TASK 3: DEVELOPMENT OF AN ENVIRONMENTAL ASSESSMENT AND MANAGEMENT PLAN FOR LEBANESE HEALTHCARE FACILITIES PARTICIPATING IN CHILD PROJECT 1.1. SETTING THE GUIDELINES TO CARRY OUT COLLECTION, STORAGE AND DISPOSAL OF MEDICAL DEVICES CONTAINING MERCURY.

REPORT PREPARED FOR:

MedWaves

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Description	**This report provides the guidelines to be followed by Lebanese healthcare facilities and local experts to carry out collection and storage of medical devices containing mercury, ensuring the safe management of the hazardous waste and its disposal to authorized waste manager.**

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ACRONYMS

Acronym	Definition
ASGM	Artisanal and small-scale gold mining
EAMP	Environmental Assessment and Management Plan
GEF	Global Environment Facility
Hg	Mercury
HTTU	High Temperature Treatment Unit
MC	Minamata Convention
MMCU	Mobile Mercury Conversion Unit
MoE	Ministry of Environment
MoPH	Ministry of Public Health
PHC	Primary Healthcare Centre
PPE	Personal Protective Equipment
SCBA	Self-Contained Breathing Apparatus
UNPF	United Nations Population Fund
UNEP	United Nations Environmental Program
WHO	World Health Organization

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1. Introduction and objectives

The Centre of Regional Activity for Consumption and Sustainable Production, also named MedWaves, is an international cooperation centre for the development and innovation in the Mediterranean basin productive sector.

Since 2018 MedWaves forms part of the "*Mediterranean Sea Program (Medprogramme): Enhancing Environmental Security - GEF ID 9607*[1]", within its framework MedWaves is implementing the project "*Component 1.1 (Child Project or CP 1.1): Reducing Pollution from Harmful Chemicals and Wastes in Mediterranean Hotspots and Measuring Progress to Impact (GEF ID 9684)*"

The following report is encompassed in CP 1.1 Output 1.4 "*Development of pilot activities in Lebanon and Tunisia on new alternatives contributing to the reduction of mercury in the health sector*". This project aims to achieve the following objective:

- To advice Lebanon in the appropriate management of medical devices containing mercury by the preparation of the **Environmental Assessment and Management Plan (EAMP)** that should be implemented, as soon as possible, in all the hospital and medical centres present in Lebanon.

Within this broad scope, the objectives of Ramboll for this assignment are identifying and synthesizing the most updated guidelines and procedures published by the reference institutions such as the World Health Organization (WHO) and the United Nations Environmental Program (UNEP) regarding the collection and disposal of medical devices containing mercury at health care facilities, including the management of the mercury-contaminated waste generated in the process.

[1] Available in: https://www.thegef.org/

2. PROJECT BACKGROUND

2.1 General characteristics of mercury

Mercury is a naturally occurring heavy metal with significant health hazard which has been used since ancient times. It is a unique metal that is liquid at room temperature, it has a freezing point of -39 ºC and a boiling point of 357 ºC[2].

Mercury is released by volcanic eruptions, often in the form of mercury salts such as mercury sulphide and as a by-product in many human activities. Mercury compounds are used in chemical manufacturing, industrial processes and are contained in many consumer and industrial products, included those ones used as sanitary devices as thermometers and sphygmomanometers (blood pressure devices).

Due to its high surface tension and volatility, elemental mercury forms small drops when spilled and vaporizes rapidly into the air. Indoors, mercury spills become an inhalation hazard[3].

Mercury vapour, when inhaled, can affect the central nervous system and, depending on exposure levels, can impair cognition and in some cases cause death. Mercury is also harmful if absorbed through cuts and abrasions of the skin. Of even more concern in terms of public health is the toxicity produced when mercury emitted into the environment accumulates in lake, river, stream, and ocean sediments. There, anaerobic organisms digest and transform it into methyl mercury, a more toxic form of mercury which accumulates and becomes concentrated up the food chain in plankton, fish, birds, and mammals including humans. Methyl mercury is an organic compound of special concern for foetuses, infants, and children because extraordinarily low doses impair neurological development[4].

Target organs of elemental mercury vapour inhalation include lungs, kidney, and central nervous system. Symptoms of mercury poisoning include shortness of breath, dyspnoea, and cough with acute exposure; chronic exposure to lower doses generally leads to irritability, depression, tremors, and slurred speech.

Exposure to elemental mercury in health care settings from spills or broken equipment, such as mercury-containing fever thermometers and sphygmomanometers, is a serious health problem for employees, patients and visitors, as well as those tasked with repairing and cleaning up such broken equipment.

Furthermore, spilling of mercury and incineration of mercury-containing medical waste contributes to both indoor and outdoor emissions.

In 2007, a survey stated that in Buenos Aires more than 40.000 thermometers were lost per year, most to breakage, in their 33 public hospitals and 38 clinics[5]. The same study performed

[2] Available at: http://www.inchem.org/documents/icsc/icsc/eics0056.htm

[3] Agency for Toxic Substances and Disease Registry, (https://www.atsdr.cdc.gov/toxprofiles/tp46.pdf accessed 20 of October of 2022)

[4] Developing national strategies for phasing out mercury-containing thermometers and sphygmomanometers in health care, including in the context of the Minamata Convention on Mercury- Maria Neira, Director of the Department of Public Health, Environmental and Social Determinants of Health, WHO. 2015. Available at: https://fctc.who.int/publications/i/item/9789241508339

[5] Karliner, J. et al. Mercury free health care. World Medical Journal, 2008, 54(2):39-45.

another survey in Mexico detailing that the national paediatric teaching hospital broke an average of 385 thermometers per month.

In 1996, before a significant number of hospital-based incinerators were closed, the United States Environmental Protection Agency (US EPA) designated the burning of medical waste as the fourth largest mercury emission source in the United States[6].

2.2 Minamata Convention

The Minamata Convention on Mercury [7]– a global legally binding instrument to protect human health and environment from the adverse effects of mercury – entered into force on 16 August 2017. Countries that are Parties to the Convention are now legally bound to fulfil a range of mandatory measures such as banning new mercury mines; phasing out mercury-added products, including thermometers, batteries, light bulbs, etc.; and regulating the use of mercury in artisanal and small-scale gold mining (ASGM).

With the Convention's core objective "to protect human health and environment from anthropogenic emissions and releases of mercury and mercury compounds," it could be said that all of the Convention's 35 articles are "health-related articles". In response to the health-related issues or activities and articles of the Convention, the Sixty-seventh World Health Assembly adopted and approved resolution WHA67.11 (2014): *Public health impacts of exposure to mercury and mercury compounds: the role of World Health Organization (WHO) and ministries of public health in the implementation of the Minamata Convention*[8].

The resolution calls on Member States to address the public health aspects of mercury and mercury compounds in the context of the health sector by identifying measures and preparatory actions to be taken by their health ministries for implementation of the health-related articles of the Convention. The resolution also calls upon the WHO Secretariat to create tools, offer guidance, and provide training materials to support Member States in managing the public health impacts of mercury and mercury compounds.

2.3 Environmental impact of mercury-containing medical devices

Mercury is used in a variety of consumer, industrial and medical products and processes. Product examples are fluorescent light bulbs and batteries, medical devices (e.g., thermometers, blood pressure instruments), laboratory chemicals, pharmaceutical products, and various temperature and moisture measurement and sensing devices (barometers, hygrometers, flame sensors)[9].

Typical mercury thermometers contain 1 milligram (mg) of mercury, regarding fluorescent lamps they contain around 5 to 10 mg of mercury each. The mercury released by breaking only one sphygmomanometer or by breaking 100 thermometers is equivalent to the mercury released by breaking 10,000 fluorescent lamps. Since mercury from only one thermometer is

[6] Treatment technologies for mercury soil, waste, and water. Washington DC, United States Environmental Protection Agency Office of Superfund Remediation and Technology Innovation, 2007. Available at :https://www.epa.gov/sites/default/files/2015-08/documents/treat_tech_mercury_542r07003.pdf

[7] United Nations Environmental Program (UNEP). Minamata Convention. Available at: https://www.mercuryconvention.org/en

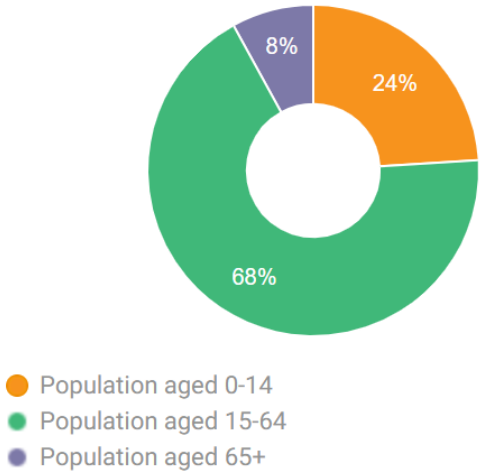
[8] Public health impacts of exposure to mercury and mercury compounds: the role of WHO and ministries of public health in the implementation of the Minamata Convention. Available at: https://apps.who.int/iris/handle/10665/162849

[9] Youth Round Table Society. 9-8-38, Opposite Aagman Hotel, Akab Bajaja, Faizabad (U.P.) 224001 India . Available at: https://ipen.org/sites/default/files/documents/YRT%20Mercury%20Use%20from%20Health%20Care%20System%20factsheet.pdf

enough to contaminate a 20-acre lake such that the fish would be unsafe to eat, a release involving several thermometers and sphygmomanometers could potentially be a grave environmental and public health problem[10].

2.4 Lebanese Health Sector

According to the United Nations Population Fund (UNPF) on 2022 Lebanon has a population of 6.7 million people distributed in the following age groups[11]:



In May 2018 the Ministry of Public Health (MOPH) published the "Lebanon Health Resilience Project" stating the number of public health care facilities in Lebanon:

- 33 public hospitals
- 213 Primary Healthcare Centres

The list of public hospitals that have been targeted in the project are listed in Annex I.

On the other hand, a survey conducted by the Syndicate of Private Hospitals in 2011 stated that the number of private hospitals in Lebanon is[12]:

- 116 private hospitals

The private health sector is very relevant in Lebanon and despite it is not involved in the replacement program of medical devices containing mercury it should be informed about the upcoming restriction on the use of medical devices containing mercury and the raising awareness material about mercury hazards and mercury waste management.

2.4.1 Use of Mercury in Lebanese Health Sector

[10] The Mercury Problem: Fast Facts in Going Green: A Resource Kit for Pollution Prevention in Health Care, Health Care Without Harm, Washington, DC, 2002.

[11] Data obtained from the World Population Dashboard (United Nations Population Fund). Available at: https://www.unfpa.org/data/world-population/LB

[12] National Health Statistics Report in Lebanon. Prepared by the Institute of Health Management and Social Protection (IGSPS) at Saint-Joseph University and coordinated by Dr. Michèle Kosremelli Asmar with the technical support of the WHO office in Beirut and the Lebanese Ministry of Public Health and the financial assistance of the WHO office in Beirut. Available at: 175_pdf_1.pdf (usj.edu.lb)

IndyACT, an environmental NGO based in Lebanon that forms part of the International Pollutants Elimination Network, published the report "Mercury Use in Lebanon"[13] that studied the current use of mercury in Lebanese hospitals.

The study concluded that around 84 % of the surveyed hospitals are still using mercury containing products, mainly mercury containing thermometers and sphygmomanometers, 35% of the surveyed hospitals still used gastrointestinal tubes containing mercury and 18% used barometer containing mercury. In addition, most hospitals informed that are aware of the health risks associated with the use of mercury and have mercury spill clean-up and disposal policies and procedures. Only 17% are ready to become mercury-free without financial assistance, while 67% showed interest in phasing out mercury in the presence of financial assistance.

2.5 Waste management in Lebanese health sector

Integral Waste Management or simply Waste Management is the process that encompasses the activities necessary to deal with waste, such as material that loses its usefulness after having fulfilled its mission or service for which it was produced.

Waste management begins with its collection, its transport to the prepared facilities and its intermediate or final treatment. This treatment can be the use or reuse of the waste material or its elimination.

Lebanese Government Decree 13389/2004 regulates healthcare waste. It defines the type of healthcare wastes; it requires proper waste segregation and minimization, and it sets guidelines for the collection and storage of waste. Healthcare wastes are divided into 4 categories:

1. Non-hazardous waste
2. Hazardous waste (include infectious and non-infectious)
3. Special waste (include pharmaceuticals, **chemical waste**, cytotoxic and pathological
4. Radioactive waste

Mercury containing medical devices and the elemental mercury collected in case of breakdown of thermometers are considered chemical waste.

The Ministry of Environment (MoE) is the regulatory body in charge of regulating the waste management in Lebanon and issuing the list of authorized companies allowed to transport and process hazardous waste.

At this moment the project team is still pending to confirm the list of companies authorized by the MoE to transport and manage waste from healthcare facilities. Both lists should be added as Annex III and Annex III of this report.

[13] Report "Mercury Use in Lebanon" performed by IndyACT. Available at: https://ipen.org/documents/mercury-use-lebanon

3. Environmental Assessment and Management Plan for mercury in medical devices in Lebanon

3.1 Scope

The Environmental Assessment and Management Plan (EAMP) provides the guidelines and procedure that must be implemented to manage the collection, storage, and disposal of the mercury containing thermometers and sphygmomanometers of the health care facilities chosen to participate in Child Project 1.1 (listed in Annex I).

The EAMP is based on World Health Organization (WHO) and the United Nations Environmental Program (UNEP) guidelines related to mercury waste management at health care facilities, setting high standards to ensure personal and environmental protection. The EAMP is complementary to the current legal requirements established by the Lebanese authorities. The health care facilities involved in the project should integrate the EAMP in their internal procedures within their means.

3.2 Technical guidelines for the collection and storage of mercury containing medical devices

Health care facilities shall implement a phased plan to upgrade mercury management, implementing procedures to manage the dealings depicted below[14]:

- Clean-up of mercury spills
- Temporary on-site storage of mercury containing waste at health care facilities
- Packaging, labelling and off-site transport of mercury containing waste

Healthcare facilities must be prepared for accidental spills in any area of the hospital where mercury-containing devices are used. Thus, appropriate spill kit for any size of mercury spills must be available, and a clean-up procedure must be implemented. The procedure must be written and be easily available to workers both in paper and digital.

Also, a responsible person with the appropriate training in workers safety and hazard prevention must be nominated to control and register workers training.

3.2.1 Spill kit

Mercury spill kits are commercialized and can be purchased, but in case they are not available a spill kit can be made compiling the following items and placing them in a marked container.

- **Personal protective equipment:**
    - Rubber or nitrile gloves.
    - Safety googles.
    - Respiratory protection:

[14] Source: GUIDANCE ON THE CLEANUP, TEMPORARY OR INTERMEDIATE STORAGE, AND TRANSPORT OF MERCURY WASTE FROM HEALTHCARE FACILITIES. United Nations Development Programme, GEF Global healthcare Waste Project. Available at: https://noharm-global.org/documents/guidance-cleanup-temporary-or-intermediate-storage-and-transport-mercury-waste-healthcare

        - Full or half face mask, tightly sealing and provided with an air-purifying respirator with mercury cartridges. Alternatively:
            - Tightly sealing face mask with sulphur or iodide impregnated activated carbon.
            - Tightly sealing face mask made of sandwiched activated charcoal-impregnated cloth.
            - Other specialty mask or respirator designed particularly for mercury.
            - If none of the masks stated above are available, a face mask with a 0.3-micron HEPA filter to capture amalgam particles and mercury-laden dust.
    - Coveralls, apron, and other protective clothing.
    - Disposable shoe covers.

- **Containers:**

    - Air-tight, sealable plastic bags (small and large sizes, thickness: 50 to 150 microns)
    - Small, air-tight, rigid plastic container with some water or vapor suppression agent for collecting elemental mercury.
    - Air-tight, puncture-resistant, rigid plastic or steel jar or container with a wide opening for collecting mercury-contaminated broken glass.
    - Disposable plastic tray.
    - Regular plastic waste bags (thickness: 50 to 150 microns).

- **Tools for removing mercury:**

    - Flashlight (electric torch) to locate shiny mercury beads
    - Plastic-coated playing cards or thin pieces of plastic to push mercury beads into a plastic scoop or pan; if these are not available, use index cards, pieces of cardboard, or stiff paper.
    - Small plastic scoop or plastic dustpan to catch the mercury beads.
    - Disposable tweezers to remove small broken glass pieces.
    - Eyedropper or syringe (without the needle) to draw up large mercury beads.
    - Duct tape or sticky tape to pick up tiny mercury droplets.
    - Vapor suppression agents:
        - Sulphur powder (available from pharmacies) to absorb mercury by forming mercuric sulphide.
        - Zinc or copper flakes (available from hardware stores) to absorb mercury by forming amalgams.
        - Commercial absorbent pads or vapor suppressants.
            - An example of a dry vapor suppressant is the Mercon™ Tainer[15] (Ross Healthcare) which contains a foam pad saturated with a suspension containing small amounts of sodium thiosulfate, copper sulphate, calcium chloride, and potassium iodide. Small quantities of X-ray fixer (which contains thiosulfate) or a propylene glycol solution of sodium thiosulfate and copper sulphate have also been used as vapor suppression agents

[15] Available at: https://www.grainger.ca/en/product/REFILL-MERCONTAINER-IND-/p/EPSMERCONTAINER

        - Disposable brush to remove powder or flakes.
    - Utility knife blade.

- **Materials for decontamination:**

    - Vinegar, hydrogen peroxide, and cotton swabs for final cleaning when using sulphur powder.
    - Decontaminant solution or commercial decontaminant.
        - Decontamination solutions can be made of sodium thiosulfate solution (photographic fixer); or a mixture of sodium thiosulfate and EDTA. Examples of commercially available decontaminant solutions are Spilfyter® Decon Solutions, HgX[16]® Mercury Decontaminant Solution[17] (Acton Technology), and Mercon™ Wipes[18] (Ross Healthcare). Mercon™ uses a mixture of about 0.01% by weight iodine, 0.13% copper sulfate, 0.15% ferric chloride, 1.3% ammonium chloride, and 15% isopropanol and varying amounts of propylene glycol.

Spill kits stock must be sufficient to manage the average number of accidental spills in each health care facility and must be immediately replaced when used. A minimum stock of 10 spill kits for clinics, 30 spill kits for medium hospitals, and 60 spill kits for large hospital is proposed.

3.2.2 Clean-up procedure for mercury spills

Each healthcare facility shall implement the procedure presented in Table 1**,** according to their capabilities, maximizing the protection for their patients and workers.

Table 1. Clean-up procedure for mercury spills.

Clean-up procedure for mercury spills
Step 1 - Determine the extent of the spill
Determine on what surfaces the mercury was spilled and how far the mercury beads have been dispersed. This is denominated as the "**contaminated area**".
Step 2 – Immediately block off foot traffic and evacuate the area
Ask everyone to leave the room or the general area, giving priority to pregnant women and children. Do not allow anyone to walk across the contaminated site or to go near areas where the mercury has travelled. If the extent of a small spill is not immediately obvious, block off traffic for a radius of about **2 meters around the centre of the spill**. Prevent access to the area by putting up signs and, if necessary, seeking help from other staff persons, and then leave the area to prepare for clean-up.
Step 3 – Check people health state
Check to see if anyone's skin, shoes or clothing was splashed with mercury. If shoes or parts of clothing were contaminated, they should be removed and left around the spill area before allowing the person to leave. Skin that was in contact with mercury should be washed with an alkaline soap. Seek **assistance to provide first-aid** to anyone requiring immediate medical attention.
Step 4 – Contain the spill, minimize the spread of vapours to interior areas

[16] Available at: https://liquidsafety.com/us/products/893

[17] Available at: https://www.intertek.com/testing/environmental/mercury-decontamination-solutions/

[18] Available at: https://www.grainger.com/product/MERCON-Mercury-Wipes-Mercury-Wipes-3KWN9

Close all interior doors that lead to other indoor areas. Turn off central ventilation, heating or air conditioning systems that circulate air from the spill site to other inside areas of the building. After making sure that windows and exterior doors open to outside areas that are free of people, open the windows and exterior doors to **dilute the vapor concentrations in the room**.

Step 5 – Reduce vapor concentrations in the spill area if possible

If mercury was spilled over a drain, sink or wash basin, work with the facility engineer to remove and replace the "J", "U" or "S" trap -see detailed pictures on pipes connections below-.

Put a sheet of plastic or a plastic tray under the work area to catch any mercury that might spill out. Hold the old trap over a tray while transferring the mercury to the **air-tight container**. Dispose of the old trap as hazardous waste.

Step 6 –Clean-up procedure

Change to old clothes if possible. Remove jewellery, watch, mobile phones, and other metal containing items. Get the mercury spill kit.

Put on personal protective equipment (PPE). Put on the apron or coveralls, disposable shoe covers, rubber or nitrile gloves, goggles, and respiratory protection before re-entering the spill site. Make sure metal items such as eyeglass frames are covered by PPE.

Remove visible mercury beads and broken glass. Starting from the outside of the spill site and moving towards the centre, carefully remove visible mercury beads and broken glass. Use tweezers to remove broken glass pieces and place them in the jar or wide-mouthed container over the tray. Using a playing card or piece of plastic, slide the mercury beads onto the plastic dustpan or scoop, and away from any carpet or porous surface. Use a **slow, short, sweeping motion to prevent spreading mercury** droplets. Carefully place the mercury beads into the plastic container partially filled with water or vapor suppression agent. Do this over the tray to catch any spillage. You can also use an eyedropper or syringe for small beads.

Search for and remove tiny mercury droplets and glass pieces by shining the flashlight at different low angles to the floor and looking for reflections from the shiny droplets and glass. For very tiny droplets, it may be easier to pick them up using sticky tape but be careful since they may not always stick. Place the sticky tape in the sealable plastic bag.

Clean-up cracks and hard surfaces, sprinkle sulphur powder on cracks and crevices, and on hard surfaces (tile, linoleum, wood, etc.) that had come in contact with mercury; a colour change in the powder from yellow to reddish brown indicates that mercury is still present, and more clean-up is needed. If so, sprinkle zinc flakes or copper flakes to amalgamate any residual mercury. Use the brush or small broom to remove the powder and/or the metal flakes and place them in the sealable plastic bag. An alternative way to clean hard surfaces after adding sulphur powder is to wipe them with vinegar-soaked cotton swabs, followed by peroxide-soaked swabs. Place the swabs in a sealable plastic bag.

Step 7 – Remove contaminated materials

Carpets, carpet padding, upholstery, curtains, rugs, bedding, and other soft materials cannot be cleaned easily. Use the utility knife to cut out pieces of carpet, padding, and other soft materials that are contaminated with mercury. Place the contaminated materials in a sealable plastic bag.

Dispose of or decontaminate clean-up material. Place all contaminated materials used during the clean-up (including cards, plastic pieces, cardboard, paper, rags, cotton swabs, paper towels, sticky tape, piece of soap, brush, or broom) into a leakproof, sealable plastic bag. Other items (tweezers, plastic scoop, tray, eyedropper, utility knife, etc.) should either be disposed with the contaminated items in the sealable plastic bag or cleaned thoroughly with the commercially available mercury decontaminant solution (commercially available), alternatively thiosulfate solution (photographic fixer); or a mixture of sodium thiosulfate and EDTA can be used.

Label and seal all contaminated material. Ensure that the air-tight jar and container are filled with enough water to cover the elemental mercury and broken glassware, close the jar and container tightly, label, and place each in a re-sealable plastic bag. The jar and container should be stored safely for future use. Place all sealed plastic bags with

mercury-contaminated waste inside a second plastic bag, seal the outer bag using duct tape, and affix a label ("Mercury: Hazardous waste" or as directed by local authorities) and include a brief description of the contents. The mercury waste can be stored temporarily on site (see next section).
Remove and dispose or decontaminate PPE. Remove PPE beginning with the shoe covers which should be placed in another sealable bag. Then remove the gloves by grasping one glove with the other, peeling off the first glove, sliding the fingers under the remaining glove at the wrist, peeling off the second glove, and discarding both gloves in the sealable plastic bag. Next, remove the goggles by the head band or earpieces. Remove the apron or coverall without touching the front and turn inside out. Finally, remove the face mask or respirator without touching the front. Dispose of the gloves, shoe covers, apron (and regular face mask if used in lieu of a specialty mask) in the sealable plastic bag, which should be stored along with the mercury waste. Decontaminate goggles and respirators or specialty face mask using the decontaminant solution.
Step 9 – Hygiene measures to renewal the area
Wash hands and all exposed skin. Use alkaline soap and water to scrub all exposed skin and rinse thoroughly.
Ventilate the spill area. Place a fan next to the spill area to volatilize mercury and a second fan in a window or doorway to move air to the outside air for **48 hours or more**. If this is not possible due to central heating or air conditioning, increase the air exchange rate for the building for several days to reduce any mercury vapor concentrations. *NOTE: If more than the amount in one thermometer was spilled on a wood floor or other porous material, use heaters to heat the room to about 30º C while blowing the air to the outside using a fan or blower for at least 48 hours. Treating the porous flooring with a sealant is an added safety option.*
Step 10 – Communication with Occupational Health Unit
Write a report on the spill incident. The report can be used to improve safety in the facility.

3.2.3 Medical monitoring

If the spill resulted in acute exposure to a patient or health worker, conduct blood and urine tests, provide support for respiratory and cardiovascular function and, if necessary, initiate chelation therapy if the person is symptomatic of acute mercury poisoning.

3.2.4 Instruments and/or procedures to be avoided

- **Do not use a vacuum cleaner** to pick up the mercury and mercury-contaminated items. The mercury will become airborne by way of the vacuum's exhaust and spread the contamination. Moreover, the vacuum cleaner will become contaminated and would have to be disposed as hazardous waste.

- **Do not wash mercury-contaminated clothing, rugs, or other fabrics in a washing machine**. The washing machine and wastewater may become contaminated. Treat contaminated clothing as solid waste contaminated with mercury and dispose them properly.

- **Do not use a broom** to sweep up the mercury. It can break the mercury into smaller beads, spreading them.

- **Do not pour mercury down the drain**, as doing that you may contaminate your plumbing, septic system, or your local sewage treatment plant.

- **Do not spread mercury that has gotten onto your shoes**, if possible, clean the shoes with the decontaminant solution. If the shoes cannot be decontaminated, wrap them in a plastic bag and dispose of them properly.

3.2.5 Guidelines for temporary on-site storage of mercury containing waste at health care facilities

These guidelines relate to the design of the spaces and procedures associated to temporary on-site storage of mercury devices, mercury-contaminated waste, and elemental mercury at healthcare facilities[19], main topics are depicted in Figure 1.

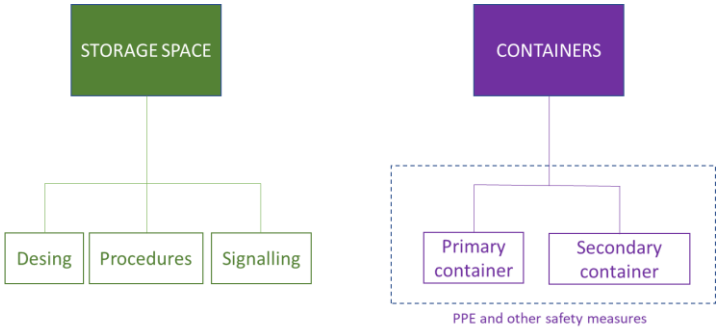


Figure 1. Storage space and containers requirements.

3.2.5.1 Design requirements

Figure 2 presents the required conditions for the space.

[19] Based on various sources including: "Technical Guidelines for the Environmentally Sound Management of Waste consisting of Elemental Mercury and Wastes Containing or Contaminated with Mercury," 5th Draft, Secretariat of the Basel Convention, Geneva, May 14, 2010; "Municipal Collections of Mercury," J. Alphin, South Central Recycling Association of Massachusetts; Chemical Control Order for Mercury and Mercury Compounds DENR No. 97-38, Philippine Department of Environment and Natural Resources, December 23, 1997.

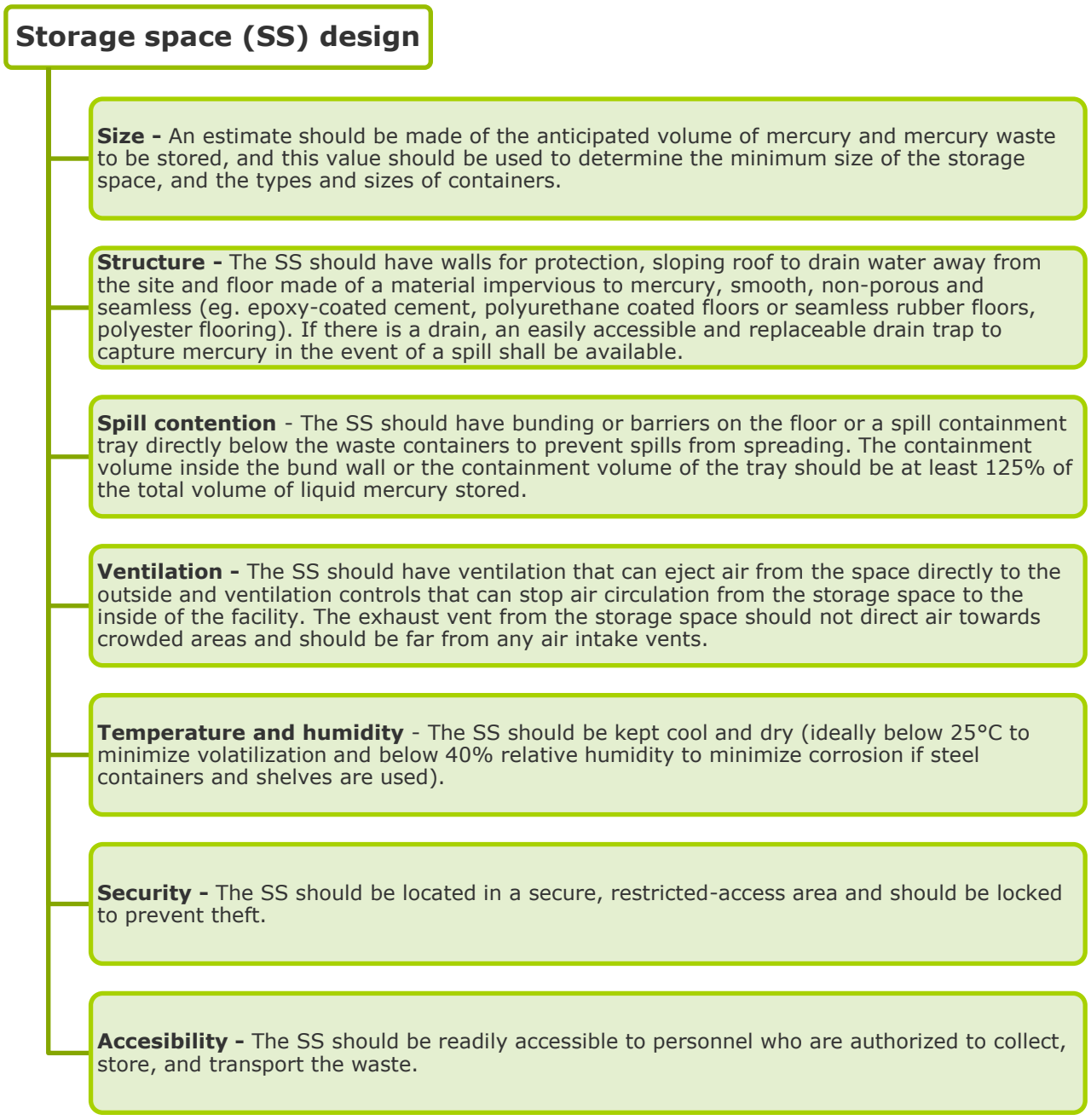


Figure 2. Design requirements for the storage of mercury containing wastes.

3.2.5.2 Procedures to be implemented

Figure 3 presents the required conditions for the space.

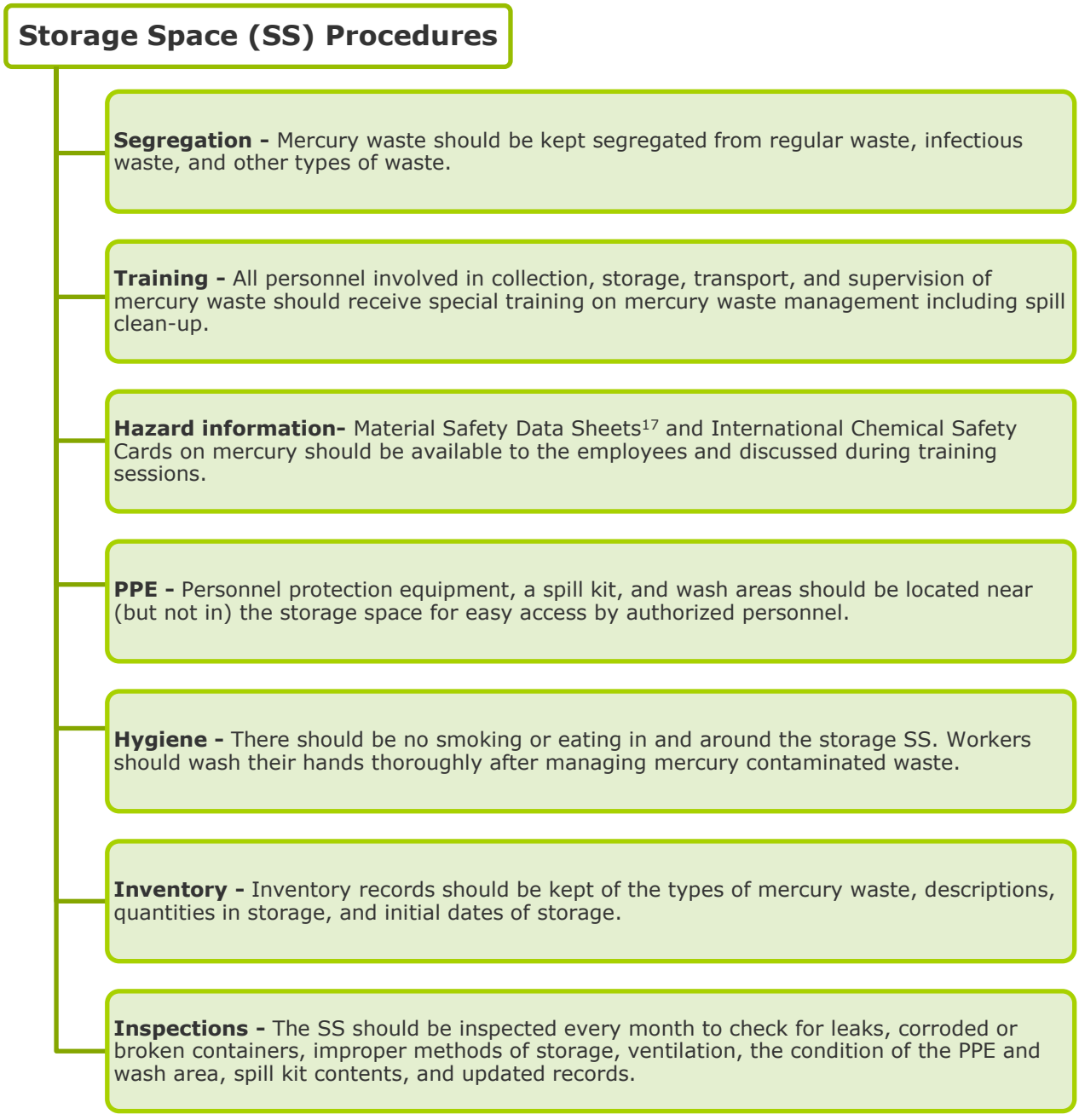


Figure 3. Procedures to be implemented in the storage space.

[20] Available at: https://fscimage.fishersci.com/msds/14020.htm
[21] Available at: http://www.inchem.org/documents/icsc/icsc/eics0056.htm

3.2.5.3 Requirements for labelling and signalling

Figure 4 presents the required signalling for the storing space.

Storage Space (SS) Signaling

Entrance and exit- The entrance and exit doors of the SS should be marked with warning signs, such as "Danger: Hazardous Mercury Waste" and the skull and crossbones symbol for toxic or poisonous waste.

Containers - The waste containers should be labelled "Hazardous Mercury Waste" along with a description of the contents and the initial date of storage and the hazards labelling for mercury according to United Nations Globally Harmonized System *see Figure 4, Hazards labelling for mercury according to United Nations Globally Harmonized System*.

Figure 4. Mandatory signalling for the storage space.

May be corrosive to metals
Fatal if inhaled
May damage fertility or the unborn child
Causes damage to central nervous system and kidneys
Causes damage to the central nervous system and the kidneys through prolonged or repeated exposure
Very toxic to aquatic life with long lasting effects

Transportation
UN Classification
UN Hazard Class: 8; UN Subsidiary Risks: 6.1; UN Pack Group: III

Figure 5. Hazards labelling for mercury according to United Nations Globally Harmonized System.

3.2.5.4 Requirements for the storage of elemental mercury

Table 2 presents the minimum requirements that should be addressed when choosing a container to store mercury containing wastes and the safety measures that workers should adopt to manipulate elemental mercury.

Table 2. Requirements for the containers containing mercury waste.

Storage of Elemental Mercury
Primary container characteristics
1. Easy to open and re-seal. 2. Leak-proof and airtight. 3. Made of a material: - resistant to mercury at room temperature - resistant to corrosion - not brittle 4. Small enough such that the weight of mercury is not too heavy to lift (a typical ergonomic weight limit is 23.5 kg). 5. Small enough such that the weight of mercury does not exceed the strength of the container.
Safety Measures
A **vapor suppression agent** or water should be added to the primary container to protect workers when adding more mercury. **PPE for workers** managing elemental mercury waste: a) Rubber or nitrile gloves. b) Safety googles. c) Respiratory protection. d) Coveralls, apron, and other protective clothing. e) Disposable shoe cover. **The primary container shall be marked** with the type of mercury waste ("Elemental Mercury") and the date mercury was first place Is recommended to provide a **secondary container** that further prevents the release of mercury vapor. If the marking of the primary container cannot be seen, a label must be placed outside the secondary container. Containers should be on top of a **spill-control tray or plastic pan** with a containment volume exceeding the total volume of the container.

3.2.5.5 Requirements for the storage of medical devices and mercury wastes

Table 3 presents the requirements for containers for storage of waste medical devices containing mercury, as well as the safety measures that workers should adopt to manipulate medical devices wastes containing mercury. Please note the slight differences with the previous table.

Table 3. Requirements for the containers for medical devices containing mercury and mercury wastes.

Storage of Medical Devices
Primary container characteristics
1. Easy to open and re-seal. 2. Leak-proof and airtight. 3. Made of a material: - resistant to mercury at room temperature - resistant to corrosion - not brittle 4. **Puncture-resistant** unless the medical devices are placed in their original portable cases or individual boxes used during shipment.
Safety Measures
Since unbroken mercury devices (e.g., thermometers and sphygmomanometers) are fragile, they should be stored in a manner that reduces the chance of breakage. **PPE for workers** managing medical devices containing mercury: a) Rubber or nitrile gloves. b) Safety googles. c) Respiratory protection. d) Coveralls, apron, and other protective clothing. e) Disposable shoe cover.

The primary container shall be marked with the type of mercury device, the quantities inside the container, the initial date of storage, and any additional description if necessary.

Is recommended to provide a **secondary container** that further prevents the release of mercury vapor. If the marking of the primary container cannot be seen, a label must be placed outside the secondary container.

3.2.6 Guidelines for the packaging, labelling and off-site transport of mercury containing waste at health care facilities

The general guidelines relating to the packaging, labelling and off-site transport of mercury devices, mercury-contaminated waste, and elemental mercury at healthcare facilities[22] are explained below.

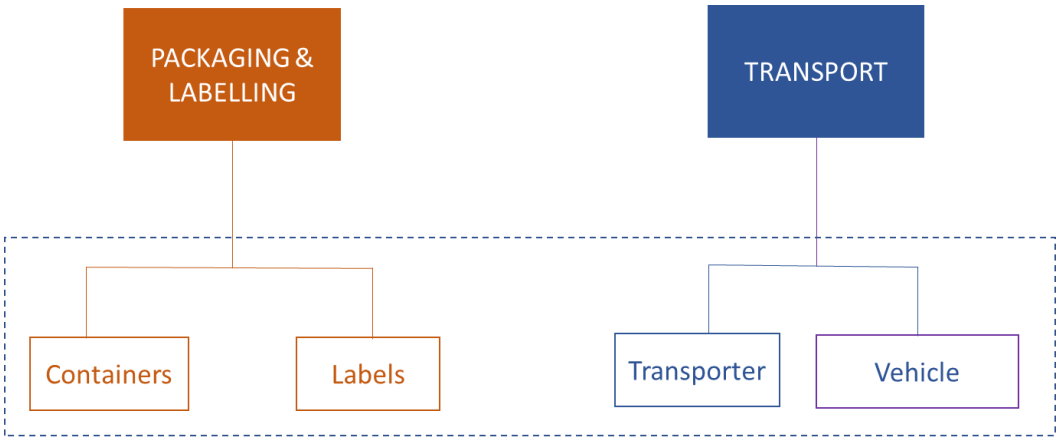


Figure 6. Main items associated with packaging, labelling and transport of mercury-containing waste

3.2.6.1 Requirements for the packaging and labelling of mercury waste to be transported

Table 4 presents the packaging and labelling requirements when mercury-containing wastes need to be transported.

Table 4. Requirements for packaging, labelling and off-site transport of mercury wastes.

Packaging and labelling of mercury waste to be transported
Packaging requirements for transporting mercury waste
The transport container must be: 1. Structurally sound. 2. Made of a mercury resistant material.

[22] The guidelines in this section are based on various sources: "Storing, Transporting and Disposing of Mercury," U.S. Environmental Protection Agency, updated February 22, 2022. Available at: http://www.epa.gov/hg/spills/ ; "Technical Guidelines for the Environmentally Sound Management of Waste consisting of Elemental Mercury and Wastes Containing or Contaminated with Mercury," 5th Draft, Secretariat of the Basel Convention, Geneva, May 14, 2010; "Dangerous Goods Emergency Action Code List 2009," National Chemical Emergency Centre, AEA Technology, UK, 2009; "UN Recommendations on the Transport of Dangerous Goods - Model Regulations," Fifteenth revised edition, United Nations, 2007; "Management of Mercury Containing Equipment," Publication WA 1004-2006, Wisconsin Department of Natural Resources, 2006; "Municipal Collections of Mercury," J. Alphin, South Central Recycling Association of Massachusetts; "Mercury-Containing Lamp Waste Management: A Management Guidebook," Innogy Solutions, prepared for UNDP GEF, Philippine Efficient Lighting Market Transformation Project and Environmental Management Bureau; Chemical Control Order for Mercury and Mercury Compounds DENR No. 97-38, Philippine Department of Environment and Natural Resources, December 23, 1997.

3. Airtight and leak proof.
4. Certified as "Packing Group iii" according to the United Nations requirements for the transport of dangerous goods under class 6 (Toxic substances).

The mercury waste should be packed carefully with packing material such as plastic bubble wrap or plastic packing foam to prevent breakage inside the container. Other packing options include bentonite clay (sold as commercial cat litter and found in Fuller's earth), kaolinite (sold for medicinal use, paper production, and farming), and vermiculite (used by gardeners as a soil conditioner, in packaging, and as insulation). These clay minerals can absorb mercury and act as a barrier to prevent spreading[23]. Commercial mercury absorbent products can also be used.

Labelling requirement for transporting mercury waste

The label should include:

1. "Hazardous Mercury Waste"
2. Special handling procedures, if necessary.
3. Emergency contact numbers.
4. Name and contact information of the generator.
5. Hazards labelling for mercury according to United Nations Globally Harmonized System as shown in Figure 5.
6. The United Nations transport pictograms. Mercury compounds are generally categorized under Class 6.1 (toxic substances) (and elemental mercury (UN number 2809) (Figure 7) under Class 8 (corrosive substances) (Figure 8).

Figure 7. UN Transport Pictogram - 6

Figure 8. UN Transport Pictogram - 8

3.2.6.2 Requirements for the transport of mercury-containing waste at health care facilities

Table 5 presents the transport requirements when mercury wastes need to be transported.

Table 5. Requirements for the transport of mercury waste.

Requirements for the transport of mercury waste
Requirements for the transporter of mercury waste
The transporter **must be authorized to manage dangerous waste by the Ministry of Environment**. The transporter should have a **routing plan, emergency response or contingency plan**, and **emergency phone numbers** before transporting mercury waste. The transporter should also have **a spill kit** (as described in section 3.2.1 Spill kit)**, PPE** (as described in section 3.2.1.1 Spill kit)**, first-aid kit, fire extinguisher, labels, and extra containers** in the passenger compartment **for use in case of a spill**. It is recommended that the transporter undergoes **specific training for mercury waste,** that could include **legal obligations, planning, routing, handling, visual inspection, packaging, labelling, loading/unloading, securing, placarding, manifest or consignment forms, occupational safety, hazard recognition, hazard mitigation** (including ways to minimize the possibility and the consequences of accidents), **use of PPE, spill response planning, use of spill kits, emergency procedures, and accident reporting**.
Requirements for the vehicle used to transport mercury waste[24]
1. It should be a **closed vehicle**.

[23] "Efficiency of industrial minerals on the removal of mercury species from liquid effluents," R. Melamed and A.B. da Luz, Science of The Total Environment 368 (1), 403-406, September 2006; "Mercury adsorption by montmorillonite and vermiculite: a combined XRD, TG-MS, and EXAFS study," M.F. Brigatti et al., Applied Clay Science 28 (1-4),1-8, January 2005; "Feasibility of compacted bentonite barriers in geological disposal of mercury-containing waste," R. Sjöbloma et al., Applied Clay Science 23 (1-4), 187-193, August 2003.

[24] Adapted from Safe management of wastes from health-care activities, 2nd Edition. World Health Organization. June 12, 2014. Available at: Safe management of wastes from health-care activities, 2nd ed. (who.int)

2. The body of the vehicle should be of a suitable size commensurate with the design of the vehicle and the load to be transported.
3. There should be a **bulkhead between the driver's cabin and the vehicle body**, which is designed to retain the load if the vehicle is involved in a collision.
4. There should be a suitable **system for securing the load during transport**.
5. Empty air-tight containers, plastic bags, PPE, spill kits, cleaning equipment, and decontaminating agents should be carried in a separate compartment in the vehicle.
6. The registered vehicle should be **marked with the name and address of the waste carrier**.
7. The licensed transporter should have appropriate **warning signs and placards** displayed on the registered vehicle in accordance with the **United Nations pictograms for the transport of Dangerous Goods**. Mercury compounds are generally categorized under Class 6.1 (toxic substances) and elemental mercury (UN number 2809) under Class 8 (corrosive substances) (see previous Figure 7 and Figure 8).

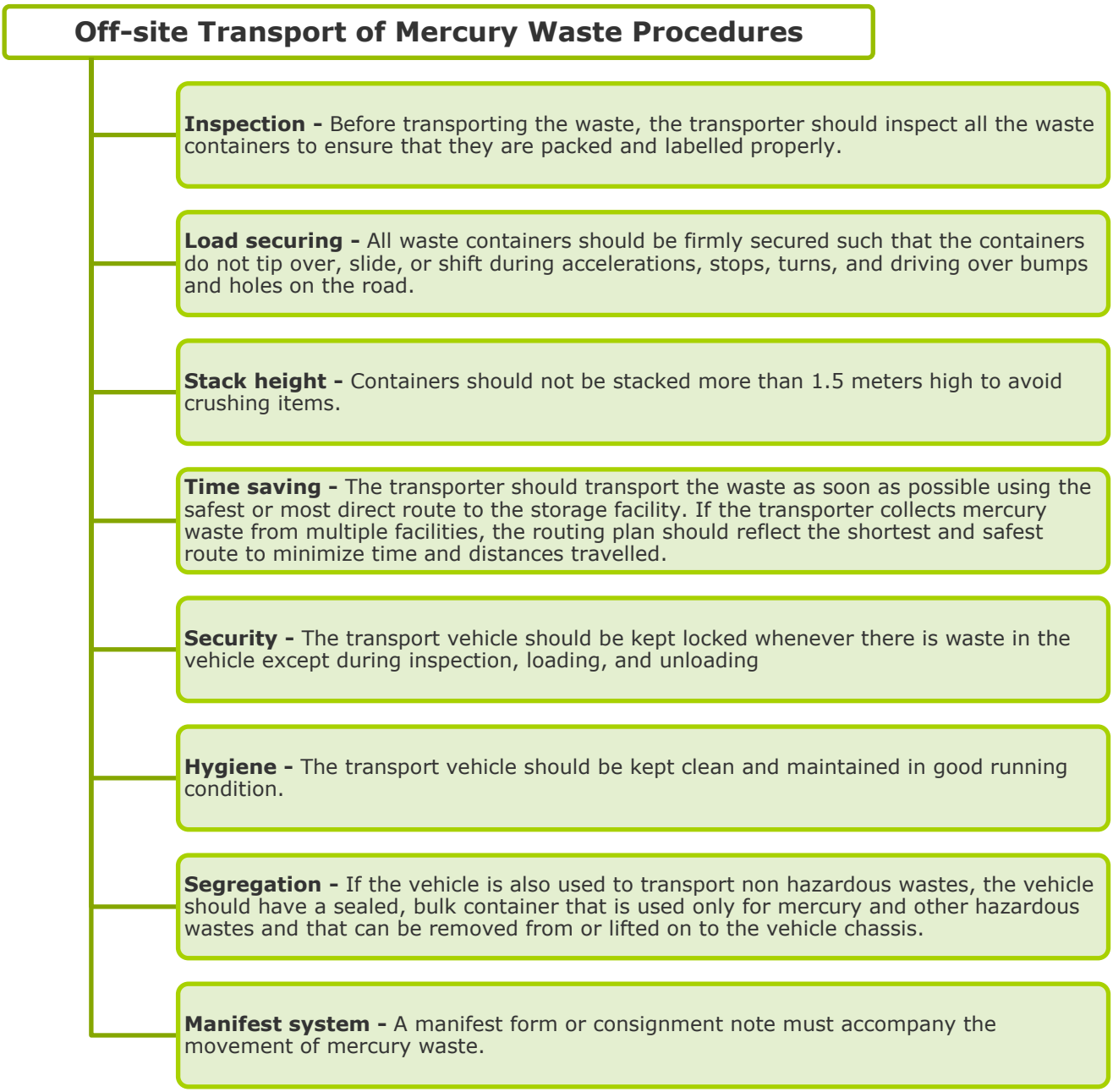


Figure 9. Procedures for mercury wastes transported off-site.

The manifest or consignment note should identify the source of the waste, the transporter, the storage facility, and the relevant government authority (MoE).

The waste generator, transporter, and storage facility should each have copies of the manifest or consignment note. Each copy should contain the signatures of the persons handling the waste from the generator to the storage facility, as well as the names of the responsible persons representing the waste generator, transporter, and storage facility. Copies of the manifest or consignment note should be kept by the waste generator, transporter, and storage facility.

The waste generator should keep a copy of the manifest or consignment note for at least five years from the date of shipment. The licensed transporter should keep a copy of the manifest and other records of each shipment for at least five years from the date of shipment, and these records may be made available to the MoE.

3.2.7 Guidelines for intermediate storage of mercury contaminated waste at a central facility

These general guidelines[25] relate to a centralized facility that will be used for intermediate storage, i.e., until such time as long-term storage (terminal storage) or mercury treatment and disposal facilities become available in Lebanon.

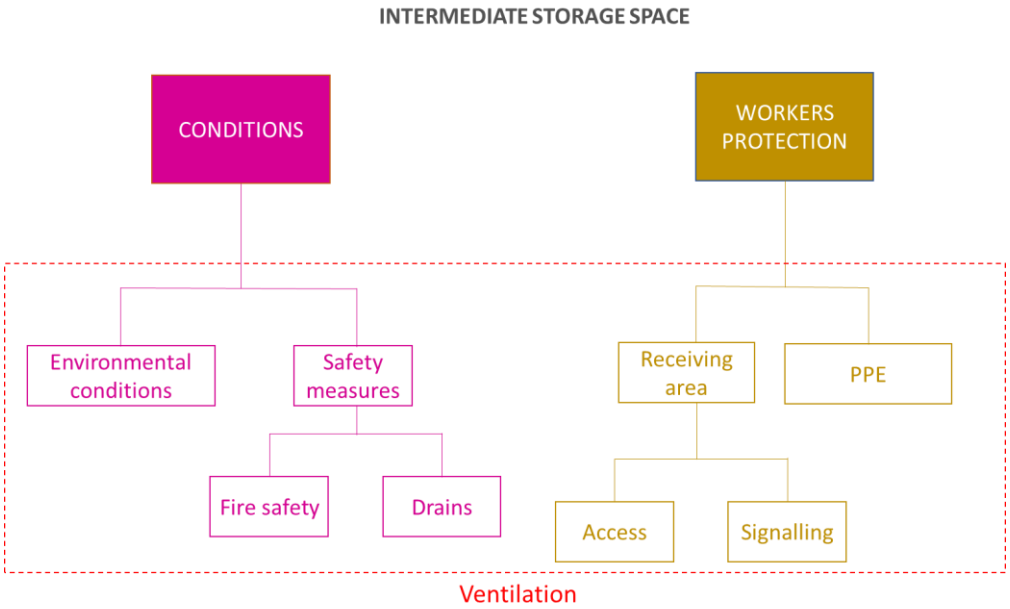


Figure 10. Intermediate Storage Space requirements.

[25] The guidelines are based on several sources. "Technical Guidelines for the Environmentally Sound Management of Waste consisting of Elemental Mercury and Wastes Containing or Contaminated with Mercury," 5th Draft, Secretariat of the Basel Convention, Geneva, May 14, 2010; "Development of Options Analysis and Pre-Feasibility Study for the Long Term Storage of Mercury in Asia and the Pacific," (Draft Report), March 18, 2010; "U.S. Department of Energy Interim Guidance on Packaging, Transportation, Receipt, Management, and Long-Term Storage of Elemental Mercury," Oak Ridge National Laboratory, prepared for the U.S. Department of Energy, Washington, DC, November 13, 2009; "Terminal Storage Options of Mercury Wastes in the Philippines," Ban Toxics!, March 31, 2009; "Meeting DNSC's Mercury Challenge," Defense National Stockpile Center, Defense Logistics Agency, June 14, 2007; "Mercury flows and safe storage of surplus mercury," Concorde East/West Sprl, prepared for European Commission Directorage General for Environment, Brussels, August 2006; "Mercury Stewardship Storage of Mercury," Quicksilver Caucus, October 2003; "Preliminary Analysis of Alternatives for the Long Term Management of Excess Mercury," EPA/600/R-03/048, U.S. Environmental Protection Agency, August 2002.

3.2.7.1 General requirements for the intermediate storage space

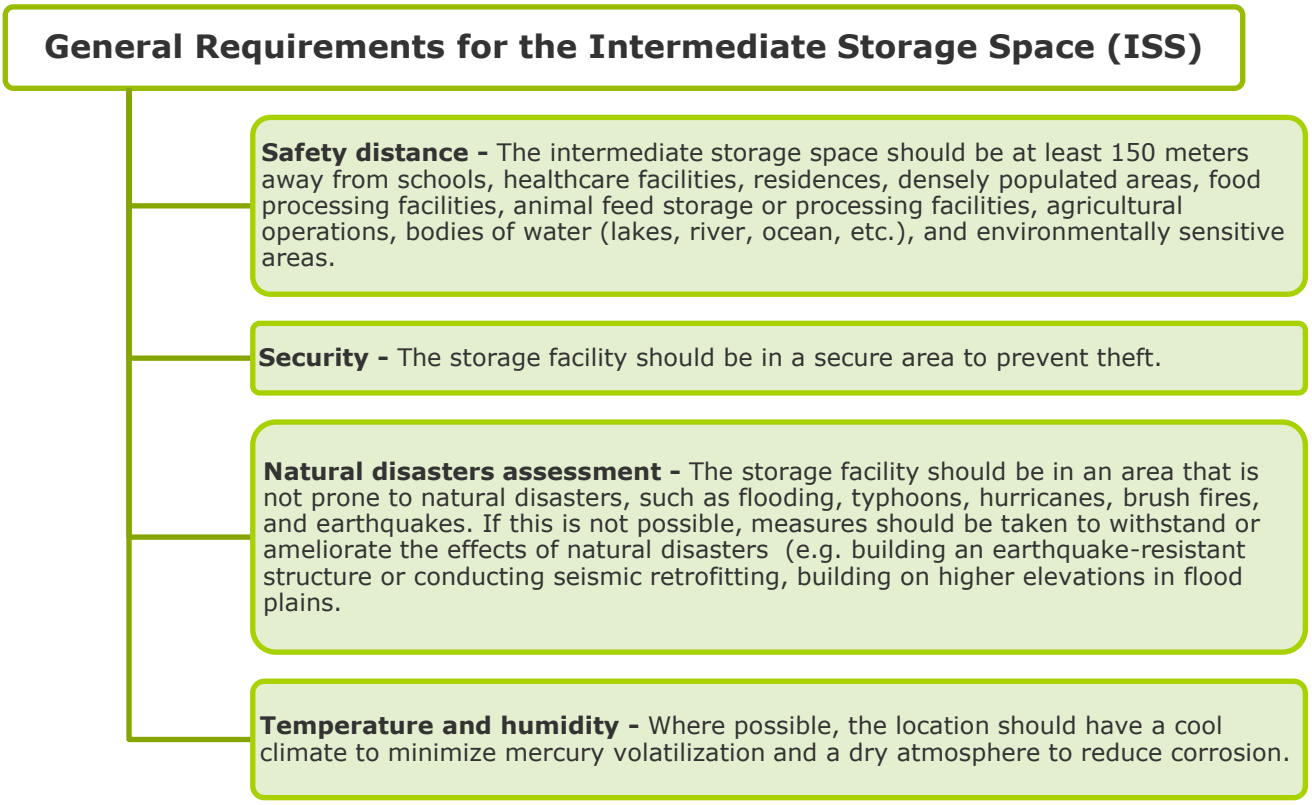


Figure 11. Conditions of the intermediate storage space that have to be controlled

3.2.7.2 Overall design requirements of the intermediate storage space

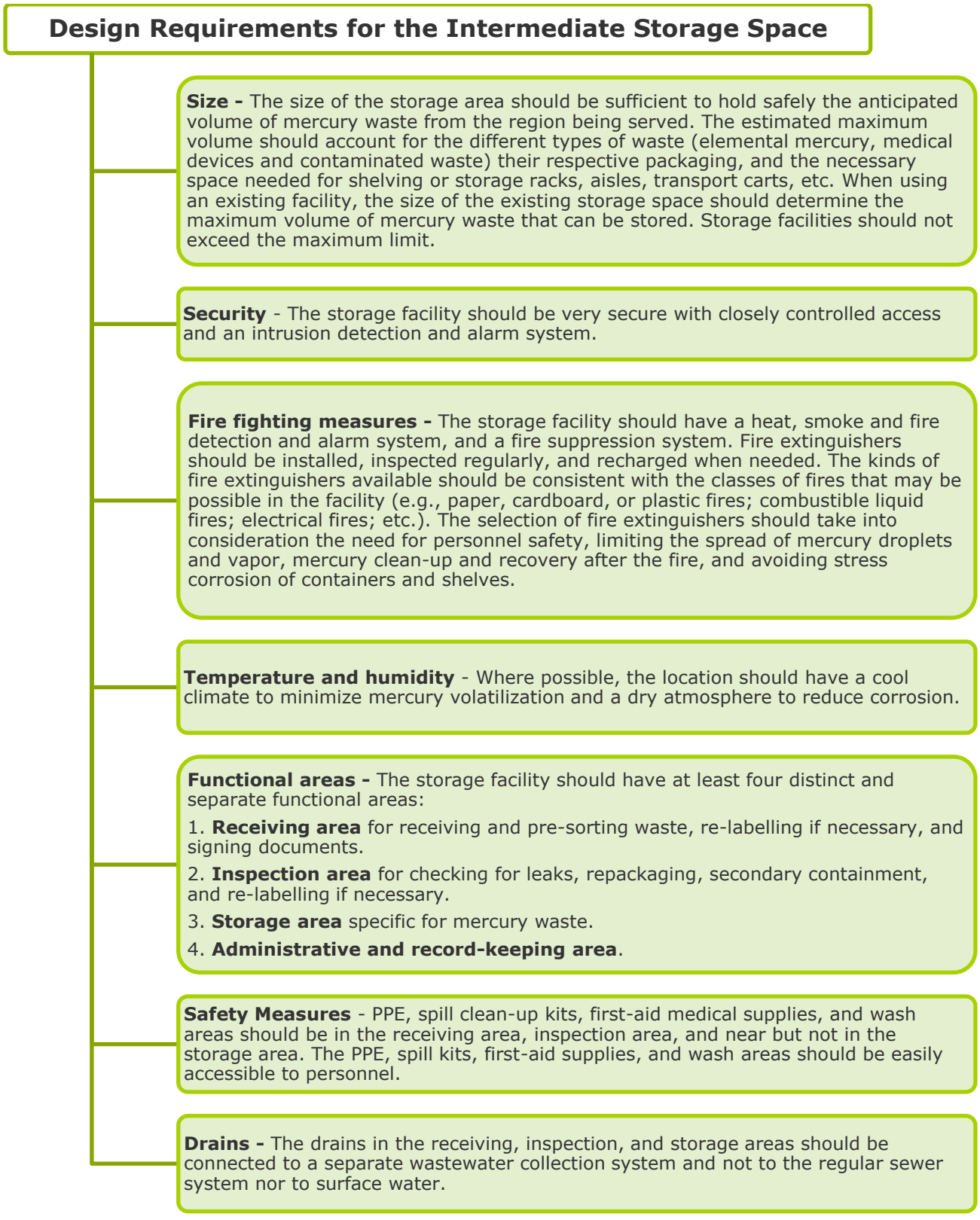


Figure 12. Intermediate store space conditions.

Spill kits components are described in section **3.2.1.**

The personal protective equipment for personnel of the intermediate storage space have more restrictive requirements as medium or large spills events are possible. These are summarised in Table 6.

Table 6. PPE recommended for the ISS.

Intermediate Storage Space
Personal protective equipment
a) Rubber or nitrile gloves. b) Safety goggles. c) Respiratory protection: self-contained breathing apparatus (SCBA) for large spills, fit-tested full- or half-facepiece air-purifying respirator with mercury vapor cartridges, face mask with sulphur or iodide impregnated activated carbon, face mask made of sandwiched activated charcoal-impregnated cloth, or other mask designed specifically for mercury. d) Polymer or rubber-based, protective full-body suits for large spills and protective coveralls. e) Disposable shoe covers. f) Helmets.

3.2.7.3 Requirements for the waste reception area

These requirements are summarized below.

Table 7. Receiving area requirements.

Receiving Area Requirements
Signalization
The receiving area should have signalization to guide waste generators and transporters around the area and to instruct them about the safety measures and procedures.
Equipment
The receiving area should have: a pre-sort table for incoming waste; a cart made of impervious material such as steel, rubber or hard plastic (do not use aluminium carts); spill kits and emergency supplementary containers for leaking containers or broken packaging; PPE for the staff; and a separate table or counter for signing documents.
Transport of waste
A cart should be used to transfer the waste to the inspection area and to move the waste around the facility.

3.2.7.4 Requirements for the inspection area

These requirements are summarized below.

Table 8. Safety and hygiene requirements.

Inspection Area Requirements
Location
The inspection area should be located near the receiving and storage areas. Because of the possibility that leaking containers may be brought in, the inspection area should have engineered spill-control features including containment dikes or bunding on the floor.
Monitorization system
The inspection area should have a mercury vapor detection probe, detector tubes[26], or other methods to detect leaking mercury containers.
Ventilation
The inspection area should have local exhaust ventilation, such as a fume hood or enclosed hood, built in accordance with national guidelines. Ideally, the hood should be connected to an activated carbon filter or other device specifically designed to remove mercury before the air is discharged. The minimum average face velocity of the hood, when in use, should be about 0.5 meters per second. The exhaust stack should be at least 15 meters away from any fresh air

[26] 1 Examples of mercury detection tubes (which are generally cheaper than continuous mercury monitors) include AUER/MSA (https://www.msasafety.com/global?referrer=detection), Dräger (https://www.draeger.com/es_es/Home), Gastec (https://www.gastec.co.jp/en/), Matheson-Kitagawa (https://www.mathesongas.com/pdfs/gasequipment/Model-8014-Kitagawa-Precision-Detector-Tubes.pdf), and Sensidyne, LP (http://sensidyne.com/index.php).

intakes to the building and should extend at least 3 meters above the roof line. When the hood is in use, the exhaust air velocity should be at least 15 meters per second to overcome downdraft effects.
Spill containment
The inspection area should have a spill control tray or containment device over which the waste should be inspected. The containment volume of the tray should be large enough to hold the maximum amount of liquid mercury expected by the facility to be received for inspection.
Equipment
The inspection area should have emergency supplementary containers to be used for leaking containers, packaging to replace broken or inadequate packaging, labels for re-labelling containers, spill kits, and PPE for the staff.

3.2.7.5 Requirements for the intermediate storage area

These requirements are summarized below.

Table 9. Conditions and necessities of the intermediate storage area.

Storage Area Requirements
Signalization
The storage area specific for mercury waste should be clearly marked with warning signs on all doors leading to the storage area. Copies of the spill response and emergency procedures should be on display in the storage area and kept with the spill clean-up kits and PPE.
Monitorization system
The storage area for mercury waste should have continuous or periodic monitoring of mercury levels in ambient air using mercury vapor monitors[27]. Periodic monitors should sample mercury levels at least daily. The monitoring equipment should be able to detect mercury in air in parts per billion[28].
Ventilation
The inspection area should have local exhaust ventilation, such as a fume hood or enclosed hood, built in accordance with national guidelines. Ideally, the hood should be connected to an activated carbon filter or other device specifically designed to remove mercury before the air is discharged. The minimum average face velocity of the hood, when in use, should be about 0.5 meters per second. The exhaust stack should be at least 15 meters away from any fresh air intakes to the building and should extend at least 3 meters above the roof line. When the hood is in use, the exhaust air velocity should be at least 15 meters per second to overcome downdraft effects.
Engineered spill-control features
The storage area specific for mercury waste should have engineered spill-control features to prevent mercury spills from exiting the area; these should include: - Flooring that does not have cracks, seams, or other openings where mercury could get lodged in. - A floor sealant system that is impervious to mercury and makes it easy to collect spilled mercury such as a durable (6 mm thick) plastic flooring or seamless epoxy-coated concrete. - Suitable containment dikes incorporated into the floor sealant on all doors of the storage area.
Shelving and racks
Shelving and storage racks should be able to support the weight of mercury waste and have back-and-side cross bracing or back-and-side panels to prevent sway. The shelves and racks should not be above shoulder height.
Waste segregation
Mercury waste from health facilities may be segregated according to the following risk categories based on the amounts of available mercury: - Risk Level 1 (highest risk): elemental mercury, unbroken sphygmomanometers, and medical devices containing large amounts of mercury (gastro-intestinal tubes, oesophageal dilators, large mercury float switches and relays from electrical equipment). - Risk Level 2: unbroken mercury thermometers, small mercury switches and small relays from electrical equipment. - Risk Level 3: broken glassware contaminated with mercury, mercury clean-up waste. - Risk Level 4: fluorescent lamps, compact fluorescent bulbs, dental amalgam. **If continuous monitoring of mercury levels is not conducted,** shelving and storage racks for Risk Levels 1 and 2 should be fitted with plastic containment trays or shelves made of a material impervious to mercury such as steel. The containment volume of each tray should be at least 125% of the total volume of liquid mercury stored on the tray. An option is the use of slightly sloped storage rack for containers of elemental mercury to facilitate discovery of leaks.
Natural disaster assessment

[27] Examples of continuous monitors include Tekran Continuous Emission Monitors (http://www.tekran.com/), Lumex Mercury Analyzers (https://www.lumexinstruments.com/catalog/atomic-absorption-spectrometry.php), Mercury Instruments Mercury Vapor Monitors (http://www.mercury-instrumentsusa.com/), Envea (https://www.envea.global/), Brooks Rand Labs (http://www.brooksrand.com/), and PS Analytical (http://www.psanalytical.com/index.html). The monitors can be supplemented with mercury passive samplers for workers (e.g, SKC Inorganic Mercury Passive Sampler, https://www.skcltd.com/index.php/passive-samplers/9-uncategorised/211-520-series-%20%20%20%20inorganic-mercury-sampler).

[28] The exposure limit of 0.02 mg per m3 is equivalent to 2.4 ppb at 20o C or 68o F. The equipment should be able to detect at this level.

In areas of seismic activity, additional bracing, straps, and cushioning of containers are necessary to prevent movement and breakage of containers, especially for Risk Levels 1 and 2.
Incompatible chemicals
In facilities that store other types of hazardous waste, mercury waste should not be stored near incompatible chemicals such as acetylene, alkali metals (lithium, sodium), aluminium, amines, ammonia, calcium, fulminic acid, halogens, hydrogen, nitric acid with ethanol, oxalic acid, and oxidizers.
Inspection
Lighting, aisle space, stacking, arrangements of containers, and placement of labels and markings should be designed to facilitate inspection of the storage area.
Transfer for long-term storage
The storage area should be designed to facilitate the transfer of mercury waste to a long-term (terminal) storage facility or a treatment and disposal facility in the future.

3.2.7.6 Requirements for the administrative and record-keeping area

These requirements are summarized below.

Table 10. Management requisites and administrative issues.

Administrative and record keeping area requirements
Location
The administrative and record-keeping area should be separated from the receiving, inspection, and storage areas. Records should be maintained in good order and kept in a secure location.
Technical Documents
The administrative and record-keeping area should maintain copies of Material Safety Data Sheets[20] and international chemical safety cards[21] which should be readily available to the staff.
Hygiene measures
The storage facility should be a non-smoking facility. There should be no eating in the storage area.

3.2.7.7 Waste generation, transport, and management manifests

In order to document the generation, transport and management of the mercury-containing waste materials, a waste manifest system needs to be implemented. This system should be organized as indicated below.

Manifest System

- **Tracking -** A manifest form or consignment note must accompany the movement of mercury waste.
- **Indentifiers** - The manifest or consignment note should identify the source of the waste, the transporter, the storage facility, and the relevant government authority.
- **Register -** Copies of the manifest or consignment note should be kept by the generator, transporter, and storage facility. Copies of the manifest or consignment note should be kept by the storage facility until the waste is removed from the facility. The copies should be made available to the MoE.

3.3 Mercury waste management technologies suitable for Lebanon

In 2022 the Waste Management Area of the UNEP Global Mercury Partnership published the document "Catalogue of Technologies and Services on Mercury Waste Management" with a view to disseminate information of technologies, products and, services related to proper mercury waste management[29].

The catalogue contains information from a total of 12 companies that provide a great variety of services related to mercury waste management. Each company specializes in certain processes such as recovery, removal, decontamination, distillation, stabilization, etc. and also refers to certain mercury-containing waste sources such as dental amalgam or artisanal gold mining.

Among the services included in the catalogue, a technology provided by Econ Industries Services GmbH (Econ) appears to be potentially applicable to Lebanon, as this company provides on-site treatment of mercury wastes and mercury conversion for final disposal.

The local treatment of these wastes offers opportunities to developing countries, which will especially benefit from the knowledge transfer and job creation, the reduction of transport emissions and the avoidance of transboundary waste shipment, as well as the health and safety improvements resulting from the use of this technology.

The technology developed by Econ, called **VacuDry®**, uses indirect heat and a vacuum to separate mercury from the wastes. Econ produces on-site mercury waste treatment equipment as well as mercury conversion services for entities of all sizes. The available technologies are described below:

- **VacuDry® Vacuum Distillation** - The VacuDry® process is a specially designed vacuum distillation. The material is continuously mixed and heated under a controlled vacuum to safely evaporate water, hydrocarbons and mercury. It can be utilized for all waste streams containing metallic mercury and mercury compounds with a boiling point of up to 450°C. Capacity: up to 100 t/day; in combination with soil washing, it raises to 500 t/day.

- **Mobile Mercury Conversion Unit (MMCU)** - The MMCU is designed for on-site mercury conversion. Mercury is converted to stable and non-toxic mercury sulphide (HgS) and packed for final disposal. Capacity: 0.5 to 5 tons per day.

- **High Temperature Treatment Unit (HTTU)** – The HTTU is designed for industrial scale treatment of spent catalysts and other mercury and sulphur containing wastes. In the HTTU, HgS, and other mercury compounds are decomposed at high temperatures. Hydrocarbons and sulphur are oxidized. SO_2 created by the process is neutralized in the off-gas treatment system. Capacity: 100 kg to 2.5 tons per hour.

The Mobile Conversion Unit is a cost/effective option as it could be purchased by MoE and it could be rented by the different companies authorized for dangerous waste management upon demand.

[29] "Catalogue of Technologies and Services on Mercury Waste Management", published on 2022 by Waste Management Area of the UNEP Global Mercury Partnership. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/27819/WMA_catalog.pdf?sequence=1&isAllowed=y

It is noted that this is a preliminary evaluation of existing technologies and that the final selection of management and treatment options for mercury-containing sanitary waste should be made in a wider context which also should consider hazardous wastes produced in other contexts in Lebanon.

4. Examples of on-site storage

The following examples simulate the waste management strategy designed by a hospital and a small clinic according to the guideline recommendations[30].

4.1 On-site storage on Hospital A

Hospital A decides that the basement is a good place to site the storage space since it is off limits to patients and visitors but is readily accessible to the personnel involved in mercury storage.

Hospital A estimates that they need to store 1000 unbroken fever thermometers, 20 unbroken sphygmomanometers, 500 broken thermometers, 350 litres of clean-up waste and 40 ml of elemental mercury that is being accumulated.

Based on calculations using the above quantities, the storage plan is as follows:

1. The 1,000 thermometers are carefully wrapped in a plastic bag and taped together to form a compact volume of about 2-litres; the thermometers— along with crumpled paper, plastic bubble wrap, or packing foam to prevent breakage— are then placed in a 3-litre stainless steel can with a tight-fitting lid (primary container). The outside of the can is marked with the quantity, description, and date. The can is placed inside a 4-litre, 50- or 75-micron thick, transparent, sealable plastic bag (secondary container).
2. The 20 unbroken sphygmomanometers are placed back in their original 2 litre cases which have labels that identify the contents (primary container). The cases are taped together in groups of 4 and placed in 50-to-100-micron thick garbage bags which are taped close with duct tape or strong adhesive tape (secondary container). A label is placed on the outside of the garbage bag.
3. The 500 broken thermometers are placed in a 3-liter, marked, stainless steel can (primary container). The can is placed inside a 4-litre, 50- or 75-micron thick, transparent, sealable plastic bag (secondary container).
4. The 350 litres of clean-up waste (contaminated rags, fabric and other materials that do not have sharp edges or points) are placed in multiple, 50- or 75-micron thick, sealable plastic bags (primary containers). The plastic bags are labelled and placed in two steel or plastic drums (secondary container), each with a capacity of 220 litres and a gasketed, manual latching lid to prevent vapor release. The outside of the drums is labelled.
5. The 40 ml of elemental mercury are stored in a marked, 100 ml, wide mouth, polyethylene terephthalate or PET bottle (primary container) that is at least 0.3 mm thick with a tight-fitting lid. [Note: Carbonated soda drink bottles are

[30] Source: GUIDANCE ON THE CLEANUP, TEMPORARY OR INTERMEDIATE STORAGE, AND TRANSPORT OF MERCURY WASTE FROM HEALTHCARE FACILITIES. United Nations Development Programme, GEF Global healthcare Waste Project. Available at: https://noharm-global.org/documents/guidance-cleanup-temporary-or-intermediate-storage-and-transport-mercury-waste-healthcare

generally made of 0.3 mm thick PET plastic.] A small amount of water is added as a vapor suppressant. The bottle is placed inside a 150-micron thick, transparent, re-sealable plastic bag (secondary container), which in turn is placed on a plastic tray with raised edges.

Hospital A determines that a 2 x 3-meter storage room in the basement is large enough to hold the mercury waste. The door to the room is marked "Danger: Mercury Waste". A hole is cut in the wall or ceiling to install an exhaust vent fan, which is connected to the existing electrical wiring. When turned on, the fan blows the air from the room out to an empty yard. The heating, ventilation and air-conditioning vents in the room are fitted with a mechanical damper plate or a pre-cut plastic sheet that can be taped to the vent to prevent air circulation to other parts of the hospital during a spill. A flexible plastic bunding strip, affixed to the floor by an adhesive, goes around the area where the mercury waste is stored to prevent any spill from spreading. Outside the door of the basement is a cabinet with a spill kit, PPE, MSDSs, a copy of the inventory, and other records.

The healthcare waste management coordinator supervises mercury storage and uses a checklist to inspect the storage room every month. The coordinator and the other personnel involved in mercury waste receive special training on mercury waste management including spill clean-up.

4.2 On-site storage on Clinic B

Clinic B determines that the laboratory is a good place to site the storage space since it is off limits to patients and visitors but is readily accessible to the personnel involved in mercury storage.

Clinic B estimates that they need to store 20 unbroken fever thermometers, 2 unbroken sphygmomanometers and 10 ml of elemental mercury. No further accumulation of elemental mercury or amalgam is expected since the clinic has phased out mercury use.

Based on calculations using the above quantities, the storage plan is as follows:

1. The 20 thermometers are carefully taped together and placed in a 500 cc, tall, wide-mouth, HDPE plastic bottle and cushioned with pieces of polystyrene foam, e.g., Thermocol or Styrofoam broken off from disposable coffee cups or from "peanuts" used for packing to prevent breakage (primary container). The cap is sealed with tape and the bottle is marked with the quantity, description, and date. The bottle is placed inside a 150mm x 200mm, 50-micron thick, transparent, sealable plastic bag (secondary container).
2. The 2 unbroken sphygmomanometers are wrapped in packing foam, taped up, and placed in a marked, rectangular, polypropylene container (such as a plastic food container) with a re-closable lid (primary container). The container is marked and placed in 50-micron thick, transparent garbage bags which is taped shut with adhesive tape (secondary container)
3. The 10 ml of elemental mercury are kept dry in a small, 100 ml, stainless steel container with a tight-fitting lid (primary container). The container is clearly marked, and the edges of the lid are sealed with tape. The container is placed inside a 50-micron thick, transparent, sealable plastic bag (secondary container).

Clinic B decides that the bottom shelf of a locked, steel, safety cabinet can serve as its storage space. The waste containers are placed in a plastic tray with raised edges to prevent spread of mercury in the event of breakage. The door to the cabinet is marked "Danger: Mercury Waste". The cabinet is next to the laboratory fume hood which discharges air directly to a hood exhaust stack that extends 2 meters above the roof line. A spill kit, PPE, MSDSs, a copy of the inventory, and other records are found in another part of the laboratory.

The laboratory manager supervises mercury storage and inspects the storage cabinet every month. The manager and other personnel receive special training on mercury waste management including spill clean-up.

ANNEX I. LIST OF PUBLIC HOSPITALS

The list is provided by Ms. Nathalie Karam the local consultant participating in the Child Project[31].

PUBLIC HOSPITALS TARGETED IN THE PROJECT

1. Baabda governmental hospital
2. Baalbeck governmental hospital
3. Bcharreh governmental hospital
4. beirut governmental hospital
5. Bent jbeil governmental hospital
6. Daher elbachek governmental hospital
7. Dr Abdullah Al Rassi Governmental Hospital
8. Ehden governmental hospital
9. Ftouh keserwan governmental hospital
10. Governmental Hospital of Beirut Quarantine
11. Hasbaya governmental hospital
12. Hermel governmental hospital
13. Jezzine governmental hospital
14. Kana governmental hospital
15. Kartaba Governmental Hospital
16. Marjaayoun governmental hospital
17. Mays el jabal governmental hospital
18. Nabatieh governmental hospital
19. Orange Nassau governmental hospital
20. President elias harawi governmental hospital
21. Rachaya governmental hospital
22. saida governmental hospital
23. Shahar gharbi govermental hospital
24. Siblin governmental hospital
25. Sir Denniye governmental hospital
26. sour governmental hospital
27. Tannourine governmental hospital
28. Tebnin governmental hospital
29. Tripoli governmental hospital

[31] Source: Email. Nathalie Karam (personal communication November 22, 2022).

ANNEX II. LIST OF COMPANIES AUTHORIZED TO TRANSPORT DANGEROUS WASTE

ANNEX III. LIST OF COMPANIES AUTHORIZED TO MANAGE WASTE FROM HEALTHCARE FACILITIES