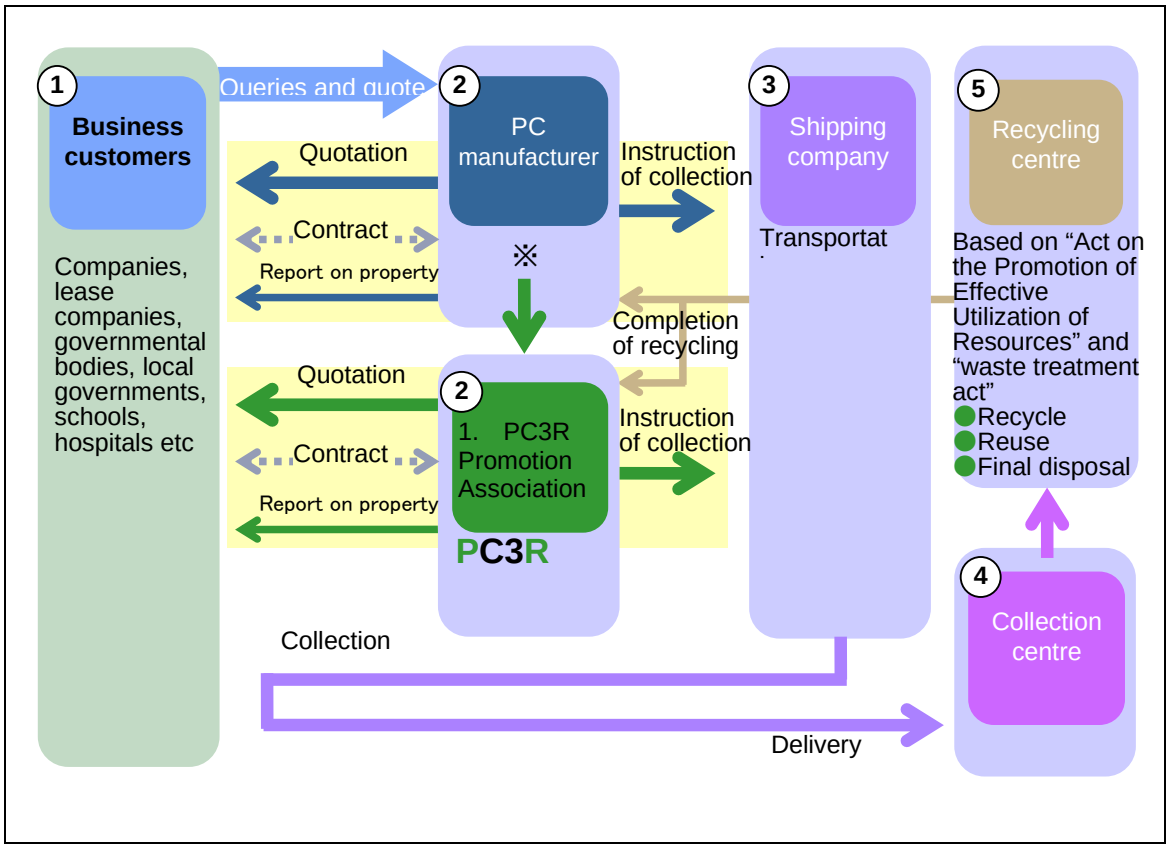
Information about the recovery system	Description of technology to recover mercury	Example of handling of a liquid crystal backlight by a PC recycling company ・The LCD is sold as a reuse part with the fluorescent tubes and inverters intact. ・For LCDs that are broken and cannot be reused, the treatment of fluorescent tubes or other parts connected to the fluorescent tubes is contracted out to intermediate treatment companies. ・In order to prevent the fluorescent tubes from being damaged, if the display is badly broken, the fluorescent tube is not forcibly removed and handled together with other connected parts.
	Process flow to recover mercury from used products	In the PC recycling process, dismantling is generally carried out manually. One of the PC recycling companies uses the following method for handling LCD. 1) Separate the reusable LCD from non reusable ones →The reusable portions are sold as reuse parts 2) For the PCs which cannot be reused, the fluorescent tubes are taken out. However if it is difficult to take only the fluorescent tubes out, it is taken out together with the connected parts. 3) Store the fluorescent tubes in a special container specified by the intermediate treatment company. →When a certain amount is collected, contract out the treatment Refer to the section on "fluorescent tubes for lighting" for the method of treatment of fluorescent tubes by the intermediate treatment company
	Ways to handle materials other than mercury	General process ・The recycle process of PCs differs according to the manufacturer but a general process is shown in figure 3
	Description of pollution control measures	・Recycling of PC is done by manual segregation using hands and the dispersion of hazardous material by unnecessary damages to the parts is prevented.
Awareness raising	Target population	Generators of used PC (businesses/households)
	Activity period/frequency	On a as per need basis During the purchase of PC
	Media used for awareness raising and messages delivered	・Pamphlets and websites etc of local governments Provide information on enquiry places for information related to disposal of PC, along with rules of waste segregation ） ・(Website of PC3R promotion association) Provide information related to outline of the act on PC recycling, procedures to be followed during the disposal of PCs and information on facts regarding recycling of PCs ・Website of Manufacturers Provide information on the company's recycling methods and also provide information about where to direct enquiries）
	Responsibility of relevant stakeholders	・PC3R promotion association and PC manufacturers: Information disclosure to the consumers for the implementation of collection and recycling of used PCs ・Local government: Dissemination of information on waste segregation
	Cost sharing of relevant	The respective entities involved in notifications and information

stakeholders	dissemination.
Remarks (if any)	Activities like accepting site visits and visiting local schools are also carried out. This results in an effective transfer of information regarding PC recycle and environmental impacts and some companies use this as an opportunity to provide information on the proper method of disposing PCs.
References and interviewees	1) Nagata Katsuya , Kawakami Keiichi: Recycling of Household Personal Computers in Japan:, Waste management Research Vol14, No3, pp121-128, 2003 2) PC3R promotion association : Figures on the collection and recycling of used PCs (FY 2008) (http://www.pc3r.jp/association/recycle_result.html) 3) Recycle by PC manufacturers, Journal of MMIJ, Vol.123, p823-827, 2007 4) METI: 3R Policies (http://www.meti.go.jp/policy/recycle/main/admin_info/law/02/index.html) 5) Interview with companies (February 2010)
Graphs or photos that can be used for the Good Practices	Yes (see below)



Source: http://www.pc3r.jp/home/recycle_flow.html

Figure 4.4.1 Collection system for PC from households



Source: http://www.pc3r.jp/office/index.html

Figure 4.4.2 Collection system for PC used by businesses

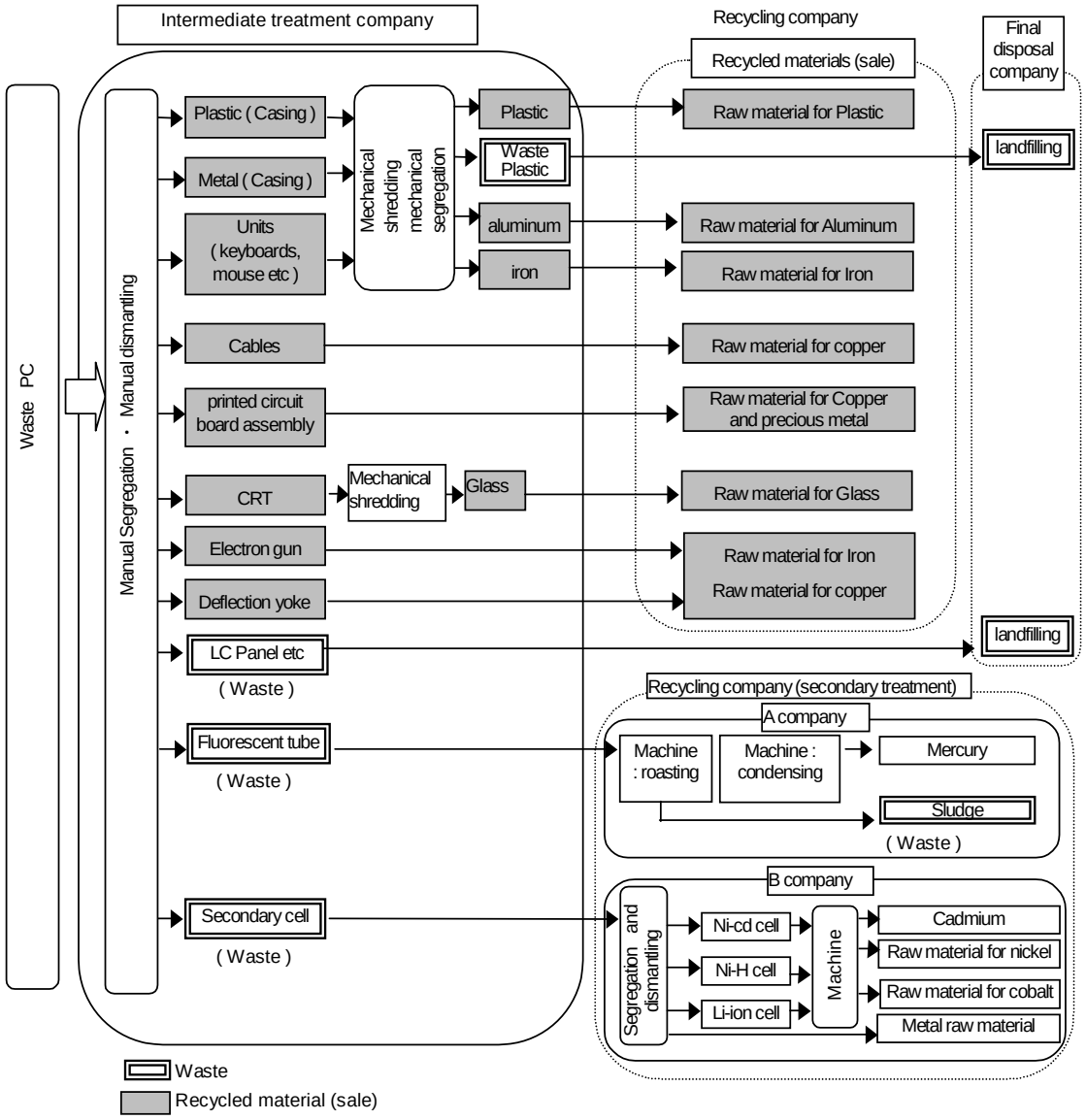


Figure 4.4.3 General Process of PC Recycling

Table 4.4.1 Results of the collection and recycling of used computers collected from households

	Amount collected (t)	Number collected	Treatment amount for recycling(t)	Amount of recycled materials used for production (t)	Ratio of recycled materials used (%)
Desktop computers	1,413.6	127,176	1,268.9	919.2	72.4
Laptop computers	270.3	75,074	211.8	102.9	48.6
Display	1,609.7	93,383	1,609.5	1,162.4	72.2
LCD	486.9	62,512	366.5	255.7	69.8
Total	3,780.5	358,145	3,456.7	2,440.2	

Table 4.4.2 Results of the collection and recycling of used computers collected from business establishments

	Amount collected(t)	Number collected	Treatment amount for recycling (t)	Amount of recycled materials used for production (t)	Ratio of recycled materials used (%)
Desktop computers	1,889.7	188,112	1,385.3	1,143.3	82.5
Laptop computers	414.1	133,967	267.0	161.2	60.4
Display	1,283.0	83,312	1,215.4	939.6	77.3
LCD	667.1	108,475	432.3	318.9	73.8
Total	4,253.9	513,866	3,300.0	2,563.0	

4.5 Dental Amalgam

4.5.1 Setting dental amalgam management practice standard in Canada

49. In 2001, Canada worked with provincial governments to begin addressing the issue of mercury-containing products through the Canada-wide Standards (CWS) process, which included the active engagement of provincial counterparts and interested non-governmental organizations in addition to public consultations. After conducting an assessment of priority product-related sources, the Canadian Council of Ministers of the Environment (CCME) endorsed CWSs for mercury-containing lamps and for dental amalgam waste.

50. The goal of the CWS for Dental Amalgam Waste was to reduce national mercury releases from dental facilities in Canada (4700 kg) by 95% by 2005 from a 2000 baseline. Despite very good cooperation and publicity by the Canadian Dental Association, as of 2006, a survey estimated that 70% of dentists implemented best management practices for their dental amalgam waste. CCME concluded that the CWS was not achieved, Environment Canada decided to take action to achieve the CWS target by using a Pollution Prevention Notice that would apply to dentists who have not met the CWS. The proposed Notice was published on April 18, 2009, and Environment Canada expects to publish the Final Notice in *Canada Gazette* in March 2010.

General information	Target product	Name	Dental amalgam
		Annual sales volume in the target area	A 2007 study based on an extensive survey of dentists indicates that: - 2,051 kg of mercury are used in new and replacement restorations - 2,614 kg of mercury are generated as scrap amalgam - 2,703 kg of mercury were removed in amalgam restorations
		Weight/volume of mercury included in the product	The dental amalgam mixture in commonly used “silver fillings” can consist of up to 50% mercury by weight.
	Target area (province, country, or region)		Canada
	Year started		2002
	Background (problems identified before the introduction of the system)		During filling removal, grinding produces small fragments of amalgam which pass through the traditional filter systems of dental offices and hence contaminate the sewer systems or septic beds serving these offices. Collection of amalgam fragments by filtration results in silver and mercury that can be recycled. However many dentists dispose of these fragments either in biomedical waste which is incinerated, in residential waste that may be incinerated, or by rinsing it down the sink.

<table>
<tr><td></td><td>Steps to introduce the system (incl. legal basis)</td><td>The Canada-wide Standard (CWS) on Mercury for Dental Amalgam Waste was endorsed by the Canadian Council of Ministers of the Environment (CCME) in 2001. The CWS calls for the installation of ISO 11143 certified separators and other best management practices in order to reduce releases of mercury from dentistry in Canada by 95% by 2005, from a baseline of 2000. The Canadian Dental Association (CDA) and the Environment Canada (EC) signed a Memorandum of Understanding in 2002 committing the CWS.</td></tr>
<tr><td></td><td>Major outcomes of collection/recovery</td><td>The mercury Canada-wide Standard for dental amalgam waste target of 95% reduction of releases was not achieved (57% reduction in 2007 against 2003), however the percentage of dentists with ISO 11143 certified separators has increased from 27% nationally to 70%. It was recommended that EC takes further actions under the Canadian Environmental Protection Act to assist jurisdictions in achieving the Canada-wide Standard target.

Table 1 - Comparison between data collected from the 2003 and 2007National Survey of Dentists.

<table>
<tr><th></th><th>2003</th><th>2007</th><th>2003 vs 2007</th></tr>
<tr><td>Total amount of Hg used in dental</td><td>5352kg</td><td>4665kg</td><td>-3%</td></tr>
<tr><td>Quantity of Hg being placed in teeth</td><td>2314kg</td><td>2051kg</td><td>-11%</td></tr>
<tr><td>Quantity of Hg present in removed dental amalgam restorations</td><td>2472kg</td><td>2703kg</td><td>+9%</td></tr>
<tr><td>Quantity of Hg trapped in solids</td><td>989kg</td><td>1081kg</td><td>+9%</td></tr>
<tr><td>% of dentists using ISO certified</td><td>27%</td><td>70%</td><td>+43%</td></tr>
<tr><td>Quantity of Hg being released to the environment from removed dental amalgam restorations</td><td>1046kg</td><td>452kg</td><td>-57%</td></tr>
<tr><td>% of dentist who had engaged a licensed waste carrier to manage amalgam appropriately[3]</td><td>N/A</td><td>71.2%</td><td>-</td></tr>
</table>
[1] Conventional solids separators at the chair-side and vacuum pump.

[2] A high efficiency amalgam separator that meets ISO 11143:1999 standards (International Standard Organization 1999).

[3] Appropriate management may include landfilling in an approved, confined, engineered landfill with leachate collection systems, such as a hazardous waste landfill, recycling to either produce reusable materials such as mercury, silver and copper, or for stabilization/immobilization in a form that may be retired permanently.</td></tr>
<tr><td></td><td>Major challenges faced in implementing the system and ways to overcome those challenges</td><td>Complying with the best management practices includes buying an amalgam separator and hiring a carrier to send the waste for recycling or appropriate disposal. Cost might be a perceived issue even if both of these actions are simple and not time consuming to perform. In addition, certain dentists have the incorrect perception that mercury is safe in the environment based on the fact that it is safe in the mouth of their patients (Health Canada statement) and it is a naturally occurring element.</td></tr>
<tr><td></td><td>Remaining issues to be solved</td><td>As of 2007, 70% of the dentists were in compliance with the CWS. Of the 2703kg of amalgams removed from teeth by dentists, only 452kg would enter wastewater as a result of the use of amalgam separators; this could be reduced to 18kg if all dentists used separators.
As a result, Environment Canada has published a draft Pollution Prevention Planning Notice that requires dental clinics that have not established best management practices as outlined in the CWS to prepare pollution prevention plans detailing how they will implement them and to provide periodic reports on the status of implementation.
Final Publication of the Pollution Prevention plan for dental amalgam is expected in March 2010.</td></tr>
</table>

Information about the collection system	Description of the collection system	Contact Amalgam Waste Best management practices: Install an International Organization for Standardization (ISO) certified amalgam separator (ISO 11143) or equivalent and maintain it according to the manufacturer's instructions. Use disposable traps and filters in your dental units. Using universal precautions (gloves, glasses and mask), remove the chair-side trap from your dental unit and place the entire trap into a break/puncture-resistant, airtight container labelled: "Mercury Waste: Contact Amalgam." Fasten the lid securely onto the container. Using universal precautions (gloves, glasses and mask), remove the vacuum pump filter from your dental unit. Fasten the lid securely onto the filter. Label the filter "Mercury Waste: Contact Amalgam." Once traps and filters have accumulated, contact a carrier for recycling, or proper disposal, or your provincial or territorial environment agency. Please verify with your provincial/territorial/municipal authorities if a certified hazardous waste carrier is required under their legislation. Other options: Using universal precautions (gloves, glasses and mask), remove chair-side trap vacuum pump filter from the dental unit. Remove all visible amalgam by tapping the trap and filter contents into a container labelled "Mercury Waste: Contact Amalgam." Close the lid tightly. If the trap and filter are visibly clean, throw them into the regular garbage if they are disposable or insert them back into dental unit if reusable. If the trap and filter are not visibly clean, they must be placed in a contact amalgam container for pick up by a carrier for recycling or proper disposal, or your provincial or territorial environment agency. Please verify with your provincial/territorial/municipal authorities if a certified hazardous waste carrier is required under their legislation. Don'ts: Do not place contact and non-contact amalgam in the same container. Do not place contact amalgam waste in the same container as bio-medical wastes or sharps. Do not rinse traps and filters in the sink. Do not throw disposal traps that contain amalgam particles into the garbage. Do not wipe traps/filters with paper towel or any other material, as this creates additional contaminated waste. <u>Non-Contact Amalgam Waste</u>[7] Best management practices: Separate non-contact unused amalgam waste from used amalgam waste. Collect non-contact amalgam waste in a break/puncture-resistant, airtight container. Label the container "Mercury Waste: Non-contact Amalgam." Once the container is full, contact a carrier for recycling, or proper disposal, or your provincial or territorial environment agency. Please verify with your provincial/territorial/municipal authorities if a certified hazardous waste carrier is required under their legislation. Don'ts Do not throw amalgam into the garbage. Do not wash amalgam particles down the drain. Do not transport amalgam yourself. Do not place non-contact amalgam waste in your sharps container.

	Responsibility of relevant stakeholders	<u>The Canadian Dental Association (CDA):</u> • Make determined efforts to ensure that dentists take action to achieve the objectives of the CWS. • Provide amalgam waste management data to the EC on an annual basis from 2002 to 2007. <u>Minister of the Environment/Environment Canada (EC):</u> • Support the CDA in its efforts to incorporate into the CWS. • Conduct data analyses and in cooperation with the CDA, produce a summary report addressing the reported compliance with the Best Management Practices for Amalgam Waste in Canada. <u>Dentists</u>: • Implement the Best Management Practices in your dental office, which includes installing and maintaining a certified amalgam separator and hiring a carrier to send the waste for recycling or appropriate disposal. <u>Local governments</u>: • The CCME consists of federal, provincial (except Québec), and territorial environment ministers. Each CCME member is responsible for implementing the CWS in its own jurisdiction, with the goal of effective, efficient, and harmonized implementation. Governments will report to the public on progress towards attaining the agreed-upon standard. <u>Hazardous waste carriers</u>: • Pick up the waste at the dental clinics and transport it to the recovery facilities. <u>Hazardous waste treaters/mercury recovery facilities</u>: • Process the recovered mercury for recycling or long term disposal.
	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders	• Depends on the region, location of the dental clinics and the carrier selected, cost could vary • Depends on the equipment selected, some separator need to be replaced more often (removable filters vs replacing the whole unit)
	Transport and storage methods for collected used products	Typical method used for any hazardous waste; In some provinces, dental amalgam waste is not considered as hazardous waste.
	Ways to handle collected used products where a mercury recovery facility is not located in the target area (e.g. storage, export to the countries with mercury recovery facilities, etc.)	Same as other hazardous waste; must consult with provincial / federal / international regulations.
Information about the recovery system	Description of technology to recover mercury	The mercury is recovered from amalgam wastes through a distillation process and reused in new products. Environment Canada does not have a detailed knowledge of how the mercury is recovered. Companies are protective of their technologies because of market-competition.

[7] Non-Contact amalgam waste is amalgam waste that has never been in a patient's mouth. It is generally surplus amalgam left after a new restoration has been completed.

	Process flow to recover mercury from used products	No information available
	Ways to handle materials other than mercury	No information available
	Description of pollution control measures	No information available
Awareness raising	Target population	Dental facilities where, at any time, the following activities are performed by licensed dentists for tooth restoration: a. insertion and/or reparation of dental amalgam; or b. alteration and/or removal of dental amalgam; or c. disposal of dental amalgam; or d. use, possession or disposal of elemental mercury.
	Activity period/frequency	2002-2007
	Media used for awareness raising and messages delivered	Media: dental events, journal, workshop, curricula of all Canadian dental schools, web site Message: • Mercury is a toxic substance on the List of Toxic Substances on Schedule 1 of the Canadian Environmental Protection Act (CEPA), 1999. When dental amalgam is washed down the drain and enters the environment, it can be converted to methylmercury, which is a more harmful form of the substance. Methylmercury is harmful to the environment as it can build up in living organisms over time and is highly toxic to fish and wildlife. • The CWS calls for the installation of ISO 11143 certified separators and other best management practices in order to reduce releases of mercury from dentistry in Canada by 95% by 2005, from a baseline of 2000.
	Responsibility of relevant stakeholders	Minister of the Environment/Environment Canada (EC) : • Organize 12 regional workshops to assist dental practitioners across Canada during 2002-2003 in consultation and with the cooperation of provinces and territories, the CDA and its corporate members. • Prepare an article for publication in the journal in 2002 and for each subsequent year until 2007, to describe progress on the implementation of the Memorandum of Understanding. • Continue with outreach and education efforts directed to the dental community, through the Mercury and the Environment (www.ec.gc.ca/mercury) web site and through presentations and exhibits at dental conferences on Best Management Practices. The Canadian Dental Association (CDA): • Promote the incorporation of a training component to address amalgam waste management in the curricula of all Canadian dental schools.
	Cost sharing of relevant stakeholders	N/A
Remarks (if any)		Some provinces and municipalities like Ontario and Vancouver have developed regulations and bylaws to control mercury releases from dental practices. Some jurisdictions, like Ontario, have also developed useful resources such as waste management diagrams and Best Management Practices.
References and interviewees		http://www.ec.gc.ca/MERCURY/DA/EN/c-w-s.cfm
Graphs or photos that can be used for the Good Practices		No

4.5.2 Collection of dental amalgam in Massachusetts (USA)

General information	Target product	Name	Dental amalgam
		Annual sales volume in the target area	Data on annual sales of amalgam in the US can be found at: http://www.newmoa.org/prevention/mercury/imerc/factsheets/dental_amalgam.pdf. US sales ranged from about 62,000 (2001) to 33,000 (2007) pounds per year. On a population basis these values imply that 1308 (2001) and 966 (2007) pounds of mercury were used in dental amalgam preparations in Massachusetts. However, mercury amalgam entering the waste-stream is a function of waste generated during both the installation of new amalgam and removal of old restorations. The latter will reflect use over many years and the replacement rate. Thus, the amount of mercury entering the waste stream per year may be larger than the total currently being used.
		Weight/volume of mercury included in the product	Amalgam is typically comprised of about 50% elemental mercury.
	Target area (province, country, or region)		Commonwealth of Massachusetts, USA
	Year started		Mandatory program effective April 24, 2006. Voluntary program initiated in 2001. Voluntary early compliance program with incentives initiated in 2004.
	Background (problems identified before the introduction of the system)		Amalgam waste from dental practices and clinics is a significant source of mercury releases to the environment when it is thrown into the trash or washed down a drain. Potential environmental release pathways for waste dental amalgam include wastewater (e.g., sludge disposition, incineration, land application, and direct water discharges) and disposal to solid waste (e.g., incineration and landfills).

	Steps to introduce the system (incl. legal basis)	• After limited success of a 2001 voluntary programs, the Massachusetts Department of Environmental Protection (MassDEP) worked with the Massachusetts Dental Society (MDS) and other stakeholders in 2004 to establish a two-tiered program for dental practices and facilities to address waste dental amalgam. The program consisted of an early compliance voluntary phase from 2004 to 2006 that used incentives to encourage early use of amalgam separator pollution controls and additional best management practices (BMPs). Program components included certifying to MassDEP that targeted dental practices were using amalgam separators and recycling amalgam waste containing mercury. As a primary incentive to participate, permit fees were waived for those certifying under the voluntary early compliance program. Participants were also exempted from the regulations under development, with potentially more stringent requirements, for several years. • At the time the early compliance program was launched in 2004, MassDEP also announced that mandatory requirements would be drafted and become effective in 2006. • MassDEP developed regulations requiring dental facilities to install and operate amalgam separators, and to use BMPs for waste amalgam containing mercury. • MassDEP developed these regulations for dental facilities with assistance from a stakeholder workgroup including individual dentists, MDS representatives, sewerage authorities, and environmental groups. • On April 24, 2006, MassDEP issued 310 CMR 73.00: Amalgam Wastewater & Recycling Regulations for Dental Facilities.
	Major outcomes of collection/recovery	• More than 70 percent of dentists certified under the early compliance program. • Regulations mandating the use of amalgam separators were adopted, on schedule, in 2006. • Compliance audits indicate more than 98 percent of covered practices have installed amalgam separators.
	Major challenges faced in implementing the system and ways to overcome those challenges	• Lack of national standards. • Initial outreach and awareness-raising efforts in 2001, only led to a modest increase in amalgam separator use. • Some dental offices were not able to access and submit electronic certification forms requiring an alternative submittal process. • Compliance verification is challenging due to the large number of facilities and agency resource constraints. This issue was addressed using electronic self certification forms with site visits by agency enforcement staff to verify compliance. These were made to randomly selected offices chosen using statistically determined sample size criteria.
	Remaining issues to be solved	Compliance with other BMPS is difficult to verify.

Information about the collection system	Description of the collection system	In the regulation, the Dental Amalgam/Mercury Recycling certification program requires dental practices and facilities to certify to MassDEP every five years that they: • Have installed an amalgam separator system that serves every dental chair in the practice or facility where waste amalgam is generated. The system must be one that has been demonstrated to remove at least 98 percent of the amalgam waste containing mercury (using the ISO 11143 protocol or an equivalent method acceptable to MassDEP)[8]. • Maintain and operate the amalgam separator system according to manufacturer specifications. • Use only non-corrosive and biodegradable cleaners to clean vacuum system lines. • Recycle all amalgam waste containing mercury. • Ensure that facility staffs are informed about procedures for handling waste amalgam, and that at least one employee is familiar with procedures for operating and maintaining the installed amalgam separator system. • Keep records to document that the program requirements being met. Certifications are submitted electronically using a standard form Dental practices send amalgam waste directly to a recycling facility that has obtained a Class A Hazardous Waste Recycling Permit from MassDEP, or a recycling facility located in another state that is authorized by that state to reclaim mercury. Otherwise, they may send it to a licensed hazardous waste facility or a consolidation facility, which will in turn send the amalgam waste to a reclamation facility.
	Responsibility of relevant stakeholders	<u>The Massachusetts Department of Environmental Protection (MassDEP):</u> • Accept and follow up certifications of dental practices. Assists dental offices in completion of certification forms. Developed electronic certification form and database application. Maintains certification database. Conducts compliance audits and takes enforcement action as necessary. <u>Massachusetts Dental Society (MDS):</u> • Assists in providing outreach to member dentists and facilities. <u>Dental Practices</u>: • Install and use amalgam separators that remove at least 98% of the waste amalgam in wastewater • Recycle amalgam waste containing mercury (send amalgam waste to a recycling facility authorized to reclaim mercury) • File and renew (every five years) certifications to MassDEP • Comply with regulatory requirements.

[8] Dental practices participating in this early compliance program before March 1, 2005, were exempted from MassDEP amalgam separation system installation, operation, maintenance and upgrade regulations, and related fees, until February 1, 2010. Dentists who submitted voluntary certifications after February 28, 2005, but before February 1, 2006, were exempted from additional amalgam separator rules and fees until February 1, 2007.

	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders	Amalgam separator costs vary between manufacturers and would likely vary substantially between countries. In MA, dental offices are responsible for the full cost of system purchase, installation and maintenance.
	Transport and storage methods for collected used products	**Recommended Practices for Contact Amalgam[9]** • Always use personal protective equipment (gloves) when handling contact amalgam. • Render teeth containing amalgam non-infectious by chemical means. • Store amalgam wastes in separate airtight containers labelled "extracted teeth". • Clean or replace screens, traps, or filters on a regular basis. • Clean screens, traps, and filters before cleaning vacuum lines. • Recycle all waste amalgam. **Recommended Practices for Non-Contact Amalgam[10]** • Store amalgam wastes in separate airtight containers labelled "extracted teeth," "scrap amalgam," "traps," etc. • Recycle all waste amalgam. **Shipping** • A common carrier (such as the U.S. Postal Service, United Parcel Service, Federal Express, or other shipping service) may be used to transport amalgam waste. Dental practices are not required to use a licensed hazardous waste transporter.
Information about the recovery system	Description of technology to recover mercury	Amalgam separators typically rely on rather simple technologies including sedimentation, filtration and in some cases ion-exchange resins, to remove mercury amalgam and dissolved mercury from dental office wastewater.
	Process flow to recover mercury from used products	Mercury captured in amalgam separators may be recovered through a retort process. In some US states, disposal of recovered mercury amalgam to a hazardous waste landfill facility may be allowed.
	Ways to handle materials other than mercury	Other metals that are typically included in amalgam, including silver, are also captured and may be recovered.
	Description of pollution control measures	Amalgam separators are considered a type of pollution control device.
Awareness raising	Target population	Targeted: Dental practices likely to generate wastewater containing amalgam mercury, including general dentists, pediatric dentists, endodontists, and prosthodontists. Exempted: Oral surgeons, periodontists and orthodontists.
	Activity period/frequency	Initial voluntary efforts commenced in 2001. Two-tiered early compliance voluntary-mandatory approach initiated in 2004.
	Media used for awareness raising and messages delivered	Outreach conducted by MDS and MassDEP via professional meetings, newsletters, mailings and other channels. Self-certification conducted via Internet filing with assistance from

[9] "Contact Amalgam" has been in contact with the patient and includes teeth containing amalgam from patient/extractions, scrap amalgam from patient/old fillings, chair-side traps, screens, and amalgam sludge from vacuum pump filters and other amalgam capture devices.
[10] "Non-Contact Amalgam" has not been in contact with the patient and includes broken or unusable amalgam capsules, excess amalgam, and empty amalgam capsules from restorative treatment.

		MassDEP and MDS.
	Responsibility of relevant stakeholders	Filing dental practitioners certify, subject to legal penalties, installation of amalgam separator and use of best management practices.
	Cost sharing of relevant stakeholders	
Remarks (if any)		
References and interviewees		Massachusetts Department of Environmental Protection. "Dental Amalgam Recycling" http://www.mass.gov/dep/service/dentists.htm#management
Graphs or photos that can be used for the Good Practices		No

4.6 Batteries

4.6.1 Collection and recycling of batteries (elimination of mercury in batteries) in Japan

General information	Target product	Name	Primary battery (dry-cell battery)
		Annual sales volume in the target area	Production of primary cell – about 3600 million pieces per year (figure for 2008 calendar year) (http://www.baj.or.jp/statistics/01.html)
		Weight/volume of mercury included in the product	Not applicable Manufacture of mercury battery was abandoned in 1995 http://www.baj.or.jp/knowledge/chronology.html
	Target area (province, country, or region)		Japan (all nation covered)
	Year started		1986
	Background (problems identified before the introduction of the system)		In November 1983 at the conference of the Japan Society of Air Pollution, the Tokyo Metropolitan Institute for Environmental Protection reported their research results about mercury emission from waste incinerators. This report was publicized widely through mass media and raised public awareness of risks of mercury released from waste batteries and needs for battery collection system. In July 1985, the Living Environment Council under the Ministry of Welfare publicized the report, "*consideration on appropriate measure for used dry-cell battery*". The major points of this report were as follows: • The primary measure for the problem is reduction of the mercury content in the dry-cell batteries • The municipalities need region-wide scheme for joint collection and treatment of dry-cell batteries due to the following reasons • Generation of used dry-cell batteries per municipality is not sufficiently high • Dry-cell batteries require special treatment and need to utilize the treatment technology of private sectors *According to the report of the Tokyo Metropolitan Institute for Environmental Protection, mercury concentrations of flue gas from waste incinerators were usually 0.05 – 0.1 mg/m^3. However if only one button type mercury battery is added to wastes, mercury concentration of flue gas is increased up to 15-30 times (1.5 mg/m^3).

	Steps to introduce the system (incl. legal basis)	**1. Voluntary collection of used mercury-containing batteries started by manufactures under the Battery Association of Japan (BAJ)** **2. The notification of then-Ministry of Welfare (MOW)[11] and then-Ministry of International Trade and Industry (MITI)[12] "*Necessary actions for used dry-cell battery disposal*", issued on January 11, 1984.** In the notification, the Japanese government requested the BAJ to carry out the following activities. • Reduction of total mercury content in dry-cell batteries • Enhancement of the existing voluntary collection of used mercury-containing batteries **3. The written reply from BAJ to then-MOW and then-MITI, "*Environment Protection Measures*", issued on January 12, 1984.** The BAJ informed the Japanese government that they would take the following approach from February of 1984: • Restriction of exploiting new usage of mercy-containing batteries • Enhancement of collection of used mercury-containing batteries ➢ Distribution of battery collection bins (one collection bin shop/store, 111,100 bins in total) ➢ Public relation activities (e.g., preparation and distribution of PR posters, information dissemination through mass media) ➢ Request to relevant industries (e.g., electric and electronic equipment, photos and camera, clock and watches, acoustic aid, etc) and municipalities for cooperation ➢ Collection and treatment (used dry-cell batteries are collected in a reverse way (from retailer to wholesaler, and manufacturer) as well as collected through six branch offices with cooperation of the collection company) ➢ Monitoring (BAJ monitors the status of battery collection every three months) • Research on mercury reduction in alkaline and manganese batteries • Research on mercury-free product alternatives • Research on the impact of landfilled used alkali and manganese batteries on soil (JMWA also requested BAJ to reduce mercury contents in batteries; more detailed information will be added)

[11] Present Ministry of the Environment
[12] Present Ministry of International Trade and Industry

	Steps to introduce the system (incl. legal basis)	**4. The notification of then MOW "*The plan for region-wide collection and treatment of used dry-cell batteries*", issued on February 6, 1986.** The notification was addressed to the director of waste management department of the prefectural government. It requested the prefecture to inform each municipality of the plan developed by JSWA which contains the following items and to promote its implementation. **Objective**: To establish a region-wide scheme for collection and treatment of used dry-cell batteries, with due consideration of 1) safe and efficient collection and transportation, 2) safe, environmentally-friendly, and cost-effective treatment and disposal, 3) treatment system with mercury recycling, and 4) administrative efficiency. **Target**: Municipalities with intention to conduct joint transportation, treatment, and disposal among those conducting separate collection of used dry-cell batteries. **Region-wide collection and treatment**: see "Activity Overview" for details.
	Major outcomes of collection/recovery	• **Six hundred and thirty (630)** organizations are the members of the network for the region-wide scheme for collection and treatment of used dry-cell batteries (**1,137** municipalities, as of March, 2008) • The amount of used dry-cell batteries treated since 1986 is **132,591 tons** (as of March, 2008) • Since early 1990s, the amount of dry-cell batteries collected and treated increased. Collected amount increased by approximately **2,800 tons** between 1992 and 2007, and treated amount increased by **1,600 tons** in the same period (see Fire 4 and Table 1). • The amount of recycled mercury from used dry-cell batteries has steadily decreased (in 1992, **1,100 kg** of mercury was recycled, while only **100 kg** of mercury was recycled in 2007). This is attributed to voluntary efforts initiated by manufactures of BAJ, which promotes reduction of mercury content in batteries (see Table 1).
	Major challenges faced in implementing the system and ways to overcome those challenges	In order to collect used dry-cell batteries, the government is promoting the collection and treatment of the dry-cell batteries on a regional scale and the business sector is also implementing initiatives like installing collection box for recollection.
	Remaining issues to be solved	Not applicable

Information about the collection system	Description of the collection system	Used batteries are collected by municipalities and recycled thereafter (see Figure 4.6.1). **Collection** *(From households to municipalities)* Typical collection schemes of used dry-cell batteries by municipalities are as follows: • Collection of batteries from each household or office at source • Collection of batteries from shops or stores that voluntarily place a collection bin • Manual separation of batteries from all the collected incombustible waste etc. The municipalities (or the company commissioned by the municipality) collect dry-cell batteries and store them in a proper way until they are transferred to Transfer Station (the collection spot for joint transportation of the collected used batteries from several cities or districts). Batteries are usually stored inside of drum cans at the sheltered place in order to avoid rain. **Transportation** *(From the municipalities to the Treatment Center)* The municipalities (or the companies commissioned by the municipalities) transport the collected used dry-cell batteries from storage place of their own city/district to the Transfer Station.

Information about the collection system	Description of the collection system	The municipalities in principle entrust the designated transporters (such as Nippon Express Co., Ltd,) with transportation of the collected used dry-cell batteries between the Transfer Station and the Treatment Center (the Itomuka Factory of Nomura Kohsan Co., Ltd.[13]), which is officially nominated as treatment center of dry-cell batteries by the Waste Treatment Technology Development Center under the Japan Waste Management Association (JWMA)[14], except in the case that the municipalities transfer the batteries by themselves to the Center. The transporters transfer containers (with a 5 ton capacity) of the collected used dry-cell batteries from the Transfer Station to the designated Treatment Center (usually containers are transported to Itomuka by railroad, shipment or truck). The transporters report the status of transportation of used dry-cell batteries to the JWMA. **Treatment and Disposal** Municipalities entrust treatment and disposal of the collected dry-cell batteries to the Treatment Center, which is officially designated by JWMA. The Treatment Center treats dry-cell batteries through mercury recycling system (see Figure 4.6.2 for example of treatment flow) and dispose of wastes in an environmentally sound manner (recycled mercury is usually sent to the fluorescent lamp manufacturing plants or other types of plants using mercury as a raw material). The Treatment Center reports the status of treatment and disposal of used dry-cell batteries to the JWMA. **Monitoring** JWMA checks the status of transportation, treatment, and disposal of used dry-cell batteries and report the results to the municipalities.

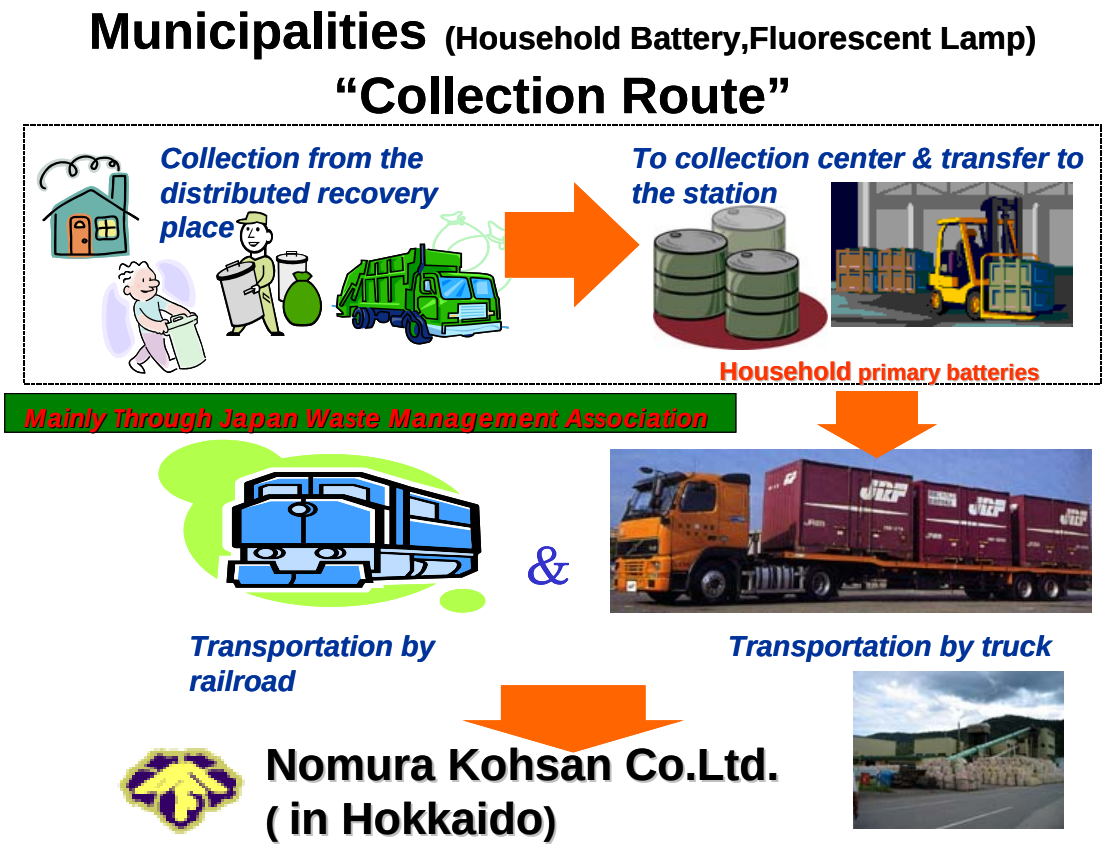
[13] The Itomuka Factory of Nomura Kohsan Co., Ltd., was designated by JWMA as the sole Treatment Center for dry-cell batteries at the time of 1986. Itomuka is located in Hokkaido, the northern island of Japan and used to have the largest mercury mine (annual mercury production was 200 tons). However, they closed the mining business due to decrease in demand of mercury. Since then, with technology and know-how of mercury mining, the Nomura Kohsan treat (detoxification and recycling) hazardous wastes containing mercury (e.g., dry-cell batteries and fluorescent lamps).

[14] JWMA is a public association, whose mission is to promote efficient waste management and to contribute to the protection of living environment and the improvement of public hygiene by conducting surveys and researches and managing data essential to the achievement of efficient management and improvements in technology in the waste management activities of local public bodies.

	Responsibility of relevant stakeholders	**Municipalities** • Collection and environmentally sound storage • Transportation to the Transfer Station which collects used batteries for joint transportation • Transportation from the Transfer Station to the Treatment Center (usually entrust it to the designated transporter) • Cost payment for collection, transportation, treatment and disposal of used dry-cell batteries **Transporters** • Transportation of containers (with a 5 ton capacity) of used batteries from the Transfer Station to the Treatment Center • Report the status of transportation to JWMA • Treatment Center (the Itomuka Factory of Nomura Kohsan Co., Ltd.) • Treat dry-cell batteries through mercury recovering system and dispose of wastes in environmentally sound manner • Report the status of treatment and disposal to the JWMA **JWMA (Japan Waste Management Association)** • Report the status of transportation, treatment, and disposal to the municipalities **Manufactures of BAJ (Battery Association of Japan)** • Voluntary collection of used dry-cell batteries
	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders	The local governments participating in the collection being carried out by the "Japan waste management association(JWMA)" on a regional scale are sharing the cost for items classified as "cost for collection boxes etc", "cost for collection and transportation" and "JWMA management cost for used dry-cell battery treatment". For this, the local governments are using funds available from their general account budget.
	Transport and storage methods for collected used products	Although it differs according to the client, in general, used dry cell battery is collected and transported in the following manner. • Container for collection : 200l iron drums • Specification of transportation vehicle : The drums are loaded into 5ton containers and transported by designated collection and transportation companies • Storage of collected batteries: Indoor storage is preferred. If outdoor, storage until treatment is done in places with concrete floors to prevent underground seepage in case of leakage and are covered with water proof sheets
Information about the recovery system	Description of technology to recover mercury	Mercury recovery technology adopted by Nomura Kohsan. 1. Impurities (foreign materials) are taken out from the collected dry cell batteries 2. Roasted in a rotary kiln and the mercury vaporized. The kiln temperature is in the range of 600 to 800 degree Celsius. 3. The mercury vapor is cooled and is collected by gas treatment apparatus like condenser tower and is ultimately collected as metallic mercury or mercury compounds. 4. The collected mercury is refined and is transformed into high-purity metallic mercury

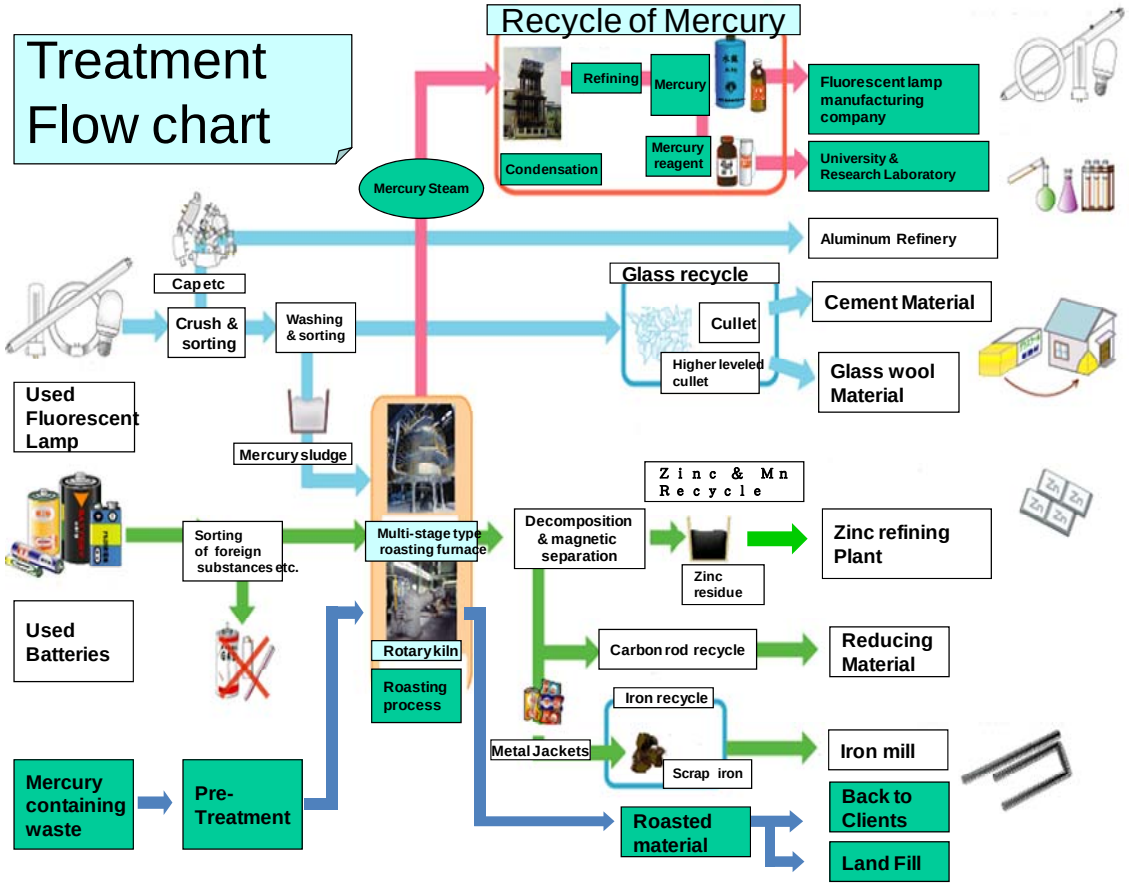
	Process flow to recover mercury from used products	The process flow is shown below. 1. Feed hopper → 2. Roasting furnace (rotary kiln) → 3. Secondary roasting furnace → 4. cooling tower, cleaning tower (scrubber) , venturi scrubber → 5. wet type ESP → 6. activated carbon adsorption tower The process diagram for the whole factory is shown in figure 2.
	Ways to handle materials other than mercury	Materials other than mercury in dry-cell batteries are collected as slag after being roasted in a rotary kiln. Slag is shredded and separated using magnets and recycled as shown below Outer casing – collected as iron scrap by magnetic separation and recycled Zinc slag (comprising mainly of zinc and manganese) - Used as a raw material for zinc bare metal at a zinc smelting plant Carbon core rod – Used as a reduction agent or fuel http://www.nomurakohsan.co.jp/business/disposal02.html
	Description of pollution control measures	Atmospheric emission of Mercury The concentration of mercury in the flue gas is managed by maintaining a self imposed voluntary emission standard Emission of mercury into water bodies The water used for treatment of dry-cell batteries is recycled, and there is no external emission outside the treatment system Slag Used as a recycled material. Non-usable portion is taken as a residue to a managed sanitary landfill.
Awareness raising	Target population	Public (In Japan used dry-cell is generally collated by the local governments as a general domestic waste. The collection system also varies and hence the explanation to the public is also carried out separately by the local governments themselves)
	Activity period/frequency	As per need (Provided along with newsletters etc regarding methods of segregation and collection. Information is also provided when new residents come to the city office for paperwork)
	Media used for awareness raising and messages delivered	Pamphlets, Governmental websites etc
	Responsibility of relevant stakeholders	Local governments : Provide document to the public on rules regarding collection Battery association of Japan : Collection of information on the treatment methods of used dry cells, joint research on the environmental impacts from landfilling of dry cells, cooperation to the government and the local governments through initiatives such as helping to disseminate production of mercury free dry cell
	Cost sharing of relevant stakeholders	Collection cost for the used dry cell collected by the local governments is covered by the local governments themselves. The cost for voluntary collection by companies is covered by the companies themselves.

Remarks (if any)	In February 1986, when the notification of MOW "*The plan for region-wide collection and treatment of used dry-cell batteries"* was issued, the Nippon Express Co., Ltd, and the Itomuka Factory of Nomura Kohsan Co., Ltd, were designated as the Transporter and the Treatment Center of used dry-cell batteries. Now several private companies are involved in this scheme and Toho Zinc Co., Ltd., also treats used dry-cell batteries.
References and interviewees	Journal of Solid and Liquid Wastes 14(3), 1984.03, P.34-P.36 '*Problems of the disposal proposition-disposal proposals of the used mercury based batteries'*, Ministry of Welfare, Ministry of International Trade and Industry, and Battery Association of Japan. Journal of Solid and Liquid Wastes 22(5), 1992.05, P.111-P.117, *'The activities by the Dry-cell battery manufactures for the realization of the mercury free batteries'*, Battery Association of Japan Annual Report on Sound Material-Cycle Society in Japan, 2001, *'Column 12: Problems of the waste dry-cell batteries"*, Ministry of the Environment, Japan Japan Labor Year-book, No.55, 1985 ed. Japan Waste Management Association http://www.jwma-tokyo.or.jp/body/activity_others.html Battery Association of Japan http://www.baj.or.jp/ Nomura Kohsan Co.,Ltd http://www.nomurakohsan.co.jp/
Graphs or photos that can be used for the Good Practices	Yes (see below)



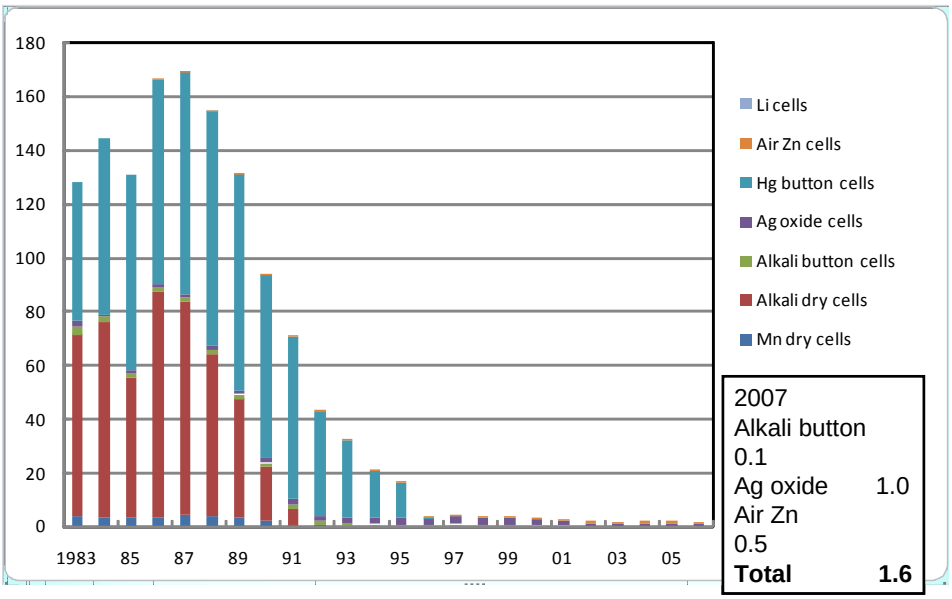
Source: Presentation by Mr. Hiroshi Miura, Nomura Kohsan Co.Ltd., "Recycling and Collection System for Mercury – containing Waste" at the Consultation Meeting of Asia and Pacific on Mercury, Tokyo, Japan, 9 September 2008.

Figure 4.6.1 Image of Region-wide Collection System of Used Dry-cell Batteries



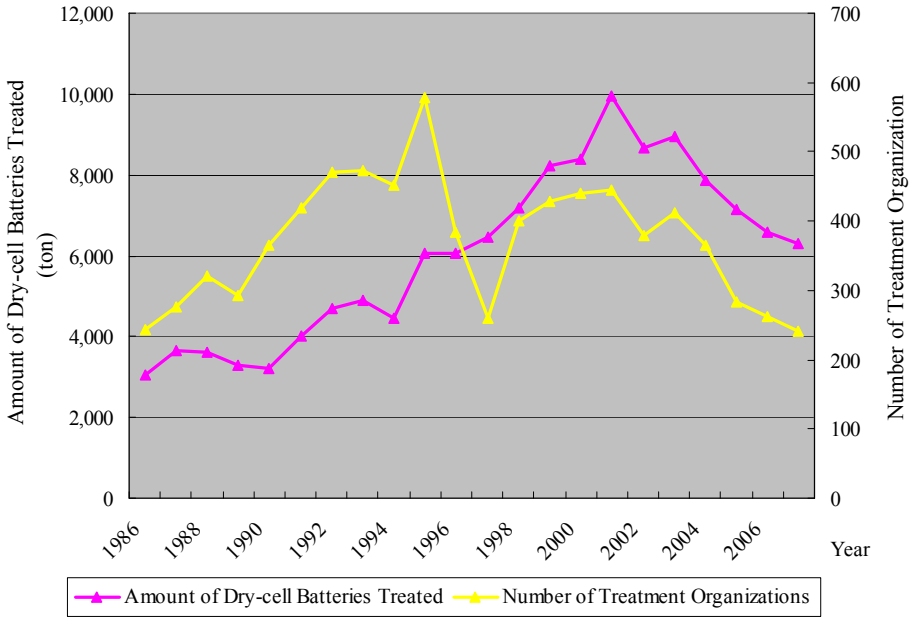
Source: Presentation by Mr. Hiroshi Miura, Nomura Kohsan Co., Ltd., "*Recycling and Collection System for Mercury – containing Waste*" at the Consultation Meeting of Asia and Pacific on Mercury Tokyo, Japan, 9 September 2008

Figure 4.6.2 Used Mercury-containing Products Treatment Flow at Nomura Kohsan Co., Ltd.



Source: Presentation by the Japanese Ministry of the Environment "*Japan's Experience: Activities implemented to Reduce Risks associated with Mercury*" at the Consultation Meeting of Asia and Pacific on Mercury, Tokyo, Japan, 9 September 2008.

Figure 4.6.3 Trend of Mercury Use in Batteries in Japan



Source: Japan Waste Management Association (http://www.jwma-tokyo.or.jp/body/activity_others.html)
Note: Year is based on Japanese fiscal year (from April to March in next year)

Figure 4.6.4 Trend of Amount of Treated Dry-cell Batteries and Number of Treatment Organizations

Table 4.6.1 Trend of amount of collected dry-cell batteries and recycled mercury.

Year	1992	1998	2004	2005	2006	2007
Amount of collected dry-cell batteries (tons)	7,600	12,000	12,100	11,300	11,500	10,400
Amount of recovered mercury (kg)	1,100	300	260	170	130	100

Note:

1. The amount of recovered mercury is solely from the tube shaped dry-cell batteries; the other types of batteries, such as button cells or mercury batteries, as well as other waste products containing mercury (e.g., mercury thermometers, electric thermometers, or fluorescent lamps) are not included.
2. Year is based on Japanese fiscal year (from April to March in next year)

Source: Japan Waste Management Association (http://www.jwma-tokyo.or.jp/body/activity_others.html)

4.6.2 Battery collection campaign in Panama

General information	Target product	Name	Dry batteries
		Annual sales volume in the target area	Year 2009 Unit 700 Kg (estimate)
		Weight/volume of mercury included in the product	224 Kg-Hg (estimate)
	Target area (province, country, or region)		Panama (all nation covered)
	Year started		July 2009-December 2010 (implemented as a project)
	Background (problems identified before the introduction of the system)		• During 2005 the dry batteries imports in Panama were around 571 Kg (National Customs authority). • The mercury entrance factor index in this stage is 320 kg-Hg/tons according to the UNEP Toolkit. • This index represents 182.72 kg-Hg introduction to Panama via dry batteries containing mercury. • The half of the dry batteries goes to waste treatment facilities (91.36 kg-Hg), and 25% each liberated by air and soil (45.68 kg-Hg each). • Therefore, the project "put the batteries with the batteries" was initiated to promote alternatives to dry batteries use and collect & dispose properly used dry batteries.
	Steps to introduce the system (incl. legal basis)		III CSR Forum "All against Mercury". Sept. 9-10 2009 Full Media Coverage (TV, Newspaper, Internet, Radio) Introduction of the first 25 tin collectors in Oct. 2009 1st. ECO Fair participation, January 9-10, 2010 Art & info workshops. Tin collector's placement. Meeting with the National Environmental Agency's General Administrator and the National Planning Director about the Zero Mercury Initiatives. One on one presentation to micro, small & Large companies. Meeting with the Health, environment and development committee at the National Congress.

	Major outcomes of the campaign.	The seeds had been seeded and the campaign is on the way. ✓ 100 people attended the two days III CSR Forum "All against Mercury". ✓ 300 kids had participated in 10 Art & Info workshops. ✓ 600 people visited our stand at the 1st. Eco Fair in Panama City, Panama. ✓ Major newspapers had addressed the mercury issues, with more than 120.000 national readers. ✓ Strategic alliances signed with RECIMAX, Eco Balance and Real Boquete Foundation. ✓ 1 blog has been set up http//:mercuriocero.blogspot.com ✓ 1,000 flyers and 25 posters had been printed and hand it. ✓ 1 Municipality signed (22,000 habitants) and 50 plastic containers and info will be hand it by Real Boquete Recycling foundation to as many small businesses in Boquete Town. ✓ 1World Heritage Area signed (22,000 Habitants) and 30 plastic containers and info had been handed by kids to small businesses in Casco Antigua's World Heritage area. ✓ 10 tin collector are in place in business & one municipality (Boquete Town) ✓ We had recovered 100 pounds of batteries and expect to recover 1 Ton in April 24 & 25. ✓ 1 micro business will be transform to a mercury free and sustainable operation.
	Major challenges faced in implementing the system and ways to overcome those challenges	Lack of information from the general public as well as business. Lack of interest from all sizes of business to invest in environmental initiative both internal and external regarding mercury issues. Lack of legislation against import of mercury containing products as well as waste management.
	Remaining issues to be solved	Massive interest (critical mass)

Information about the collection system	Description of the collection system	➢ The plastic containers are part of the school, house & small businesses strategy and we ask children and owners to bring their own plastic collector to the workshops with the national visual artist Gabriela Batista. Then they are invited to collect batteries for a period of time (3 months) and deliver them to a specific meeting point. ➢ Tin collector are part of the medium and large business and municipalities strategy and they sponsorship them for an annual amount of money that ranges from US$500 to US$15,000 depending on the sponsorship program they are interest it. We will collect the containers every three months or sooner depending of the amount of batteries disposed with our strategic partners (waste management companies and recycling initiatives). ➢ We have an additional collection method that is totally free of charge or collectors and is basically done by people interest to dispose their batteries in a proper way and had found that our program fill their expectative. ➢ We are also making a general call to collect batteries and other mercury containing products and bring them to a collection point by April 24 & 25, 2010. ➢ By June 5th. 2010 we will be have the first batch of batteries neutralized and encapsulated in cement.
	Responsibility of relevant stakeholders	GPNP[15]: Development, implementation, international results presentation Ecologic, S.A.: Promotion and sales, implementation, Media & PR, local results presentation Retail business: The local & national governments: Implementation of large scope initiatives. Boquete Town Municipality (22,000 habitants), Casco Antigua's Office (22,000 habitants in a World Heritage area in old Panama city), Environment National Agency (ANAM) & Panama Canal Authority, both government agencies. Business: Bottles and plastic containers are been reuse from people homes and recycling centres. 25 out of 100 tin containers had been bought by Ecologic, S.A, and 10 tin cans out of 25 had been sponsored so far by different businesses. Local newspapers & other media: News, articles and video and photographs used for national broadcast. Corporación La Prensa (La Prensa & Día a Día Newspapers)

[15] GPNP is Grupo Parques Nacionales Panama, a local NGO, established in July 2003, actually with 562 local and international members. The organization has been a member of the U.N. Global compact program since Sept. 2007, U.N. Mercury Project partner since Sept. 2008, and Zero Pollution Alliance since May 26, 2008.

	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders	Estimate Total Cost are US$50,000 25% GPNP/Alianza Contaminación Cero 25% Ecologic, S.A./Gabriela Batista 50% Small, medium & large business
	Transport and storage methods for collected used products	Strategic partners, waste management companies like Eco Balance, S.A. and RECIMAX Recycling services, S.A. will give us support for collection, transportation and temporary storage in Panama Province. In Boquete Municipality in the province of Chiriqui, 250 miles from Panama City, Real Boquete Recycling foundation and the Municipality are supporting the initiative.
	Ways to handle collected used products where a mercury recovery facility is not located in the target area (e.g. storage, export to the countries with mercury recovery facilities, etc.)	We had done extensive research about this issue and we had decided not to export the batteries since there are no recycling facilities in the area. We are going to physically and chemically stop the corrosion process and encapsulate the plastic containers in cement. With these blocks we will be able to build public facilities like squares, sidewalks and steps in marginal and difficult access communities. This is done in countries like Argentina.
Information about the recovery system	Description of technology to recover mercury	No batteries recycling technology
	Process flow to recover mercury from used products	No mercury recovery from batteries
	Ways to handle materials other than mercury	No other material will by handle
	Description of pollution control measures	Physically and chemically stop the corrosion process and encapsulate the plastic containers in cement.
Awareness raising	Target population	3,300,000 peoples
	Activity period/frequency	July 2009 –December 2010 (18 months)
	Media used for awareness raising and messages delivered	Media: local news papers, TV, Internet and Radio Message: Human health and environmental risk associate with mercury and other toxic metal's containing products. "Putt on the batteries with Batteries" segregation program
	Responsibility of relevant stakeholders	Ecologic, S.A.: III RCS Forum "All against mercury" organization, sponsorship of 25 initial tin cans, 10 workshops for 300 people and the 1st. Eco Fair participation, GPNP/Alianza Contaminacion Cero: Elaboration of the message and coordination of the campaign. "Ponte las pilas con las pilas". Elaboration of Mercury containing products BEP Manual for the central America region. Data recompilation and interpretation for national and international presentations. Gabiela Batista: Panamanian Visual Artist, art & info workshop's leader, designing civic application and uses for encapsulated material
	Cost sharing of relevant stakeholders	US$ 1,000 Media Outlets US$ 2,000 GPNP /Alianza Contaminación Cero. US$ 2,000 Ecologic, S.A. US$ 1,000.00 Visual Artist Gabriela Batista US$ 6,000.00 Business sponsorship US$ 12,000.00 Total amount invested

Remarks (if any)	New and large scope program implementation will require international founding (JICA, USAID, EU)
References and interviewees	Mr. Jorge G. Conte Burrell (Zero Pollution Alliance). (2009) Put on the batteries with batteries (material presented at the UNEP Waste Partnership Area Meeting in Tokyo, Japan on March 13, 2009).
Graphs or photos that can be used for the Good Practices	No

4.6.3 Collection and recycling of batteries based on EPR in Sweden

General information	Target product	Name	Batteries
		Annual sales volume in the target area	**Mercury (kg of sold batteries containing mercury)** Year 2008 - 10 300 kg Year 2007 - 10 000 kg Year 2006 - 12 600 kg Year 2005 - 9 900 kg Year 2004 - 10 600 kg Year 2003 - 9 500 kg Year 2002 - 10 400 kg Year 2001 - 13 000 kg Year 2000 - 24 000 kg Year 1999 - 8 000 kg
		Weight/volume of mercury included in the product	Sweden has the same limits as stated in the Directive. At the moment the directive is 2006/66/EC (before it was called (91/157/EC). The Directive (2006/66EC) states that Member states shall prohibit the placing on the market of batteries containing more than 0.0005 % of mercury by weight. This shall not apply to button cells with a mercury content of no more than 2 % by weight.
	Target area (province, country, or region)		Sweden (all nation covered)
	Year started		1997
	Background (problems identified before the introduction of the system)		• Battery collection began in Sweden in the 1970s. A nationwide campaign informing citizens about the collection of batteries containing mercury and cadmium was started in 1987 and concluded in 1993, when industrial actors undertook to ensure that nickel-cadmium batteries were collected. It didn't work quite as well as the industrial actors wanted so the Swedish EPA took over the information again. We have been managing the information campaigns until 2008. The 1st of January 2009 a new ordinance entered into force in Sweden and now the battery producers have all the responsibilities for collection, information and so forth. • Batteries may contain the toxic heavy metals such as cadmium, mercury and lead. Since it is difficult for consumers to differentiate hazardous batteries from others, Sweden has decided that all batteries are to be turned in, thereby preventing these metals from contaminating the environment. This is the deal for all over Europe now since the new Batteries Directive (2006/66/EC) entered into force the 26th of September 2008.
	Steps to introduce the system (incl. legal basis)		In conjunction with the initiation of the new Battery Ordinance in 1997, the battery collection project (BCP)[16] was started. All batteries and products with built-in batteries must be collected and sorted. The goal is to avoid any batteries, or products with built-in batteries, being thrown away with household refuse. This conjunction is now replaced with a system with producer responsibility. This means the Swedish EPA is monitoring the producers instead of taking part in the campaigns and so forth.

[16] The BCP was started as cooperation between the Swedish EPA, the Swedish Association of Local Authorities and Regions (SALAR), the Swedish Association of Waste Management (RVF) and the Swedish Battery Association.

	Major outcomes of collection/recovery	**Mercury (kg of collected batteries containing mercury)** Year 2008 - 104 400 kg (this high numbers is because some of the municipalities have been collecting batteries without sending them to recycling and now they did) Year 2007 - 17 000 kg Year 2006 - 12 000 kg Year 2005 - 8 000 kg Year 2004 - 18 000 kg Year 2003 - 28 000 kg Year 2002 - 18 000 kg Year 2001 - 16 000 kg Year 2000 - 10 000 kg Year 1999 - 15 000 kg
	Major challenges faced in implementing the system and ways to overcome those challenges	It's hard to get people to return used batteries. Some people still throw them in the household waste even if they have seen a lot of information. The problem is to get people to act the according to the information they get.
	Remaining issues to be solved	It will be interesting to see how the producers will take their responsibilities and how they will inform consumers.
Information about the collection system	Description of the collection system	Collection and recycling of batteries as well information about this, is restricted by Swedish law, Government Regulation (2008:834) on producers' responsibility for accumulators. This regulation is based on Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators. The new regulation is valid from first of January 2009, and from that date the producers are responsible for collecting and recycling of batteries. Portable batteries are collected on several collection points in each municipality. Collection points are to be found, in shops, in municipal recycling centres, near recycling stations and in other suitable places. In some municipalities batteries are collected through curb-side collection. Start batteries and industrial batteries are collected through municipal recycling centres, through sales points and car repair shops. Collected batteries are sorted after type and content and sent to different recycling plants. At the recycling plants, each metal is recycled in its own process. The recycled material is used in new production, many times in production of new batteries.

	Responsibility of relevant stakeholders	Most producers of waste electric and electronic equipment, including batteries, are organized through El-Kretsen, which work for common handling and recycling of smaller batteries. In the same way most producers of start batteries and industrial batteries are organized through BlyBatteriRetur, which work for common handling and recycling of lead batteries. El-Kretsen and BlyBatteriRetur have chosen to collect batteries in cooperation with the Swedish municipalities. For communication about collection and recycling of batteries El-Kretsen and BlyBatteriRetur cooperate with Avfall Sverige, Swedish Waste Management under the name Batteriinsamlingen. Consumers: • Turn in all spent batteries to the municipality's collection system, or to retail outlets that take in batteries. • Turn in built-in hazardous batteries into the place of purchase, or to the collection station designated by the municipality.
	Necessary costs for the collection and the recovery systems and cost sharing of relevant stakeholders	There is only a fee on batteries containing cadmium nowadays.
	Transport and storage methods for collected used products	
Information about the recovery system	Description of technology to recover mercury	Please contact producers to see where they send mercury batteries. It's up to them. Talk to El-Kretsen for example: www.elkretsen.se
	Process flow to recover mercury from used products	
	Ways to handle materials other than mercury	
	Description of pollution control measures	
Awareness raising	Target population	• All households, other large-scale consumers • Since the autumn of 2000, all fifth-graders and, consequently, their families and teachers • Since 2005 pre-school materials have been available for 3-5year olds
	Activity period/frequency	1999-
	Media used for awareness raising and messages delivered	The Battery Collection Project started an information campaign in1999 to raise awareness among the public about where to return used batteries. The goal of the campaign is to ensure that nobody throws away batteries with their household refuse. Nor should used batteries be stored at home; they should be turned in for collection. Another important mission is to raise awareness regarding what products contain built-in batteries. • The Swedish battery collection boxes are called "nesting boxes". The campaign's messengers were animated battery characters who appeared in various TV films and wanted nothing more than to go home to their nesting boxes. The campaign attracted a great deal of attention among both the public and the media. 70 percent of those who had seen the campaign were very positive to the message.

		• In the autumn of 2000, the country's fifth-graders took part in a competition to manufacture and decorate existing battery collection boxes. With the help of a group of teachers a school information kit was also produced for use in the instruction of intermediate-level pupils. Teachers receive an annual offer to order the material free of charge. The animated battery characters also appear in the school information kit, which can be ordered free of charge by teachers and reaches about 25percent of all intermediate-level pupils every year. • Free material [17] for pre-school children has now also been produced. The material is based on the same animated battery characters as the school material, and is designed to suit 3-5 year olds. In 2005 the material was sent out to 67,000 pre-school children. • Competition to manufacture and decorate existing battery collection boxes among fifth-graders in 2005. • Nationwide-campaign in 2001 and 2002 on the theme "The most dangerous batteries can't be seen". • Billboards with sounds • Posters • Website • Special telephone number to the Battery Collection Project's information office which people can call for further information
	Responsibility of relevant stakeholders	Swedish EPA: • Are monitoring the producers. Swedish Battery Collection Association: • Batteriinsamlingen is cooperation between El-Kretsen, BlyBatteriRetur and Swedish Waste Management (Avfall Sverige).
	Cost sharing of relevant stakeholders	
Remarks (if any)		
References and interviewees		Batteriinsamlingen: http://www.batteriinsamlingen.se/files/translations/pdf/batterycollection(engelska).pdf http://www.batteriinsamlingen.se/info-in-english/ European Commission: http://ec.europa.eu/environment/etap/inaction/showcases/eu/332_en.html
Graphs or photos that can be used for the Good Practices		No

[17] The pre-school materials include a memory game, an A-Z pointing board, a story book and teaching materials.

5 Management of Mercury during Waste Combustion

5.1 Flue Gas Control

5.1.1 Setting Emission Standards

51. (examples of emission standards will be added).

5.1.2 Analysis Methods of Mercury in Flue Gas

52. Examples of analysis methods of mercury in flue gas include the following:

- JIS K 0222: Analysis Method for Mercury in Flue Gas (Japan Industrial Standards 1997)
- US EPA Method 0060: Determination of Metals in Stack Emissions (US EPA 1996)
- EN 13211: Air quality - Stationary source emissions - Manual method of determination of the concentration of total mercury (European Committee for Standardization 2001)
- EN 14884: Air quality - Stationary source emissions - Determination of total mercury: Automated measuring systems (European Committee for Standardization 2005)

53. For the speciation of mercury, the following example is available.

- ASTM D6784 - 02(2008) Standard Test Method for Elemental, Oxidized, Particle-Bound and Total Mercury in Flue Gas Generated from Coal-Fired Stationary Sources (Ontario Hydro Method) (ASTM International 2008)

5.1.3 Flue Gas Treatment Technology

54. There are wet and dry systems to remove gaseous mercuric chloride and elemental mercury in flue gas. In either case of applying wet or dry system, it is necessary to remove other hazardous pollutants in flue gas such as acid gas and dioxins. Therefore, simultaneous removal process has been developed, and this process is introduced as Good Practice case in Japan in 5.3.1.

5.1.3.1 Wet System

55. Basic mechanism of wet system is to make water-soluble mercuric chloride (in gaseous form) contact water and absorbed to water, which is simple and effective. However, removal of insoluble elemental mercury is difficult by a regular absorption method; additives that acidify elemental mercury are required. Wet system is introduced for the purpose of absorbing acid gas (halogenated hydrogen and SOx) in flue gas; therefore, it is required to function as acid gas removal devices. It is necessary to treat mercury transferred to water through separation and solidification. Such wastewater treatment process generates residues containing mercury. Important processes of wet system are absorption and treatment of wastewater containing mercury. Major factors for selecting wet system include cost performance, mercury and acid gas removal rates, and achievable mercury limit. In addition, treatment of residues generated through wet system and final disposal are also important factors to select flue gas treatment system.

56. Wet scrubbers are used for acid gas treatment; they can help with the capture of mercury if the pH is low enough or with the use of scrubber reagents (European Commission 2006). (Description about the reason why the low pH is required to be added.)

57. Mercury removal using wet scrubbers has attracted attention because the solution in the WS contains a substantial amount of mercury. The reported mercury-removal efficiency of a WS ranges from 30 to 87%, and an estimated 70% of the mercury in flue gas in waste incinerators is transferred to the solution, which suggests that it is a useful technology for mercury removal (Takaoka 2005a).

58. Table 5.1.1 summarises wet systems to remove mercury from flue gas with more than 80% removal efficiency is reported.

Table 5.1.1 Wet Systems to Remove Mercury from Flue Gas with more than 80% Removal Efficiency

Treatment Method	Applicable conditions	Mercury Removal Efficiency	Other Environmental Benefits	Reference
Adding hydrogen peroxide to wet scrubber solution with activated carbon injection		99.5 %	Reduction of HCl and SO_2	2
Adding liquid chelating reagents and copper or manganese salts to wet scrubber solution		92 – 97 % (dependent on the inlet mercury concentration)	Removal of HCl, HF, and SO_2	3
		Copper salts: 84.5% Manganese salts: 87.7% (About 50 % of mercury vapour and mercury oxide and about 100% of soluble mercury is removed.)	Removal of HCl, HF, and SO_2	1
Adding NaClO to wet scrubber solution		80-96%	Effective in the reduction of NOx	1
Low pH wet scrubbing and additive addition	• The pH is well controlled below 1 • Chloride concentrations are high enough for the crude flue-gas Hg content to be almost entirely ionic	around 85% (removal efficiency higher than 90 % can also be achieved with a technique adding bromine containing wastes or by injection of bromine containing chemicals into the combustion chamber)	Removal of HCl, HF, and SO_2	2

Reference:
1. Arai, Norio (supervised) (2000): Syokyaku Seiseibutsu no Hassei to Yokusei Gijyutsu (Generation and Control Technologies of Products from Incineration in Japanese).
2. European Commission (2006): Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste combustion.
3. Ide A., Kokado, M., Monaka T. (1985): (title of article) (in Japanese), *Toshi to Haikibutsu*, 15, 67-86, 1985.

5.1.3.2 Dry System

59. Basic mechanism of dry system is to transfer and stabilize gaseous mercury species to solid sorbent. It is assumed that mercury is stabilized by physical adsorbent at low temperature around room temperature and that gaseous mercury is stabilized by reaction to solids or chemical reaction on the surface of sorbent at higher temperature, but detailed mechanism are not known. Dry system using solid sorbent can be used for removal of SOx and halogenated hydrogen (sorbet is selected according to target pollutants). It is necessary to separate, collect and store mercury species condensed and transferred from gaseous to solid form under the dry system. Otherwise, sold sorbent adsorbed mercury should be stored. Upon the selection of dry system, the following factors should be considered: efficiency of achievable mercury limit concentration, process costs, treatment of used sorbent, and final disposal of residues generated through the process.

60. Existing waste incinerators may be equipped with bag filters or electrostatic precipitators. Fly ash also functions as sorbet although its capability is low, but its capability increases when unburned carbon is included. In addition, injection of slaked lime for removing acid gas and activated carbon for removing dioxins are usually practiced; these solids also remove mercury.

61. Bag filters (BFs), electrostatic precipitators (ESPs), cyclones are used for capturing particulates. If a BF is used downstream of reagent injection, in addition to its dedusting effect, it acts as a complementary reactor. The pressure drop through the fabric material distributes the flue-gas on the adhered cake containing some deposited reagent and, due to the low velocity of the gases, the residence time is long. A BF can, therefore, contribute to the treatment of acid gases, gaseous metals such as Hg and Cd, and POPs (Persistent Organic Pollutants) such as PAH, PCB, dioxins and furans (European Commission, 2006).

62. ESPs remove particulate mercury adsorbed on dust, but the gaseous mercury is not removed; mercury removal efficiency remains only 10-40%. To remove dioxins from flue gas, the heat and corrosion resistance of bag filters has been improved; this technology is now applicable to waste incinerators with relatively high flue gas temperatures. The pollutant removal efficiency of bag filter increases as the flue gas temperature decreases. According to many studies, it is possible to remove 70–90% of the mercury from flue gas at 150ºC or less. The principle of mercury removal using a bag filter is adsorption on the fly ash layer; the removal of mercury species is dependent on the fly ash composition (Takaoka, 2005b).

63. The adsorption by activated carbon and lignite coke has an effect on dioxins as well as on Hg and other substances (European Commission, 2006). Packed bed of activated carbon/coke seems effective for removal of dioxins and mercury a packed bed of activated carbon or activated coke. Experiences of operating an activated carbon tower for mercury removal show that the outlet concentration is generally below 4 mg/m3N in many systems, using various process conditions (Takaoka, 2005b).

64. Table 5.1.2 summarises dry systems to remove mercury from flue gas with more than 80% removal efficiency is reported.

Table 5.1.2 Dry Systems to Remove Mercury from Flue Gas with more than 80% Removal Efficiency

Treatment Method	Applicable conditions	Mercury Removal Efficiency	Other Environmental Benefits	Remarks	Reference
Injection of activated carbon upstream of a bag filter		95% (metallic Hg: below 30μg /Nm^3)	• Effective for dioxin removal • Effective for the treatment of acid gas because of addition of alkali agent	The fire risk is significant with activated carbon.	2
		80-90% (removal efficiency improves to 95% if flue gas is cooled down)			1
Addition of agents such as sodium sulphide collected by bag filter	Temperature below 180 degree Celsius (experiment)	90%			1
Injection of calcium hydroxide collected by bag filter	150 degree Celsius at the inlet of bag filter	60-90% (Removal efficiency reduced as flue gas temperature decreases)	Same as the removal of HCl		1

1. Arai, Norio (supervised) (2000): Syokyaku Seiseibutsu no Hassei to Yokusei Gijyutsu (Generation and Control Technologies of Products from Incineration in Japanese).
2. European Commission (2006): Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste combustion.

5.1.3.3 Comparison of emission control technology

65. Table 5.1.3 compares emission control technology by mercury removal efficiency, costs and residues to be generated.

Table 5.1.3 Comparison of Emission Control Technology by Mercy Removal Efficiency, Costs, and Residues

Emission control technology	Hg reduction (%)	Annual costs (US$ 2008/ tonne waste)			Residues to be generated	
		Annual investment costs	Annual operating costs	Annual total costs	Wastewater, sludge	Collected dust

Emission control technology	Hg reduction (%)	Annual costs (US$ 2008/ tonne waste)			Residues to be generated	
		Annual investment costs	Annual operating costs	Annual total costs	Wastewater, sludge	Collected dust
wet scrubber (wSC) with alkaline addings – medium efficiency if emission control	20	0,12	0,08	0,20	✓	-
waste separation – medium	60	0,60	0,60	1,20	-	-
dry ESP – optimized	70	1,84	6,99	8,83	-	✓
ESP+wet scrubber+activated carbon with lime+FF – optimized	99	2,31	2,48	4,79	✓	-
two-stage scrubber+wetESP – optimized	90	2,31	1,82	4,13	✓	-
virgin activated carbon injection (SIC)+FF – optimized	80	2,19	4,02	6,21	-	✓
virgin activated carbon injection (SIC)+venturi scrubber+ESP – optimized	95	5,25	6,15	11,40	✓	✓
virgin activated carbon injection (SIC)+venturi scrubber with lime milk+caustic soda+FF– optimized	99	5,78	7,08	12,86	✓	✓

Source (excluding the column "residues to be generated" and "Required technology level"): UNEP. (2008b)

5.2 Wastewater Treatment

5.2.1 Setting Effluent Standards

66. (examples of effluent standards will be inserted).

5.2.2 Analysis Methods of Mercury in Wastewater

67. (examples of analysis methods of mercury in wastewater will be inserted).

5.2.3 Wastewater Treatment Technology

68. Removal of mercury from wastewater from wet scrubbers and leachate from landfills is required; basic mechanism of mercury removal from wastewater containing water-soluble mercury species is separation and condensation of mercury. Condensation and separation of mercury can be achieved through chemical precipitation (sulphur precipitation), using liquid sorbent, chelating agent, and ion exchange resin. Upon the selection of mercury removal technology from wastewater, factors such as achievable mercury concentration limit, residue treatment and storage of collected mercury should be considered.

69. Table 5.2.1 summarises treatment systems for wastewater containing mercury.

Table 5.2.1 Treatment Systems for Wastewater Containing Mercury

	Methods	Applicable condition	Mercury Removal Efficiency	Other Environmental Benefits	Remarks	Reference
Precipitation	Addition of sulphide				Mercury (II) sulphide solubility	1

	Methods	Applicable condition	Mercury Removal Efficiency	Other Environmental Benefits	Remarks	Reference
					product is 4.0×10^{-53}	
	Addition of chelate agent					1
	Physicochemical treatment + sulphide (Na_2S, Tri-Mercaptan - TMT) addition		99%	Precipitation of other heavy metals		2
	Chemical precipitation (lime, caustic, sodium sulphide, soda ash)		NA		Sulphide is most desirable.	3
Adsorption	Adsorption by activated carbon (powder, granular)		NA	Adsorption of other heavy metals and organic materials		3
	Adsorption by ion exchange resin		NA		Especially effective to mercury removal whose concentration is 1-10ppb.	3
	Mercury separation by utilization of resin filter (mercury ion exchanger after acid cleaning)		NA		Acid is neutralized by lime solution.	2
	Adsorption by chelating resin	Low concentration of metal ions	NA			3

1. Arai, Norio (supervised) (2000): Syokyaku Seiseibutsu no Hassei to Yokusei Gijyutsu (Generation and Control Technologies of Products from Incineration in Japanese).
2. European Commission (2006): Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste combustion.
3. Secretariat of Basel Convention. (2008) Draft Technical Guidelines on the Environmentally Sound Management of Mercury Waste.

5.3 Cases of Managing Mercury during Waste Combustion

70. Setting emission standards for mercury concentration of flue gas from waste combustion and enforcing such standards is an effective way to control mercury emissions. Several countries have set mercury emission standards for waste incinerators; each country has its unique basis to set a specific numerical value as an emission standard for mercury. This section introduces examples of mercury emission standards and their enforcement schemes. Same type of practices is observed in the treatment of wastewater from wet scrubber.

71. Table 5.3.1 summarises target process, basis, type of practice, and country of Good Practice cases. Detailed information about these cases can be found in the following sections.

Table 5.3.1 Summary of Good Practice Cases for Management of Mercury during Waste Combustion

Process	Features of Practices		Country	Relevant Section
	Basis	Type of Practice		
Treatment of flue gas from waste incinerators	Legal	Co-benefits of controlling major air pollutants	Japan	5.3.1
	Legal	Local emission standard and management target standard (municipal waste incinerators)	Kyoto Prefecture, Japan	5.3.2

Process	Features of Practices		Country	Relevant Section
	Basis	Type of Practice		
	Legal	Local emission standard and management target standard (industrial waste incinerators)	Fukushima Prefecture, Japan	5.3.3
	Legal	Emission standard	USA	5.3.4
Treatment of wastewater from wet scrubber	Legal	Effluent standard and technology to meet the standard (wastewater from wet scrubber of waste incineration facility)	Japan	Included in 5.3.2
	Legal	Effluent standard and technology to meet the standard (landfill leachate)	Japan	5.3.5

* Current document does not include these cases yet.

5.3.1 Co-benefits of controlling major air pollutants in Japan

72. In Japan, the Air Pollution Control Law (1968) and the Law Concerning Special Measures against Dioxins (1999) regulates emissions from waste incinerators. While national emission standards are set for particulates, SOx, NOx, HCl, and dioxins/furans in flue gas from waste incinerators, those for mercury have not been set. However, meeting these emission standards for air pollutants other than mercury, especially emission standards for dioxins including furans and co-planer PCBs, brought a benefit of reducing mercury emissions from waste incinerators.

(Explanation of tables below and general measures to meet these emission standards)

Table 5.3.2 National SOx and HCl Emission Standards for Waste Incinerators

SOx	HCl
Permissible emission (Nm3/hr) = $K \times 10^{-3} \times He^2$ Where, K: constant specified for each area (16 values ranging from 1.75 to 17.5) He: effective stack height in meters (actual stack height plus height of smoke ascent)	Hydrogen chloride: 700 mg/Nm3

Table 5.3.3 National Particulate and NOx Emission Standards for Waste Incinerators

Soot and Dust			NOx	
Type	Scale	Standard	Scale	Standard
Waste material continuous incinerator. (by vortex combustion method.)	4t	0.04g		450ppm
	2 - 4t	0.08g		
Peculiar waste continuous material[*8] incinerator.	4t	0.04g	40,000m^3 -	250ppm
	2 - 4t	0.08g	- 40,000m^3	700ppm
Waste material continuous incinerator. (others.)	4t	0.04g		250ppm
	2 - 4t	0.08g		
Waste material incinerator (others.)	- 2t	0.15g	40,000m^3 -	250ppm
			- 40,000m^3	-

Note: applicable to waste incinerators with grate area 2 m^2 or above and incineration rate 200 kg/h or above.

Table 5.3.4 National Dioxins* Emission Standards for Waste Incinerators

Size of Waste Incinerator	Emission Standards
a stoker area of 2 square meters or greater with an hourly incineration capacity of at least 200 kilograms, less than 2,000 kilograms.	New facility: 5 ng-TEQ/m3N Existing facility: 10 ng-TEQ/m3N
an hourly incineration capacity of at least 2,000 kilograms, but less than 4,000 kilograms.	New facility: 1 ng-TEQ/m3N Existing facility: 5 ng-TEQ/m3N

Size of Waste Incinerator	Emission Standards
an hourly incineration capacity of 4,000 kilograms or greater.	New facility: 0.1 ng-TEQ/m3N Existing facility: 1 ng-TEQ/m3N

Note: Dioxins* include polychlorinated dibenzofrans, polychlorinated dibenzo-para-dioxins, and co-planer PCBs.

73. Sakai et. al. (2006) studied co-benefits of controlling persistent organic pollutants in municipal solid waste incineration. They investigated eighteen metals emitted from municipal solid waste incineration systems were investigated in order to determine the co-benefit of controlling Unintentional Persistent Organic Pollutants (UPOPs). The two facilities have improved combustion conditions and retrofitted air pollution control systems in which electric precipitators were replaced by fabric filters (see Table 4). Activated carbon adsorption was also used after retrofitting. The metal concentrations in the furnace outlets were >10 mg/m3N for Zn, 1□10 mg/m3N for Pb, T-Cr, Sb, Sn, Cu, Mn and Ba, 0.1-1.0 mg/m3N for Ni, Cd, V and Co, and 0.01-0.1 mg/m3N for T-Hg, As and Se. The concentrations of Be, Te and Tl were less than 0.05 mg/m3N. The efficiency of removal of Hg in the air control units improved from 22% to more than 90% after retrofitting. The removal efficiency of PCDDs/DFs also improved by the same measures (see table 5). The co-benefit of mercury emission control resulting from UPOP control technologies such as carbon adsorption was confirmed.

Table 5.3.5 Two Facilities investigated in the study

		Facility A	Facility B
Type		Stoker type, continuous combustion	Stoker type, continuous combustion
Incineration capacity		600t/day (200t/24h x 3 furnaces)	180t/day (90t/24h x 2 furnaces)
Air pollution control	Before retrofitting	Electric precipitator + Wet emission gas treatment	Electric precipitator + Wet emission gas treatment
	After retrofitting	Quenching tower + Bag filter type dust collector + Wet emission gas treatment (injecting activated carbon into rinse water)	Quenching tower + Bag filter type dust collector + Dry emission gas treatment (injecting activated carbon)
Sampling		Precipitator inlet waste gas Stack inlet emission gas Bottom ash Fly ash	Precipitator inlet waste gas Stack inlet emission gas Bottom ash Fly ash

Source: Sakai et. al. (2006)

Table 5.3.6 Concentrations of PCDDs/DFs (Facility A, B)

Facility	Sample	Unit	Before retrofitting		After retrofitting	
			Gaseous	Particulate	Gaseous	Particulate
A	Boiler outlet	ngTEQ/m^3_N	0.039	0.68	0.0093	0.4
	Stack gas	ngTEQ/m^3_N	0.83	0.0092	0.043	0.00049
	Bottom ash	ngTEQ/g	0.0028		0.0019	
	Fly ash	ngTEQ/g	1.2		0.095	
B	Boiler outlet	ngTEQ/m^3_N	0.2	0.15	1.5	0.13
	Stack gas	ngTEQ/m^3_N	3.6	0.0024	0.19	0.00036
	Bottom ash	ngTEQ/g	0.13		0.0008	
	Fly ash	ngTEQ/g	0.87		0.58	

Source: Sakai et. al. (2006)

74. The rate of removal of dust by the emission gas treatment equipment improved after retrofitting. The heavy metals removal rate also improved accordingly. In particular, the Hg removal rate increased from 20% to over 90%. In general, the heavy metal removal rate was higher than the dust removal rate. The relationship among bag filter temperature, activated carbon injection and mercury removal rate was examined at full-scale incinerators. The mercury removal rate tended to increase when the temperature at the BF outlet was lowered. The mercury removal rate could be stabilized by injecting activated carbon. At a temperature below 190°C, the mercury removal rate was over 98% (Sakai et al. 2006).

5.3.2 Local emission standard and management target standard in Kyoto

General information	Target management process	Flue gas treatment/flue gas cleaning water treatment
	Target area (province, country, or region)	Kyoto Prefecture, Japan
	Year started	1995
	Background (problems identified before the introduction of the system)	Background to Kyoto Prefecture`s ordinance regarding flue gas standard for mercury ・ The "Kyoto Prefecture pollution prevention ordinance ("old ordinance" hereinafter)" of March 1971 designated mercury and its compounds as a hazardous substance. However, due to limited knowledge on measurement technologies, emission standard was not set. ・ However the Kyoto Prefecture Central Environmental Council ("council", hereinafter) in November 1995 stated in "Report on the review of basic ordinance regarding environmental protection ("report", hereinafter)" that "It is necessary to set regulatory standards for pollutants that have been designated as hazardous by the old ordinance but for which no standards have been established". Hence in December 1992 a regulatory standard was introduced in the "Ordinance to protect and preserve Kyoto Prefecture's environment ("present ordinance", hereinafter). ・ After the establishment of the prefecture ordinance, during the reconstruction of the Clean Centre (North East) in March 2001, Kyoto City established a target value for the concentration of mercury in flue gas (voluntary standard: 0.05mg/m3N). While determining the target value, the opinion of academics and the facility present for flue gas treatment at the clean centre were taken into account. ・ Further, during the reconstruction of the clean centre (Northern) in 2007, the planned target value (0.05mg/m3N) for the concentration of mercury in flue gas was established in the EIA report.
	Major outcomes of implementing emission/effluent standards	・ The target values described above are summarized in Table 5.3.7. ・The monitoring values for data obtained from North Clean Centre are summarized in Table 5.3.8. Once environmental assessment is conducted, monitoring of actual performance is carried out in order to assure that the planned emission targets are achieved. In the case of the rehabilitation of North Clean Center in Kyoto, flue gas is continuously monitored at the stack and sampled for four times per year for the analysis of dioxins and other substances.
	Major challenges faced in implementing the process and ways to overcome those challenges	Not applicable
	Remaining issues to be solved	Not applicable

Information on legal/voluntary system	Legal basis or basis for voluntary systems (e.g. voluntary agreements between government and industry) for emission/effluent standards (if any)	Flue gas standard for Mercury : Ordinance to protect and preserve Kyoto Prefecture's environment
	Standard on mercury concentration	Mercury and its compounds emission standards Border of premises: 0.002 mg/Nm3 Outlet of stacks: 0.2 mg/ Nm3
	Rationale for the standard values	Rationale behind the standard value ・As it is very difficult to establish the relation between the concentration at the stack outlet and the concentration at the border of the premises for all individual cases, the concentration at the stack outlet is set as 100 times that of the concentration at the premises of the boundary for hazardous substances. ・The standard for the concentration at the premises boundary is set by referencing the standard established (*) in 1995 (Recommended value for the acceptable concentration set by Japan Society for occupational health (TLV-TWA of the ACGIH in cases where there are no recommended values)) and by using the following logic. 1. The recommended value for the acceptable concentration is established for workers but in a general environment elderly and children are also present. Hence considering the extent of exposure to these groups, a multiplication factor of 10 is established. 2. The recommended value for the acceptable concentration assumes that a worker is exposed for 8 hours in a normal day. However in a general environment, it is assumed that the expose is for 24 hours and hence an uncertainty factor of 3 (24/8) is established. 3. From 1. and 2. above, the recommended value for the acceptable concentration is subjected to an uncertainty factor of 30 and the standard for the premises boundary is established. *The value was revised in 1998 to 0.025mg/m3 (source)http://joh.med.uoeh-u.ac.jp/oel/index.html
	Steps to introduce the standard	The report of the Kyoto Prefecture Central Environment council, states "It is necessary to set regulatory standards for pollutants that have been designated as hazardous by the old ordinance but for which no standards have been established", which led to the establishment of the emission standard.

	Enforcement scheme	**Initiatives to implement the prefecture ordinance** ・Explanation of the contents of the regulation concerning atmospheric emissions during training courses aimed at pollution prevention management personnel designated by the ordinance ・It is necessary to submit a notification according to the ordinance when setting up designated facilities. Explanations on the emission standard were also done during the time of acceptance of these notifications. **Kyoto Prefecture's initiatives to accomplish the prefecture ordinance** 1)Establishment of the target value ・After the reconstruction of the clean centre (North Eastern) in 2001, the planned target value (voluntary standard of 0.05mg/m3N) for the concentration of mercury in flue gas was established during the reconstruction of the clean centre. 2) Monitoring of mercury level in flue gas ・The monitoring of mercury concentration in the 4 clean centers present in the city is being carried out and all the centres, irrespective of whether the have a target value or not, are meeting the value of 0.05mg/m3N. 3) Establishment of flue gas treatment facility ・Tenders are being given out to install equipments in order to meet the target of 0.05mg.m3N. All the clean centers in the city are equipped with wet type cleaning towers.
Technical information	Name of technology to meet the standard value	**Example of the Kyoto City Clean Centre (Northern)** ・Kyoto City Clean Center (Northern) has installed the following equipments. These equipments do not specifically target mercury only but contribute to controlling dioxins, acid gases, dust and other heavy metals and hence help to reduce the total emission of hazardous materials into the environment. **Flue gas treatment technologies** 1) Flue gas quencher 2) bag filter 3) wet type scrubbers 4) activate carbon adsorption bed 5) catalysed denitrification unit **Treatment technologies for treatment of effluent from wet type gas scrubbers** 6) coagulation-sedimentation, filtering 7) chelating resin tower **Treatment technologies to treat remainder sludge generated from coagulation-sedimentation process** 8) Dewatering after solidification using polymer coagulant **Treatment technology for fly ash** 9) chelate treatment

	Description of technology (incl. applicable conditions)	◆**flue gas treatment technologies** **1) Gas quencher** Cooling of the flue gas by spraying water **2) Bag filter** Hydrated lime is sprayed before the bag filter. A Teflon filter bag extracts minute hazardous materials that form after reaction with the hydrated lime. The temperature in the inlet of the bag filter is about 150 to 160 degree Celsius. It is likely that heavy metals are extracted with dust in the bag filter. **3) wet scrubbers** Caustic soda solution is effective against acidic gases like SOx and HCl whereas washing by liquid chelate is effective in extracting mercury and other heavy metals **4) activated carbon adsorption tower** In order to comply with extraction of non regulated substances, the gas is passed through a tower filled with activated carbon resulting in a clean flue gas. **5) Catalysed denitrificaiton unit** Ammonia is purged through the flue gas and the nitrogen oxides are broken down by catalysts. ◆**Effluent treatment technology** **6) coagulation-sedimentation, filtering** The coagulation-sedimentation is carried out in two steps. The reagents used are ferric chloride, coagulation aid agent, caustic soda and chelate. Mercury is the main target. **7) Chelating resin tower** Effluent is passed through a tower filled with chelate resin. This treatment mainly targets mercury. The chelate resin reaches its end of use period in 3 years after which it will be treated in an adequate manner as industrial waste.
	Process flow of the technology application	Refer to Figure 5.3.1 in the following link (http://www.city.kyoto.lg.jp/kankyo/page/0000058041.html)

<table>
<tr><td></td><td>Mercury removal efficiency, achievable mercury concentrations</td><td>flue gas
・The flue gas concentration immediately after the furnace and at the chimney is being measured (refer table 2)
・The extraction ratio of the mercury present in the flue gas is 70%-95%(As the concentration in the outlet is below the lower limit of quantification (0.006mg/m3N), the calculation of the extraction ratio comes out to be a relatively small number if the concentration of the input is also low)
Effluent
<table><tr><td></td><td>Before treatment</td><td>after treatment</td></tr><tr><td>concentration</td><td>0.3mg/L</td><td>Under 0.0005mg/L</td></tr><tr><td>extraction rate</td><td>―</td><td>99.8％</td></tr></table>Figures for FY2008, annual average
Fly ash
<table><tr><td></td><td>Before chelate treatment</td><td>after treatment</td></tr><tr><td>concentration</td><td>12-18mg/kg</td><td>less than or equal to the landfill acceptance standard for industrial waste (0.005mg/L for mercury and its compounds)</td></tr><tr><td>analysis method</td><td>Bottom sediment analysis method</td><td>Environmental agency notification S46.12, No 59 table 1</td></tr></table>From the viewpoint of extraction of mercury it can be said that the technology being applied is sufficient</td></tr>
<tr><td></td><td>Other environmental benefits</td><td>・As demonstrated in table 3, adequate level of flue gas treatment benefits have been obtained for hazardous materials identified by the prefecture ordinance.</td></tr>
<tr><td></td><td>Further treatment needs (incl. amount of ashes and sludge generated through the treatment)</td><td>The bottom ash is landfilled after undergoing chelate treatment. The sludge generated from the treatment of the effluent is hardened by using polymer coagulant, is dewatered and then landfilled</td></tr>
<tr><td></td><td>Initial and running costs (incl. facility’s capacity)</td><td>Facility specification of clean center (northern)
<table><tr><td>type of furnace</td><td>Fully continuous combustion type incinerator (stoker furnace)</td></tr><tr><td>capacity</td><td>400 tpd (200 tpd x 2 furnaces)</td></tr></table>Scrubber : Construction cost about 5 million yen. Usage of caustic soda (48%) is about 360kl/year
Effluent treatment facility: The construction cost is about 2.9 million yen. The amount of liquid chelate being used for mercury extraction is about 4.6m3/year.
Labour cost to operate the facility: The operation of the plant is done by 24 people (6 people in 4 teams) in 2 shifts. Besides that other 17 people are engaged in equipment maintenance, operation planning and maintenance planning.</td></tr>
<tr><td>Awareness raising</td><td>Target population</td><td>Installers of designated facilities* for smoke (includes waste treatment companies)</td></tr>
</table>

		* For details, refer to table 2 in the following link (only in Japanese) http://www.pref.kyoto.jp/reiki/reiki_honbun/aa30004851.html
	Activity period/frequency	Activities of Kyoto Prefecture Besides holding explanatory sessions when the ordinance was formulated, explanation of the contents of the regulation concerning atmospheric emissions during training courses aimed at pollution prevention management personnel designated by the ordinance is also being carried out. Further, it is necessary to submit a notification according to the ordinance when setting up designated facilities. Explanations on the emission standard are also given during the time of acceptance of these notifications.
	Media used for awareness raising and messages delivered	After training session using text materials, a test is conduction. The content of the training session are as follows ・Regarding Kyoto Prefecture's environmental legislations ・Trends on atmospheric regulations (including standards) ・Trends on regulations for effluents ・Trends on regulations regarding industrial waste ・Activities relating to the promotion of a cyclic society ・Promotion of measures towards prevention of global warming
	Responsibility of relevant stakeholders	Event conduction in accordance with "Ordinance to protect and preserve Kyoto Prefecture's environment" by Kyoto Prefecture. The target participants are pollution prevention management personnel (excluding those related to noise, vibration and dioxin) identified by Article 4 item 12 of the "Act on Improvement of Pollution Prevention Systems in Specified Factories (law no 107 of 1971)"
	Cost sharing of relevant stakeholders	The cost for organizing the event was covered by Kyoto Prefecture. The participants paid for the text materials distributed (2500 yen)
Remarks (if any)		
References and interviewees		Interview with Kyoto city（2010.01.07） Interview with Kyoto Prefecture（2010.01） Report from the 38th Kyoto Prefecture pollution management personnel training course （http://www.pref.kyoto.jp/news/kankyoka/38koshuyoryo.pdf）
Graphs or photos that can be used for the Good Practices		Yes (see below)

Table 5.3.7 Comparison of Planned Emission Targets of Waste Incinerator to be Rehabilitated and Local Standards in Kyoto City

Substance	Unit	Planned Emission Targets	Local Emission Standards
Soot and dust	g/Nm^3	≤ 0.01	≤ 0.04
SOx	ppm	≤ 10	≤ 40
NOx	ppm	≤ 30	≤ 250
HCl	ppm	≤ 10	≤ 430
Mercury	mg/Nm^3	≤ 0.05	≤ 0.2
Dioxins	ng/Nm^3	≤ 0.1	≤ 0.1

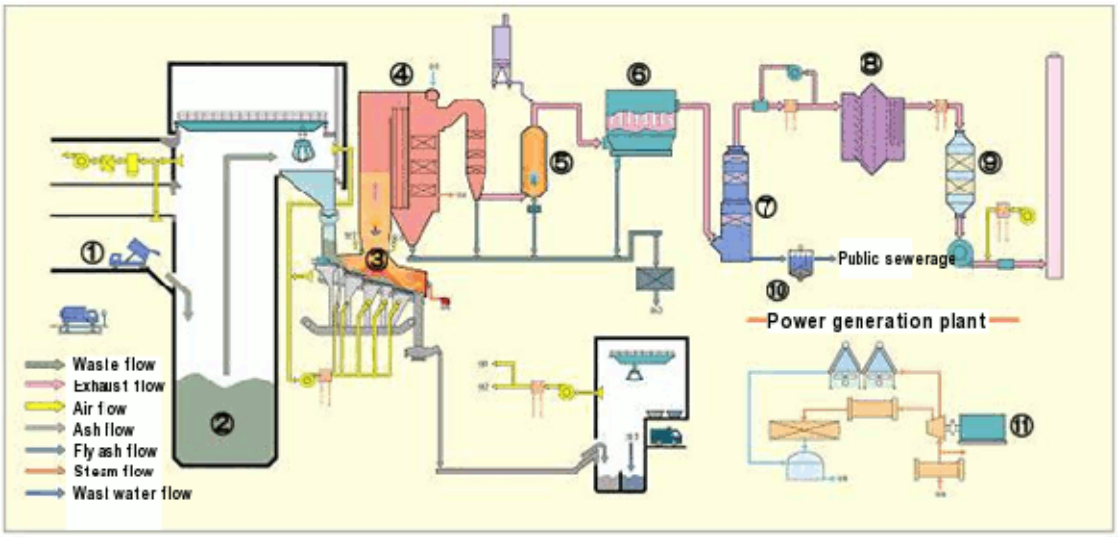
Source: Kyoto City (2001): Outline of Planning Document for the Study to be Conducted after the Rehabilitation of North Clean Center in Kyoto (in Japanese), http://www.city.kyoto.jp/kankyo/envm/assess/hokubucc/gaiyou4/youyaku.html

Table 5.3.8 Mercury concentration in the flue gas (FY 2008) Unit, mg/m3N

Place of measurement	April 22nd, Furnace no1		September 4th, Furnace no1		December 18th, Furnace no1		June 24th, Furnace no2		October 9th, Furnace no2		February 17th, Furnace no2	
Boiler outlet	0.046		0.092		0.11		0.11		0.042		0.034	
Chimney inlet	0.006	less than	0.006	less than	0.006	less than	0.006	less than	0.006	less than	0.006	less than
Extraction ration	86.9	%	93.4	%	94.5	%	94.5	%	85.7	%	82.3	%

Table 5.3.9 Concentration of hazardous materials in the flue gas（FY2008）

Parameters	Unit	Standard	Boiler outlet (average)		Chimney inlet (average)		Treatment ratio (%)	
			Furnace no 1	Furnace no 2	Furnace no 1	Furnace no 2	Furnace no 1	Furnace no 2
zinc	mg/㎥N	20	26	25	Less than0.02	Less than 0.02	≧99.9	≧99.9
Ammonia	mg/㎥N	0.3	0.39	0.24	Less than 0.004	Less than 0.004	≧98.9	≧98.3
Cadmium	mg/㎥N	0.2	0.26	0.31	Less than 0.004	Less than 0.004	≧98.4	≧98.7
Chromium	mg/㎥N	0.2	0.18	0.16	Less than 0.01	Less than 0.01	≧94.5	≧93.6
Mercury	mg/㎥N	0.2	0.083	0.062	Less than 0.006	Less than 0.006	≧92.7	≧90.3
Bronze	mg/㎥N	0.3	1.7	1.6	Less than 0.005	Less than 0.005	≧99.7	≧99.6
Lead	mg/㎥N	0.3	3.7	3.3	Less than 0.02	Less than 0.02	≧99.4	≧99.3
Manganese	mg/㎥N	1	0.49	0.83	Less than 0.02	Less than 0.02	≧95.9	≧97.6
Tin	mg/㎥N	7	0.16	0.21	Less than 0.04	Less than 0.04	≧75.0	≧80.6
Nickel	mg/㎥N	3	0.04	0.07	Less than 0.02	Less than 0.02	≧45.4	≧71.4
Arsenic	mg/㎥N	2	0.011	0.014	Less than 0.004	0.004	≧62.5	≧72.0
Chlorine	ppm	3	Less than 0.05	Less than 0.05	Less than 0.05	Less than 0.05	—	—
Bromine	ppm	0.3	0.35	0.27	Less than 0.03	Less than 0.03	≧91.5	≧88.8
Fluorine	mg/㎥N	5	0.7	Less than 0.5	Less than 0.5	Less than 0.5	≧28.5	—
Sulfuric acid	mg/㎥N	3	87	97	Less than 0.2	Less than 0.2	≧99.7	≧99.7
Formaldehyde	ppm	2	Less than 0.2	Less than 0.2	Less than 0.2	Less than 0.2	—	—



1. Platform
2. Refuse pit
3. Incinerator
4. Boiler
5. Gas quenching tower
6. Filter-type dust collector
7. Wet scrubber
8. Activated carbon reactor
9. Catalytic denitrification tower
10. Wastewater treatment equipment
11. Steam turbine generator

Figure 5.3.1 Treatment process flow for Clean Centre (Northern)

5.3.3 Local emission standard and management target standard in Fukushima, Japan

General information	Target management process	Flue gas treatment/flue gas cleaning water treatment
	Target area (province, country, or region)	Fukushima Prefecture, Japan
	Year started	October 1986 : Installation and operation of the incinerator April 1998: Alteration of the incinerator
	Background (problems identified before the introduction of the system)	N/A
	Major outcomes of implementing emission/effluent standards	Flue gas Hg concentration: less than or equal to 0.1mg/m^3N (average)
	Major challenges faced in implementing the process and ways to overcome those challenges	There are two types of mercury in flue gas: elemental mercury and divalent mercury. Divalent mercury is soluble in water and can be extracted using wet scrubbers. Capture of mercury from waste effluent has been technologically established. However, elemental mercury exists in the gaseous state in the flue gas and its removal requires advanced process like physical adsorption using activated carbon which has high technological and cost requirements.
	Remaining issues to be solved	N/A

Information on legal/voluntary system	Legal basis or basis for voluntary systems (e.g. voluntary agreements between government and industry) for emission/effluent standards (if any)	Concentration of mercury in the flue gas and the effluent : Prefectural ordinance (Fukushima Prefecture ordinance and enforcement regulation on preservation of the living environment etc) Concentration of mercury in dewatered sludge and combustion residue : Landfill acceptance standard as stipulated in the "Waste Management and Public Cleansing Act"
	Standard on mercury concentration	Prefectural ordinance 1) Mercury concentration in the flue gas : 1mg/m^3N（Incinerators with capacity of 1ton/hr or more） 2) Mercury concentration in the effluent : 0.005mg/L (Public water bodies except those area designated as "special effluent regulation areas" that require special water protection measures) Landfilling standard 3) Leaching standard : 0.005mg/L
	Rationale for the standard values	Basis for setting the standard 1) Prefectural ordinance 2) 10 times the environmental standard. The same value as the effluent standard specified in the "Water pollution prevention act " 3) Same as above
	Steps to introduce the standard	The local governmental bodies have specified the "Pollution prevention agreement standard". For example ・Total volume of flue gas emitted from multiple smoke emitting facilities into the atmosphere from within the same boundary does not exceed 40,000m^3/h ・The average effluent amount is 10,000m^3/day or more Factories that satisfy the conditions stated above are requested to enter into the "Pollution prevention agreement". This facility has accepted the request and has entered into the "pollution prevention agreement".
	Enforcement scheme	Reporting to the respective local government
Technical information	Name of technology to meet the standard value	This facility has adopted the following technologies. All the following do not exclusively target mercury but have been introduced to comply with requirements of regulations on emission control of hazardous materials. Flue gas treatment technologies 1) Gas quencher 2) Gas scrubber 3) Wet type electrical dust collector (Mist Cottrell) Effluent treatment technologies 4) Neutralisation tank 5) Condensation tank 6) Chemical mixing facility 7) Activated carbon adsorption treatment Technologies for sludge treatment 8) Condensation tank 9) Dewatering equipment

	Description of technology (incl. applicable conditions)	Majority of the mercury is transferred into the flue gas and is subsequently transferred to the effluent through the flue gas treatment processes. The flue gas treatment processes adopted are as follows. **Flue gas treatment technologies** **1) Gas quencher** Combustion gas with temperatures of 900℃ are quenched to about 80℃using water spray. **2) Gas scrubbers** Flue gas is neutralized using sprays of alkali based liquids. **3) Wet type electrical dust collector (Mist Cottrell)** Extracts dust and mist from the flue gas. The mercury is transferred to the effluent mainly during processes 1) and 2) described above. The mercury in the effluent is separated from the effluent during the effluent treatment process by chelating agents (diethyldithiocarbamic acid based) and is transferred to the effluent treatment sludge. The sludge is dewatered and is taken to landfill (controlled type) as dewatered sludge. A part of the mercury introduced into the system is emitted in the slag is a form that does not leach out. The slag is also disposed into a landfill (controlled type).
	Process flow of the technology application	Refer to the following link （http://www.kurekan.co.jp/project/flow.htm）
	Mercury removal efficiency, achievable mercury concentrations	Hg concentration in the flue gas : less than or equal to 0.1mg/m3N(average) Hg concentration in the dewatered sludge: less than or equal to 10mg/kg(average) Hg concentration in the effluent : less than the lower limit of quantitation (0.0005mg/l) The treatment capacity and the mercury feed amount of the facility is as shown below. Treatment capacity : 130.68 ton/day (mixed combustion) Mercury concentration in industrial waste (maximum acceptance concentration) : Less than or equal to 100mg/kg of total mercury (However, the feed amount of industrial waste is adjusted so that the total treatment amount of mercury does not exceed 50g/day)
	Other environmental benefits	N/A
	Further treatment needs (incl. amount of ashes and sludge generated through the treatment)	Slag and dewatered sludge are disposed off in a landfill (controlled type)
	Initial and running costs (incl. facility's capacity)	Calculation not possible
Awareness raising	Target population	Industrial waste treatment business
	Activity period/frequency	Implemented as a part of sales effort

	Media used for awareness raising and messages delivered	1) Website ・Technological information (outline of the facility, published papers etc) is displayed 2) Website of "Grading evaluation system of industrial waste treatment businesses " ・This facility satisfies the requirements of "Grading evaluation system of industrial waste treatment businesses " and information of this facility is also displayed in their website.
	Responsibility of relevant stakeholders	N/A
	Cost sharing of relevant stakeholders	Operating cost of the facility
Remarks (if any)		N/A
References and interviewees		Interview with the relevant personnel（2010.04.27） http://www.kurekan.co.jp/index.htm
Graphs or photos that can be used for the Good Practices		No

5.3.4 Emission Control in USA

75. (information will be added when it is provided.)

5.3.5 Setting effluent standards and treating leachate with chelating resin in Japan

General information	Target management process	Treatment of Leachate
	Target area (province, country, or region)	A landfill for Industrial waste with governmental involvement, Japan
	Year started	2002
	Background (problems identified before the introduction of the system)	Background to the installation of chelating tower in this facility This is a landfill with leachate management present. Although a high concentration of mercury is not anticipated in the leachate, a chelating tower for mercury was installed to ensure that no adverse impact to the surrounding environment would occur.
	Major outcomes of implementing emission/effluent standards	Present situation After the commencement of the operation of the facility in 2002, mercury has never been detected in the treated effluent.
	Major challenges faced in implementing the process and ways to overcome those challenges	Not applicable
	Remaining issues to be solved	Not applicable
Information on legal/voluntary system	Legal basis or basis for voluntary systems (e.g. voluntary agreements between government and industry) for emission/effluent standards (if any)	Ministerial ordinance regarding technical standards on landfills for municipal solid waste and industrial waste.

	Standard on mercury concentration	Alkyl mercury: should not be detected Mercury and mercury compounds: 0.005mg/L
	Rationale for the standard values	Ten times the environmental water standards Same value as the effluent standard specified in "Water Pollution Prevention Act".
	Steps to introduce the standard	Not applicable
	Enforcement scheme 2)	Scheme required by the ministerial ordinance (only matters relating to mercury) • Two or more ground water samples from either the peripheral boundary of the landfill or from the ground water collection facility are to be taken and analyzed as follows. • Groundwater test parameters including mercury are to be measured and recorded before the commencement of landfilling • After the commencement of landfilling, ground water samples from the landfill are to be measured and recorded at least once a year. • If any deterioration in water quality is detected, the cause is to be investigated and adequate measures taken • The measurement and recording of data for treated effluent is to be done at least once a year for parameters for which effluent standards are present (including mercury) • Periodically investigate the condition of the performance of the leachate treatment facility and if any irregularities are detected , take prompt actions to rectify the problem.
Technical information	Name of technology to meet the standard value	Chelating treatment facility for mercury • The effluent treatment facility is installed so that the treated effluent from the landfill can meet the effluent standard • The chelating tower has specifically been installed to target mercury.
	Description of technology (incl. applicable conditions) 3)	Technology for mercury • Two chelating towers have been installed of which one is for mercury and the other is for other heavy metals • For mercury, a phenolic resin called "MIYOSHI resin EPOLAS Z-7" is used in the chelating tower as the resinous material Other additional facilities installed to treat organic and other parameters are shown below. Biological treatment facility Treat organic matter and extract Nitrogen components Coagulation and sedimentation facility Extraction of contaminants Sand filtration facility Fine contaminants not extracted by coagulation and sedimentation are extracted Activated carbon adsorption facility Advanced treatment using activated carbon Chelating treatment (heavy metal / mercury) Targeting heavy metals apart from mercury Disinfection facility Outflow after disinfection by chlorine
	Process flow of the technology application	Refer to Figure 5.3.2 （Source：http://fish.miracle.ne.jp/shimakkc/facilities.pdf）

	Mercury removal efficiency, achievable mercury concentrations	Cannot be calculated because mercury has not been detected in the leachate
	Other environmental benefits	Water samples taken from sampling wells around the facility are within the respective standards and limits. The effluent meets the effluent standard.
	Further treatment needs (incl. amount of ashes and sludge generated through the treatment)	Amount of sludge generated from the effluent treatment facility : About 3 tons per month
	Initial and running costs (incl. facility's capacity)	Capacity of the effluent treatment facility：110m3 per day. Cost breakdown is shown below <u>Initial cost</u> Construction cost only for the chelating tower for mercury cannot be calculated <u>Operation cost</u> Operation cost related to mercury is 0 yen per year. (Chelating materials have not been changed in the operating period between 2002 and 2009)
Awareness raising	Target population	Industrial waste generators within the prefecture
	Activity period/frequency	On a as per need basis along with other business development activities
	Media used for awareness raising and messages delivered	1) Dedicated website • Technical information (outline of the facility, outline of the leachate treatment plant) 2) Visits to generators of industrial waste within the prefecture and advertising by direct mail • Providing technical information as a part of business development activity 3) Website of "Good practice evaluation system for industrial waste treatment businesses " • The facility complies with the "Good practice evaluation system for industrial waste treatment businesses "and information regarding this facility is uploaded in their website.
	Responsibility of relevant stakeholders	Not Applicable
	Cost sharing of relevant stakeholders	Operation cost of the facility
Remarks (if any)		A local meeting is adjourned every 3 months where explanation on intake of waste and measurement and analysis data of the leachate is given. The meeting is attended by representatives of the local community and the government. Further, the facility accepts site visits by the local community, provides information and carries out exhibitions at the community hall and also carries out PR activities at seminars.
References and interviewees		1) Telephone interview 2) http://www.env.go.jp/recycle/kosei_press/h980616a/h980616a-2.html 3) http://www.miyoshi-yushi.co.jp/yuka_jigyou/pdf/epo.pdf
Graphs or photos that can be used for the Good Practices		Yes (see below)

(to be inserted)

Figure 5.3.2 Flow of Leachate Treatment

6 Disposal of Mercury Waste

6.1 Disposal of Waste Contaminated with Mercury at Landfills

6.1.1 Legal Framework on Disposal of Waste Contaminated with Mercury at Landfills (to be completed)

Type of Landfill	Characteristics of Landfill	Acceptance Criteria	Legal Basis

6.1.2 Analysis Methods to Determine the Mobility of Mercury in Waste

76. Examples of analysis methods to determine the mobility of mercury in waste is found in Table 2.1.3.

77. For chemical analysis of mercury (total mercury and methylmercury) in environmental samples (fish/shell fish, water, sediment/soil, plants, atmosphere/air) and human samples (hair, blood, urine, umbilical cord), following material and manual can be referred.

- Japan Public Health Association (2001): Preventive Measures against Environmental Mercury Pollution and Its Health Effects, http://www.nimd.go.jp/english/kenkyu/docs/manual.pdf
- Ministry of the Environment, Japan (2004): Mercury Analysis Manual, http://www.nimd.go.jp/english/kenkyu/docs/2004_march_mercury_analysis_manual(e).pdf

6.1.3 Solidification and Stabilization Technology

78. Table 6.1.1 shows examples of treatment technologies for contaminated with mercury (collected dusts and sludge generated through mercury-containing wastewater treatment).

Table 6.1.1 Examples of Treatment Methods for Waste Contaminated with Mercury

Treatment Methods	Mercury handling	Initial and running costs	Remarks	Reference
Cement solidification	Solidification	Treatment costs: EUR25/ton	high pH of cement-based systems can result in significant leaching of amphoteric metals (Pb and Zn).	2
Cementation (including treatment by special chelating agent)	Stabilization/solidification		Necessary to insolubilization and reduction treatment of mercury that cannot expect insolubilization effects of hydroxide	1
Acid leaching/heavy metal immobilization	Stabilization		Necessary to treat sludge containing heavy metals	1

1. Arai, Norio (supervised) (2000): Syokyaku Seiseibutsu no Hassei to Yokusei Gijyutsu (Generation and Control Technologies of Products from Incineration in Japanese).
2. European Commission (2006): Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste combustion.

6.1.3.1 Grout/Portland Cement Stabilization

79. Cementitious stabilization/solidification (S/S) is one of the most widely used techniques for the treatment and ultimate disposal of hazardous waste and low-level radioactive waste. Cementitious materials are the predominant materials of choice because of their low associated processing costs, compatibility with a wide variety of disposal scenarios, and ability to meet stringent processing and performance requirements. Cementitious materials include cement, ground granulated blast furnace slag, fly ash, lime, and silica fume. Various clays and additives are used to help immobilize contaminants or otherwise enhance the waste form properties. Treatment of

the waste to precipitate soluble mercury as the sulphide may be desirable prior to S/S. Amalgamation is the suggested stabilization technique. It is desirable to remove and recycle (preferable) or amalgamate metallic mercury from contaminated waste. In general, high temperature stabilization techniques (e.g., vitrification, thermoplastic encapsulation) must remove mercury prior to stabilization or risk contaminating the offgas with mercury (Center for Remediation Technology and Tools-US EPA 1996).

6.1.3.2 Sulphur Polymer Stabilization/Solidification (SPSS)

80. The Sulphur Polymer Stabilization/Solidification (SPSS) is considered to be an encapsulating process for the immobilization of hazardous and radioactive wastes and one of the major stabilization/solidification processes. In SPSS, elemental mercury or mercury-containing waste is reacted with sulphur polymer cement (SPC) (a thermoplastic material composed of 95 wt% elemental sulphur) to form a stable mercury sulphide compound with significantly reduced leachability and, for elemental mercury, lower vapour pressure. The reacted mixture is then melted, mixed, and cooled to form a monolithic solid waste form in which the stabilized mercury sulphide particles are microencapsulated within a sulphur polymer matrix (Adams 2004). SPSS mercury treatment is conducted in two steps (Initiatives Online 1999):

- Stabilization: In the first step, mercury and powdered SPC react and form mercuric sulphide. The reaction vessel is placed under an inert gas atmosphere to prevent the formation of mercuric oxide, a water soluble and highly leachable compound. The reaction vessel is heated to about 40°C to accelerate the reaction, and the materials are mixed until the mercury is completely reacted with the sulphur; and
- Solidification: When the mercury is chemically stabilized, additional SPC is added, and the mixture is heated to 130°C until a homogeneous molten mixture is formed. It is then poured into a suitable mould, where it cools to form a solid waste form.

6.1.3.3 (information about other technologies will be added)

6.1.4 Cases of Disposal of Waste Contaminated with Mercury

81. Table 6.1.2 summarises target process, basis, type of practice, and country of good practice cases.

Table 6.1.2 Summary of Good Practice Cases for Management of Waste Contaminated with Mercury

Process	Features of Practices		Country	Relevant Section
	Basis	Type of Practice		
Treatment of residues containing mercury (fly ash from MSW incinerator)	Legal	Landfill acceptance criteria and technologies to meet the criteria	Japan	6.1.4.1
Prevention of landfill fire	Voluntary	(if information is obtained, case of improving landfill management to reduce landfill fire is inserted)		

6.1.4.1 Treatment and Disposal of Fly Ash Generated from Municipal Solid Waste Incinerator in Kawasaki, Japan

General information	Target residue	Fly ash generated from municipal solid waste incinerators
	Target area (province, country, or region)	Kawasaki city (The total amount of waste brought into this facility amounts to about 50% of the waste generated in the city), Japan
	Year started	Commencement : December 1991 Completion of construction : September 1995 Operation : From October 1995

	Background (problems identified before the introduction of the system)	When the construction of this facility was planned in 1990, no regulations existed for the emission of mercury and dioxins in flue gas from waste incinerators. However, as there was a possibility of regulations on dioxins being introduced in the future, it was decided to install facilities that could satisfy the emission levels of dioxins in the flue gas that could be expected in the future. It was also planned that the facility would satisfy the emission standards of mercury and other hazardous substances when they were introduced in the future. Regarding fly ash, it was decided to implement a treatment method that would satisfy the landfill acceptance criteria.
	Major outcomes of setting disposal standards	The fly ash, after satisfying the acceptance criteria, is landfilled.
	Major challenges faced in implementing the residue management and ways to overcome those challenges	None in particular for mercury. The amount of mercury mixed in the waste itself is decreasing. Regarding fly ash, effort is being made to satisfy the landfill acceptance criteria for lead and all other substances.
	Remaining issues to be solved	Hold down within the economic limits the amount of chelating agent used for the treatment of fly ash whilst satisfying the landfill acceptance criteria
Information on legal/voluntary system	Legal basis or basis for voluntary systems (e.g. voluntary agreements between government and industry) for residues disposal standards (landfill waste acceptance standards) (if any)	Method designated by the minister of health and welfare as the method for recycling and disposal of "specially managed municipal solid waste" and "specially managed industrial waste"(Notification no 194 of the minister of health and welfare issued on 1992/7/3) Standard on the landfill disposal of waste generated from the recycling and disposal of dust (Environmental agency notification No 42 of 1992/7/3)
	Standard on mercury concentration in residues to be landfilled	Alkyl mercury : Not to be detected Total mercury : 0.005mg/L
	Rationale for the standard values	10 times the environmental standard value
	Enforcement scheme	The contracted operation and management company conducts the elution test for the treated fly ash once in two months. The city also conducts a voluntary test once a year.
	Supplement information about Standards to be identified as "hazardous waste" or "contaminated soil/sludge" in terms of mercury	Not applicable
Technical information	Name of technologies to meet the standard values	The facility is a continuous operation type mechanical incinerator that annually incinerates 180,000 tons of municipal solid waste. The technologies used for the treatment of waste water, fly ash and the flue gas are as follows. Treatment flow of flue gas ・Boiler (decrease of temperature) ・Desalting reaction tower (spray of hydrated lime slurry) ・Filter type dust collector Treatment of fly ash ・Treatment using chelating agent ・Ash pit (stored along with bottom ash) Treatment of wastewater

		・Activated sludge treatment ・Chemical treatment ・cyclic use
	Description of technologies (incl. Applicable conditions)	The treatment of fly ash is explained below. <u>Treatment using chelating agent</u> ・Add 4% (by weight) of liquid chelating agent and water to the fly ash. ・Prevent the elution of heavy metals by adequately mixing using a mixer <u>Storage in the ash pit</u> ・Fly ash after treatment using chelating agent is stored along with bottom ash in the ash pit.
	Process flow of the technology application	Refer to Figure 6.1.1
	Achievable mercury concentrations in leachate	Satisfy the standard required by the law.
	Other environmental benefits (if any)	Also satisfies the standard as required by law of hazardous substances other than mercury.
	Further treatment needs	Not applicable
	Initial and running costs (incl. facility's capacity)	<u>Initial cost</u> ・Calculation of construction cost for fly ash treatment facility not possible <u>Running cost</u> ・Cost of chelating agent: In the order of multiple of 10 million yen/year (Figure for FY 2009 amount of chemical agents used is 140t/yr) <Reference> ・Operation management of the incineration facility: 7 persons x 5 groups (24 hours operation) ・Others, includes additional 14 technical staffs
Awareness raising	Target population	1. Facility – Dissemination to the public 2. City – Notification to the specified facilities within the city
	Activity period/frequency	As required
	Media used for awareness raising and messages delivered	1) Information dissemination through website and acceptance of site visits. 2) Explanation of the regulated contents to the applicant during the process of license application. Explanation on existing standard and regulated contents also conducted during seminars conducted to explain the changes in the legislations or ordinance. Further, information dissemination also conducted at meetings conducted to provide information from the city to the businesses.
	Responsibility of relevant stakeholders	N/A
	Cost sharing of relevant stakeholders	1) Operation cost of the facility 2) City`s budget

Remarks (if any)	• Incineration amount of Municipal solid waste : 180,000 tons/yr • Generation amount of treated ash (Fly ash after mixing bottom ash and chelating agent) : About 24,000 tons/yr * Water content in the treated ash about 25% *Fly ash : Bottom ash ≒1 : 5（Based on generated amount） • Kawasaki city collects fluorescent lamps as "general waste" and incinerates them. The treatment amount of fluorescent lamps and other glass materials is about 166 tons/yr (source 3, amount estimated based on composition ratio of household waste) • Used alkali batteries are collected as recyclable waste. • This facility acquired ISO14001 accreditation in 2001 and announced in 2008 that it is compliant to ISO.
References and interviewees	1) Interview with city officials (June, 2010) 2) Ushima treatment center website（http://www.city.kawasaki.jp/30/30ukisi/index.html） 3) Kawasaki city Environment department : FY 2008 report on waste emission (January, 2009)
Graphs or photos that can be used for the Good Practices	Yes (see below)

(to be inserted)

Figure 6.1.1 Kureha Style Process Flow of Waste Incineration

6.2 Permanent Storage of Waste Consisting of Elemental Mercury

6.2.1 Legal Framework on Permanent Storage of Waste Consisting of Elemental Mercury

(example of EU regulation)

6.2.2 Cases of Permanent Storage of Waste Consisting of Elemental Mercury

(Cases will be added as experiences are earned.)

7 Remediation of Sites Contaminated with Mercury Waste

7.1 Steps to clean up contaminated sites

82. (Description about practical steps to clean up contaminated sites).

- Identification of contaminated sites
- Identification of responsible parties for remediation
- Development and implementation of remedial plan
- Post-remediation of contaminated sites

7.2 Remediation Programme

83. In the last decade, countries around the world have begun to put forth significant effort to better understand the nature and extent of the mercury problem and also have worked collaboratively to coordinate research and assistance efforts, especially between developed and developing countries. The amount and variety of mercury-containing products in the USA and Europe has declined significantly, but there remain many activities in developing countries that continue to consume and emit mercury. As a result, there are contaminated sites requiring characterization and remediation that are from past activities worldwide, ongoing manufacturing, and especially coal-burning power plants and ASM.

84. While both developed and most developing countries have environmental standards governing ongoing activities using mercury and containment and cleanup of mercury-contaminated sites, many in developing countries go unenforced or unmonitored. Cleanup of mercury-contaminated sites in developed countries is mostly underway and there are many levels of federal and state programmes dictating activities. Unfortunately, developing countries typically must rely on outside expertise and money to address their contaminated sites.

85. Worldwide collaboration on mercury issues has resulted in a number of programmes that focus primarily on pollution prevention and emissions reduction from the use of mercury, but some of the same programmes also have components that address remediation and cleanup of existing mercury-contaminated sites. Table 7.2.1 provides a summary of these programmes.

Table 7.2.1 Worldwide programmes for mercury-contaminated sites remediation

Programme	Remediation Component
The World Bank - Environmentally Sustainable ASM	The World Bank has funded various projects. One of which relates to remedial technologies and cleanup of sites: • The Urgent Environmental Investment Project - Azerbaijan is demonstrating mercury cleanup technologies and procedures by decontaminating one heavily polluted area and testing pilot-scale sludge treatment; developing a low-technology method for mercury recovery; transporting wastes; constructing a safe, new landfill; designing and implementing a monitoring programme for mercury releases, and conducting follow-up assessments.
North American Regional Action Plan on Mercury	The Action Plan has many components limiting the use of mercury, and one goal concerning remediation of mercury-contaminated sites: • Encouraging development and use of effective mercury waste-stabilization and disposal techniques and methods.

7.3 Remedial Techniques

86. Examples of remedial techniques for mercury-contaminated sites are summarized in Table 7.3.1.

Table 7.3.1 Mercury contaminated sites – remediation techniques (Hinton 2001; Sugio et al. 2008; Negishi et al. 2009)

Remedial Alternative	Comments
Excavation and Treatment: Collect contaminated soil for centralized treatment; technically simple using conventional mechanized equipment; excavation can be complicated and more expensive based on site conditions including overlying structures, surround land features (lakes, creeks, etc.) and groundwater level.	
Physical Separation 1. Use sieving to remove rubble and coarse portions; 2. Water rinse to remove medium fractions (50 mm to > 0.1 mm); 3. Use hydrocyclones, spiral and classifiers, and fluidized beds to remove fines (silts, clays or organics, etc.) (Hempel 1998); and 4. Dewater and isolate the remaining mercury-enriched sludge or fine fraction using treatment methods such as thermal methods.	▪ Well established; ▪ Effective at reducing the volume of contaminated soils; ▪ Generally does not require the use of other chemicals; ▪ Most effective for soils dominated by coarse materials (i.e., sand and gravel) with some (< 20%) fines; and ▪ Requires additional treatment of resulting mercury-containing sludge.
Thermal Treatment 1. Dry excavated soil at 100°C; 2. Transfer to a heating drum and maintain temperature of 600°C; 3. Heat exhaust gas in afterburner to 800-900°C and then collect the hot exhaust gas and cool to it 150°C; 4. Use filter to remove dust and air scrubber to remove SO_2; and 5. Recover mercury from the gas phase using a gas washing system (Hempel 1998), charcoal filter (Renner 1995), iodine impregnated scrubber or through condensation.	▪ Potential effective means for Mercury recovery from contaminated soil; and ▪ Organic contaminated soils are commonly treated using thermal processes.
Hydrometallurgical Treatment 1. Apply leaching agents to excavated materials; 2. Capture leaching liquid including leaching agent and leached mercury; and 3. Chemically separate mercury from leaching agent.	▪ The two most promising hydrometallurgical techniques are electrokinetic or electroleaching and leaching methods; and ▪ Commonly applied leaching agents include halide compounds such as hypochlorite or hydrobromic acid, iodine in the form of potassium iodine, and a mixture of nitric acid and NaCl (Hempel 1998).
In-Situ Recovery: Treat contaminated soil in place; less established techniques and more uncertainty regarding the effectiveness of in-situ compared to ex-situ treatments due to subsurface heterogeneity; clean-up times tend to be longer than ex-situ treatments; may become more cost-effective than excavation and treatment methods for many mercury-contaminated sites because contaminated soil and groundwater remain in the subsurface.	
Soil Vapour Extraction 1. Cover ground surface with a tarpaulin or other cover system; 2. Ensure lateral airflow through the impacted area; and 3. Use a vacuum to force air through the unsaturated zone.	▪ Effectiveness is primarily dictated by contaminant volatility and availability to air channel; ▪ Soil heating can be costly over large areas; and ▪ Soil heating combined with soil vapour extraction may become an effective means of mercury removal in the vadose zone.
Permeable Reactive Walls 1. Install permeable reactive walls below the	▪ Employed at many organic and metal impacted sites; ▪ Walls are geochemically engineered to transform relatively benign and/or immobile form and ideally can

Remedial Alternative	Comments
ground surface perpendicular to the flow of contaminated groundwater; and 2. Dissolved compounds react with wall constituents to precipitate contaminants into relatively benign or immobile compounds.	operate passively for extended periods with little or no maintenance; ▪ Wall constituents include: ▪ Zero-valent iron for various organic and inorganic contaminants; and ▪ Proposed: hydroxyapatite, zeolites, hydrous ferric oxides and bone char phosphate.
In-situ Leaching and Extraction 1. Inject solubility-enhancing chemicals upgradient from the zone of contamination to enhance mercury solubility in groundwater; and 2. Remove contaminants using pump-and-treat systems.	▪ Reduces clean-up time; ▪ Improves recovery rate from groundwater; ▪ Generally limited to treatment of contaminants impacting groundwater in a dissolved form (HgCl-, HgS or as a non-aqueous phase liquid; ▪ Not well demonstrated; and ▪ Injection of leaching agents into the subsurface for enhanced contaminant mobility is often unacceptable.
Electro-Kinetic Separation 1. Transform metal into a soluble form with or without the injection of solutions; 2. Electric current mobilizes the solubilised metal towards an electrode; and 3. Collect accumulated metals at the electrode, typically through excavation.	▪ Heavy metals such as mercury migrate towards electrodes placed in the soil where they accumulate and can be removed at a lower cost than excavating the entire impacted area; ▪ Higher cost, longer time; and ▪ Effectiveness is highly dependent on soil type.
Interceptor Systems Install interceptor system such as trenches and drains	▪ Extremely simple and effective at recovering mercury as free product; ▪ Limited by topography and stratigraphy; and ▪ Mercury in residual saturation not addressed.
Phytoremediation Plants assimilate and concentrate mercury from soils	▪ Promising, but unproven technology; ▪ Cost effective remediation of shallow soils over a fairly widespread area; and ▪ Limited access to vegetation by wildlife and time required for clean-up.
Passive Remediation-Wetlands Use wetlands for mercury immobilization	▪ Controversial as wetland-type environments are intrinsically amenable to the conversion of mercury to methylmercury; and ▪ Wetland can ultimately treat up to 1 million gallons of water daily.
Bioremediation Use bacteria that are resistant to Hg^{2+} and/or organomercurial compounds having the ability to volatilize metal mercury (Hg^0) from inorganic and organic compounds (e.g.	▪ Verification tests have been undertaken; and ▪ Necessary to develop methods to capture volatilized mercury.
Containment: Inhibit contaminants mobilization and minimize ecological and human exposure; cleanup of many contaminated sites is often not feasible due to financial or technical reason.	
Pump-and-Treat Install extraction wells below the water table within or slightly downgradient from the zone of contamination.	▪ Frequently employed cost-effective alternative; ▪ Must operate in perpetuity to prevent off-site migration; ▪ Well placement and pumping rate chosen to ensure capture of contaminated groundwater and limit recovery of clean water; and

Remedial Alternative	Comments
	▪ Monitoring wells installed around the contaminant plume required to assess containment and hydrogeochemical conditions.
Impermeable Barriers, Surface Seals and Drains Install impermeable barrier, surface seas, or drains to prevent off-site migration of the contaminants	▪ Geo-technically engineered approaches; and ▪ Each system has limitations with respect to emplacement depth and uncertainty concerning permeability and barriers may surround the contaminated zone entirely remove the potential for groundwater flow through the source.
Stabilization and Solidification Mix impacted soil with additives to reduce mobility or leachability of contaminants	▪ Stabilization binds contaminants to the solid and is often accomplished by reduction in soil permeability; ▪ Solidification technique improve physical characteristics of materials for easier excavation and transport; ▪ Subsurface mixing is less established than aboveground techniques; and ▪ In-situ stabilization may become an effective solution for difficult to access contamination.
Sediment Capping Place subaqueous cap of clean and ideally isolating material over contaminated sediments	▪ Increased solubility and diffusability of methylmercury must be considered; and ▪ Site specific issues must be assessed prior to cap design including: qualities of the watercourse (bathymetry, currents, wave energies and seasonal variability, etc.); functions of the waterway (water supply, wastewater discharge, recreational use, etc.); and geoenvironmental properties (sediment, soil, and rock stratigraphy and individual attributes, hydrogeologic conditions, etc.)

7.4 Cases of Remediation of Contaminated Sites

7.4.1 Minamata Bay, Japan – The Damage Caused by Mercury Poisoning (more information will be added)

87. Chisso Corporation had used mercury as a catalyst to produce acetaldehyde and vinyl chloride and discharged wastewater containing mercury and methylmercury into Minamata bay for about 40 years. The total amount of mercury discharged into Minamata bay was estimated to 70 – 150 mercury·tonnes and 616 methylmercury·kg for the period. There were more than 1,500,000 m^3 (2,090,000 m^2) of the bottom sediment polluted with more than 25 ppm of mercury concentration (Minamata City Hall 2000).

88. In order to restore Minamata bay polluted with mercury, the Kumamoto Prefecture Government had implemented the restoration project in Minamata bay from 1974 to 1990. The area where mercury concentration in sediment was more than 25 ppm was divided by steel sheet piles. The other area where mercury concentration in sediment was less than 25 ppm was dredged by the dredgers, and the dredged sediment was reclaimed inside the area divided by the steel sheet piles. The surface on the reclaimed area was covered by the liner sheets and Shirasu deposit (white arenaceous sediment). Then, the surface was covered by cover soil as the landfill containment (Minamata City Hall 2000). The total cost for restoration, as of May 2001, was about 48 billion JPY (about 390 million USD) (Ministry of the Environment, Japan 2002), and it shows that restoration needs vast amounts of money. The area is now the public park.

7.4.2 Chemical Plant Area in Marktredwitz, Germany

89. The Chemische Fabrik Marktredwitz (CFM) site occupies 0.5 km^2 and was previously operated as a chemical production facility. It is located in the city center of Marktredwitz, Bavaria, Germany. Founded in 1788, CFM was one of the oldest chemical manufacturing facilities in the world. The facility was closed in 1985 because the subsurface soil and groundwater was severely contaminated. Mercury was processed at the CFM site for the production of pesticides, herbicides, and other mercury-containing products. There were accidental spills of used solvents, chemical wastes, and treatment residuals that were stored onsite. The primary contaminant of concern at

the site is mercury in the concrete and brick-structures of the buildings and in the subsurface soil; concentrations between 300 and 5,000 mg/kg were detected. In 1988, the state of Bavaria decided to fund the remedial action on the site. The County of Wunsiedel, a co-founder of the project, was charged with the management of the remedial action project.

90. In 1988, the development of a concept for comprehensive remediation of the CFM site was initiated with the objective of allowing the site to be developed as a housing and shopping area. The remedial concept consists of applying the innovative Harbauer technology to clean up the soil and debris to an extent that allows landfilling of the treated solids. The remedial approach incorporates the following elements (North Atlantic Treaty Organization's Committee on the Challenges of Modern Society 1998):

- Protection of the nearby creek, "Kösseine," by installation of a vertical groundwater barrier and a groundwater pump-and-treat system;
- Demolition of technical facilities and buildings;
- Soil excavation and backfilling (The soil on the site had to be excavated to an average depth of 4 m below the original ground surface. The excavation pit was backfilled with clean soil);
- Soil and debris treatment (A total mass of 57,000 metric tons of excavated soil and debris contaminated with greater than 50 mg/kg mercury was treated in the off-site Harbauer treatment facility); and
- Landfilling of treated soil near the soil treatment plant (Excavated soil from the site containing less than 50 mg/kg mercury was landfilled directly).

8 References (to be completed)

European Commission. (2008): Options for Reducing Mercury Use in Products and Applications, and the Fate of Mercury already Circulating in Society, http://ec.europa.eu/environment/chemicals/mercury/pdf/study_report2008.pdf .

GMP. (2006): Manual for Training Artisanal and Small-Scale Gold Miners, UNIDO, Vienna, Austria, http://www.globalmercuryproject.org/documents/non_country%20specific/training%20manual%20for%20miners%20Marcello%2015.pdf

Hinton, J., Veiga, M. (2001): Mercury Contaminated Sites: A Review of Remedial Solutions, NIMD Forum 2001 - Mercury Research: Today and Tomorrow, Minamata City, Japan, National Institute for Minamata Disease, Ministry of the Environment, Japan, 73-84, http://www.facome.uqam.ca/pdf/Minamata_Forum_2001.PDF

Negishi, Atsunori, Keigo MORIYA, Fumiaki TAKEUCHI, Tsuyoshi SUGIO. (2009): Suigin Osen Dojo no Biseibutsu niyoru Jokakoho no Jissyoshiken (Verification of Mercury-contaminated Soil Remediation Method with Microorganisms) (in Japanese). Presentation at Civil Engineering and Construction Technologies, 271-278, Japan Society of Civil Engineers.

Japan Electric Lamp Manufactures Association (2008a): Q&A about Fluorescent Lamps and Used Fluorescent Lamps (in Japanese), http://www.jelma.or.jp/07kankyou/pdf/environment05.pdf

Japan Electric Lamp Manufactures Association (2008b): Q&A about HID Lamps and Used HID Lamps (in Japanese), http://www.jelma.or.jp/07kankyou/pdf/environment02_06.pdf

Kyoto City (1995): Kyoto-fu Kankyo wo Mamori Sodateru Jorei Seko Kisoku (Implementation Rules of Kyoto City Ordinance for the Protection and of the Environment), http://www.pref.kyoto.jp/reiki/reiki_honbun/aa30004851.html

Ministry of the Environment, Japan (1973): Analytical Method of Heavy Metals Contained in Industrial Wastes - Ministry of the Environment Notification No. 13, http://www.env.go.jp/hourei/syousai.php?id=11000013, (Japanese)

Sakai, Shin-ichi, Akiko KIDA, Shigehiro SHIBAKAWA, Akihiro MATSUMOTO, Hajime TEJIMA, Nobuo TAKEDA. (2006): Co-benefit of Controlling Unintentional Persistent Organic Pollutants (UPOPs) in Municipal Solid Waste Incineration, in 4th i-CIPEC, September 26-29, 2006, Kyoto, Japan.

Sugio, Tsuyoshi, Mitsuko FUJII, Yumika NINOMIYA, Tadayoshi KANAO, Atsunori NEGISHI, and Fumiaki TAKEUCHI. (2008): Reduction of Hg^{2+} with Reduced Mammalian Cytochrome c by Cytochrome c Oxidase Purified from a Mercury-Resistant *Acidithiobacillus ferrooxidans* Strain, MON-1, Biosci. Biotechnol. Biochem., 72 (7), 1756-1763, 2008.

Takaoka, Masaki (2005a): (title of article) (in Japanese), Haikibutsu Gakkaishi, 16, 213-222, 2005.

Takaoka, Masaki (2005b): Control of Mercury in Waste-to-Energy Incinerators in Japan, paper presented at the China Workshop on Mercury Control from Coal Combustion, 2005, Beijing.

Takaoka, Masaki. (2001): Identification of Mercury Removal Mechanism by Fly Ash Layer in Flue Gas from Municipal Solid Waste Incineration [in Japanese].

UNEP. (2009): Report on Global Atmospheric Mercury Assessment: Sources, Emissions and Transport, http://www.chem.unep.ch/MERCURY/GC25/K0950102%20GC-25-INF26-Add1.pdf.

UNEP. (2008a): Technical Background Report to the Global Atmospheric Mercury Assessment, http://www.chem.unep.ch/mercury/Atmospheric_Emissions/Technical_background_report.pdf

UNEP. (2008b) Report presenting the costs and benefits for each of the strategic objectives (UNEP(DTIE)/Hg/OEWG.2/5/Add.1

UNEP. (2008c): UNEP (DTIE)/Hg/OEWG.2/7/Add.1 - Report on the major mercury-containing products and processes, their substitutes and experience in switching to mercury-free products and processes, http://www.unep.org/hazardoussubstances/Portals/9/Mercury/Documents/OEWG2/2_7_add_1.pdf

UNEP/SETAC. (2009): Life Cycle Management: How business uses it to decrease footprint, create opportunities and make value chains more sustainable, http://www.unep.fr/shared/publications/pdf/DTIx1208xPA-LifeCycleApproach-Howbusinessusesit.pdf

USEPA. (2008): Analysis of Mercury-Added Products and Substitutes, http://www.epa.gov/hpvis/rbp/RBP%20Support_Analysis%20of%20Mercury-Added%20Products%20and%20Substitutes_10.31.2008_FINAL.pdf