GUIDELINES

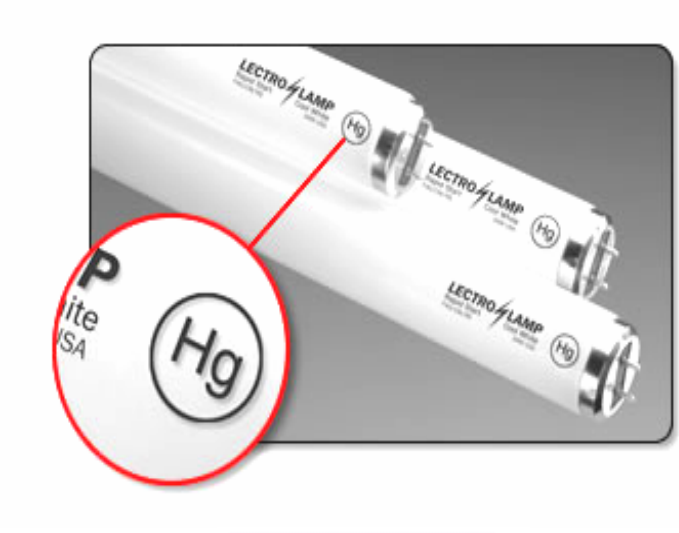
FOR

ENVIRONMENTALLY SOUND

MERCURY MANAGEMENT

IN

FLUORESCENT LAMP SECTOR



CENTRAL POLLUTION CONTROL BOARD

MINISTRY OF ENVIRONMENT OF FORESTS

PARIVESH BHAVAN, EAST ARJUN NAGAR,

DELHI- 110032

WEB SITE: www.cpcb.nic.in

November 2008

OBJECTIVE

Mercury-bearing lamps (fluorescent, compact fluorescent, mercury vapor, sodium vapor and metal multi-vapors and mixed) use mercury as a vital component for their functioning. Mercury concentration in these lamps varies considerably depending on the manufacturer, the type of lamp and the manufacturing year.

Once the life time of these lamps have ended, they generate a hazardous waste due to the release of mercury, which must be properly disposed of. As the use of fluorescent lamps (FLs), including Fluorescent Tube Light (FTL) and Compact Fluorescent Lamp (CFL), is increasing due to its energy efficiency over the conventional incandescent lamps; the amount of FLs that have to be treated is growing, too. Though these FLs release relatively less quantity of mercury, when disposed as compared to other mercury lamps; they remain of major concern due to the large & further growing number of FLs in service, particularly, in domestic sector.

Therefore, the Ministry of Environment & Forests, Government of India had constituted a Task Force for evolving a policy for management of mercury and a Technical Committee to suggest a set of Guidelines, recommending measures & standards, for environmentally sound management of mercury in fluorescent lamp sector. These present guidelines are applicable, in principle, to other mercury-bearing lamps, as well.

1.0 BACKGROUND

1.1 NATURE, OCCURRENCE, DISTRIBUTION & CHEMISTRY OF MERCURY IN THE ENVIRONMENT

Mercury is the only metal element, which is liquid at ambient temperature and also called *Quicksilver* because of its silvery white appearance. It rarely occurs free in nature and mainly found as bright red crystalline solid *Cinnabar Ore (HgS)*.

Mercury is odourless, lustrous liquid metal that sinks in water and falls under heavy metals category. It is mobile, ductile and converts into malleable mass on being solidified at –39 ^{0}C, which may be cut with a knife. Each and every atom of mercury is capable bio-chemically to disable an enzyme or other critical protein in our body. Thus, mercury has the potential to produce significant health effects through series of bio chemical reactions in our body.

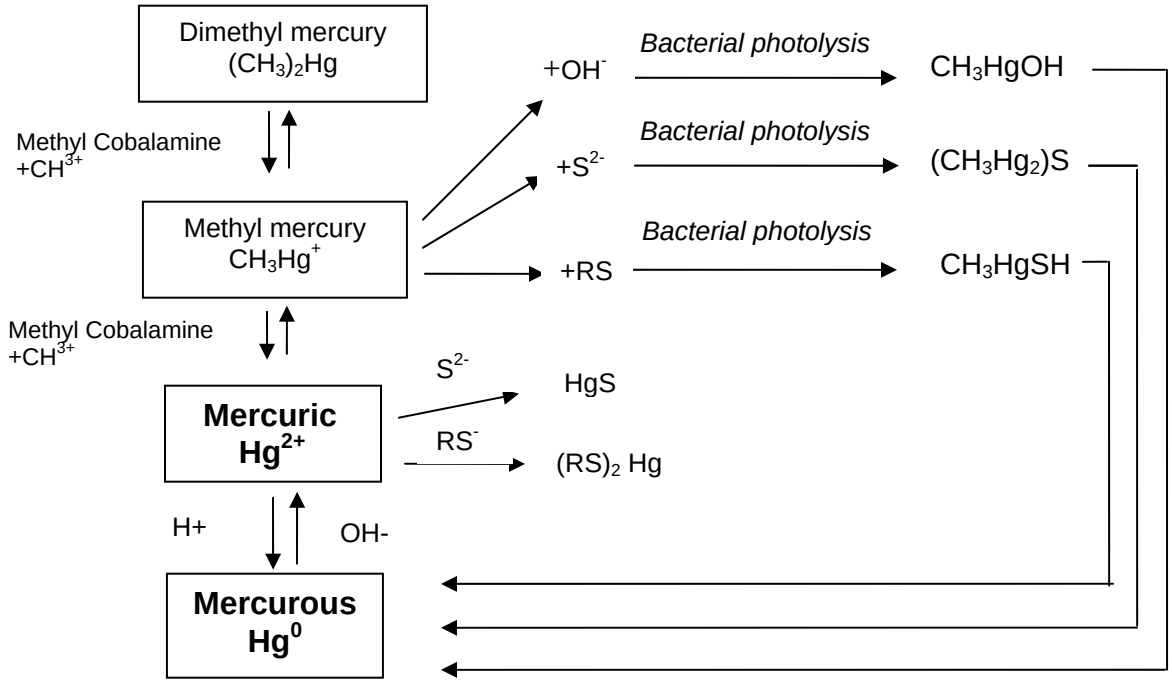
Physical Chemistry of Mercury	
Chemical Symbol	Hg (Hydrargyrum)
Atomic Weight	200.61
Atomic Number	80
Valency	+1, +2
Density	13.456
Boiling Point	356.9 ^{0}C
Solidity	-39 ^{0}C

Mercury is a natural component of the earth. Average abundance is assumed to be 0.05 gm/kg in the earth's crust but can vary significantly in different areas. It can be mobilized by volcanic activity and weathering of rocks. From the 25 known mercury minerals, only cinnabar deposits have been harvested for the extraction of mercury, a large number of them located in the Mediterranean basin. It occupies only 2-3% of the earth's surface but contains about 65% of world's mercury resources. The three biggest deposits are located in Spain, Slovenia and Italy, representing two thirds of the annual global mercury production.

In nature, mercury is rather found within compounds or as inorganic salts, when the mercuric ions (Hg^{+2}) combine with inorganic ligands. Some of them, like mercuric chloride ($HgCl_2$), are sufficiently volatile to exist as atmospheric gases, but due to water solubility and chemical reactivity of the gases they are more rapidly deposited from the atmosphere than elemental mercury gas. They show shorter atmospheric lifetimes. Combined with carbon, various organic mercury compounds are formed. The most common is methyl mercury Hg $(CH_3)_2$.

Besides its elemental form (Hg^0), mercury can be found in the nature in different speciation conditions. One of them is ionic mercury, that is, under certain environmental conditions, able to originate organic compounds known as organo-mercury. Mercury can exist as a cationic species because of the oxidation of the elemental mercury, producing mercurous ((Hg^{+1})) and mercuric ((Hg^{+2})) ions. Such ions can cause irreversible damages to

several organs, when animals and human organisms, are exposed to them. Even worse, they could lead the organism to death. As well as the inhalation of mercury vapors, the ingestion of food containing organo-mercury, especially methyl mercury (CH_3Hg^+), represents great health risks.



ENVIRONMENTAL CHEMISTRY OF MERCURY

1.2 LIGHTING INDUSTRY IN INDIA

Lighting industry has an annual growth of about 12% per annum in the last 4 years. Amongst the various products, the consumption of CFLs has contributed a very large growth rate, as high as 50% in 2006. This product segment has registered total quantity of > 100 million pieces during 2006 and as per the estimates; the figure is likely to cross 140 million pieces this year i.e. year 2007. A lot of new plants have been put up in CFL

in the last one year and today the CFL manufacturing capacity in India has crossed 100 million.

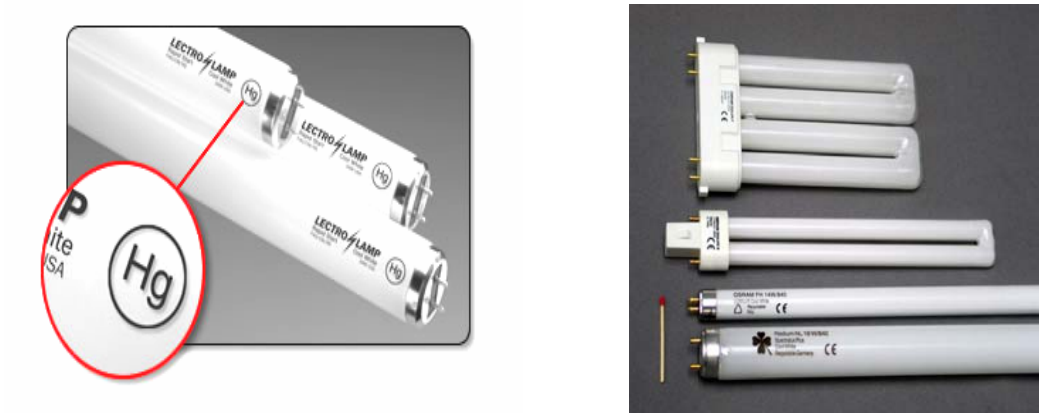
Incandescent lamp (GLS) production has further increased by more than 20% during 2006. Similarly, the fluorescent lamp market has shown a growth of 10% in 2006. HID lamp segment has equally shown good results of 24% growth in 2006. It is estimated that the luminaries market has been growing at least 25 to 30% per annum for the last two years.

Mercury is an essential ingredient for most energy efficient lamps. Fluorescent lamps and high intensity discharge (HID) lamps are the two most common types of lamps that utilize mercury. Fluorescent lamps provide lighting for most schools, office buildings, and stores. HID lamps, which include mercury-vapor, metal halide, and high-pressure sodium lamps, are used for streetlights, floodlights, and entertainment, sports and industrial lighting. Followings types of lamps contain mercury:

(i) Fluorescent Tube Lamps (FTL)
(ii) Compact Fluorescent Lamps (CFLs)
(iii) High Intensity Discharge (HID) Lamps, including Mercury Vapour, Metal halide and high Pressure Sodium
(iv) Neon Lamps (some use mercury and phosphor powder)

[High Pressure Mercury Lamps]

[Mercury Blended Reflector Lamp]



Fluorescent Lamps containing Mercury

Fluorescent Tube Lights (FTLs)

A 40-watt fluorescent tube emits 2,150 lumens as compared to 455 lumens by a standard incandescent 40-watt bulb. In addition, fluorescent tubes typically last longer and create much less heat than incandescent lamps. The newer generation, in fluorescent tube contains, T-8 and T-5 tube lights, especially with tri-band phosphor and is highly energy efficient.

Compact Fluorescent Lamps (CFLs)

Compact fluorescent lamp is energy efficient as most of the electric energy used is converted into light rather than heat. CFL are simply small fluorescent tubes with attached electronic ballast. When compared to standard incandescent bulbs, they consume 80% less electricity and last ten times longer.

Light Emitting Diodes (LEDs)

LEDs are new entrant to the field of lighting and are causing lighting revolution in areas where lighting intensity required is not very high. These LEDs have about 11 years of life, a real advance in lighting technology. This small light has no element to break, no glass to shatter and is not affected by heat or cold and can be lit up using ordinary batteries or very low voltages. These are at present used in a big way in automobile industry and for traffic lights. Research is going on to improve upon the quality of LED for its use in lighting applications.

Due to heavy electrification in villages during the last financial year, the Incandescent Lamp has seen unprecedented growth of over 20% during the year 2006. CFL however continues to grow @ about 40% p.a. Similarly, another Energy Efficient Product like Metal Halide Lamp has also been growing between 20 to 24% per annum. Fluorescent Tube Light continues to enjoy market growth of over 10% on regular basis. It is estimated that all Energy

Efficient Products shall continue to grow at the same speed for the next 3 years at least.

Table: WORLD CFL PRODUCTION vs. INDIAN CFL CONSUMPTION

Year	World (million pcs) Production	%growth	Total Indian Consumption (million pcs)	% growth
2001	820	-	27	-
2002	880	7	34	26
2003	1144	30	36	6
2004	1500	31	43	27
2005	1930	29	67	56
2006	2650	37	100	49
2009 (Estimated)	**6000**		**220**	

Source: ELECTRIC LAMP AND COMPONENT MANUFACTURERS ASSOCIATION OF INDIA (ELCOMA)

1.3 ROLE OF MERCURY IN FLORESCENT LAMPS

A Fluorescent lighting system consists of two or three main components: The fluorescent lamp, The Ballast, and the Starter system. The basic concept behind a fluorescent lamp is that a flow of electrical current occurs between two metal conductors placed in a glass tube, a process also known as arcing. That current flow passes through the gases in the tube (argon and a small amount of mercury in a gaseous phase) and excites the mercury atoms in the gas phase. The excited atoms emit photons, some of which are vibrating at ultraviolet frequency.

The ultraviolet light strikes a phosphor coating on the inner part of the glass. The phosphor responds to the ultraviolet light by producing a bright visible light. For a fluorescent lamp to start working, the potential of the electricity provided to the electrical conductors (called cathodes) inside the lamp must be greater than the initial electrical resistance of the gas in the lamp so that the electricity may begin arcing through the gas. The amount of mercury required is very small, typically measured in milligrams, and varies by lamp type, date of manufacture, manufacturing plant and manufacturer.

A fluorescent lamp mainly contains argon gas. When a flow of electrical current passes through argon gas, several wavelengths of light are produced, including short-wave ultraviolet light. However, argon gas, alone, doesn't produce sufficient short-wave ultraviolet to greatly excite the phosphors used in most fluorescent tubes. The fluorescent powder i.e. phosphor consists of calcium phosphate, Al_2O_3, Polyethylene oxide, dispersion agent etc., in water.

To generate more ultraviolet, a small amount of mercury is added to each lamp. Although the mercury is in liquid form when the lamp is not operating and the lamp is at room temperature, the mercury vaporizes when the electrical flow through the argon gas starts, and the presence of gaseous mercury greatly increases the ultraviolet light produced.

Mercury also helps increasing the amount of current that can flow through the gas, and in turn that helps generate even more ultraviolet light. This ultraviolet light strikes a layer of phosphor that is coating the inner part of the fluorescent lamp, and in turn the phosphor blocks most of the ultraviolet light. Because of the ultraviolet light, the phosphor emits various frequencies of visible light. Manufacturers blend phosphors to produce various shades or colors of visible light. In some cases, the glass that the lamp tubing is made of is also tinted to provide the desired light color. Some manufacturers build fluorescent lamps that produce several shades of white as well as colors like red, yellow, blue and green. Some phosphors are brighter than others, so depending on the materials used, a fluorescent lamp can produce different levels of light, despite consuming the same amount of electricity. Other design factors can affect the efficiency and life expectancy of a fluorescent lamp.

1.4 MANUFACTURING PROCESS OF FLUORESCENT LAMPS

Straight glass shells are cut to required size and bend to U shape. Later these tubes are washed with DM water at 65-75 ^{0}C temperature and then dried by hot air at 70-80 ^{0}C for about 25 minutes. After drying they are coated with fluorescent powder coating prepared with a binder and DM water. The coated tubes are again dried by hot air at temperature 70-80 ^{0}C for about 25 minutes.

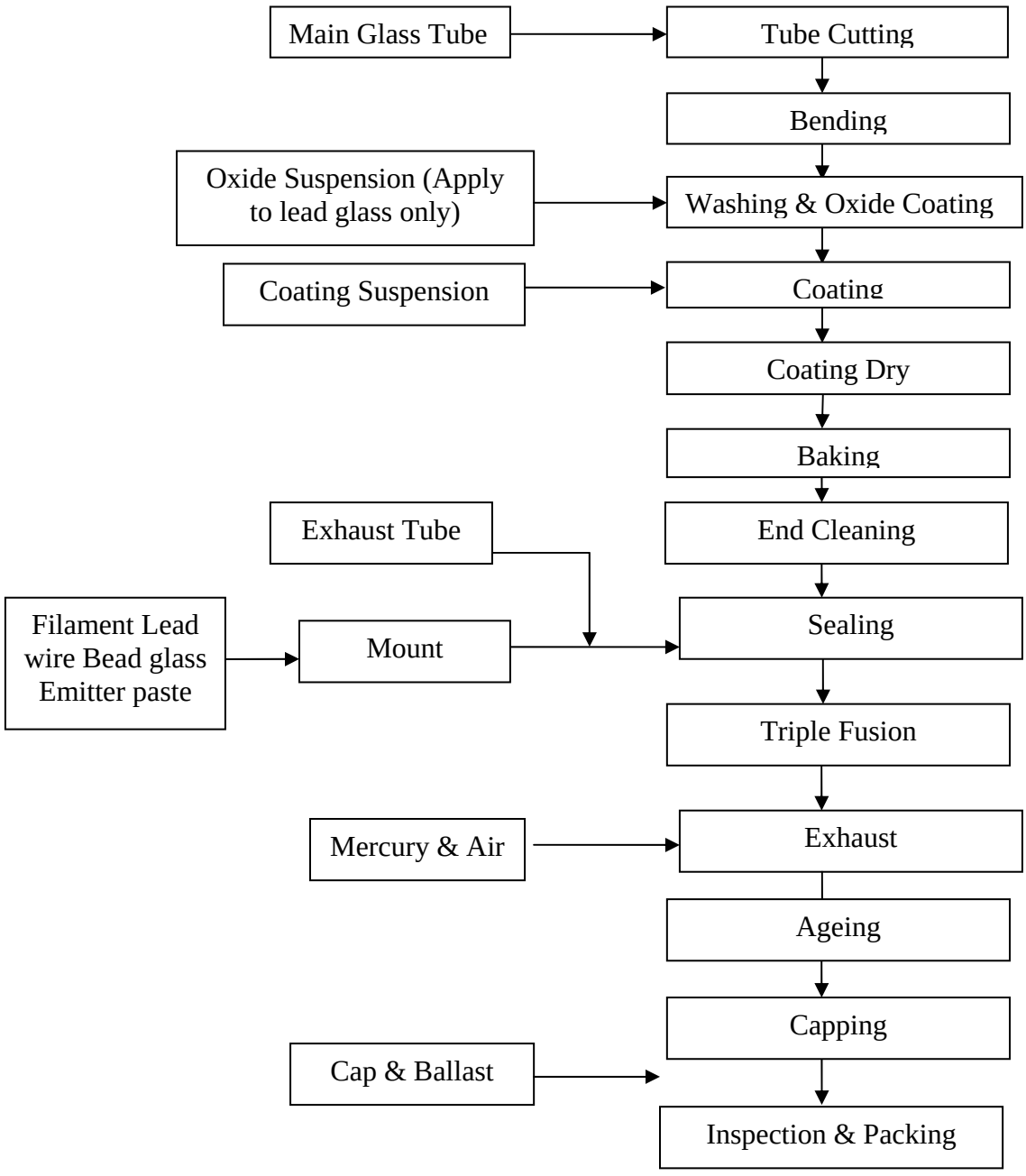
These tubes are transferred to backing machine, and are subjected to a temperature of about 550 ^{0}C for about 3 minutes. There after they are transferred to end wiping and ends are wiped. These shells are loaded to sealing machine with mounts on one side of each U tube. The sealed tubes are then transferred to machine for making make U tube.

Sealed and used tube groups are then transferred to Exhaust Machine, for evacuation, Cathodes are heated and required quantity of mercury is introduced. Cathode heating and activation is continued. Required quantity of inert gas is injected in the tubes and the tubes are vacuum – sealed by using tipping burners. These lamps are subjected to Aging process. Thereafter these lamps are pasted with PVC covers lamps are backed at 120 ^{0}C for about 1 ½ Minutes to make a good binding between PVC cover and glass. The wires are inserted into the ballast and soldered. These lamps are tested and base fitting process is done. Total lamp is rechecked and aluminum caps are fitted and soldered on top. The PVC base and cap is crimped by tool and Quality Assurance (QA) department inspects these lamps. After checking they are sent for packing and dispatch.

A common process flow-chart for producing fluorescent lamps is presented below:

PROCESS FLOW CHART FOR

MANUFACTURE OF FLUORESCENT LAMPS



1.5 MERCURY CONSUMPTION IN INDIAN INDUSTRY

Mercury is used in small amounts per lamp in a number of different types of discharge lamps, with fluorescent tubes and compact fluorescent lamps (CFLs).

Range of Mercury Consumption in different types of FLs

The concentration of mercury in different type of lamps may vary and it depends upon the type of technology, used in the dosing of mercury i.e. liquid mercury & pill technology. The typical mercury concentration in mercury bearing lamp sectors is given in the table:

Typical Mercury Concentration in Mercury bearing Lamp

S No.	Type of Lamps	Mercury Content (mg/lamp)	Country/ Region for data
1	Fluorescent Tubes (double end)	15 (1997) 10(2002) 15-45 10-22 23-46 15-60	European Union Russia USA Canada India
2	Compact Fluorescent Lamp	5 10 12-30	European Union Canada Russia

		3-12	India*
3	Mercury Vapor & Metal Halide Lamp	~ 20 (75 W) ~ 250 (1000 W)	Global
4	High Pressure Sodium Lamp	~ 8.3 (50 W) ~ 25 (1000W)	Global

Source: UNEP - Toolkit for identification and quantification of Mercury release - November 2005.

*On the basis of inspections and information collected from the manufacturers.

It is estimated that total Mercury consumption in FTL sector is around 7.5 MT Hg /annum, considering about 250 million units/annum of production and average 30 mg of Mercury in each FTL.

It is estimated that total Mercury consumption in CFL sector is around 0.5 MT Hg /annum, considering about 100 million units /annum of production and average 5 mg of Mercury in each CFL.

2.0 MERCURY MANAGEMENT IN FL SECTOR

2.1 MERCURY EMISSION

The major sources of mercury release are as follows:

(i) Vent attached to Hg dosing machine.

(ii) Used/broken lamps/cut glass tubes used in dosing of Hg in the process.

(iii) Mercury distillation.

(iv) Mercury spills.

The mercury release (into the environment) from the fluorescent lamp sector is estimated at around 8 MT (considering the entire lot of FLs being manufactured in the country as replacement of used lamps), of which approximately 2 MT of mercury is estimated to be released into air environment.

The permissible level of mercury, as per Factories Act 1948, in workspace air is 0.1 mg/m^3; whereas IDLH (Immediately Dangerous to Life or Health Concentration) value is 10 mg/m^3.

2.2 WASTE GENERATION

Following types of wastes are generated from the fluorescent lamp sector:

(i) Glass waste (with & without mercury).

(ii) Waste Phosphor Powder.

(iii) Waste Mercury (in liquid & vapor phase).

(iv) Waste Electronic & plastic components.

(v) Residue from Mercury distillation facility.

(vi) Waste from air pollution control system.

The estimated weight of a typical CFL is 0.04 kg without base, which is expected to contain around 20% of waste (by weight) as mercury-contaminated waste. The typical 1.2-metre

fluorescent lamps contain approximately 0.26 kg of glass, 0.02 kg of combined metals and 0.01 kg of phosphor powder.

2.3 PRESENT TREATMENT & DISPOSAL PRACTICES IN INDIA

Manufacturer's Level:

At the lamp manufacturing level, fluorescent lamp manufacturing units have varied level of waste management practices. Some have adopted practice of proper crushing, under vacuum extraction, followed by segregation of glass (with & without mercury contamination), phosphor powder and liquid/vapor mercury. The mercury vapor is collected and adsorbed on an activated carbon pad. Most others have very crude way of handling and disposing mercury-bearing wastes generated from the process. Many manufacturing units have crude type of distillation facility for the purification of raw mercury obtained from the Market. The residue obtained from the distillation of raw mercury is reportedly sent to TSDF.

Such crude set up, for handling of mercury-contaminated materials, is expected to result in mercury emissions from such waste handling facilities. There has not been enough thrust given on the recovery of mercury at such facilities, as observed. Also in India, there is no specific norm prescribed for the mercury emission in FL sector at present.

Consumer Level:

As per the present observed practice at consumer level in the society at large, often, the used lamps are collected by the kabari from the households and collectively handed over to the glass recyclers for the recovery of glass material. This is all operative in a highly unorganized sector.

It has, also, been observed that, the used lamps are thrown in the garbage bins and finally into the municipal garbage dumpsites, contaminating air, water and soil. Most of the used lamps are broken either at transit solid waste bins (provided by local civic authority) or broken during the transport to the final disposal site. A portion of the mercury, in vapor form, is released into the air; whereas rest of the mercury is released onto the soil with further possibility of getting into the surface and/or ground water bodies through the leachate from soil.

2.4 INTERNATIONAL SCENARIO FOR COLLECTION, TREATMENT & DISPOSAL OF USED FLUORESCENT LAMPS

As per the available information on the international scenario on collection, handling, transportation, treatment and disposal of mercury-bearing lamps, most western countries follow WEEE (Waste Electrical & Electronics Equipment) Directives based on the concept of Extended Producers' Responsibility. The US has independent market-oriented system, where the consumer is required to pay money and efforts, both, for collection,

treatment and disposal at the centers recognized by the concerned regulatory authority. There is no proper information available in respect of China and Japan, in this regard.

The current practices for collection, treatment & disposal of used FLs, as adopted by various countries, are presented in the following Table:

Sr. No.	Country	Collection of Used lamps	Disposal / recycling	Regulation
1	USA	Generator has to hand over Handler or Authorised Recycler	Authorised Recycling Unit	Universal Waste Rule
2	European Union (EU)	Producers to set up collection system for households and other end users	Authorised Treatment Facility	Waste Electrical and Electronic Equipment (WEEE) and Restriction on Hazardous Substances Directives (RoHS) Directives
3	Germany	Collection Centers	Lamp Recycling Facilities	Recovery and disposal Act
4	Sweden	Producers' responsibility for the collection, Treatment & Disposal	Producers responsibility for recycling	Waste Ordinance
5	Russia	DNA	DNA	Federal Law – Waste of Production and Consumption

6	Taiwan	Retailers as Collection Centers	Authorized Recycling facilities	Waste Disposal Act
7	Finland	Municipalities have an obligation to arrange collection of FLs and other Hg containing waste from households	Waste lamps may only be treated by a company authorized for handling hazardous waste	WEEE Directive
9.	China	DNA	DNA	Law of Environmental Protection
10.	Japan	DNA	DNA	Law for Promotion of Effective Utilization of Resources

DNA: Details not available

Most advanced countries have proper legal back up to support environmentally safe disposal of mercury-contaminated used lamps, particularly at community level, e.g. WEEE Directive for European Union, Universal Waste Rules for USA, etc.

3.0 EFFECTS OF MERCURY ON HUMAN HEALTH

Mercury is very toxic and linked with a wide range of health effects including irreversible damage to the human nervous system. The severity of health effects from mercury exposures is influenced by the following factors:

(i) Chemical form of mercury i.e. inorganic or organic mercury,

(ii) Dose,

(iii) Age of the person exposed (the foetus is the most susceptible),

(iv) Duration of exposure,

(v) Route of exposure i.e. inhalation, ingestion, dermal contacts, and

(vi) Health of the person exposed

Table: Health Effects of mercury

Sr. No.	Mercury Form	Sources of environmental contamination	Environmental effects	Source of human contamination	Toxicity related health effect
1.	Methyl mercury	Mercury disposed off in water bodies	Tendency to bio-magnify in the food chain, contaminating fish and marine mammals	Consumption of contaminated fish and marine mammals	Methyl mercury is classified as a possible human carcinogens
2.	Mercury	Combustion of coal, incineration of mercury bearing waste	Deposit in the environment and sometimes travel long distances	Deposit in water bodies and also falls with rain water	Enters body via food
3.	Mercury vapours	-	-	Ambient air, dental amalgam	Dangerous if inhaled or ingested

Followings are the routes of mercury exposure:

Inhalation:

Mercury vapor is highly toxic via inhalation. It can cause severe respiratory tract damage. Symptoms of mercury toxicity include sore throat, coughing, pain, tightness in chest, breathing difficulties, shortness of breath, headache, muscle weakness, anorexia, and gastrointestinal disturbance, ringing in the ear, liver changes, fever, bronchitis and pneumonitis. Mercury can be absorbed through inhalation with symptoms similar to those appearing after ingestion.

Ingestion:

Ingestion (through mouth) of mercury may cause burning of the mouth and pharynx, abdominal pain, vomiting, corrosive ulceration, bloody diarrhea. Ingestion may be followed by a rapid and weak pulse, shallow breathing, paleness, exhaustion, tremors and collapse.

Skin Contact:

Contact of mercury with skin causes irritation and burns to skin. Symptoms include redness and pain. It May cause skin allergy and sensitization. Mercury can be absorbed through the skin with symptoms parallel to ingestion.

Eye Contact:

Contact of mercury with eye causes irritation and burns to eyes. Symptoms include redness, pain, blurred vision; may cause

serious and permanent eye damage, also depending upon exposure.

Chronic Exposure:

Chronic exposure of mercury through any route can produce central nervous system disorders. It may cause muscle tremors, personality and behavior changes, memory loss, metallic taste, loosening of the teeth, digestive disorders, skin rashes, brain damage and kidney damage. Mercury can cause skin allergies and accumulate in the body. Repeated skin contact with mercury can cause the skin to turn gray in color. Mercury is a suspected reproductive hazard; may damage the developing foetus and decrease fertility in males and females.

4.0 GUIDELINES ON MERCURY MANAGEMENT AT VARIOUS LEVELS

4.1 MANUFACTURER'S LEVEL

The manufacturers may adopt such practices for fluorescent lamp manufacturing, so that the mercury can be handled properly in order to have minimized impact upon the environment.

4.1.1 Mercury Consumption:

Mercury content in fluorescent lamps, which has been observed to be in the range 3-12 mg per lamp in CFL sector and 15-60 mg per lamp in FTL sector, may be reduced to an optimized level, using internationally best available technology.

4.1.2 Process Technology:

The manufacturers of FLs may adopt the internationally best available technologies, including mercury dosing & lamp flushing techniques such as:

(i) Pill dosing techniques, in place of direct dosing of liquid mercury, for desired optimum content of mercury in the Lamp, and

(ii) Argon flushing, in place of mercury flushing, in order to have less consumption of mercury in the process;

The above techniques help prevent losses of mercury to the environment at various stages of mercury handling and control of mercury releases in compliance to the prevailing norms.

The Bureau of Indian Standards (BIS) may evolve the standards for mercury consumption and dosing technologies, so as to minimize the consumption of mercury in the process of fluorescent lamp manufacturing.

4.1.3 Raw Mercury Distillation:

The distillation set up, if required to be used for purification of raw mercury and the recycled mercury recovered from the process, may be completely leak proof and operating under proper vacuum. The provision of a proper fume extraction system may be made to take care of fumes or mercury vapors generated, if any, around the distillation set up. The outlet of such extraction system may be connected to a proper Air

Pollution Control System (APCS) as described in the subsequent section.

4.1.4 On-site Storage, Treatment & Disposal of Mercury-bearing Wastes:

The on-site storage, treatment & disposal of mercury bearing wastes may be done, in compliance to the conditions prescribed in the Consent/Authorization document issued by the respective State Pollution Control Board/PCC, so as not to contaminate air, water and soil.

The manufacturing facilities shall make necessary provisions, as mentioned below, for the proper on-site storage, treatment and disposal of mercury-contaminated wastes:

On-Site Storage:

All the solid wastes, including mercury-contaminated wastes, may be stored in a segregated manner. The mercury-contaminated wastes may be stored on a concrete platform under a shed, as per the provisions made under Hazardous waste Rules, 2003, so as to prevent the release of mercury from the waste storage site into the air/water environment.

Treatment & Disposal:

(i) All mercury-contaminated used lamps & cut glass tips (used for mercury filling) may be treated / recycled either in a Recycling Unit developed at the production site or at

any authorized Lamp Recycling Unit (LRU). Such LRU shall comply with all the requirements as specified, separately, in this Section.

(ii) All emission sources (attached to the unit operations, involving handling of mercury) and the exhaust system covering the production floor shall be connected to proper air pollution control system (APCS) for removal of mercury vapors, if any. The APCS may be either HEPA (High Efficiency Particulate Arrestor) Filter system or Activated Carbon Filter system or any other equivalent efficient (for removal of mercury) system. This may, also, be connected to APCS of the Recycling Unit, if it exists on-site.

(iii) All the emission outlets shall comply with the norms prescribed for mercury in the Consent document. The norm for mercury emission may be considered as 0.2 mg/Nm3, as also prescribed under EP Act for mercury emission from other categories of industries.

(iv) The Mercury, trapped in the water through cut glass tips or broken FLs, may be recovered through a proper distillation system. This can be done, even, through a proper distillation set up provided for the distillation of raw mercury or distillation set up provided for recovery of Mercury from the phosphor powder.

(v) The manufacturer shall maintain records related to all the wastes, including mercury-contaminated wastes,

generated from the manufacturing facility. The records, also, related to the recovery of mercury and other useable components from the processing (if practiced on-site) of mercury-contaminated wastes shall be maintained.

All the unrecoverable wastes from the FL manufacturing site shall be disposed properly. The waste(s) shall be sent to a TSDF site, if found hazardous based on the provisions (compliance with contents mentioned in schedule II) under HWM Rules, 2003. The FL manufacturing unit may have to become a member of a TSDF site, accordingly. The records, pertaining to the generation, storage, treatment, transportation and disposal of such unrecoverable wastes shall, also, be maintained properly.

(vi) All the metal wastes generated from above Recycling Unit shall be sold out to the authorized metal recyclers.

The SPCBs/PCCs may incorporate above requirements in the Consent/ Authorizations as conditions and may, also, like to stipulate other such conditions, in this regard.

Lamp Recycling Unit (LRU)

1. A Lamp Recycling Unit (LRU) shall have an environmentally sound Treatment-cum-Recycling facility for the used mercury-bearing fluorescent lamps and other such wastes, to be provided either at FL manufacturer's site or as a common facility at

community level. Such facility shall aim at maximizing recovery of mercury, phosphor powder, other metals and plastics, etc., apart from controlling the release of pollutants. Such facility may cover at least following systems:

(i) Lamp Crushing System, under vacuum, for separation of mercury-contaminated Phosphor powder & mercury vapors from other crushed components, so as not cause release of any pollutant, including mercury vapor – Segregation of metals, electronic components and plastics from crushed components for recovery.

(ii) System for segregation of Mercury vapour from the phosphor powder.

(iii) Proper Air Pollution Control System (APCS) for mercury release control (in compliance to the prescribed norms) - APCS may be either HEPA (High Efficiency Particulate Arrestor) Filter system or Activated Carbon Filter system or any other equivalent efficient (for removal of mercury) system for separation of mercury vapor from mercury-contaminated phosphor powder - Proper disposal of mercury-contaminated filter pads to TSDF.

(iii) Distillation system – for proper separation & recovery of mercury from mercury-contaminated phosphor powder.

(iv) On-line Mercury monitoring system, to have check on emission of mercury, which has to be in compliance to the consented norms.

2. The LRU shall have following capabilities, in addition to the provision of above facility:

(i) The LRU must get registered with the concerned authority and fulfill the requirements as mentioned above. It shall carry valid Consent & Authorization documents that will cover collection & Transportation operations, as well.

(ii) The emission outlet shall comply with the norms for mercury prescribed in the Consent document. The norm for mercury emission may be considered as 0.2 mg/Nm3, as also prescribed under EP Act for mercury emission from other categories of industries.

(iii) The LRU must appoint properly trained manpower to handle hazardous substances, in respect of treatment/recycling.

(iv) The LRU may dispose all the unrecoverable wastes from the treatment site, either to a TSDF site or municipal waste disposal site, depending upon the hazard potential left in them. The hazard potential can be ascertained in the light of provisions (compliance with contents mentioned in schedule II) under HWM Rules, 2003. The LRU may have to become a member of a TSDF site, accordingly.

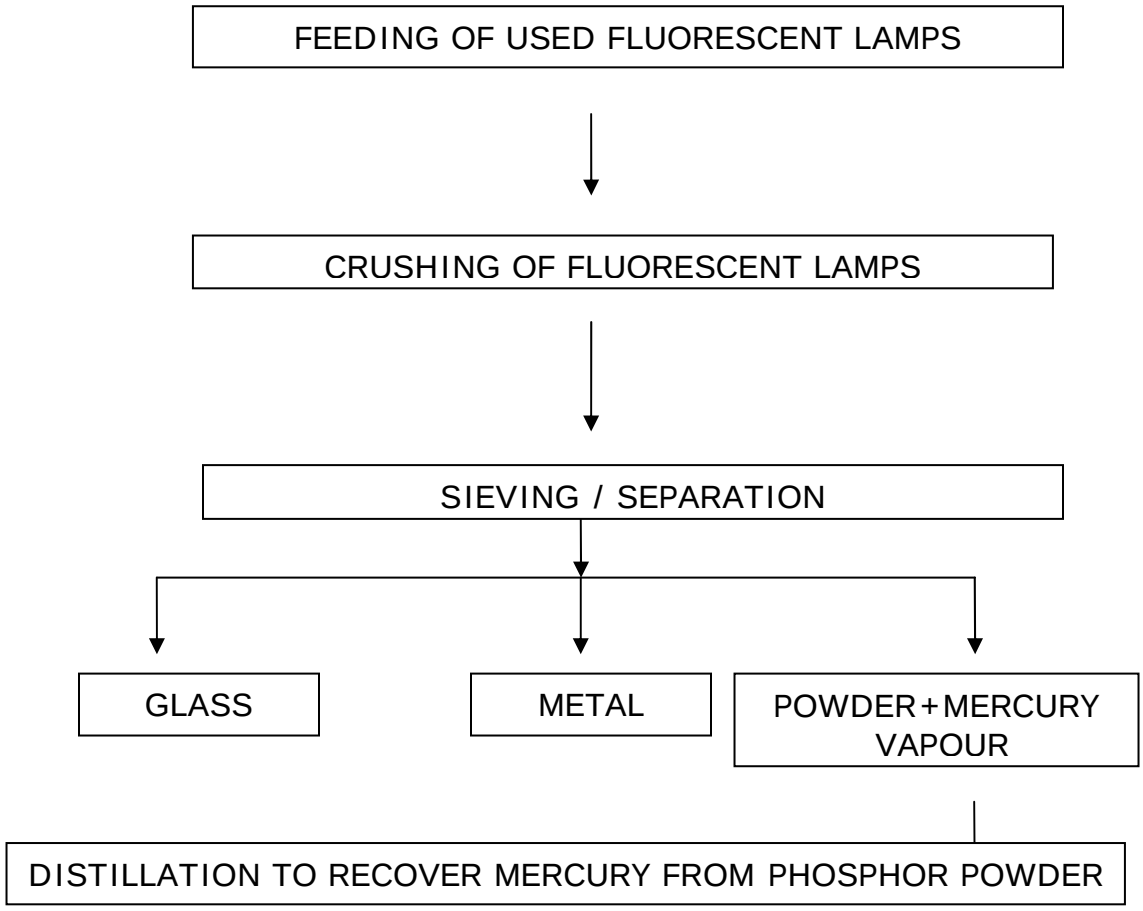
(v) The LRU may maintain proper records of used FLs collected & recycled, recovery of mercury and other components. It shall, also, maintain the records pertaining to the generation, storage, transport and disposal of the wastes generated from LRU.

(vi) The LRU may take up ambient air quality monitoring, particularly, in reference to mercury levels with a specified

frequency. The source emission monitoring may be taken up once in a month through a recognized laboratory, for third party verification.

3. The schematic for such LRU is as depicted below:

SCHEMATIC FOR A LAMP RECYCLING UNIT



4.1.5 Mercury Handling:

The following precautions may be taken in addition to observing some good practices, while handling the mercury at manufacturing stage:

(i) The breakage of lamps, which has potential of releasing the mercury, must be avoided, to the extent possible.

(ii) Due care must be taken for proper cleanup of broken CFLs & FTLs within the premises, for the possible recovery of the spilled mercury. All the broken lamp parts should be picked up carefully, so as to collect entire lot of spilled mercury. The mercury, thus collected, may be stored separately in a closed bin, along with other mercury-bearing wastes, for further recovery (purification & reuse) of mercury by distillation. A detailed note of guidance, on mercury spillage control, is provided in next sub-section.

(iii) Secondary containers (Catch Basins and Pans) should be made of impervious material (e.g. plastic or smooth finish paint) with edge lips. Steep lips are more effective than gentle rises in trapping spilled mercury.

(iv) Adequate vapor-containment systems should be in place, wherever mercury is handled. All such systems, including the room exhaust system, should be connected to proper air pollution control system for removal of mercury vapors, if any. This would help avoid, to a very large extent, building up of mercury vapors in process area.

(v) The distillation set-up, used for the purification of raw or impure mercury, must be operated under proper vacuum-

sealed condition, so as not to release any mercury vapors during the distillation.

(vi) Concrete floors sealed with epoxy and working surfaces with no crevices are preferred for working with mercury. Vinyl flooring may be used in laboratories. Tiled floors/table tops should not be used in areas where mercury is used.

(vii) Avoid storing or handling mercury near sinks. Spilled mercury could run into the sink, lodge in the trap, ruin the pipe by amalgamating with and weakening the metal, and then be released into the environment or a retention tank system designed only for dilute solutions in rinse water.

(viii) Mercury should always be stored in tightly closed bottles that do not shatter on impact (i.e. avoid soda glass bottles and if glass bottles have to be used they should have a secondary containment). The bottles should be kept in locked cupboards, placed in a cool, well ventilated room, with restriction on access. Bottles containing mercury should always be properly labeled, identifying the substance and the hazards involved.

(ix) The manufacturers may, also, put a leaflet in the packing of CFL and FTL, which would narrate the details of precautions to be taken at the user end, in case of breakage of lamp resulting in spill of mercury, at domestic level.

4.1.6 Mercury Spill Management at Manufacture's Facility:

If a mercury spill occurs at the manufacturing site, the following precautions may be taken:

a. Mercury Spill Control Kits should be available in areas where mercury is used. Mercury Spill Control Kits should contain gloves, protective glasses, Hg absorb powder, mercury sponges, and a disposal bag. A special Mercury Vacuum Cleaner may also be made available for cleaning mercury spills; mercury decontamination may be carried out using water soluble mercury de-contaminants like polysulphides.

Mercury Spill Control Kit

Special Mercury Vacuum

b. Train all the workers involved for the proper handling of mercury which may include the use of spill control kit. The workers should use appropriate personal protective clothing and equipment that must be carefully selected, used, and maintained to be effective in preventing skin contact with mercury vapor. The selection of the appropriate personal protective equipment (PPE) (e.g. gloves, sleeves,

encapsulating suits) should be based on the extent of the employee's potential exposure to mercury vapor. Small spills of metallic mercury usually can be cleaned up safely by the workers involved, if they have had the proper training of using the Mercury Spill Control Kits.

c. Avoid walking on or touching surfaces contaminated with mercury.

d. Promptly notify the plant/factory Safety Officer of spill if any.

e. Spread plastic sheets over surfaces onto which mercury could drop or run during spill cleanup. Tape the sides of the sheets to the floor. NOTE: such plastic sheets, and other clean up items, must be disposed of as mercury contaminated hazardous waste.

f. Remove any dust or oil, which may have become contaminated with mercury during spill and cleanup. Use detergent or a solvent to remove oil or grime, or use a vacuum, to remove dust. Be certain to adhere to all appropriate controls during spill cleanup.

g. Use mercury kits with hand-powered miniature vacuums or sponges to clean up spills whenever practical. Replace mercury kit items after use.

h. To avoid the spread of contamination, never sweep mercury contaminated material or blow it off of surfaces with compressed-air nozzles. Instead, vacuum or seal it off in place. Use a specially designed and dedicated vacuum for cleaning up large mercury spills.

4.2 CONSUMER LEVEL

4.2.1 Handling of Used/Broken Fluorescent Lamps (FLs):

The consumers may handle and dispose the used lamps as described below:

Domestic Consumers:

(i) The consumer must ensure that (s)he does not throw used lamps in the general trash bin but hands them over (in a properly packed form) to a kabari (an individual) or a collection agency identified by an authorized Lamp Recycling Unit for proper recycle / disposal of used FLs.

(ii) The used intact FLs may be stored either in the same boxes in which new lamps are brought or other boxes of similar size. They should be stored upright. The due precaution may be taken while packing more than one used lamp, so as not cause the possibility of breakage during the storage and transportation.

(iii) Even, the broken FLs, after due clean up as mentioned in section 4.2.2, may be handed over for safe recycling and disposal.

Bulk Consumers:

(i) The bulk consumers must ensure that used lamps are not disposed in the general trash bin but handed over (in a properly packed form) to an authorized Lamp Recycling

Unit (for proper recycle / disposal of used FLs) either direct or through a collection agency identified by such facility.

(ii) The bulk consumers must create special type of disposal bins (suitable for the purpose) at site for depositing the used lamps only. The management of the institute may issue necessary instructions, to ensure this, to staff and workers handling lamps.

(iii) The used intact FLs, as collected above, may be stored either in the same boxes in which new lamps are brought or other boxes of similar size. They should be stored upright. The due precaution may be taken while packing more than one used lamp, so as not cause the possibility of breakage during the storage and transportation.

(iv) Even, the broken FLs, after due clean up, as mentioned below, may be handed over for safe recycling and disposal.

(v) The concerned official of the Institute may inform the authorized Lamp Recycling Unit, for the timely disposal of the used lamps. Such used lamps should not, preferably, be stored exceeding a period of one year.

Guidelines for Cleanup of Broken FLs:

The amount of mercury in a CFL is very small, about five milligrams, or the size of the tip of a ball point pen. If a CFL bulb breaks, a small amount of the mercury vapor will be released in the air. It is important, though, to carefully clean up and dispose of a broken CFL to avoid spreading around the phosphorus powder, glass and any remaining mercury.

Here are some guidelines for cleaning up a broken CFL:

(i) Open a window and leave the room (restrict access) for at least 15 minutes. If you have fans, place the fans in the windows and blow the air out of the room. Note: If the room has no windows, open all doors to the room and windows outside the room and use fans to move the air out of the room and to the open windows.

(ii) Remove all materials you can without using a vacuum cleaner:

- Wear disposable rubber gloves, if available (do not use your bare hands)
- Carefully scoop up the fragments and powder with stiff paper or cardboard
- Wipe the area clean with a damp paper towel or disposable wet wipe
- Sticky tape (such as duct tape) can be used to pick up small pieces and powder

(iii) Place all cleanup materials in a plastic bag and seal it, and then place in a second sealed plastic bag, dispose it properly and wash your hands after disposing of the bags.

(iv) The first time you vacuum the area where the bulb was broken, remove the vacuum bag once done cleaning the area (or empty and wipe the canister) and put the bag and/or vacuum debris, as well as the cleaning materials, in two sealed plastic bags in the outdoor trash or protected outdoor location for normal disposal.

4.2.2 Consumer Awareness:

All the consumers, individual domestic consumers and bulk consumers (offices, institutions, large residential complexes, etc.) should get fully aware about the potential health impact of mercury-bearing lamps, through audio-visual media and the product leaflets. The precautions, to be taken while cleaning up the broken FLs should, also, be known to the consumers.

As a part of such awareness programs, the consumers, even at individual level, are expected to participate actively with constructive suggestions and provide the feedback, for the overall success of mercury management in fluorescent lamp sector.

4.2.3 Collection, Transport, Treatment & Disposal of Used FLs:

The fluorescent lamp manufacturers (either on individual or on association basis) may either develop or identify Lamp Recycling Unit(s) and establish a network of such LRUs across the country, for environmentally sound collection, transport, treatment, recycling and disposal of used FLs from the consumers. Such identified LRU, to be operating on common basis for the consumers in a defined region, shall have the set up as described under Section 4.1.6 for proper treatment/recycling and, also, a complete set up for collection & transportation of used FLs.

The following may be considered, at various stages of collection, transportation, treatment and disposal of used FLs at consumer level:

The persons or agencies (duly authorized by the concerned authority for the purpose) involved in collection and transportation of used FLs may be recognized as Handlers.

Collection:

The collection of used lamps may be done mainly by two ways:

(i) Collection of used lamp (FLs) from bulk consumers may either be arranged by the management of above set-up (institutions, etc.) for direct disposal to LRU or by the LRU which may arrange to pick up used lamps from such collection sites through an identified collection agency.

(ii) Collection of used lamps (FLs) from individual domestic consumer may be arranged by the LRU, either through *kabaris* (individuals appointed for the purpose by LRU) or an identified collection agency for door to door pickup.

Transportation:

(i) The Handler (e.g. Kabari or representative of LRU) of used FLs in transit should take care of selection of proper vehicle and carriage so as to minimize breakage of used FLs.

(ii) There should not be any intermediate transfer of materials in the transit stage. The collected used FLs should be straight transported to the LRF for further processing.

(iii) The Handler should be trained to take care of mercury spills, if any, that takes place en-route the journey to LRU.

Treatment, Recycling, and Disposal:

A Lamp Recycling Unit (LRU), developed as a common facility for the environmentally sound collection, transport, treatment, recycling and disposal of used FLs from the consumers, shall have the set up as described under Section 4.1.4 for the treatment-cum-recycling, in addition to the set up required for proper collection and transportation of used FLs.

Such LRU may have following facilities, in addition to that required as mentioned above:

- Adequate used lamp Storage facilities, with stacking on a pucca platform, preferably under a shed
- Mercury spill collection system for further treatment on-site, as described under Section 4.1.6.
- Mechanical feeding system, if possible, to have better check on the breakage of lamps
- Training of the Handlers, covering manpower (either *kabaris* or a collection agency) engaged for the collection and transportation of used lamps to the treatment site.

****