(DRAFT)

Environmentally Sound Management of Mercury Waste in Health Care Facilities

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Abbreviations

BMW	-	Bio-medical Waste
BMW Rules	-	Bio-medical Waste (Management & Handling) Rules, 1998
CBWTF	-	Common Bio-medical Waste Treatment Facility
HW (M, H & TM) Rules	-	Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2008
HCF	-	Health Care Facility
Hg	-	Mercury
IMA	-	Indian Medical Association
OSHA	-	The US Occupational Safety and Health Administration
PCC	-	Pollution Control Committee
SPCB	-	State Pollution Control Board
TSDF	-	Treatment Storage and Disposal Facility

1. Introduction:

Mercury is the only common liquid metal. Its usefulness stems from its unique combination of weight, ability to flow, electrical conductivity, chemical stability, high boiling point and relatively low vapor pressure. For centuries, mercury was the ideal choice for use in medical devices that measure temperature (thermometers) and pressure (sphygmomanometers), and in other applications where density and flexibility were needed (esophageal dilators). In chemicals, including pharmaceutical, mercury is also being used as a preservative. In addition to above, mercury-containing devices and materials have been an integral part of Health Care Facility (HCF) operations for decades, for many other applications.

Considering the possible spillages of mercury in view of the use of mercury containing devices by the HCFs, it is felt necessary to prepare and circulate guidelines for proper management of mercury bearing waste generated from HCFs. These guidelines has been prepared with a view to ensure that necessary precautions to be taken by the health care staff in the event of mercury spillages possibly due to the unintentional breakage of mercury based devices and its handling in an environmentally sound manner. This document provides guidance on the precautions to be taken to avoid mercury spillages during the use of medical instruments, precautions to be taken in case of mercury spillage, mercury spill collection procedures, storage of mercury waste and the final disposal options in general for mercury bearing waste generated from HCFs.

1.1 Salient features of mercury

Elemental mercury (Hg) is a heavy, silvery metal that melts at 38.9^{0}C and boils at 357 ^{0} C. It is the only metal that is liquid at room temperature. Drops of mercury have a high surface tension and appear round. The liquid droplet is very mobile and can combines with other metals such as tin, copper, gold, and silver to form alloys (called amalgams). An exception is iron which does not amalgamate with mercury. The density of mercury is 13.5 g/cm ^{3} at 25 ^{0}C. Mercury has the highest volatility of any metal, forming a colorless, odorless gas. When mercury is spilled, it can break into very small droplets resulting in a large total surface area. These tiny droplets can volatilize at a faster rate with an instant increase in room temperature and proper room ventilation can safely dilute the mercury concentration, but in most bio-medical instruments the use of mercury is confined. The amount of elemental mercury vapor produced is related to the amount of mercury spilled, surface area (amount of beads produced), room temperature (vapor increases with warmer air), air flow and physical

disturbance of the spilled material.

Small droplets of spilled mercury can lodge in cracks, adhere to carpet fabric, mix with dust, go down drains, stick to the soles of shoes, and dissolve to form alloys with the metals in watches and jewellery. Some materials are resistant to mercury. Salient characteristics of mercury are given in **Table 1.**

1.2. Sources of mercury:

a) **Natural sources**: volcanoes are responsible for approximately half of atmospheric mercury emissions.

b) **Anthropogenic sources**:

- 65% from stationary combustion, of which coal-fired power plants are the largest aggregate source.
- 11% from gold production. 6.8% from non-ferrous metal production, typically smelters.
- 6.4% from cement production.
- 3.0% from waste disposal, including municipal and hazardous waste, crematoria, and sewage sludge incineration.
- 3.0% from caustic soda production.
- 1.4% from pig iron and steel production.
- 1.1% from mercury production, mainly for batteries.
- 2.0% from other sources.
- biomass burning

1.3. Pathways of mercury release to the environment

The use of these mercury-containing items in Health Care Facilities (HCFs) creates many pathways by which mercury may be released into the environment. The following are likely primary pathways of mercury release to the environment :

a) releases of mercury into the environment by medical waste incinerators due to burning of medical waste mixed with the waste containing mercury and other chemicals used in HCFs;
b) Land filling of mercury-containing medical waste without any pre-treatment;
c) release of mercury into the wastewater stream
d) spillage of mercury in working environment and wards.

The most common routes of exposure in the HCFs include inhalation of inorganic mercury vapor after a spill or accidental skin contact with mercury. Accidental spills of liquid mercury can increase the levels of mercury in the air or wastewater of a healthcare facility. Small droplets of spilled mercury may lodge in cracks, mix with dust, or go down drains. Mercury may adhere to fabrics, shoe soles, watches, or jewellery, on which it can be transported to other locations. A small spill of mercury in a carpeted patient room can become a major clean-up challenge. The mercury used in healthcare facility can have a broad impact on the surrounding community if spills or waste enter the groundwater and way into the food chain. For all these reasons, mercury spills in the HCFs has to be managed properly and effort should be made by adopting principles of reduce, re-use, re-cycle or recovery options or even eliminate the use of mercury in HCFs in a phased manner.

1.4 Behaviour of mercury in the environment: Mercury is a persistent, mobile and bio-accumulative element in the environment and retained in organisms. Most of the mercury found in the environment is inorganic since mercury is never broken down into other chemical and harmless form. Once mercury enters into the environment, mercury permanently exists in the environment by changing its chemical forms depending on the environment. The possible behaviour of mercury in the environment is depicted in **Figure.1.**

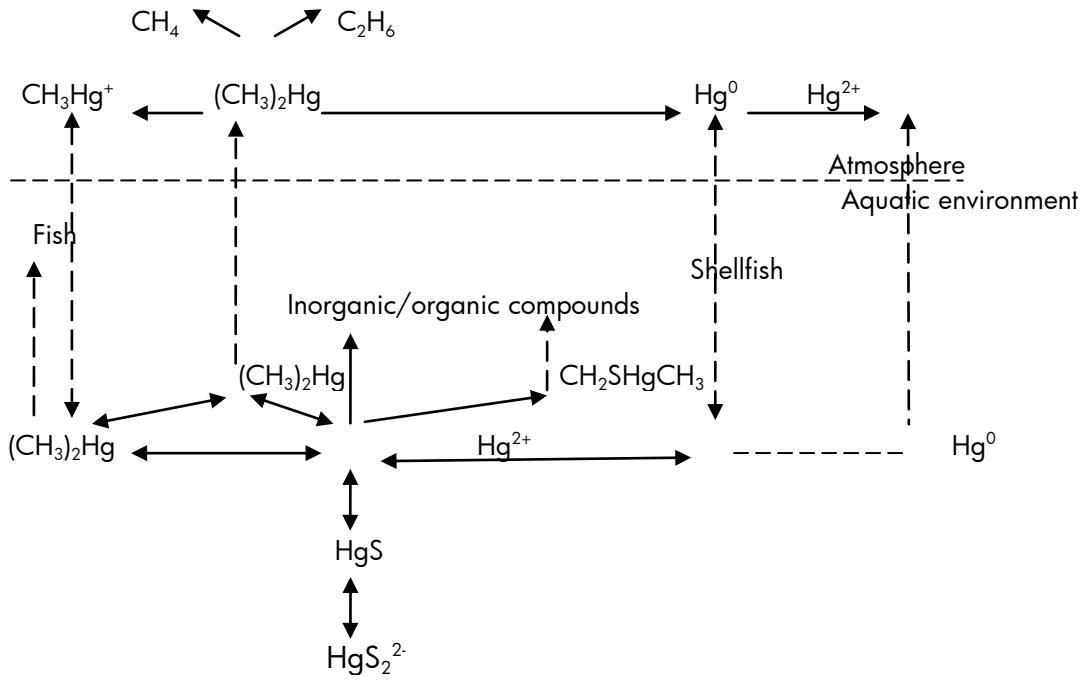

Fig. 1 Behaviour of mercury in the environment

1.5 Problem associated with mercury:

Mercury vapors are colourless and odourless, therefore, at high levels, are very toxic. Mercury is a potent neurotoxin, a global priority pollutant and a persistent bio-accumulative (meaning that it is a process by which a toxic gets accumulated in animal tissues). It persists in the environment for a long time, and it is extremely toxic in small amounts. Exposure to mercury impacts the central and peripheral nervous system and it can damage the brain, spinal cord, kidneys, eyes and liver. Mercury easily crosses the placenta, passing from mother to unborn child, where it can impact neurological development of the fetus.

Human exposure to mercury can occur through inhalation, ingestion, or skin contact. The clinical symptoms of acute inhalation of high levels of mercury vapor include gastroenteritis (stomach upset), chills, nausea, malaise, chest pains, shortness of breath, coughing, gingivitis, excessive salivation, anuria (urine production stops), uraemia (urine products appearing in the blood), nephritis (kidney disease leading to kidney failure), anorexia (lack of appetite), ataxia (difficulty in moving) and diarrhea. Symptoms of chronic exposure to mercury include weakness, weight loss, gastrointestinal disturbances; a tremor that begins with the fingers, eyelids, and lips and progresses to generalized trembling of the body and violent spasms of the extremities; and behavioural and personality changes including increased excitability, memory loss, insomnia, and depression. Additionally, there may be a painful scaling or peeling of the skin of the hands and feet.

2. Mercury use in health care facilities

Mercury-containing products can be found almost anywhere in the HCFs. They range from medical instruments and clinical laboratory chemicals to electrical equipment, fluorescent lamps (such as Fluorescent Tube Lamps (FTL), Compact Fluorescent Lamps (CFL), High Intensity Discharge (HID) Lamps and cleaning solutions. Some of the mercury based instruments used for diagnosis purposes by the health care facilities are as follows:

a) Thermometers (used for measurement of body temperatures);
b) Sphygmomanometers (used for measurement of blood pressure);
c) Dental amalgam;
d) Esophageal dilators (also called bougie tubes);
e) Cantor tubes and Miller Abbott tubes (used to clear intestinal obstructions);
f) Laboratory chemicals (fixatives, stains, reagents, preservatives);

g) Medical batteries etc.,

Summarized mercury content in some of the medical instruments used in health care facilities and their applications is given in **Table 2.**

2.1. **Thermometer (Mercury):** A thermometer containing mercury that measures body temperature within the range of 35°C – 42°C. It is estimated that on an average, a typical thermometer may contains 0.5 to 3.0 grams of mercury. Major reason for breakage of clinical thermometers in wards is the instrument slipping out of the hand while shaking it to bring the temperature down. The monthly average rate of mercury based glass thermometer in a 300 bedded hospital is around 70 and if the hospital is attached with a nursing school, the break rate can be much higher. The breakage of mercury thermometer should be handled carefully while collecting and confirming spilled mercury.

Fig.2. Mercury base Glass Thermometer

Fig. 3. Mercurial Sphygmomanometer & Service kit

2.2. **Sphygmomanometers:** Sphygmomanometers are used exclusively for blood pressure measurements. This includes a mercury manometer, an upper arm cuff, a hand inflation bulb with a pressure control valve and requires the use of a stethoscope to listen to the korotkoff sounds and mercury dependent. A typical barometer contains about 450 grams of mercury.

2.3. **Dental amalgam:** Mercury is frequently used for dental amalgam. Amalgam is the mercury alloy used primarily for dental fillings. The mercury is set free under certain circumstances by external effects such as mechanical or biological influences. Mercury tends to vaporize from the amalgam and gets impregnated in the gums. After few years, some patients might develop a white silvery line on their gums, called **"***Amalgam Tattoo***"**.

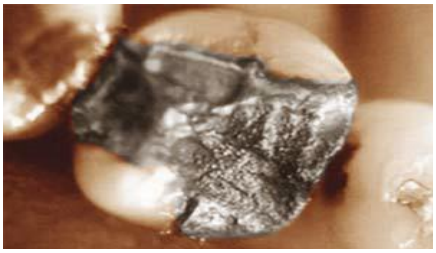

Fig. 4 & 5. Mercury in Dental Amalgam

Prior to the mid-1980s, dentists mixed their own mercury dental clinics. They used dental amalgam dispensers to dispense a proportionally measured amount of liquid mercury combined with silver, tin, and copper, as well as small amounts of other metals, including zinc, indium, or palladium. After mixing, the resulting amalgam was packed into a person's tooth, creating a filling.

Dental amalgam dispensers mixed elemental mercury with other powdered metals to create a dental amalgam used in tooth restoration and for filling cavities. Dental amalgam still contains mercury but is currently sold in pre-packaged capsules. Non-mercury alternatives for dental amalgam are made of resin and composite materials, including glass ionomer cement, gold foil, gold alloy, and metal and ceramic dental fillings and crowns.

Fig. 6. Proportional dental amalgam dispenser with elemental mercury

Dental amalgam dispensers can leak or malfunction causing a mercury release. Spills from bulk elemental mercury that is stored on-site would present a significant risk of exposure as well as extensive cleanup costs. Estimates of mercury used in dentistry suggest that the average dentist using 2 or 3 pounds (1 to 1.5 kg) annually.

2.4. Esophageal dilators: An esophageal dilator, also referred to as a bougie tube, is used to dilate the esophagus of a patient in response to medical conditions or treatments that cause esophageal narrowing or tissue shrinkage. The dilator is a long, flexible tube that is slipped down the patient's throat into the esophagus, where it remains in place for several minutes before it is extracted. Older esophageal dilators consist of thick latex-coated tubing with approximately 2-3 pounds of elemental mercury at the bottom of the tube. The mercury in esophageal dilators is used as a weight at the bottom of the tube. The density and liquid properties of mercury make it ideal to use as a flexible weight, necessary to insert the tube into the patient's constricted esophagus.

Fig.7. Esophageal dilators with mercury weights

2.5. **Feeding tubes :** A feeding tube is a medical device used to provide nutrition to patients that cannot obtain nutrition by swallowing. They are used to administer food or drugs. The most common feeding tube is the nasogastric tube, which is passed through a patient's nose, past the throat, and into the stomach. The tubes are usually made of polyurethane and silicone. Older tubes can contain a small amount of mercury as a weight at the bottom of the tube, which helps guide the tube into place using gravity. Weighted feeding tube may contain mercury greater than one gram. The polyurethane coating of a feeding tube is not easily broken during normal handling. However, if a leak or break occurs, there is a chances of mercury spill.

2.6. **Gastrointestinal tubes :** A gastrointestinal tube is used to eliminate intestinal obstructions. Types of gastrointestinal tubes include Miller Abbott, Blakemore, and Cantor tubes. The tube is passed down a patient's esophagus, through the stomach, and into the small intestine to help remove or reduce intestinal obstructions. Historically, these tubes had a balloon containing mercury as the flexible weight, which would help guide the tube into place. When filled to capacity, these devices contained approximately 2 pounds of mercury. The large amount of mercury contained in gastrointestinal tubes would cause a significant risk of exposure as well as extensive cleanup costs if spilled.

2.7. **Miller-Abbott tube :** a double-channel intestinal tube with an inflatable balloon at its distal end, used for diagnosing and treating obstructive lesions of the small intestine. The tube is inserted via a nostril and gently passed through the stomach and into the small intestine. Used in humans in the treatment of intestinal obstruction. The mercury in esophageal dilators is used as a weight at the bottom of the tube. The density and liquid properties of mercury make it ideal to use as a flexible weight, necessary to insert the tube into the patient's constricted esophagus. Over time, the latex covering of the esophageal dilator tubing can become brittle and cracked, which may lead to a mercury release. Older mercury-containing esophageal dilators have been known to rupture during handling or use causing potential hazards to environment, patient, and employees of HCFs. The large amount of mercury contained in esophageal dilators would present a significant risk of exposure as well as extensive cleanup costs if spilled.

Fig.8. Blakemore gastrointestinal tube

2.8. **Intraocular pressure devices:** Small bags of mercury were historically used as weights to apply pressure to the eye prior to cataract surgery. These mercury-filled balloons, which were the size of a small egg, contained approximately 175 grams of elemental mercury that was double or triple bagged and placed on the patient's eye prior to surgery. When placed on the eye, the weight of the mercury on the eyeball kept fluid from accumulating at the normal rate, softening the eyeball prior to surgery. This practice reduced the pressure within the eyeball, simplifying surgery. However, this method is no longer used. These mercury-filled balloons can be easily broken or ruptured - especially as they get older and the integrity of the rubber balloon degrades.

2.9. **Strain gauge:** A strain gauge is a sensor attached to a plethysmograph, which measures arterial blood flow. The strain gauge consists of elemental mercury contained in a fine rubber tube, which is placed around a patient's limb or digit (e.g., forearm, leg, calve, finger, or toe). A standard limb-style mercury strain gauge contains approximately 1.25 grams of elemental mercury. Pressure is applied to the patient's limb and the increase in its circumference is measured. This measurement indicates changes in blood flow and is used to measure blood pressure and check for blood clots. The technique is called 'strain gauge plethysmography'. The mercury is contained in a silastic rubber tube. Swelling of the body part results in stretching of the tube, making it both longer and thinner, which increases electrical resistance. The mercury is used as a measuring element for this electrical continuity. Strain gauges seldom break during normal handling and use, hence requires proper care from mercury exposure due to such mercury spill.

Fig.9. Limb strain gauge – used for leg

As a gauge ages, the copper electrodes at the ends are dissolved into the mercury. It appears as a darkening of the mercury, which begins at the end of the gauge and progresses toward to middle. This process causes the pressure in the gauge to go down, and eventually the gauge will lose electrical continuity when it is stretched too far. If this happens, the strain gauge will no longer work.

Fig. 10. Digit strain gauge – used for fingers and toes)

2.10. Urinometer: A urinometer was an instrument used to measure the specific gravity of urine. It was a glass device with a mercury-weighted bulb and an air-filled stem with graduated scale above. Urinometers are basically small hydrometers with a relatively small amount of mercury - less than one gram. When the urinometer is placed in liquid, the float displaces a certain weight and the level to which it sinks is a measure of specific gravity.

Mercury may be contained in the bulb of the urinometer, acts as a weight, which makes the urinometer float upright in the liquid urine. The point on the scale, which is in line with the upper level of urine, represents the specific gravity. In a urinalysis, the specific gravity is used to indicate the general functioning of the kidneys, including the kidney's ability to reabsorb water and chemicals.

Urinometers were used for measuring the specific gravity of urine before more sophisticated technological means were introduced. They are rarely used today, and research indicates that new mercury urinometers are no longer produced or available for sale. Today, the most common method used in hospitals and health care facilities to measure specific gravity in a urinalysis is to use urine dipsticks.

Fig.11. Mercury Hydrometer/ Urinometer

2.11.X-Ray Machines: X-ray machines can contain small mercury levelling switches as part of the positive beam limitation (PBL) system, also referred to as the automatic collimation system, which is mounted on the x-ray tube housing. The PBL system is an automatic collimation system used in stationary radiographic equipment. The mercury switches in this system usually account for approximately 3-4 grams of mercury per machine, although some may contain significantly more.

A positive beam limitation system uses four miniature mercury switches to assure perpendicularity between the x-ray beam and the film and maintain precise control over the radiation beam. As long as the system remains intact, there is a low probability of mercury releases from this device. However, x-ray machines may contain other sources of mercury in the x-ray film and chemical processing solutions (e.g., fixer). Therefore, care should be taken whenever handling this equipment to prevent a mercury release.

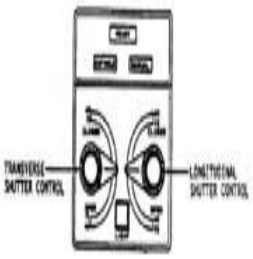

Fig.12. X-Ray Machine

2.12. Mercury Cells (Batteries): Mercury cells are primary cells consisting of Zinc Oxide, a cathode of Mercuric Oxide (HgO) mixed with graphite (about 5 %) and an electrolyte of Potassium Hydroxide (KOH) saturated with Zinc Oxide (ZnO). The electro-magnetic force (EMF) of mercury cell is about1.3 volts and by suitable design the mercury cell can be made to deliver about 0.3 ampere hour per cubic centimeter.

Fig. 13 & 14. Mercury based Button Cell Batteries and Medical Battery

2.13. Thimerosal : Thimerosal, a mercury containing preservative is added to vaccines to protect against bacterial contamination. It is composed of nearly 50 % mercury which can metabolizes to ethyl mercury and thiosalicylate.

Fig.15. Mercury in Thimerosal

Fig. 16. Thimerosal Based Vaccination

Fig. 17. Barometers used in Respiratory Therapy

2.14. Barometers in respiratory therapy: A mercury barometer is used to calibrate blood gas analyzers in hospitals. In general barometer holds 14 ounces of elemental mercury.

2.15.Fixative : One of the compounds widely used in laboratories is B-5 fixative. This mercury containing fixative has been used in histology to aid in identification of certain cell types. The tissue would be placed in a container with the B-5 fixative and left until the solution had penetrated the tissue. Then the tissue would be stained and placed onto a slide for microscopic examination. During the rinse process, there is a possibility of some mercury discharge into the facility sewer system. Several brands of B-5 fixative have been developed using Zinc Chloride instead of mercury. Laboratory suppliers should be able to provide a listing of possible substitute brands.

2.16.Cleaning Products : Small, and potentially overlooked, sources of mercury in the hospital are cleaning products. The electrolytic process of chlor-alkali production (manufacture of chlorine products and sodium hydroxide products) often relies on mercury electrodes, resulting in mercury contamination of the products. Many cleaning products consequently contain low levels of mercury. Although these products contain mercury in quantities that are in parts per million or billion, the amount of cleansers

used in hospitals can result in a contribution to mercury in wastewater through normal use.

3.0. Sources of mercury bearing waste generation in health care facilities

Mercury is present in hospitals mainly in clinical thermometers and sphygmomanometers (blood pressure gauges), where breakage results in a potentially hazardous spillage which can affect both patients and staff. In the event of higher ambient temperatures in hospitals which may enhance the release of mercury vapour after a spill. Unless such spillages are dealt with quickly and efficiently, contamination of the floor and fabric of the room will continue to produce harmful mercury vapour for years afterwards. As per the literature, in hospitals, accidental spillage due to breakage of mercury thermometers is very common and has been estimated at two thermometers per bed per year. Following are the main sources of mercury in health care facilities:

a. Accident & Emergency Department
b. Dental Department
c. Endoscopy Department
d. Instrument Repair Workshop
e. Laboratories
f. Outpatients Clinics
g. Pharmacy
h. Stores and Wards
i. wastewater drains and ETP

Apart from the above, other medical instruments, clinical reagents and laboratory chemicals, drugs, fluorescent light tubes, switches and other electrical devices are the other sources of mercury emission from health care facilities. Uses and Modes of release of mercury into the environment from health care facility is summarised in **Table 3.**

3.1. Designation of mercury waste generated from HCFs under Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008 and amendments made thereof

Mercury as such present in the mercury based instruments used in health care facilities does not fall under the category of hazardous waste. Only when the mercury spillage due to accidental or unintentional breakage of mercury based instruments, outdated instruments no longer in use or any

items contaminated with mercury including mercury spill, then such mercury waste fall under the category of 'Hazardous Waste' as defined under scheduled II of the Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008 and amendments made thereof. According to Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2008, any hazardous waste including mercury bearing waste is permitted to store on-site only for a period of 90 days unless other wise extended by the concerned State Pollution Control Board (SPCB) /Pollution Control Committee (PCC) to the generator of any such waste.

4.0. Strategies for managing mercury bearing waste in healthcare facilities

Suggested strategies for management of mercury bearing waste in health care facility include the following:

a) Segregation of reusable and non-reusable mercury containing products
b) Recycling mercury-containing products when they can no longer be used.
c) Proper handling and disposal of mercury, mercury-containing equipment, collected mercury spill and laboratory chemicals.
d) Establishing protocols for proper cleanup of spills involving mercury.
e) Enforcing compliance with suggested or institutional policies.
f) Using alternatives for products that contain mercury.

4.1. Mercury source reduction

Healthcare Sector is required to take adequate steps for eliminating mercury pollution. Further, health care facilities are required to ensure appropriate source segregation so that mercury is pulled from the waste stream before it is sent for on-site bio-medical waste treatment facility or a Common Bio-medical Waste Treatment Facility (CBWTF) for further treatment comprising incineration or autoclaving/microwaving. Such source segregation programs may require significant initial educational and implementation efforts. Also, as mercury preventing strategies while calibrating mercury based instruments, measures like working over a tray and covering drains to prevent discharge into wastewater stream are substantially helpful in preventing mercury from entering the environment.

Another preventive step to stop mercury from entering the medical waste stream is to label segregated infectious waste and ensure that broken mercury devices do not enter wrong waste streams. It is vital to ensure that

waste amalgam, broken equipment and elemental mercury and other mercury bearing waste are stored in designated areas of the hospital/medical facility and disposed of in designated containers or delivered to medical instrument manufacturers, authorized hazardous waste recycling or Treatment Storage and Disposal Facilities (TSDFs) in accordance with the Hazardous Waste (M, H & TM) Rules.

4.2. Alternatives to mercury based products in HCFs

Mercury thermometers and the sphygmomanometers are significant sources of mercury from the HCFs in the environment. If the mercury spill due to breakages of mercury clinical instruments is not cleaned up properly, the mercury may get into the air environment and pose a health risk to the human by taking the route of bio-accumulation. Hospitals can solve their mercury waste and acute mercury exposure problems by replacing mercury based instruments with the appropriate alternatives. Considering the toxic nature of the mercury, all the HCFs are required to gradually phase out mercury containing equipments (thermometer, BP Instruments etc.) and replace them with good quality non-mercury based equipments to prevent potential toxic effects of mercury on patients and health care staff –doctors, nurses and the health care workers. Some of the non-mercury alternatives in HCFs suggested are as follows:

i. Alternatives to mercury thermometers include electronic, infrared, chemical strip, and gallium, indium, tin and alcohol/spirit thermometer.
ii. Mercury sphygmomanometers cuffs can be replaced by aneroid and electronic blood pressure cuffs
iii. Use of gastrointestinal tubes weighted with tungsten gel or sterile water instead of mercury.
iv. Use of indium-gallium strain gauges, doppler and photo cell equipments in place of mercury-filled strain gauges.
v. Eliminate use of dental amalgam dispensers by switching to 'pre-encapsulated mercury amalgam alloy'.
vi. Non-mercury plethysmographic equipment is replacing the mercury containing strain-gauge equipment that is used for measuring blood pressure in fingers, toes and other specialty areas.
vii. "B-5" Fixative previously containing mercuric chloride be replaced with zinc chloride based fixative.
viii. Barometers can be replaced with aneroid units.

Summary of the above is provided in **Table 4.**

Fig.18. Mercury Free Digital Thermometer **Fig.19. Electronic Thermometer**

Fig. 20. Aneroid Sphygmomanometers **Fig. 21. Tungsten gel weighted bougies**

Fig. 22. B-5 Fixative has been developed using zinc chloride instead of mercury.

Note: All the electronic alternates do contain metallic button cells containing mercury, for which special care should be taken for disposal of these cells and for internal instruments containing mercury should strictly be avoided especially mercury containing esophageal dilator, feeding tubes, gastrointestinal tubes, dental amalgam etc.,

5.0. Necessity of guidelines for handling and management of mercury spillages and other mercury bearing wastes generated from health care facilities:

In order to protect health of the medical staff as well as the patients under going medical treatment in HCFs, proper handling of mercury spillages from the HCFs and for ensuring final disposal of mercury waste in

accordance with the Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008, it is felt necessary to prepare the guidelines. Following guidelines are suggested:

5.1. Guideline for storage of mercury based medical instruments for prevention of mercury spill :

i). Mercury-containing thermometers and other equipments used in HCFs should be kept in a container that does not have a hard bottom. Plastic container to a glass container is preferred as the possibility of breakage will be minimal.

ii). Maintenance of mercury based instruments which includes cleaning and refilling of instruments with mercury should be done only in a designated place (reserved room) and only by a properly trained and authorised staff, in accordance with the manufacturers handling procedures.

iii). To minimise spills and exposure during periodic maintenance/calibration of mercury devices (e.g. sphygmomanometers) substantially, maintenance of devices should be done by keeping the same over a tray and covering drains to prevent discharge of mercury spill into wastewater stream. Mercury based instruments should not be handled over a sink to avoid direct entry of mercury in to the waste water stream.

iv). Mercury based devices should be used only in rooms without carpeting or the flooring surface not smooth in nature.

v). Mercury devices should not be used in units with beds that have high structures or projections that can break wall-mounted sphygmomanometers, or in areas where patients cannot be moved quickly in the event of mercury spills if any.

5.2. Precautions to be taken during accidental spillages or breakages of mercury based equipments in HCFs:

Following precautions to be taken in the event of accidental spillages of mercury in the HCFs:

i). Ensure that all the patients, people and the staff are moved away from the mercury spill area.

ii). All the heaters and air conditioners which are in use should be turned off to minimise volatization of the mercury spillage.

iii). Proper ventilation has to be seen by opening windows and ventilators;

iv). Any ventilation system that would spread mercury vapour to other sensitive areas should be closed. If possible, lower temperature should be maintained as this process lowers the amount of mercury that can vaporize.

v). Cover the mercury spill with plastic to reduce evaporation into indoor air if the mercury is not going to be cleaned up immediately and is confined to a small area.

vi). Vacuum cleaner should not be used at all to clean up mercury spill as mercury will contaminate the vacuum cleaner as well as heat from the cleaner will vaporize the mercury and drastically increase exposure to the surrounding environment;

vii). Precaution should be taken not to handle mercury waste with bare hands and appropriate personal protective equipment (rubber gloves, goggles, face shields and clothing) should be used while handling mercury.

viii). As far as possible jewellery should be removed as mercury will bind with the metal and rubber gloves should be used at the time of handling mercury.

xi). After handling mercury, hands must be carefully washed before eating or drinking. The gloves used during handling of mercury should be segregated and stored safely in a designated place.

x). Broom should never be used to clean up mercury as it breaks up into mercury droplets and moves them around, making it harder to decontaminate the area.

xi). The mercury waste should never be discharged into the drain/sewer as it can lodge in the plumbing, and contaminate the septic tank and sludge in sewage treatment plants.

xii). Mercury-contaminated items should not be washed in a washing machine as the mercury can contaminate the sewage system and the washing machine.

xiii). All the items such as shoes, clothing, fabric or any item that has been contaminated with mercury during the mercury spill collection process should not be burned in open yards in any case to avoid mercury into the atmosphere.

In case of larger mercury spill, additionally following precautions need to be taken:

i) cleanup of mercury-contaminated products, steel or polyethylene drums typically used for hazardous waste are appropriate.

ii) Handle wastes at temperatures below 25°C, if possible, because of the increased volatility at higher temperatures.

iii) Place plastic sheeting or absorbent mats under containers before opening them if the surface of the containment area is not coated with a smooth surface material (paint, urethane or epoxy);

iv) Remove liquid wastes either by removing the drain plug or by pumping with a peristaltic pump and suitable chemical-resistant tubing;

v) Use dedicated pumps, tubing and drums, not used for any other purpose, to transfer liquid wastes.

vi) Clean up any spills with cloths, paper towels or absorbent; Triple rinse contaminated surfaces with a solvent such as kerosene

5.3. Accident Report:

In the event of accidental mercury spill, it should be reported to the respective State Pollution Control Board (SPCB)/Pollution Control Committee (PCC) as per Form - 6 of the Bio-medical Waste (Management & Handling) Rules, 1998 and amendments made thereof **(Annexure –I)**.

5.4. Clean up/collection of mercury spill/mercury spill management:

To prevent the mercury from entering the municipal waste streams, 'Mercury Spill Kits' are essential for the management of mercury spills and breakages. Mercury spillage collection kit should be kept at all the suitable places in HCFs to allow rapid access to use the same in the event of mercury spillages and to consolidate spilled mercury as well as to limit the amount of mercury released into the air. Every HCF should have at least **two or three kits** that are replaced once used *(The number of spill kits may be decided depending upon the number of beds)* Mercury Spill Kits need to be used only by trained personnel to prevent further exposures. Although mercury spill kits are commercially available, a spill kit can be made by putting together the following items and storing them in a marked box or portable container:

- Step-by-step instructions that are specific to the health care facility
- Personal protective equipment (PPE): rubber or nitrile gloves, safety goggles or protective eyewear, respiratory protection (Fit-tested full- or half-face piece air-purifying respirator with mercury vapor cartridges, or face mask with sulfur or iodide impregnated activated carbon, or face mask made of sandwiched activated charcoal-impregnated cloth, or other specialty mask or respirator designed particularly for mercury, or *If no specialty masks 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: 40 to 150 microns)
- Small, air-tight, rigid plastic container or glass bottled half filled 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
- Plastic tray
- Regular plastic waste bags (thickness: 40 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 dust pan to catch the mercury beads
  - 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: Sulfur powder (available from pharmacies) to absorb mercury by forming mercuric sulfide or Zinc or copper flakes to absorb mercury by forming amalgams
  - Commercial absorbent pads or vapor suppressants which contains a foam pad saturated with a suspension containing small amounts of sodium thiosulfate, copper sulfate, calcium chloride, and potassium iodide. Small quantities of x-ray fixer (which contains thiosulfate) or a propylene glycol solution of sodium thiosulfate and copper sulfate have also been used as vapor suppression agents)
  - Brush to remove powder or flakes
- Utility knife blade
- Materials for decontamination:
  - Vinegar, hydrogen peroxide, and cotton swabs for final cleaning when using sulfur powder
  - Decontaminant solution or commercial decontaminant (made of 10 % sodium thiosulfate solution or a mixture of sodium thiosulfate and EDTA).

Fig.23.Mercury Spillage Kit Fig. 24.Dental Amalgam Collection Kit

Whenever a spill kit is used, the most senior staff involved in the cleanup should take responsibility for ensuring that the contents are replenished as soon as possible. All spill kits should have a sheet attached indicating when they were used and verifying that the expended supplies have been replaced. The sheet should be signed and dated by the responsible staff.

5.5. Suggested steps for clean up mercury spill in HCFs:

i). Evacuate area : Remove everyone from the area that has been contaminated and shut the door. Turn off interior ventilation system to avoid dispersing mercury vapour throughout the HCF. Put off heaters/blowers which are in use.

ii). Put on face mask : In order to prevent breathing of mercury vapour, wear a protective face mask as suggested under Section 5.4.

Fig. 25. Mercury Vapour-Proof Masks

iii). Put on old clothes: Change into old clothes and shoes that can be discarded if they become contaminated in the mercury mitigation process.

iv). Remove jewellery: Remove all jewellery from hands and wrists so that the mercury cannot combine (amalgamate) with the precious metals.

v). **Wear gloves :** Put on rubber or latex gloves. If there are any broken pieces of glass or sharp objects, pick them up with care. Place all broken objects on a paper towel, fold the paper towel and place in a puncture proof plastic bag or container provided with lid. Secure the plastic bag/container and label it as containing items contaminated with mercury as stipulated under Hazardous Waste (M, H & TM) Rules, 2008.

vi). **Locate mercury beads:**

Locate all mercury beads and look for mercury in any surface cracks or in hard-to-reach areas of the floor. Check a wide area beyond the spill. Use the flashlight to locate additional glistening beads of mercury that may be sticking to the surface or in small cracked areas. Cardboard sheets should be 'used to push the spilled beads of mercury together'.

vii). **Use syringe without a needle/eyedropper and sticky tape:** A syringe (without a needle) shall be used to suck the beads of mercury. Collected mercury should be placed slowly and carefully into an unbreakable plastic container/glass bottle with an airtight lid half filled with water. After removing larger beads, use sticky tape to collect smaller hard-to-see beads. Place the sticky tape in a punctured proof plastic bag and secure properly.

Commercially available powdered sulfur or zinc stains mercury a darker colour and can make smaller beads easier to see (powder sulfer may be used because (i) it makes the mercury easier to see since there may be a color change from yellow to brown and (ii) it binds the mercury so that it can be easily removed and suppresses the vaporization of any missing mercury).

viii). **Collection in leak-proof bag or container:** Place all the materials used during the cleanup, including gloves, mercury spills collected from the spill area into a leak-proof plastic bag or container with lid and sealed properly and labeled in accordance with the Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008 and such collected waste should be stored in a designated area only.

ix). **Cleaning of the floor surfaces contaminated with mercury and cleaning of room surfaces:** Sprinkle sulfur or zinc powder over the area. Either powder will quickly bind any

remaining mercury. In case, zinc powder is used, moisten the powder with water after it is sprinkled and use a paper towel to rub it into cracks in the flooring. Use the cardboard and then dampened paper towels to pick up the powder and bound mercury. Place all towels and cardboard in a plastic bag and seal all the bags that were used and store in a designated area.

All the mercury spill surfaces should be decontaminated with 10 % sodium-thiosulfate solution.

Keep a window open for 24 to 48 hours to ventilate after the cleanup. After ensuring all the mercury has been removed, resume normal vacuuming and utilise the cleaned area for routine operation.

x). Labelling : All the bags or containers containing items contaminated with mercury should be marked properly as stipulated under the HW (M, H & TM) Rules, 2008 **(Annexure –II).**

5.6. Storage of collected mercury bearing waste:

It is vital to ensure that mercury waste amalgam from dental health care facilities, mercury based broken equipments and or obsolete mercury devices and other items contaminated with elemental mercury are labeled properly and stored safely in a separate collection containers or puncture proof bags/containers in a designated storage areas of the health care facilities or an authorised centralized storage facility to be developed by the associations of HCFs located in that region or Indian Medical Association (IMA) or State Health Department. The storage area is required to be provided with a temperature control provision to avoid vaporization of mercury and other provisions for proper storage of mercury wastes (i.e proper lighting, epoxy lining, mercury spill kit provision, proper mercury spill collection pit etc.,). As far as possible, the storage of mercury bearing waste within the health care facility for a longer period should be avoided and it should be sent to the authorized Centralized Storage Facility. The accumulated wastes in a centralized temporary storage area need to be disposed of within 90 days safely following the manifest in accordance with the Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2008 notified under the Environment (Protection) Act, 1986, in consultation with the respective State Pollution Control Board (SPCB)/Pollution Control Committee (PCC).

Suggested precautions for storage of mercury bearing wastes is as follows:

i) Storage sites inside multi-purpose buildings should be in a locked dedicated room or partition that is not in an area of high use.

ii) Wastes should not be stored on or near "sensitive sites" (e.g. hospitals or other medical care facilities, schools, residences, food processing facilities, animal feed storage or processing facilities, agricultural operations, or facilities located near or within sensitive environmental sites).

iii) Ventilating a site with carbon filtration of exhaust gases is considered when exposure to vapors for those who work in the site and those living and working in the vicinity of the site is a concern.

iv) Dedicated buildings or containers should be in good condition and made of hard plastic or metal, not wood, fibreboard, drywall, plaster or insulation.

v) The roof of dedicated buildings or containers and surrounding land should be sloped so as to provide drainage away from the site.

vi) The floors of storage sites inside buildings should be concrete or durable (e.g., 6 mm) plastic sheeting. Concrete should be coated with a durable epoxy.

vii) The storage area should be marked or delineated clearly by fencing, posts, or walls in order to limit access to it.

viii) A recording system on the condition of the storage area should be established, details of which shall include the observations, name of inspector, date inspected, etc.

ix) The outside of the storage site should be labelled as a waste storage site (giving details w.r.t type of waste stored & its quantity, storage duration, contact details in case of any emergency etc.).

x) The site should be subjected to routine inspection for leaks, degradation of container materials, vandalism, integrity of fire alarms and fire suppression systems and general status of the site.

xi) Only trained personnel should be handling containers in storage.

xii) A copy of the Material Safety Data Sheet should be available in the area.

xiii) Only authorised transporter should be engaged for transportation of such substances or mixtures to any authorised recovery unit, re-users (manufacturers of medical instruments) or CBWTF operator or TSDF.

Steps to be followed for mercury spill clean up is given **Figures 26.**

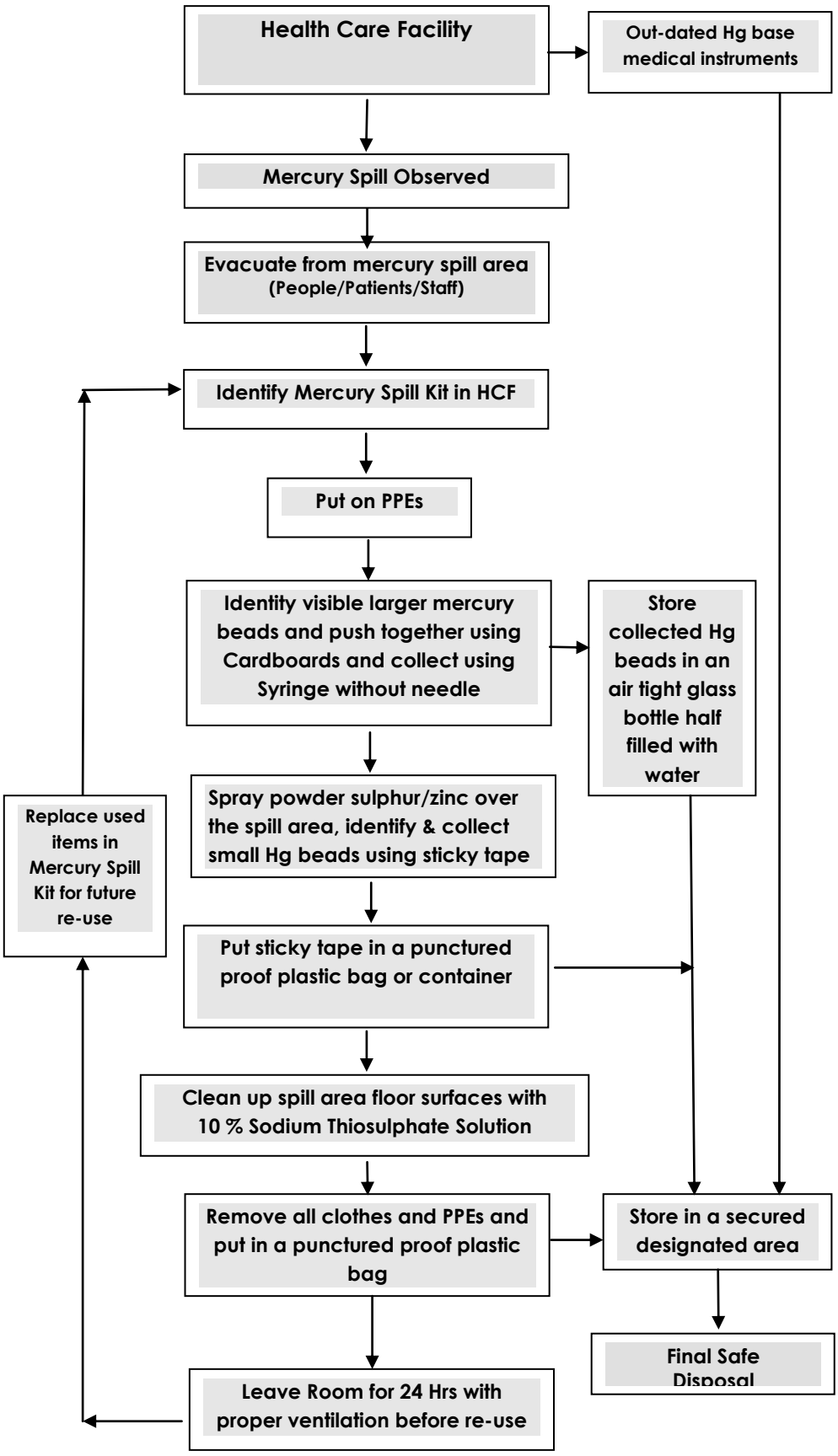

Fig. 26. Mercury spill cleanup procedure

5.7. Mercury waste disposal options

Fig. 27. Outdated Medical Instruments containing mercury

All the used and out-of-service mercury-containing medical devices and the mercury bearing waste from spills, waste from mercury devices that are taken out of use, the ongoing collection of dental amalgam waste, and waste from digital thermometer batteries that contain trace amounts of mercury and therefore require end of life management. While disposing the mercury bearing waste, care should be taken that the manifest as stipulated under the Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2008 is followed to ensure that the mercury waste is delivered at a designated place for the intended purpose. Rule 21 i.e **Manifest system (Movement Document to be used within the country only for transportation of hazardous waste) and** manifest to be carried while transporting the waste to the designated place as stipulated under the Hazardous Waste (Management, Handling & Transboundary Movement) Rules, 2008 is enclosed at **Annexure – III and Annexure –IV** respectively.

More environmentally acceptable **disposal options** for mercury bearing waste are suggested as follows

a) **Disposal through medical equipment manufacturers**:

Considering the added benefits of reducing the amount of mercury ending up in the environment, and decreasing the demand for new raw mercury, as far as possible, mercury bearing waste should be "recycled" into new mercury-containing products following the principles of extended producer responsibility (EPR) as EPR is a suite of policy tool for reducing the generation of wastes by promoting greater recycling and resource recovery.

b) **Disposal of mercury bearing waste through mercury recovery units:**

Most encouraging and sustainable mercury disposal option is to forward mercury bearing waste for reclaiming of the mercury either by mercury distillation or roasting methods and reuse of recovered mercury in manufacture of mercury base instruments. However, at present, there are no mercury recovery units in the Country like in the developed world. However, mercury distillation method being used by the existing mercury based chloro-alkali plants for recovery of mercury from waste sludges etc need to be developed in the Country.

c) **Disposal through Hazardous Waste Treatment Storage and Disposal Facility (TSDF):**

Disposal option for disposal of mercury bearing waste containing residual mercury and not economically viable for recovery, such waste need to be disposed of through a nearby authorized Common Hazardous Waste Treatment, Storage and Disposal Facility (TSDF) following the manifest as stipulated under the HW (M, H & TM) Rules, 2008 for final disposal of such waste in a secured landfill after ensuring pre-treatment by stabilization technique meeting the requirements of criteria for final disposal of hazardous waste in a secured landfill as suggested under the CPCB guideline. State-wise list of TSDFs which are presently in operation are given in **Table 5.**

d) **Disposal through a Common Bio-medical Waste Treatment Facility (CBWTF):**

Very feasible option for disposal of mercury bearing waste is to handover properly segregated mercury bearing waste to an authorised common bio-medical waste treatment facility (CBWTF) representative being CBWTF operator collects the waste daily from the member health care facility, on charge basis for further treatment and safe disposal as to be authorised by the SPCB/PCC under the BMW Rules.

Suggested mercury waste disposal options are given in **Fig. 28.**

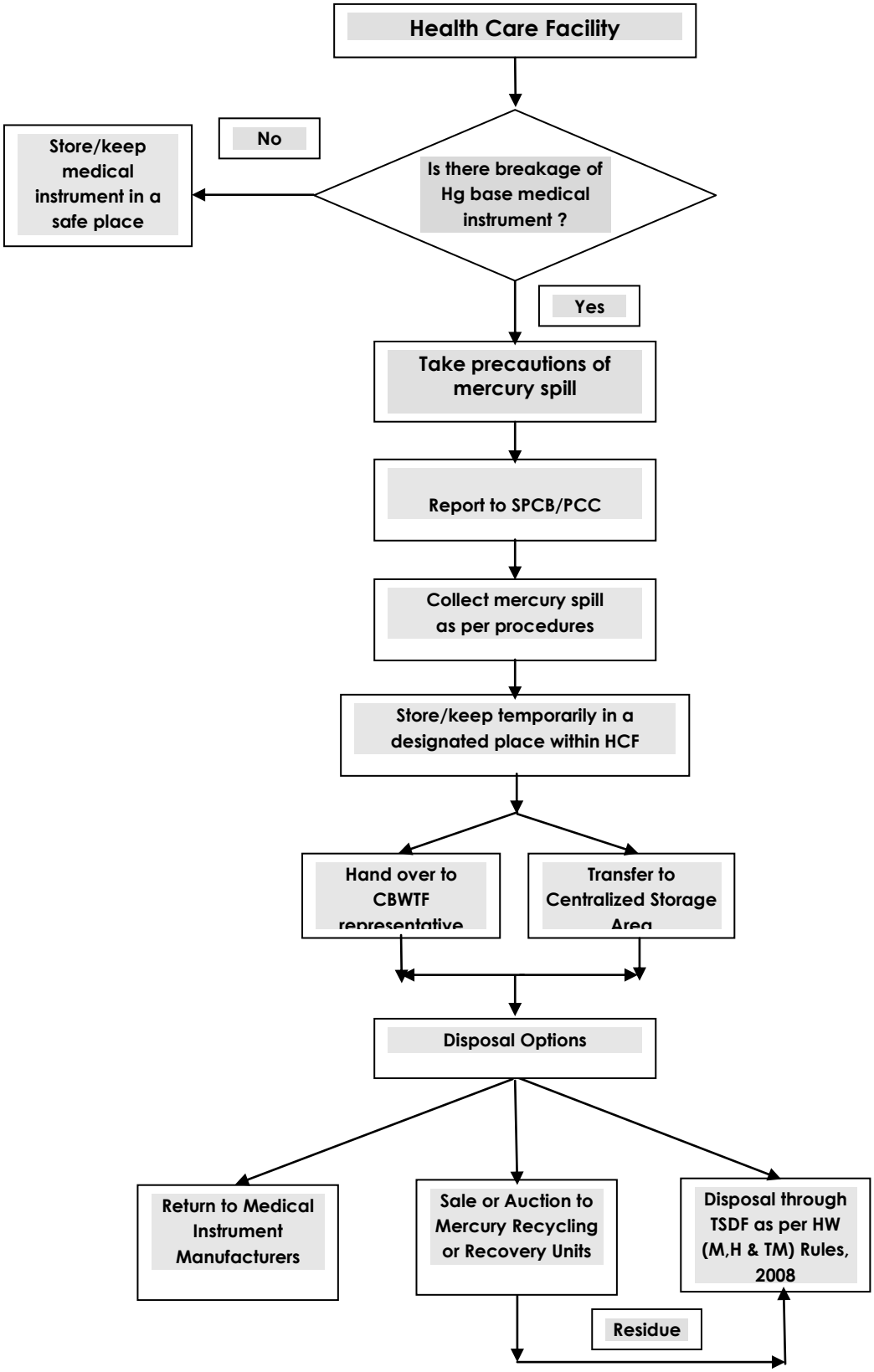

Fig. 28. Final disposal options for mercury waste from HCFs

6.0. Maintenance of stock inventory and records for purchase, used/broken, disposed mercury bearing wastes/materials:

In order to arrive at annual average mercury spills due to breakages of the medical devices containing mercury in HCFs, there is a need to maintain proper records with regard to the annual purchase of mercury based instruments, no. of instruments broken, no. of mercury based instruments available as on the date, quantity of mercury spillage & its collection, storage methods, final disposal method followed to prevent the loss of mercury in environment. Such records need to be maintained and statement to be submitted by HCFs along with annual report to be submitted by the HCFs in accordance with the Bio-medical Waste (Management & Handling) Rules, 1998 i.e. on or before 31 st January every year.

7.0. Training and awareness activities:

Awareness of the hazards of mercury is crucial to maintain the health and safety onsite. The owners of the health care facility should take pro-active role in maintaining the 'safe management of mercury waste in a healthcare facility' with an objective to minimize exposure to patients, health workers, waste workers, and the community, and to prevent environmental pollution. In order to accomplish these objectives, a mercury waste management plan is essential. A plan should include *Education and training of staff and community* – awareness-raising, public education, periodic training on mercury management, simulation (response to mock spills). As a part of periodic awareness/training programme, following aspects be emphasized, which include:

(i) *Chemical properties of mercury, probable health impacts*
(ii) *Proper maintenance of mercury devices* – safe procedures for calibration and preventive maintenance
(iii) *Appropriate labelling and collection* – segregation of mercury from infectious and regular wastes, use of appropriate containers, labelling
(iv) *Mercury spill management* – spill kits, proper procedures, staff training
(v) *Mercury waste collection plan* – procedures for on-site storage and transport, a designated storage area
(vi) *External management strategies* – take-back arrangements with vendors for used or obsolete mercury devices, arrangements with approved mercury recycling facilities (if available), phase-in of non-mercury devices

(vii) *Proper disposal methods* – transport to approved treatment and disposal facilities (if available)

Apart from awareness workshops, poster display within the premises of HCE may be made in all the wards. A protocol for on the spot first aid facility particularly for mercury inhalation, ingestion or exposure should be prepared and should be made available at easily approachable place.

It is also important to have individuals available at all times who are trained and familiar with management of mercury spills and the use of a spill kit in the Health Care Facility. Notices/placards should also be adequately posted throughout the facility listing trained individuals with contact numbers for easy access to such trained personnel in the event of any mercury spill.

8.0. Policies and the workplace/indoor air standards for mercury in health care facilities for voluntary compliance:

Most exposures occur as a result of inhaling mercury vapor or by getting mercury on the skin when cleaning up a spill of metallic mercury. Employees in HCFs can encounter mercury spills from broken thermometers , barometers, and standard barometers and other sources.

Recommendation from the Scientific Committee on Occupational Exposure Limits for elemental mercury and inorganic divalent mercury compounds, SCOEL/SUM/84, European Commission, May 2007; the threshold limit value (daily exposure level above which it is believed a worker could suffer adverse health effects) or TLV assigned by the American Conference of Governmental Industrial Hygienists (ACGIH) is 0.025 mg per m^3 averaged over a normal 8-hour work day and a 40-hour work week. The National Institute for Occupational Safety and Health Administration (NIOSH) has a recommended exposure limit (REL) for mercury vapor of 0.05 mg per m^3 as a time-weighted average (TWA) for up to a 10-hour work day and a 40-hour work week where as The US Occupational Safety and Health Administration (OSHA) regulates the level of mercury vapors to which workers can be exposed i.e Permissible Exposure Limit (PEL) and for mercury vapor is a ceiling value of 0.1 mg per m^3 in air.

All the HCFs make ensure that mercury spill cleanup materials are readily available in adequate numbers at all the identified areas apart from mercury spill response plan. Appropriate personnel are trained on mercury cleanup procedures.

Adequate measures should be taken in health care facilities so as to make the mercury free environment such that the mercury levels in ambient air (especially after clean up of any mercury spill) at all the work zone environment of the Health Care Facilities is maintained at 0.01 mg/Nm^3 (time weighted average concentration 08 hrs) & 0.03 mg/Nm^3 as short term exposure limit (15 minutes), as stipulated under the Factories Act, 1948 **(5)**.

Policy on mercury usage, handling procedures, safe guards, spill collection and clean up kit etc need to be formulated and placed in HCFs. Mercury plans and policies should also consider such critical issues as [4]:

(i) Ensuring that a competent staff person trained in mercury spill cleanup is always available

(ii) Ensuring that personal protective equipment is always available for the cleanup staff

(iii) Training for all staff on how to respond to a mercury spill, how to secure an area in the event of a mercury spill, and who to report a spill to

(iv) Guidelines that specify the circumstances when the patient(s), visitors, and staff should be evacuated from the area before cleanup

(iv) Guidelines that specify what to do with mercury spills that occur during a medical or surgical procedure

(v) Guidelines that specify when a room is "clean enough" to re-occupy

(vi) Preparation of incident reports that describe the spills, the cleanup methods used, unusual circumstances, and follow-up

(vii) Documentation of training of general staff and staff specializing in mercury cleanup; documentation of each spill incident; use of documentation to evaluate causes of incidents, effectiveness of responses, medical monitoring of individuals exposed to mercury, and preventive measures; and regular reporting of results to the administration.

(viii) The healthcare facility should be prepared for a spill in any area of the hospital where mercury-containing devices are used.

Mercury waste management in hospitals need to be established to ensure that no mercury enters the sewage system/municipal bins and bio-medical waste and all the mercury bearing waste is dealt in accordance with the HW (M, H & TM) Rules, 2008. Also, all the HCFs should prefer to use only non-mercury based medical instruments on voluntary basis.

Considering the probable impacts due to the mercury pollution, there is a need to take a policy decision by the State Governments or Union Territory Administration for switching over to the non-mercury base medical instruments in place of mercury base medical instruments in a time bound manner as implemented by the Delhi Government in National Capital.

9.0. Regular monitoring to detect exposure, health impacts study and maintenance of records:

Mercury released from mercury waste exists in the environment (water, sediment, soil, plants and air) or accumulates in the food chain and is taken by human through consuming fish and seafood, or mercury vapour directly enters into human body or is adsorbed on human hair. In order to monitor mercury level in environment due to mercury waste, it is necessary to analyze various samples, such as biological samples (fish and shellfish), environmental samples (water, sediment, soil and air), plants and human samples (hair, blood and urine).

As the activity is limited to Health Care Sector, medical examination which includes a blood test or urine analysis for the Health Care Staff especially those having chances for exposure/ exposed to metallic mercury and handling mercury based instruments should be done ***at least once in six months,*** and records be maintained in this regard.

Based on the medical examination, appropriate remedial measures should be taken by the HCFs i.e. The persons who directly involved in mercury exposure should be replaced by in every two years on rotation basis to minimize effects of mercury exposure and associated health impacts. Records should be submitted to Regulatory Authorities/ State Health Departments on voluntary basis.

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Table 1. Salient characteristics of mercury

General Properties	**Description**
Name	Mercury / quicksilver / hydrargyrum
Symbol	Hg
Atomic number	80
Elemental category	Transitional element
Group, period, block	12, 6, d
Standard atomic weight	200.59(2) g.mol^{-1}
Electronic configuration	[Xe]4f^{14}5d^{10}6s^{2}
Electrons per shell	2, 8, 18, 32, 18, 2
Physical properties	
Phase	liquid at standard conditions for temperature and pressure
Density (near r.t.)	(liquid) 13.534 g·cm^{-3}
Melting point	234.32 K, -38.83 °C, -37.89 °F
Boiling point	629.88 K, 356.73 °C, 674.11 °F
Critical point	1750 K, 172.00 MPa
Heat of fusion	2.29 kJ·mol^{-1}
Heat of vaporization	59.11 kJ·mol^{-1}
Specific heat capacity	(25 °C) 27.983 J·mol^{-1}·K^{-1}
Vapor pressure	P (Pa) 1 10 100 1 k 10 k 100 k at T (K) 315 350 393 449 523 629
Atomic properties	
Oxidation states	4, 2 (mercuric), 1 (mercurous) (mildly basic oxide)
Electronegativity	2.00 (Pauling scale)
Ionization energies	1st: 1007.1 kJ·mol^{-1} 2nd: 1810 kJ·mol^{-1} 3rd: 3300 kJ·mol^{-1}
Atomic radius	151 pm
Covalent radius	132±5 pm
Van der Waals radius	155 pm
Miscellaneaous	
Crystal structure	rhombohedral
Magnetic ordering	diamagnetic
Electrical resistivity	(25 °C) 961nΩ·m
Thermal conductivity	(300 K) 8.30 W·m^{-1}·K^{-1}
Thermal expansion	(25 °C) 60.4 μm·m^{-1}·K^{-1}
Speed of sound	(liquid, 20 °C) 1451.4 m/s
CAS registry number	39-97-6
Most stable isotopes	^{194}Hg, ^{195}Hg, ^{196}Hg, ^{197}Hg, ^{198}Hg, ^{199}Hg, ^{200}Hg, ^{201}Hg, ^{202}Hg, ^{203}Hg, ^{204}Hg

Table 2. Typical mercury content in some of the medical instruments used in Health Care Facilities and their applications

No.	Product	Mercury Content	Applications
1)	Dental amalgams	< 1mg (about 50% in silver coloured dental amalgams)	Tooth restoration
2)	Fever and other thermometers	0.5 to 3 grams	Fever (Temperature) measurement
3)	Manometers	300-600 g	Blood pressure measurement
4)	Sphygmomanometers	20-60 g	Blood pressure measurement
5)	Mercury batteries (mercuric oxide, silver oxide, mercury zinc, mercuric oxide, zinc air, contaminant in other types of batteries)	5-25 mg	Blood analyzers, defibrillators, fetal monitors, hearing aids,holter monitors, pacemakers, pagers, picker calibres, spirometer alarms, telemetry transmitters, temperature alarms
6)	Chemical reagents (Mercury (II) oxide, mercury chloride, mercury (II) chloride, mercury (II) sulphate, mercury nitrate, mercury iodide, sulphuric acid (commercial grade; mercury as impurity), Zenker's solution.)	-	-
7)	Pharmaceuticals	Around 0.01%	Vaccines eye drops, herbal medicines, (thimerosal, phenylmercuric acetate (PMA), phenylmercuric nitrate),; Mercurochrome;Veterinary chemicals (mercuric chloride, phenyl mercuric nitrate & sodium ethlymercurithiosalicylate)

Source: Patterns of mercury-containing products (Huber 1997; Environment Canada 2002; Mercury Policy Project 2005; UNEP 2005)

Table 3. Uses and modes of release of mercury in the environment from HCFs

Used in	**Modes of release of mercury in the environment**
Thermometers (measurement of body temperature)	Slipping and breakage during use hence Hg spillage
Barometers (in respiratory therapy to calibrate blood gas analysers)	Slipping and breakage
Sphygmomanometers (measurement of blood pressure)	Slipping and breakage during use
Dental amalgam	Hg vaporizes from amalgam and get impregnated in gum Leakage of amalgam dispensers
Esophageal dilators / bougie tubes (dilate esophagus)	Leak or breakage
Feeding tube (provide nutrition to patients)	Leak or breakage
Gastrointestinal tubes (Cantor tubes and Miller Abbott tubes, clear intestinal obstructions)	Spillage and rupture of tube
Intraocular pressure device (apply pressure to the eye prior to cataract surgery)	Broken or rupture
Strain gauge (measure arterial blood flow)	Breakage
Urinometer (measure specific gravity of urine)	Breakage
X-ray machines	Hg release by mishandling
Laboratory chemicals (fixatives, stains, reagents, preservatives)	B-5 fixative is discharged into the sewer system during rinsing of tissues
Medical batteries (blood analysers, monitors, hearing aid, halter monitor, pacemaker, spirometer, temperature alarmetc)	Breakage
Thimerosal (a Hg containing preservative to prevent bacterial contamination in vaccines)	
Cleaning products	Through wastewater

Table 4. Alternates to some of the mercury base medical instruments

No.	Product	Applications	Alternatives
1)	Dental amalgams	Tooth restoration	Dental amalgams capsule , Newer alternatives to mercury amalgam fillings are Gold, silver, gallium, ceramic, porcelain, polymers, composites, glass ionomers, etc.
2)	Fever and other thermometers	Fever measurement	electronic digital, expansion, aneroid, single-use thermometers, glass, thermometers containing a Ga/In/Sn "alloy", etc.
3)	Manometers	Blood pressure measurement	Non-mercury liquid, needle bourdon gauges, aneroid manometers, and digital manometers
4)	Sphygmomanometers	Blood pressure	Electronic vacuum gauge, expansion, aneroid
5)	Mercury batteries (mercuric oxide, silver oxide, mercury zinc, mercuric oxide, and Button Cell batteries)	Blood analyzers, defibrillators, fetal monitors, hearing aids,holter monitors, pacemakers, pagers, picker calibres, spirometer alarms, telemetry transmitters, temperature alarms	Lithium zinc, low-mercury alkaline batteries and rechargeable mercury- and cadmium free Versions
6)	Surgical - esophageal dilator		silicone-filled dilator; tungsten-filled dilator
7)	Chemical reagents	-	Mercury (II) oxide, mercury chloride, mercury (II) chloride, mercury (II) sulphate, mercury nitrate, mercury iodide, sulphuric acid (commercial grade; mercury as impurity), Zenker's solution.
8)	Cultural Uses and Traditional Medicine and Pharmaceuticals	Mercury has been used in various pharmaceuticals such as vaccines, eye drops, and other products, mainly as a preservative.	Mercury-free pharmaceuticals and chemicals such as 2-phenoxy-ethanol also be used as vaccine preservatives

		In Laboratories stains, fixatives, re-agents, and calibration solutions in the form of mercury chlorides and thimerosal*	chemical changes such as zinc formalin; process changes such as using poly vinyl alcohol for B5/Fixatives.
		In Maintenance of fluorescent lights; thermostats and levelling devices; electrical relays; and batteries	digital technology; energy efficient lighting; mercury-free batteries; and recycling of lights and batteries
		For **Housekeeping** purposes, bleach solution containing sodium hypochlorite and thimerosal additives; caustic drain cleaners*	thimerosal-free products; organic oils and compounds

Source: *Patterns of mercury-containing products (Huber 1997; Environment Canada 2002; Mercury Policy Project 2005; UNEP 2005) and Mercury-free Alternatives to Mercury-containing products (UNEP 2002; 2006)*

Table 5. State-wise Hazardous Waste Treatment Storage and Disposal Facilities in Operation

S. No.	Name of the State/UT	Number of Common TSDFs in operation
1.	Andhra Pradesh	Total 02 TSDFs with Secured Landfill Facility and Common Incinerator Facility at following sites:
		(i) M/s Hyderabad Waste Management Project (Ramky Enviro Engineers Ltd) Survey no. 684/1, Dundigal village, Qutbullapur Mandal, R.R. Dist-500 043 (A.P.)
		(ii) M/s Coastal Waste Management Project, Jawaharlal Nehru Pharma City, E-Bonangi, IDA, Parawada, Vishakhapatnam
2.	Gujarat	Total 08 TSDFs. Out of 08 TSDFs, following 04 sites have only Secured Landfill Facility:
		(i) M/s Naroda Enviro Project Ltd., GIDC Odhav, Dist-Ahmedabad
		(ii). M/s The Green Environment Services Co-op. Society Ltd. Survey no. 89-90-91, Vill Vinzol, Ahmedabad, Gujarat
		(iii). M/s Vapi Wate & Effluent Management Co. Ltd. Plot no. 4807, etc. Phase IV GIDC, Vapi, Dist: Valsad, Gujarat
		(iv). M/s Gujarat Maritime Board, Alang Dist. Bhavnagar
		And, remaining following 04 sites have Secured Landfill Facility as well as Common Incinerator Facility:
		(i) M/s Nandesari Environment Control Ltd, 519-P, GIDC, Nandesari, Dist. Vadodara.
		(ii) M/s Bharuch Enviro Infrastructure Ltd. Plot no. 9701-9716, GIDC, Ankleshwar-393002.

		(iii) M/s Gujarat Env. Protection & Infrastructure Ltd., Village Gabheni, Near Sachin G.I.D.C. Surat – 394 230. Gujarat.
		(iv). M/s Saurashtra Enviro Projects Pvt Ltd. Survey no. 415, 417 & 418, Vill Juna katariya, Tal-Bhachau, Dist-Kutch, Gujarat
3.	Himachal Pradesh	01 TSDF with only Secured Landfill Facility at M/s Shivalik Solid Waste Management Ltd. Vill Majra, P.O. Dabhota, Teh. Nalagarh, Distt Solan (H.P.)
4.	Karnataka	01 TSDF with only Secured Landfill Facility at Dabaspet
5.	Kerala	01 TSDF with only Secured Landfill Facility at M/s Keral Enviro Infrastructure Ltd., Common TSDF Project, Inside Fact-CD Campus, Ambalmedu, Kochi-682 303
6.	Madhya Pradesh	01 TSDF with only Secured Landfill Facility and Common Incinerator Facility at M/s Madhya Pradesh Waste Management Project (Division of Ramky Enviro Engineers Ltd.) Plot No. 104, Industrial Area No.-II, Pithampur, Dist- Dhar 454 775 (M.P.)
7.	Maharashtra	Total 04 TSDFs . Out of 04 TSDFs, only M/s. Trans Thane Waste Management Association, Mahape, Navi-Mumbai has only secured landfill facility. And, remaining following 03 have Secured Landfill Facility as well as Common Incinerator Facility as follows:
		(i) M/s. Vidharbha Enviro Protection Ltd., Butibori Industrial Area, Mouza- Mandawa, Taluka-Hingana, Dist- Nagpur.
		(ii) M/s. Maharashtra Enviro Power Ltd. Plot No. 56, MIDC Ranjangaon, Taluka- Shirur, Dist – Pune.
		(iii). M/s Mumbai Waste Management Ltd., Plot No. P-32, MIDC Taloja, Tal: Panvel, Dist. Raigad-410 208
8	Punjab	01 TSDF with only Secured Landfill Facility at Nimbua, Derabassi
9	Rajasthan	01 TSDF with only Secured Landfill Facility at M/s Rajasthan Waste Management Project (M/s Ramky Enviro Engineers Ltd) Survey no. 1018/13, Vill-Gudli,Tehsil-Mavli, Zinc Choraha to Debari Railway Station Road, Dist-Udaipur (Rajasthan)
10	Tamilnadu	01 TSDF with only Secured Landfill Facility at M/s.

		Tamilnadu Waste Menagement Ltd (M/s Ramky Agencies, Hyderabad) Gummidpoondi in Thiruvallur District
11	UP	Total 03. Following 03 TSDFs with only Secured Landfill Facility at :
		(i). M/s Bharat Oil & Waste Management Ltd. Gate No. 672, Vill. Kumbhi, NH-2, Kanpur Dehat (UP)
		(ii). M/s Uttar Pradesh Waste Management Project (M/s Ramky Enviro Engineers Ltd.,) Plot No. 672,Village – Kumbhi, Tehsil: Akbarpur, on Sikandara Road-NH –2, Dist – Kanpur Dehat (U.P.)
		(iii). M/s Industrial Infrastructure Services (India) Ltd. UPSIDC Leather Technology Park Banthar, Unnao, U.P.
12.	Uttarakhand #	01 TSDF with Secured Landfill Facility and Common Incinerator Facility# at M/s Bharat Oil & Waste Management Ltd. Mauza Mukimpur, Roorkee-Laskar Road, Roorkee, Haridwar.
13.	West Bengal	01 TSDF with Secured Landfill Facility as well as Common Incinerator Facility at M/s West Bengal Waste Management Ltd. J.L. no. -103, Mouza-Shrikrishnapor, P. S. -Sutahata Dist- Purba Midnapore, Haldia- 721 635 (W.B.).
14	Daman, Diu, Dadra & Nagar Haveli	01 TSDF with only Secured Landfill Facility at M/s Gujarat Enviro Protection & Infrastructure (D&NH) Pvt Ltd, Survey no. 9/1, Mota Randha Village,Silvassa-396230
	Total	**27**

Common Incinerator Facility is under construction at Roorkee, Haridwar.

Annexure -I

FORM III

(see Rule 12 of the Bio-medical Waste (Management & Handling) Rules, 1998)

ACCIDENT REPORTING

1. Date and time of accident:

2. Sequence of events leading to accident

3. The waste involved in accident:

4. Assessment of the effects of the accidents on human health and the environment,.

5. Emergency measures taken

6. Steps taken to alleviate the effects of accidents

7. Steps taken to prevent the recurrence of such an accident .....

Date ..... Signature .....
Place..... Designation.....

Note: Form –III as per Bio-medical Waste (Management & Handling) Rules, 1998 as amended

Annexure –II

FORM -11

[See rule 20(2)]

MARKING OF HAZARDOUS WASTE CONTAINER

HAZARDOUS WASTE *

Handle with Care

Waste Category No	Compatible Group .....
Total Quantity	Date of Storage
Contents and State of the Waste :	
Sender's Name & Address	Receiver's Name & Address
Phone	Phone .....
E-mail.....	E-mail .....
Tel. & Fax No	Tel.& Fax No .....
Contact Person	Contact Person .....
In case of emergency please contact	

Note :

1. *Background colour of lab I fluorescent yellow,*
2. *The words 'HAZARDOUS WASTES' & 'HANDLE WITH CARE' to be prominent and written in red in Hindi, English and in Vernacular Language*
3. *Label should be of non-washable material.*

** delete which ever is not applicable*

Annexure –III

Rule 21. Manifest system (Movement Document to be used within the country only) as per Hazardous Waste (Management , Handling & Transboundary Movement) Rules, 2008

(1) The occupier shall prepare six copies of the manifest in Form 13 comprising of colour code indicated below and all six copies shall be signed by the transporter:

Copy number with colour code	**Purpose**
Copy 1 (White)	To be forwarded by the occupier to the SPCB/PCC
Copy 2 (Yellow)	To be retained by the occupier after taking signature on it from the transporter and the rest of the four copies to be carried by the transporter.
Copy 3 (pink)	To be retained by the operator of the facility after signature.
Copy 4 (orange)	To be returned to the transporter by the operator of facility/recycler after accepting waste.
Copy5(green)	To be returned by the operator of the facility to SPCB/PCC after treatment and disposal of wastes in TSDF.
Copy6 (blue)	To be returned by the operator of the facility to the occupier after treatment and disposal of hazardous wastes in TSDF.

(2) The occupier shall forward copy number 1 (white) to the State Pollution Control Board or the Committee of the UT as the case may be and in case the hazardous wastes is likely to be transported through any transit State, the occupier shall prepare an additional copy each for intimation to such State or the Union Territory and forward the same to the concerned State Pollution Control Board or Committee before he hands over the hazardous wastes to the transporter.

(3) No transporter shall accept hazardous wastes from an occupier for transport unless it is accompanied by copy numbers 3 to 6 of the manifest.

(4) The transporter shall submit copies number 3- to -6 of the manifest duly signed with date to the operator of facility along with the waste consignment.

(5) Operator of facility upon completion of treatment and disposal operations of the hazardous wastes shall forward copy 5 (green) to the State Pollution Control Board/Committee and copy 6 (blue) to the occupier. Copy 3 (pink) shall be retained by the operator of facility.

Annexure -IV

FORM – 13

[See rule 3, 21 (1)]

HAZARDOUS WASTE MANIFEST

1.	Occupier's Name & Mailing Address (including Phone No.) :	
2.	Occupier's Registration No. :	
3.	Manifest Document No. :	
4.	Transporter's Name & Address (including Phone No.) :	
5.	Type of Vehicle :	(Truck/Tanker/Special Vehicle)
6.	Transporter's Registration No. :	
7.	Vehicle Registration No. :	
8.	Designated Facility Name &Site Address :	
9.	Facility's Registration No. :	
10.	Facility's Phone :	
11.	Waste Description :	
12.	Total Quantity :	……m^3 or MT
13.	Consistency :	(Solid/Semi-Solid/Sludge /Oily /Tarry /Slurry)
14.	Transport Description of Wastes :	
15.	Containers :	Number | Type |
16.	Total Quantity :	……m^3 or MT
17.	Unit Wt/Vol. :	…… .. m^3 or MT

18.	Waste Category Number :	
19.	Special Handling Instructions & Additional Information :	
20.	OCCUPIER'S CERTIFICATE :	I hereby declare that the contents of the consignment are fully and accurately described above by proper shipping name and are categorised, packed, marked, and labeled, and arc in all respects in proper condition for transport by road according to applicable national government regulations.
	Typed Name & Stamp Signature : Month Day Year	
21.	'Transporter Acknowledgement of Receipt of Wastes	
	Typed Name & Stamp : Signature : Month Day Year	
22.	Discrepancy Note Space	
23.	Facility Owner or Operator's Certification of Receipt of Hazardous Waste	
	Typed Name & Stamp : Signature : Month Day Year	

Note: Manifest Format as per HW (M, H & TM) Rules, 2008. This copy has to be used in accordance with Rule 21 of the manifest of the HW (M, H & TM) Rules, 2008

REFERENCES

1) Bio-medical Waste (Management & Handling) Rules, 1998 and amendments

2) Hazardous Waste (Management , Handling & Transboundary Movement) Rules, 2008 and amendments

3) Occupational Safety and Health Guideline for Mercury Vapor, U.S. Occupational Safety and Health Administration, Washington, DC; (http://www.osha.gov/SLTC/healthguidelines/mercuryvapor/recognition.html)

4) "Managing Small Mercury Spills," Fact Sheet, Health Care Without Harm Europe (Praha, Czech Republic) and Health & Environmental Alliance (Brussels, Belgium), October 2006. (http://www.noharm.org/europe/issues/toxins/mercury/resources.php)

5) Threshold Exposure Limits for mercury as per Factories Act, 1948

6) "Managing Small Mercury Spills," Fact Sheet, HCWH Europe and HEAL (ibid.); U.S. Environmental Protection Agency's website "Mercury Releases and Spills: Cleanups and Proper Disposal," updated December 2, 2009 (http://www.epa.gov/hg/spills/);

7) "Mercury Spill Information and Cleanup Guidance," Indiana Department of Environmental Management, May 2007; "Personal Protective Equipment Information for Mercury," Canadian Centre for Occupational Health and Safety, updated December 21, 1998;

8) CPCB News Letter 'Parivesh' on 'Mercury : Environmental Implications & Toxicity' of December 2009

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