Fluorescent Lamp Recycling

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Relationship Between this Document and Statutory or Regulatory Provisions

This document contains information and recommendations designed to be useful and helpful principally to businesses who use fluorescent lamps, as well as those who are responsible for overseeing lamp management activities. The secondary audience for this document is state governments, tribal governments, local governments, and the general public. This document does not impose legally binding requirements, nor does it confer legal rights, impose legal obligations, or implement any statutory or regulatory provisions. The approaches outlined in this document are recommended, but generally not regulatory. They do not change or substitute for any statutory or regulatory provisions.

This document presents technical information and recommendations based on the Environmental Protection Agency's (EPA) current understanding of a range of issues and circumstances involving the recycling of fluorescent lamps. Readers of this document are cautioned not to regard statements recommending the use of certain procedures as either precluding other procedures or information or providing guarantees that using these procedures or defaults will result in actions that are fully compliant with federal, state or local law. To this end, states and local authorities may have their own recommendations or requirements on the management of fluorescent lamps and should be consulted accordingly. The EPA welcomes public comments on this document at any time and will consider those comments in any future revisions of this document.

Forward

EPA encourages the use of fluorescent lamps because installation of energy-efficient lamps reduces the demand for electricity, which in turn reduces mercury and green house gas (GHG) emissions from utility boilers, particularly coal-fired boilers. Once the fluorescent lamps are burnt out (spent), EPA strongly encourages that they be recycled. Proper recycling not only reduces the release of mercury from spent lamps into the environment, but also allows for the reuse of the glass, metals and other components of the spent fluorescent lamps.

Because fluorescent lamps contain mercury, some spent lamps are hazardous waste under federal and state regulations. In some states, hazardous waste lamps may be managed as universal waste. It is the responsibility of the generator of spent lamps to determine whether the lamps are hazardous waste and to ensure that the lamps are managed in accordance with federal and state regulations. This document is not meant to give advice or guidance on what regulations may or may not apply to fluorescent lamps, nor does it give guidance on the appropriate ways to manage lamps in order to be in compliance with federal and state universal and hazardous waste regulations; such guidance may be found at the "Regulations" section under the "Universal Waste Handlers" heading on the "Mercury-Containing Light Bulb (Lamp) Frequent Questions" Web site at www.epa.gov/osw/hazard/wastestypes/universal/lamps/faqs.htm. Rather, this document is intended to increase the awareness; provide resources and information on safe lamp recycling practices; and encourage the recycling of all spent fluorescent lamps.

EPA is working with manufacturers and major U.S. retailers to develop, implement and expand recycling options. In addition, EPA has awarded grants to state and nonprofit organizations through its National Mercury Lamp Recycling Outreach Program for development and implementation of mercury lamp recycling outreach programs (www.epa.gov/epawaste/hazard/wastetypes/universal/lamps/outreach.htm).

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Fluorescent Lamp Recycling

Websites

Note: Web sites referenced in this document provide additional information that is relevant to fluorescent lamp recycling and may be useful or interesting. However, EPA cannot attest to the accuracy of information provided by non-EPA Web sites. Providing links to a non-EPA Web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products presented on the site.

Information on Spent Mercury-Containing Lamp Recycling
www.epa.gov/bulbrecycling
www.lamprecycle.org
www.almr.org

Energy Star Website on Compact Fluorescent Lamps (CFLs)
www.energystar.gov/cfls

EPA's Web Sites on Mercury and Mercury Containing Products
www.epa.gov/mercury
www.epa.gov/epr/products/mercury.htm

Broken Lamps Clean-up Procedures
www.epa.gov/mercury/spills/index.htm#fluorescent.

Mercury Lamp Drum-Top Crusher Study
www.epa.gov/osw/hazard/wastetypes/universal/drumtop/.

Contact Information for State Environmental Regulatory Agencies
www.epa.gov/epahome/state.htm

Information on Health Effects of Elemental Mercury
www.epa.gov/ncea/iris/subst/0370.htm
www.atsdr.cdc.gov/toxprofiles/tp46.html (Tox Profile)
www.atsdr.cdc.gov/tfacts46.html (Tox FAQs)

OSHA Guideline for Mercury Vapor
www.osha.gov/SLTC/healthguidelines/mercuryvapor/recognition.html

OSHA Information on Respirator Use
www.osha.gov/SLTC/etools/respiratory/oshafiles/faq.html

OSHA Information on Hazard Communication
www.osha.gov/SLTC/hazardcommunications/index.html

Identify Local Recycling Options for Households
www.epa.gov/bulbrecycling (click on "Where You Live")
www.earth911.org

National Priorities Environmental Partnerships (NPEP)
www.epa.gov/npep

I. Purpose

The purpose of this report is to provide information to businesses interested in recycling their spent mercury-containing lamps.[1] Mercury-containing lamps include tubular and compact fluorescent lamps, high intensity discharge lamps (mercury vapor, metal halide, high pressure sodium), and fluorescent backlights in flat panel and liquid crystal displays commonly used as monitors, TVs and instrument displays. EPA encourages the recycling of all mercury lamps and mercury-containing products.[2] This document focuses on fluorescent lamp handling, storage, and recycling. This document also provides Best Management Practices (BMPs) for the storage of spent fluorescent lamps and the use of drum-top crushers (DTCs) for compacting waste lamps.

II. Background on Fluorescent Lamps

Fluorescent lamps are an energy-efficient lighting option, using only 20 to 25% of the energy required for incandescent and other lighting technologies. Installation of high-efficiency lamps reduces the demand for electricity, which in turn reduces the amount of mercury and green house gas (GHG) emissions from utility boilers, particularly coal-fired boilers. Coal burning power plants are the largest human-caused source of mercury emissions to the air in the United States, accounting for over 40 percent of all domestic human-caused mercury emissions because the mercury that is naturally found in coal is released into the air when the coal is burned (USEPA, 2005). Also, fluorescent lamps are more cost-effective because they last up to 10 times longer than incandescent lamps. Because of these benefits, EPA encourages the use and recycling of fluorescent lamps; in some states, recycling may be required by law or regulation.

There are several different kinds of fluorescent lamps, including linear tubes, U-shaped lamps, and compact fluorescent lamps (CFLs). The amount of mercury in a fluorescent lamp varies, depending on the type of lamp, manufacturer and date of manufacture, but typically ranges between 1.7 milligrams and 15 milligrams.[3] Although manufacturers have greatly reduced the amount of mercury used in fluorescent lamps over the past 20 years and are currently taking additional steps to further reduce their mercury content, mercury is an essential component to fluorescent lamps and cannot be eliminated completely.

According to the Association of Lighting and Mercury Recyclers, approximately 670 million fluorescent lamps were disposed of or recycled in the United States in 2003 (Association of Lighting and Mercury Recyclers, 2004).[4] Now that CFLs are becoming more popular, it is estimated that the total volume of spent fluorescent lamps will increase significantly. Discarded lamps release approximately two to four tons of mercury per year into the environment. Based on

[1] While the basic principles related to lamp management can be useful for individuals, the audience for this document is businesses and other organizations. Information for households and individuals can be found on EPA's Web site at www.epa.gov/bulbrecycling/manage.htm.

[2] Please refer to www.epa.gov/epr/products/mercury.htm for additional information on the proper recycling or disposal of mercury-containing products not discussed in this document.

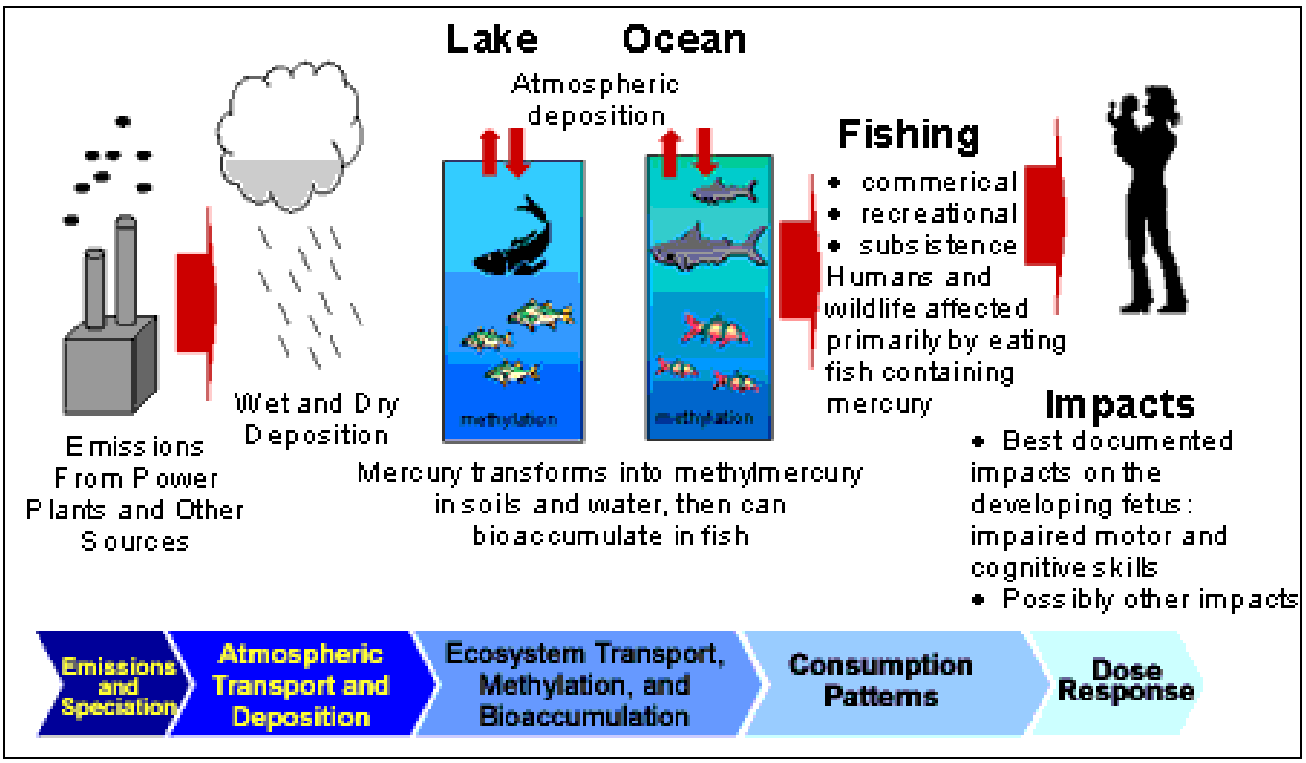
[3] Some older bulbs may contain 50 milligrams of mercury or more.

[4] As part of EPA's Mercury Lamp Recycling Outreach Program, the Association of Lighting and Mercury Recyclers worked in collaboration with EPA to increase the national recycling rate through education and outreach. This project produced several deliverables available to the public. The resources are found at www.almr.org and www.epa.gov/epawaste/hazard/wastetypes/universal/lamps/outreach.htm

information from Energy Star (2007) and Cain et al. (2007), EPA estimates that 1% of human-caused mercury releases into the air per year in the United States come from fluorescent lamps, including all commercial and residential applications. However, it takes only a very small amount of mercury to expose people or contaminate a water supply.

Mercury is not released when lamps are intact or in use; exposure is possible only when a lamp has been broken. When a lamp is broken some of the mercury in the bulb is immediately released into the air as mercury vapor. In addition, if a broken bulb is not cleaned up, or if it is cleaned up improperly, additional mercury vapor will be released into the air over time (Aucott et al, 2003; Maine DEP; 2008). Elemental mercury primarily causes adverse health effects when it is breathed as a vapor and is absorbed through the lungs. Higher exposures occur in warm or poorly-ventilated indoor spaces. Breaking a number of fluorescent bulbs in an uncontrolled or poorly controlled manner (e.g., by poorly handling and storing lamps, such that a large number break or by using a drum-top crusher that does not have a filtration system or that is incorrectly assembled) can directly expose people to dangerous levels of mercury vapor.

More broadly, as shown in the diagram below, when elemental mercury is released into the environment from broken lamps, coal combustion and other sources, it will eventually be precipitated out of the atmosphere and can be converted to methyl-mercury which accumulates in the food chain, potentially leading to adverse health affects, such as impaired neurological development of fetuses, infants, and children. Ingestion of contaminated fish is the primary route through which most humans are exposed to mercury.



Whether an exposure to the various forms of mercury will harm a person's health depends on a number of factors, including:[5]

- the chemical form of mercury (e.g., elemental or methyl);
- the route of exposure (inhalation, ingestion, dermal contact, etc.);
- the dose or the concentration to which an individual is exposed;
- the amount of time that an individual is exposed (duration of exposure);
- whether an individual is more sensitive to mercury's effects (e.g. a child, pregnant woman/fetus, elderly); and
- the health of the person exposed.

Because mercury can cause adverse health and ecological effects, EPA has made it a priority to reduce the release of mercury into the environment.

Using CFLs and other fluorescent lamps is one way Americans can reduce their energy use, thereby reducing the amount of coal burned and the amount of mercury and other pollutants released into the environment.[6] For example, a coal-fired power plant may emit 13.6 milligrams of mercury to produce the electricity required to power an incandescent bulb over its lifetime, compared to approximately 3.3 milligrams of mercury contained in a CFL. Thus, using fluorescent lamps will reduce the total amount of mercury that is emitted into the environment, even if the lamps are broken. However, more mercury can be kept out of the environment if these spent fluorescent lamps are recycled instead of being thrown into the trash, and therefore EPA strongly supports fluorescent lamp recycling.[7]

EPA encourages businesses to recycle all of their spent fluorescent lamps, including CFLs. See Section III below for more information on how to safely handle spent lamps and establish a lamp recycling program at your facility. Household consumers should contact their local municipal solid waste agency directly, their state environmental agency, or go to www.epa.gov/bulbrecycling (click on "Where You Live") or www.earth911.org to identify local recycling options.

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[5] Information on the health effects of elemental mercury is available from the IRIS database at www.epa.gov/ncea/iris/subst/0370.htm. You can also visit the Agency for Toxic Substances and Disease Registry (ATSDR) for a toxicological profile of mercury at www.atsdr.cdc.gov/toxprofiles/tp46.html.

[6] More information about CFLs can be found at www.energystar.gov/cfls. While there are economic and environmental benefits to using CFLs, it is very important to handle CFLs carefully to avoid breaking them because broken CFLs release mercury. For more information about mercury exposure from broken CFLs see www.state.me.us/dep/rwm/homeowner/cflreport.htm. For more information about cleaning a broken CFL or other fluorescent lamp see www.epa.gov/mercury/spills/index.htm#fluorescent.

[7] Fluorescent lamps that are thrown into the trash are usually sent to a landfill or incinerator. These disposal practices will likely lead to the release of elemental mercury into the environment through breakage. There is also the potential for exposure to mercury from broken lamps thrown in a dumpster, trash compactor, or trash can. Once in the environment, mercury can be converted to an organic form that accumulates in living organisms and contaminates the food chain. For the general public, most mercury exposure is experienced though the food chain (e.g., eating contaminated fish), so reducing the amount of mercury released to the environment is a vital component of protecting human health.

III. How Should Spent Fluorescent Lamps Be Managed?

There are many things that businesses can do to increase the safety of their spent fluorescent lamp management practices. It is important that spent lamps are handled and stored in ways that prevent breakage and that the lamps are properly recycled so that the mercury is kept out of the environment. The recommendations in this section can be used by businesses to manage lamps from the point that they are taken out of service to the point when they are recycled.

Please note that many states have specific requirements for lamp management. It is important that you be aware of the state requirements when developing your lamp recycling program. In addition, certain fluorescent lamps may be a hazardous waste. If they are, additional requirements will likely apply to the management of those lamps.[8] Moreover, some states require special handling of fluorescent lamps, including the recycling of all fluorescent lamps, even if they are not considered hazardous waste. Finally, even lamps that are not regulated as "hazardous wastes" should be managed carefully, because all fluorescent lamps release mercury vapor to the air when broken. For more information specific to your state, contact your state agency; a list of state agencies is available at www.epa.gov/epahome/state.htm.

A. Handling and Storage of Spent Lamps

Lamps should be handled and stored in a way that avoids breakage. To help your employees minimize lamp breakage and the release of mercury into the environment, we recommend that you consider the following lamp management storage principles:

- Designate an area within your facility to store lamps. Storage locations should be away from high-traffic areas; bigger facilities may need more than one location for easier access. The storage rooms should be clean, dry, and free of broken lamp debris. Ideally, this area would have an air handling system that is independent from the rest of the building and does not re-circulate or re-introduce air through vents and intakes.

- Employees should know whom to call if they see that a lamp is burned out.

- Workers should remove spent lamps carefully to prevent breakage, and should immediately place lamps in containers and locations where they will not break.

- Spent lamps should be stored and packed carefully in order to help prevent breakage and exposure to mercury. To this end, you should work with your recycler to fully understand the proper procedures for filling and securing boxes or containers of lamps. You can purchase specially made lamp containers for spent lamp storage. Lamp recyclers may provide containers for their customers.

- Properly manage lamps when they break. All broken lamps will release mercury into the air upon breakage and for extended periods of time if not cleaned up. Create procedures for

[8] For more information about how fluorescent lamps are regulated under federal laws and state laws, see the "Regulations" section under the "Universal Waste Handlers" heading on the "Mercury-Containing Light Bulb (Lamp) Frequent Questions" Web site at www.epa.gov/osw/hazard/wastetypes/universal/lamps/faqs.htm.

reporting and managing broken lamps, and if lamps are accidentally broken, workers should follow the clean-up procedures at www.epa.gov/mercury/spills/index.htm#fluorescent. Keep broken lamps in a sealed container (preferably glass or metal), remove the container from the building as soon as possible, and keep the container in a cool place, away from high-traffic areas. [9] Containers of broken lamps should not be opened to add or remove broken lamps. Also, follow Occupational Safety and Health Administration (OSHA), EPA, and state regulations when managing broken lamps.

- Post cleanup procedures for cleaning up broken lamps in areas where fluorescent lamps are handled or stored, including specific instructions and contact information for whom to contact in case of a broken lamp.

- Containers of spent lamps should be closed, structurally sound and constructed to provide protection from breakage during storage and transport. Containers should not be damaged in any way.

- Containers should be stable (i.e., they don't tip over easily), and they should be stored in such a way that they won't tip or fall. Containers should not be overfilled or underfilled when shipped. Care should be used when stacking boxes that the additional weight doesn't break the lamps. Do not tape or rubber band lamps together.

- Clearly identify containers of spent lamps (e.g., "Waste Lamps" or "Used Lamps"). Close and secure boxes/containers with tape.

See Figure 1 for a one-page checklist of Best Practices for Lamp Handling and Storage.

B. Recycling Fluorescent Lamps

EPA strongly encourages the recycling of all spent fluorescent lamps (including CFLs) as the preferred approach to managing lamps throughout their full product lifecycle.[10] Proper recycling not only minimizes the release of mercury into the environment, but also allows for the reuse of the glass, metals and other materials that make up a fluorescent lamp. Virtually all components of a lamp can be recycled. Recycling fluorescent lamps reduces the amount of waste going into a landfill, saves energy and reduces GHG and mercury emissions.

Spent lamps can be sent to or picked up by the recycler whole (unbroken), or, if it is not prohibited in your state, they can be crushed using a drum-top crusher (DTC) onsite. Each method of recycling has potential benefits and draw-backs.

Regardless of which recycling method you choose, below are some steps we recommend considering while managing your spent lamps. Contact your state environmental regulatory agency prior to starting a lamp recycling program in order to

[9] A study conducted by Maine Department of Environmental Protection (2008) concluded that re-sealable plastic bags do not adequately contain mercury vapor and the most effective type of container of those tested was a glass jar with a metal screw lid and gum seal. More information about this study can be found in Appendix A.

[10] Household consumers can go to www.epa.gov/bulbrecycling (click on "Where You Live") or www.earth911.org to identify local recycling options.

learn about the regulations that may be applicable. For more information specific to your state, contact your state agency; a list of state agencies is available at www.epa.gov/epahome/state.htm.

Step 1: Assess Your Facility – Assessing your facility is a key initial step. In assessing your facility, you should consider the following questions: How many fluorescent lamps are in the facility? Where are they located? How often do you change your lamps? How many spent lamps are you generating each month/year? How are you handling and storing the spent lamps? Do all employees know who to call if a lamp burns out?

Step 2: Become Knowledgeable About State and Federal Requirements for Managing Fluorescent Lamps – Consult your state's regulations for state-specific requirements for managing fluorescent lamps that may apply to your facility.[11] Lamp recyclers should be aware of state and federal requirements and should be able to provide assistance in this area.[12]

Step 3: Select a Recycler – Select a recycling contractor that will best serve your needs and provide you the assurance that your spent lamps are properly managed. Your lamp distributor might offer a recycling service. Many distributors now offer this "one-stop shopping" service to their customers. To assist in selecting a recycler, we have provided some general criteria that we recommend be considered:[13]

- **Service** – Important items include responsiveness, timeliness, program flexibility and customization, whether there will be intermediates (e.g., brokers or lighting contractors), the capabilities of the firm and the equipment they will be using.
- **Risk Management** – Important factors for evaluating recyclers include:
    1. whether they meet insurance requirements for general and pollution liability;
    2. what indemnities or other assurances they offer clients;
    3. their environmental record and compliance history;
    4. the existence of government permits and approvals for facility operation or transportation;
    5. whether the recycler maintains debris and dust-free public areas (good housekeeping practices are an important component of good environmental practices).

We encourage you to ask potential recycling contractors about any of these items, as well as to ask for references or to check with the state agency that regulates recycling facilities for compliance histories.

[11] For more information specific to your state, contact your state agency; a list of state agencies is available at www.epa.gov/epahome/state.htm.

[12] For more information about how fluorescent lamps are regulated under federal laws and state laws, see the "Regulations" section under the "Universal Waste Handlers" heading on the "Mercury-Containing Light Bulb (Lamp) Frequent Questions" Web site at www.epa.gov/osw/hazard/wastetypes/universal/lamps/faqs.htm.

[13] Lamprecycle.org, sponsored by the National Electrical Manufacturers Association (NEMA), maintains a list of companies offering to recycle or handle spent mercury-containing lamps.

Step 4: Establish a Process for Handling and Storing Spent Lamps – Lamps should be handled and stored in a way that prevents breakage. Designate an area where lamps are stored prior to recycling. See Section III.A for recommendations on storage locations, packaging and containers for spent lamps and other information about lamp handling and storage.

Step 5: Procedures for Getting Spent Lamps to the Recycler – There are several options to consider when recycling spent lamps.

- **Pick-up Service** – The type and frequency of pick-up required is important to determine prior to selecting a recycler. Pick-up options will be determined by the size of the facility and the number of spent lamps generated. The options include:
    - **Milk-Run** – This is the most common type of pick-up. A milk-run is a route in which the recycler schedules a number of pick-ups from you. Milk-run collections are usually run on a set schedule; the frequency of the collection should be determined with the recycler at the time of contract negotiations. The number and frequency of spent lamps generated by an individual company will determine the collection frequency.
    - **Dedicated Pick-up** – When a facility generates enough spent lamps to fill a truck, it may be cost effective to contract for a dedicated pick-up (either once a month or upon request).
- **Mail-In or Box Program** – This option is generally more cost-effective if you generate a relatively small amount of spent lamps. In this type of program, a recycler can provide a container to fill with the spent lamps. When the container is full, it can be sent to the recycler via a prepaid ground mail shipment program. If you are interested in this option, you should work with your lamp recycler to ensure that proper packaging, labeling and shipping requirements are met.
- **Self-Transport** – If you generate a small amount of spent lamps, have the capacity to transport them, or are located in close proximity to the recycler, you may choose to transport the spent lamps yourself to the recycler. Lamp recyclers can provide boxes that are designed to reduce breakage during transport to a recycling facility.
- **Household Hazardous Waste Collection** – Some businesses that generate small amounts of spent lamps may be able to take the lamps to a locally operated household hazardous waste collection facility in their community. Businesses should check with their local hazardous waste collection facility first to see if this is permissible.
    - Find out about household hazardous waste collection programs in your area at www.epa.gov/bulbrecycling (click on “Where You Live”) or www.earth911.org.
    - Contact your state environmental agency for more information via www.epa.gov/epahome/state.htm

Step 6: Educate Employees – Inform your employees about the dangers of mercury, the importance of minimizing the release of mercury, and your decision to recycle all spent fluorescent lamps. Employees should be trained in accordance with applicable state and federal requirements. Under provisions of OSHA's Hazard Communication Standard, employers are responsible for informing employees of the hazards and the identities of workplace chemicals to

which they are exposed. Further information on OSHA's Hazard Communication standard may be found at www.osha.gov/SLTC/hazardcommunications/index.html.

Step 7: Record and Track Data – The recycler should provide documentation that the spent lamps have been properly recycled (e.g., a receipt or a certificate of recycling).

IV. Summary of EPA's Study of Drum-Top Crushers (DTCs)

As discussed above, lamps can be managed as whole, spent lamps, or they can be crushed before being sent to a recycler. States have different regulations regarding the use of DTCs due to concerns about releases, and in some states DTC use may be prohibited or may require hazardous waste permits. Contact your state environmental agency for more information via the contact information available at www.epa.gov/epahome/state.htm

As part of its efforts to support good management of spent fluorescent lamps, the Agency released a study of the performance of DTCs for spent fluorescent lamps in August of 2006. The report is entitled, *Mercury Lamp Drum-Top Crusher Study* (EPA's DTC Study) and can be found at www.epa.gov/osw/hazard/wastetypes/universal/drumtop/. Most DTCs are designed to contain a large portion of the mercury released from spent lamps when crushed. However, if poorly designed or constructed, or if not assembled or operated properly, DTC use may result in significant releases of mercury and exposure to operators or others.

The study examined the performance of four DTCs and provides information on mercury emission control effectiveness for DTCs. It also provides information on important safety practices for crusher use, and the potential for mercury releases from DTCs in use and during non-operational periods. (See Appendix A for information on a number of other studies that have been conducted, both on DTCs and on the release of mercury from spent fluorescent lamps.) The BMPs presented in this report for the use of DTCs for the management of spent mercury lamps were developed based on the study results.[14]

A. The EPA Study of DTC Performance

To better understand the performance of DTCs and the potential for mercury release during their use, the Agency conducted a study that evaluated mercury exposures to DTC operators resulting from crushing one to two drums of lamps in a day. Each of the four DTCs tested were placed inside a constructed containment area and were used to crush one or two drums-full of lamps. Operator breathing zone and other air samples were collected during the crushing operation to assess exposure. This general procedure was repeated over five rounds of testing at three different locations. The Study evaluated the potential for release of mercury during DTC operations, during non-operational periods, and when malfunctions occur.

[14] One conclusion from the Agency's study is that the conditions under which DTC mercury releases are tested significantly affect test results and conclusions. Therefore, mercury release test results are meaningful only when all test conditions are known, including the size and ventilation rate of the testing room, the test duration, the number of lamps crushed, sampling points, sampling methods, mercury test methods, and QA/QC procedures. Ideally, future evaluations of DTC performance would be performed under a set of standardized evaluation conditions. Until such an evaluation system is created, the conditions of any test should be fully specified to understand what the results mean.

Although the DTCs generally did not cause the federal OSHA permissible exposure limit (PEL) to be exceeded under the study conditions, all the devices released enough mercury to exceed this level at least once during the test. One device that was tested consistently exceeded the PEL. (Note: Throughout this document, PEL refers to the federal OSHA PEL, which is 100 $\mu g/m^3$ (see 29 CFR 1910.1000, Table Z-2), as a ceiling limit. Thus, when this document refers to the OSHA PEL, it is referring to the 100 ug/m^3 as a ceiling limit. However, a memorandum to OSHA compliance personnel was issued on September 3, 1996, that directs compliance officers to issue citations only when an overexposure exceeds 100 $\mu g/m^3$ as an 8-hour time-weighted average (or TWA), and not as a ceiling limit. Many states have established a lower PEL of 50 $\mu g/m^3$ as an 8-hour TWA. [15])

In addition, all DTCs caused exceedances of EPA's chronic inhalation reference concentration (RfC) for mercury, which is 0.3 $\mu g/m^3$. The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. In addition to EPA's chronic RfC, a number of states (including California, Connecticut and Minnesota) recommend acute mercury vapor exposure criteria of 2.0 $\mu g/m^3$ or below. These levels are designed to be protective of the general public and are not recommended limits for workers (i.e., the operator of the DTC).

B. Study Results Regarding Releases during Normal Operations

Lamp crusher operation: All DTCs release some mercury during lamp crushing. In EPA's DTC Study, three of the four tested devices generally maintained mercury concentrations during operation within the study containment area at levels below the PEL. The fourth DTC failed to contain the mercury released from broken lamps, allowing operator exposures as high as nine times the PEL (this DTC was eliminated from evaluation after the second round of testing due to its extremely poor performance). These exposures would be expected to be lower under ventilation conditions higher than the conditions used in the study, although the releases from the fourth DTC were so significant that we believe it would result in exposures above the PEL, even in conditions with higher ventilation.

Drum and filter changes: After a drum is filled with crushed lamps, the DTC must be removed from the top of the drum and the full drum sealed for shipment to a lamp recycler or disposal facility.[16] This operation leaves the crushed lamps in the drum open to the air for a brief time period (two to ten minutes in EPA's DTC Study) resulting in the highest mercury release from the drum during routine use and so potentially the highest exposure. The majority of drum change samples recorded excursions above the PEL, as a ceiling level.

Lamp breakage outside the crusher: A number of spent lamps broke in the course of storing and handling them for crushing in the study. Lamps also occasionally broke as they were

[15] The study results were not normalized to an 8-hour TWA because DTC use patterns may vary significantly (e.g., from a few minutes to eight or more hours per day). More information about the actual use patterns of DTCs and the mercury exposures experienced by workers during non-operational periods would be necessary in order to calculate an 8-hour TWA accurately for any specific pattern of use.

[16] As noted below in Section V (Best Management Practices for DTC Use), EPA recommends that crushed lamps be sent to a commercial lamp recycler.

being inserted into the DTC feed tube, generally due to a jam in the feed tube or other problems feeding the spent lamps into the DTC. The study was not designed to directly quantify these releases; however, as shown by Aucott, et al (2003), depending on the ventilation in the area in which the spent lamp is broken, lamp breakage can result in an excursion above the PEL.

C. Study Results Regarding Releases Due to Incorrect Assembly

In order to contain the mercury, DTCs have many seals incorporated into their design. If seals are missing, damaged, or not fitted properly, mercury vapor can be released through the gaps. During one testing session, a DTC caused mercury levels in the containment area to exceed the PEL, as a ceiling level (and likely as a TWA if device use had been continued), due to a missing seal at the feed tube connection. This error was discovered when the operator noticed the release of white powder from the connection.

D. Study Results Regarding Releases from Low Mercury Lamps

Spent low-mercury lamps (lamps containing less than 4.5 mg of mercury) were used exclusively during portions of the study.[17] These lamps contain lower total mercury than many other lamps, and are often classified as non-hazardous (under the federal hazardous waste regulations) when discarded. While the low total mercury in these lamps may have contributed to keeping the mercury vapor concentrations below the federal OSHA PEL during operation of three of the DTCs in this portion of the test, crushing the low mercury lamps in the fourth DTC resulted in mercury levels in the study containment area to exceed the PEL by as much as nine fold. This illustrates that even spent low-mercury lamps can cause mercury exposures of concern when broken in uncontrolled or poorly controlled conditions.

V. Best Management Practices for DTC Use

DTCs make storage of spent fluorescent lamps easier by minimizing their volume. Commercial DTCs are designed to collect a large portion of the mercury that is found in fluorescent lamps. However, DTCs can also create some mercury exposure and handling issues. As discussed earlier in the section on the EPA DTC Study (Section IV), mercury vapor exposures in the vicinity of an operating DTC will likely exceed public health criteria (e.g., the RfC) and may exceed the OSHA PEL in certain instances.

Based on the key findings of EPA's DTC Study, EPA recommends the following practices to reduce mercury exposures and allow for maximum control of releases when DTCs are used for the management of spent lamps. As noted earlier in this document, federal and state regulations may impose additional or different requirements for managing spent lamps than the BMPs recommended here or may prohibit their use. Also see Figure 2, a checklist of Best Practices for DTC Use.

A. Choosing a DTC

A DTC should be purchased from a reliable manufacturer and should not be built by the owner or operator. Choosing a well-designed and well-manufactured DTC for use is a critical consideration. A device that is poorly designed or manufactured will likely release mercury at

[17] For more information about the amount of mercury in each type of lamp used in EPA's DTC Study, see Tables 5.1 and 5.2 of the study, which can be found at www.epa.gov/osw/hazard/wastetypes/universal/drumtop/.

significant levels, regardless of how carefully it is operated (as illustrated by one DTC in EPA's DTC Study). Design considerations include, at a minimum: 1) presence of a vacuum pump to create negative internal pressure; 2) ventilation of emissions through effective particulate and activated carbon filters to trap a high percentage of fine particulates and mercury vapor; and 3) well designed and tightly fitted seals at all connection points (e.g., the DTC to the drum, equipment mounted on the DTC, hoses and tubing, etc.). A general examination for sturdy construction may also be useful in identifying a well-made device. Information for DTC manufacturers is included in Appendix B. This information could also be useful to consider when choosing a DTC.

B. Identifying/Establishing a DTC Use Location

Sensitive Populations: Facilities where sensitive populations could be exposed to mercury from DTCs (e.g. schools, health care facilities, nursing homes) should not crush mercury lamps onsite at times when sensitive populations could be exposed either to direct emissions from the DTC or to residual emissions that might remain in the building after crushing has occurred.

Segregated ventilation system: DTCs should be used and stored in a room with adequate ventilation and a ventilation system that is completely segregated from the ventilation system for other parts of the building and does not re-circulate the air. Mercury exposure of employees who are not involved in the lamp crushing operation can be minimized by segregating the crushing room from the rest of the building. EPA's reference concentration for mercury vapor of 0.3 $\mu g/m^3$ (300 ng/m^3) is an appropriate benchmark for the mercury levels in areas where maximum exposure periods could reach 24 hours a day, 7 days a week (e.g. hospitals or residential buildings, such as apartment or condominium buildings).

Room maintenance: The room where the DTC and fluorescent lamps are stored should be kept clean of all fluorescent lamp debris. The broken glass, metal endcaps, and phosphor powder from fluorescent lamps will continuously emit mercury vapor into a room. Lamp debris in the room should be cleaned using methods designed for fluorescent lamp cleanup. See www.epa.gov/mercury/spills/index.htm#fluorescent.

Do not use a vacuum cleaner in the room where the DTC is used unless it is a dedicated vacuum designed specifically for elemental mercury. The vacuum cleaner will be contaminated, and a vacuum that is not specially designed will increase the amount of mercury vapor released into the air. Store mercury-contaminated debris in a well-sealed, metal or glass container. You should not open the DTC to put debris into the drum. Significant mercury release and exposure can result from opening the drum.

Outdoor DTC use: In temperate climates, use of DTCs outdoors may be a viable alternative to segregated indoor ventilation systems.[18] However, outdoor use locations should not be near building air intake vents or in locations where released mercury can enter the building. In addition, mercury volatilization is extremely dependent on temperature. Therefore, DTCs should not be in direct sunlight and should only be stored and used in cool, shaded areas. Lucas and

[18] Outdoor use may not be a viable alternative in very warm climates or on very warm days because increased temperature increases the volatilization of mercury.

Emery (2006) reported that even when a DTC is operated outdoors, exposures can be above the OSHA PEL. To minimize worker exposures, a large fan may be used to blow released mercury away from the operators. However, care should be taken to assure that excess mercury does not escape into the environment.

C. Operating a DTC

A DTC should only be used by trained operators and should never be left unattended while in use.

Training: Operator training in the proper assembly, maintenance, and operation of the specific DTC being used can help reduce improper assembly, improper usage and malfunction of DTCs, helping to reduce exposure potential. This training should include learning and practicing:

- operating the DTC (including filter and drum changes and feeding the spent lamps to the DTC) before it is used to crush lamps;
- inspecting the DTC to determine that it is properly assembled;
- inspecting for damage or wear to the device;
- procedures for properly cleaning up lamps that become broken outside the DTC;
- proper use of personal protective equipment that is made available (see below).

Safety equipment: Personal protective equipment (PPE) and safety equipment should be used to minimize potential injuries and mercury exposure from broken lamps or due to malfunction of the DTC. These include cut-resistant gloves, safety glasses or a face shield, dedicated shoes or disposable booties, and disposable coveralls. Clothing (disposable coveralls and shoes or booties) and safety equipment worn while operating a DTC should not be worn outside of areas designated for DTC use.

Respirators may be necessary in some cases. The need for a respirator will depend on the duration of use, the ventilation in the area where the DTC is being used, and the frequency of monitoring. To determine whether a respirator is warranted, you can consult with a certified industrial hygienist.

OSHA requires that persons using a respirator be provided a medical evaluation to determine the employee's ability to use a respirator before the employee is fit tested or required to use the respirator in the workplace. The person wearing the respirator must be fit tested prior to using a respirator to ensure that it fits the wearer and will adequately protect their health, and the employee must be properly trained before using a respirator. In order to provide protection against mercury exposures, respirator cartridges designed specifically for use with mercury are required; respirator cartridges designed for volatile organic constituents or particulates will not provide protection against mercury exposure. Further information on the proper use of a respirator, including the elements of a respiratory protection program, may be found at 29 CFR 1910.134.[19] Additionally, OSHA provides information on respirator use at: www.osha.gov/SLTC/etools/respiratory/oshafiles/faq.html.

[19] 29 CFR 1910.134 can be accessed at the Government Printing Office's Electronic Code of Federal Regulations Web site at ecfr.gpoaccess.gov.

DTC inspection and maintenance: DTC operators should inspect the device before each use for damage or improper assembly and check for negative pressure before use. Maintenance of DTCs according to manufacturer schedules (particularly for filter changes) will help keep them operating optimally. There may be significant increases in mercury release if the filters are not changed in accordance with manufacturer schedules or if operators are not properly trained in device assembly, operation, and maintenance. A log recording the date and type of maintenance performed on the unit should be maintained. DTCs should be assembled according to manufacturer's instructions and should not be modified other than by the original manufacturer.

DTC Operation: DTCs should be operated in accordance with manufacturer instructions. Operators should maintain a log of the number of lamps crushed. The number of lamps crushed per drum should not exceed manufacturers' recommendations. DTCs also should not be used continually for longer than the manufacturer recommends. Operators should not use a DTC if there is white powder on or around the DTC because this might indicate that there is a leak or that the DTC has not been properly assembled. DTCs also should not be used if there is any damage to the DTC, especially the vacuum system, seals or filters, the DTC has been incorrectly assembled, or the DTC has been modified in any way. Let the drum contents settle for at least 15 minutes before removing the DTC from the drum, and immediately seal the drum after removing the DTC.

Management of drummed crushed lamps: Crushed lamps should be sent to a commercial lamp recycler. Drums with crushed lamps may be hazardous wastes and, if so, must be managed according to applicable federal and state regulations.[20] Transferring crushed lamps to another container can result in very significant releases of mercury to the ambient air and should not be attempted. Maintaining crushed lamps in well-sealed containers, with prompt shipment to permitted mercury lamp recyclers for reclamation of the mercury and other materials, can minimize the life-cycle release of and exposure to mercury from the spent lamps.

Management of used filter material: DTC filters might be hazardous waste. It is the generator's responsibility to determine whether used filters are hazardous waste and manage them according to applicable federal and state regulations. Whenever possible, used filter material should be sent to a recycler so that the mercury can be reclaimed.

Other considerations to keep mercury emissions to a minimum: The DTC should be turned off and ports should be capped or sealed whenever the DTC is not being used to crush spent lamps. At least two operators should perform each drum change. This enables the operators to place the lid on the drum immediately after removing the DTC from the full drum. By minimizing the amount of time that the full drum is open, operators can decrease the amount of mercury releases and exposure associated with drum changes.

[20] In some states, the management requirements for crushed lamps are different depending on whether or not the lamps are hazardous waste.

D. Monitoring

Meeting Release and Exposure Benchmarks: It is important not to exceed the OSHA PEL and other relevant benchmarks, including state requirements, for mercury release and exposure. Mercury vapor is odorless and colorless, but it can be monitored using a mercury vapor analyzer. In EPA's DTC Study, even major mercury releases during operation of the poorly performing DTC were detected only by use of a mercury vapor analyzer operated with an alarm set to ring if mercury levels exceeded a set concentration.

EPA's DTC Study showed that the performance of DTCs can decrease over time, meaning that the amount of mercury being released, per spent lamp recycled, can increase. The frequency of recommended monitoring depends on the usage of the DTC. Those DTCs that are heavily used should be monitored more frequently than those that are used sporadically. In order to ensure that a DTC is continuing to capture the mercury from the broken lamps, EPA recommends that users monitor the mercury concentrations in the air around the DTC and the operator during crushing operations in the initial month of use and then at least once per every two drums of spent lamps crushed.[21] If a DTC is used in an area where the general public may be exposed to any mercury emissions from the device, EPA recommends more frequent monitoring.

Mercury vapor analyzers can be purchased or rented for periodic use. Some of these analyzers can be used reliably with minimal training. Users of mercury vapor analyzers should be sure that they are serviced according to the manufacturer recommendations, including an annual calibration to ensure measurements are accurate. Also, we recommend that a mercury vapor analyzer with a detection threshold of 0.3 $\mu g/m^3$ (300 ng/m^3) or less be used. Data recording devices are available for mercury vapor analyzers, and will produce an accurate record of the measurements made while using the device. Alternatively, a certified industrial hygienist can be hired to monitor for mercury periodically.

E. Additional Considerations Prior to Purchasing a DTC

Some states have laws and/or regulations that are more stringent than the federal regulations and require a hazardous waste permit to operate a DTC, even if the spent lamps being crushed are not considered to be a hazardous waste under federal law. For more information specific to your state, contact your state environmental regulatory agency (www.epa.gov/epahome/state.htm). Where DTC use is permitted, companies interested in using a DTC should compare the costs with whole lamp recycling. Cost calculations may consider direct and indirect costs associated with DTC use, including capital costs, maintenance, mercury vapor monitoring, employee training, and controlling environmental contamination.

[21] Over the course of EPA's DTC Study, eight drums of lamps were crushed by two of the DTCs (Devices A and C), and nine drums of lamps were crushed by one of the DTCs tested (Device B). For Devices B and C, there was a significant increase in the measured mercury concentrations between samples taken while crushing the first drum of lamps at the start of the study and samples taken while crushing the last drum of lamps at the end of the study. For Device B, airborne concentrations increased by factors of between two and four. For Device C, airborne concentrations increased by factors of between two and five. Given this potential rate of decreased performance (two to five times higher mercury concentrations for every eight drums crushed), even in cases where a DTC initially maintains mercury concentrations below benchmarks, it may release mercury at levels that exceed benchmarks after crushing one or two drums of lamps. It is important to detect and mitigate declining performance before mercury concentrations above benchmarks are realized.

F. Conclusion

These BMPs for DTC use are based on the results of an EPA study of these devices and are intended to promote the safest possible use of DTCs for those who choose to use them. DTCs release some mercury during use and must be operated optimally to minimize these releases. DTC users must comply with all federal and state requirements.

Figure 1: Checklist of Recommended Best Management Practices for Lamp Handling and Storage
***Check with your state environmental agency on lamp handling and storage requirements.**

Location:

- Designate an area within your facility to store lamps
- Storage locations should be away from high-traffic areas
- Bigger facilities may need more than one location for easier access
- Storage rooms should be clean, dry, and free of broken lamp debris
- Areas should ideally have an air handling system that is independent from the rest of the building to help minimize exposure to mercury from broken bulbs

Handling of Lamps:

- Employees should know whom to call if they see that a lamp is burned out
- Workers should remove lamps carefully to prevent breakage
- Do not leave spent lamps in a position or in an area where they can be easily broken
- Place the lamps in a sturdy container
- Create procedures for reporting and managing broken lamps
- If lamps are accidentally broken, follow the clean-up procedure at www.epa.gov/mercury/spills/index.htm#fluorescent
- Keep broken lamps in a sealed container, and keep the container in a cool place, away from high-traffic areas – preferably outdoors.
- Containers of broken lamps should not be opened to add or remove broken lamps
- Remember: Broken lamps contain mercury and may present health hazards
    - Follow OSHA, EPA, and state regulations when managing broken lamps

Storage of Spent Lamps:

- You can put spent lamps in specially made lamp containers for spent lamp storage. Lamp recyclers may provide containers for their customers.
- Containers should be closed, structurally sound, and compatible with the contents of the lamps
- Containers should lack evidence of leakage, spillage or damage that could cause leakage or releases of mercury
- Containers should be stable (i.e., they don't tip over easily), or they should be stored in such a way that they won't easily tip over
- Do not pack too many lamps into a container because the pressure could lead to breakage
- Do not stack boxes of lamps too high because lamps on the bottom could be crushed by the weight of the pile
- Do not tape lamps together or use rubber bands
- Clearly identify containers of spent lamps (e.g., "Waste Lamps," "Spent Lamps" or "Used Lamps")
- Close and secure boxes/containers with tape

Figure 2: Checklist of Recommended Best Management Practices If a DTC Is Used
***DTCs are not recommended for use at locations where sensitive individuals may be exposed.**
***Check with your state environmental agency before purchasing and using a DTC.**

Choosing a DTC:

- Purchase a commercially manufactured DTC from a reliable manufacturer, and do not build one yourself.
- Things to look for:
  1) Vacuum pump to create negative internal pressure
  2) Particulate and activated carbon filters
  3) Well designed and tightly fitted seals at all connection points
  4) Generally sturdy construction

Location for Using and Storing a DTC:

- Indoor use
  - Use and store the DTC in a room away from high-traffic areas
  - Use and store the DTC in a room with good ventilation that is completely segregated from other parts of the building
  - Do not use and store the DTC in areas where the temperature is elevated
  - Keep the DTC room clean and free of all fluorescent lamp debris
- Outdoor use
  - Use a large fan to vent any emissions away from the user to the outdoors
  - Do not use near building air intakes, building entrances or windows
  - Do not operate the DTC on hot days
- If DTC must be moved (e.g., to storage area):
  - Ensure all ports are covered/plugged
  - Avoid disturbing contents of drum

Management of drummed crushed lamps:

- Drums should be managed according to applicable federal and state regulations
- Do not open the DTC to put debris into it
- Do not transfer crushed lamps to a different container
- Drums containing crushed lamp should be:
  - Structurally sound
  - Well-sealed
- Do not store crushed lamps in areas where the temperature is elevated
- Send to a commercial recycler

DTC Inspection and Maintenance:

- Follow manufacturer's recommended maintenance schedule
- Inspect before each use for damage or improper assembly
- Check for negative pressure before use
- Maintain a log of the number of lamps crushed
- Keep maintenance log and manufacturer's manual with the DTC

Operating a DTC:

- Training:
  - Read and understand the manufacturer's manual
  - Practice operation of the DTC, filter changes and drum changes before using it
  - Inspect the DTC for proper assembly
  - Inspect for damage or wear
  - Know how to properly clean up broken lamps
  - Know use of respirators and other safety equipment
- Do not crush more lamps per drum than the manufacturer recommends
- Do not use continually for longer than the manufacturer recommends
- Recommended Safety Equipment:
  - Puncture-resistant gloves
  - Safety glasses or face shield
  - Disposal coveralls and shoes or booties
  - In some cases, fit-tested respirator with the correct mercury cartridges
- Let drum contents settle for at least 15 minutes before removing the DTC from the drum
- Immediately seal drum after removing DTC

Monitoring for mercury:

- Monitor at least once per every two drums
  - Monitoring performed by a certified industrial hygienist OR
  - Purchase or lease a mercury vapor analyzer
- NEVER use a DTC if
  - There is white powder on/around the DTC
  - There is any damage to the DTC, especially the vacuum system, seals or filters
  - The DTC has been incorrectly assembled
  - The DTC has been modified in any way

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Appendix A. Other Studies on Mercury Lamp Treatment and Handling

A number of other studies have been conducted, both on DTCs and on the release of mercury from fluorescent lamps that were broken without any emission controls. Some of these studies are discussed here to provide more information about mercury release from broken lamps.

In 1994, EPA's Office of Research and Development, Control Technology Center, produced a report entitled, *Evaluation of Mercury Emissions from Fluorescent Lamp Crushing* (EPA document no. EPA-453/D94-018). The conclusions from this report were that the amount of mercury emitted from a spent lamp depends on the way the lamp is handled after it is removed from service. The report concluded that by recovering the mercury in the spent lamps, as opposed to disposing of them without recycling, the net amount of mercury ultimately released to the environment is reduced. Specifically, the researchers found that, even in a well-covered drum-top crusher, some mercury is emitted during crushing. However, they also concluded that crushers can be designed to emit up to 90% less mercury through the inclusion of a vacuum collection system, to prevent release of mercury from the lamp feed system, and air pollution control media, such as a cyclone, a HEPA filter, and a carbon adsorber.

The Minnesota Department of Health, in consultation with the Agency for Toxic Substances and Disease Registry, Division of Health Assessment and Consultation, performed a health consultation for the State of Minnesota in 2003. The purpose of this report was to evaluate the public health issues related to levels of mercury emitted from a commercially available DTC considered for use at a Minnesota company. The DTC was running (i.e., the vacuum system was on and air was being exhausted through the air pollution control filters) for approximately ten minutes, and bulbs were being fed into the device for eight minutes. Based on the mercury analyzer readings during operation, the report summary stated, "During operation of the bulb crusher, mercury vapor concentrations in the breathing air approached MN OSHA (eight-hour) limits. The measured concentrations were about 25 times greater than an acute health-based criterion for the general public." The Minnesota Department of Health and the Minnesota Pollution Control Agency determined that "the use and proliferation of drum-top bulb crushers in Minnesota could affect the health of individuals incidentally exposed to bulb crusher exhaust." It also concluded that mercury emissions could likely be reduced by making design changes in the DTC, such as by reducing the amount of air exhausted from the device and by the inclusion of filters that react chemically with mercury or filters made of materials that adsorb mercury.

Also in 2003, Aucott, et al., conducted a study to determine the amount of mercury released into the air when mercury lamps are broken without any controls. They found that "between 17 and 40% of the mercury in broken low-mercury fluorescent bulbs is released to the air during a two-week period immediately following breakage." Additionally, higher temperatures were found to contribute to higher release rates.

In 2006, Lucas and Emery published a study assessing occupational exposures during the on-site processing of spent lamps. The authors evaluated mercury exposures encountered by workers using a commercially available DTC. Lamps were crushed in outdoor and enclosed work environments, and the impacts of processing tubular fluorescent lamps from a variety of

manufacturers were evaluated for each type of work setting.[22] The findings were similar to those in EPA's DTC Study. The mercury vapor concentration reached the federal OSHA PEL (100 μg/m^3) during both sampling events in the enclosed environment. In addition, one method of measuring mercury vapor concentration suggested that the operator's personal exposure exceeded the OSHA PEL during the two outdoor studies. It is interesting to note the high emissions in all tests, even though half of the lamps crushed were lamps that were marketed as "low mercury" lamps. The authors concluded that many phases of lamp handling pose an occupational hazard and employers should consider all phases of the lamp management process, particularly lamp handling and equipment changeout. The authors also recommended periodic monitoring and sampling to ensure that exposure limits are not exceeded.

In addition to the studies performed on linear fluorescent lamps, relevant studies have been performed to determine the amount of mercury that is released when CFLs are accidentally broken. Johnson, et al., recently characterized the release of mercury vapor from broken new and spent CFLs under simulated cleanup conditions. In the initial hour after a lamp is broken, the release of mercury vapor is rapid, leading to concentrations that were, depending on the lamp type, between 1.9% and 30% of the mercury contained in the lamp after four days. New lamps released a higher amount of mercury as compared to spent lamps. The researchers also found that "removing large glass shards by hand after breakage on a carpet" reduced mercury release by two-thirds.

Finally, on February 25, 2008, Maine's Department of Environmental Protection released a study on CFLs that was designed "to collect data to support or revise existing cleanup guidance for the breakage of a single CFL." Single CFLs were broken in a small/moderate-sized room in forty-five (45) experimental trials. The mercury concentrations were continuously monitored using Lumex mercury vapor analyzers at the five foot height (adult breathing zone) and one foot height (infant/toddler breathing zone) above the study room floor. The data collected showed that "mercury concentration in the study room air often exceeded the Maine Ambient Air Guideline (MAAG) of 300 ng/m^3 [0.3 μg/m^3] for some period of time, with short excursions over 25,000 ng/m^3 [25 μg/m^3], sometimes over 50,000 ng/m^3 [50 μg/m^3; the upper detection limit of the Lumex analyzers]." EPA has conducted an initial review of this study and, as a result, has updated the EPA CFL cleanup instructions, which can be found at: www.epa.gov/mercury/spills/index.htm#fluorescent.

[22] Lamps from different manufacturers contain different amounts of mercury and release different levels of mercury when broken or crushed.

Appendix B. Information for DTC Manufacturers

Drum top lamp crusher design is an evolving field, and many DTC manufacturers are continually developing more efficient crushing devices and practical information for DTC users. This section is based on information from EPA's DTC Study, operators of DTCs, and state regulators.

A. Potential DTC Design Modifications

The following areas for potential modifications in DTC design were identified in EPA's DTC Study:

Development of Leak Detection Systems: EPA's DTC Study found that DTCs may develop undetected leaks and release significant amounts of mercury as a result. While a portable mercury vapor monitor can easily detect rising airborne mercury concentrations, these devices are expensive to purchase and operate. Development of an effective leak detection system as part of the DTC device, such as a continuously operating pressure monitor, may reduce the need for mercury monitoring to ensure operator safety and compliance with regulatory standards.

Improvement in Mercury Capture during Drum Change: Drum changes were identified in EPA's DTC Study during normal operation with the highest potential for operator exposure to mercury concentrations above the PEL, so improvements in device designs to reduce mercury releases during this operation would be very beneficial.

Chemical Treatment of Released Mercury Vapor: Most of the mercury released from spent lamps in DTCs is elemental mercury vapor, which is volatile at room temperatures. Elemental mercury reacts with sulfiding agents very readily and quickly under environmental conditions to form mercuric sulfide. Because mercuric sulfide is a solid (powder) at room temperature, its release to the air should be much easier to control than mercury vapor. Incorporating sulfiding-agent injectors into a DTC design could potentially reduce mercury releases during all activities associated with DTC use (except lamp breakage outside the device).

B. Informing and Working with DTC Users

Provide DTC Users with Safety Information: To promote safe recycling and assist with regulatory compliance, DTC manufacturers can provide their customers with information about safe management of spent lamps and optimal operation of DTCs. We recommend that DTC manufacturers communicate the following to DTC owners and operators:

- recommended personal protective equipment;
- clear instructions on device assembly, filter changes, drum changes, and lamp crushing operations, including pictures and/or diagrams;
- instructions on how to inspect the device before each use to ensure there is no damage or wear and that it has been properly assembled;
- recommended operational time limit stated in maximum hours per day and maximum number of spent lamps crushed per day;

- information about how to perform mercury vapor monitoring and how to hire a professional to perform the monitoring;
- information about lamp recycling;
- information about management of spent filters and other spent air pollution control media; and
- information about proper management of spent lamps before and after crushing.

Use a Variety of Methods to Provide Safety Information to DTC Users: Some DTC manufacturers already provide this information to their customers. We encourage manufacturers to use a variety of methods to communicate safety information to owners and operators of DTCs. Suggested methods include:

- DTC user manual;
- instructional videos;
- training courses;
- personal communication between the manufacturer and the customer;
- manufacturer Web sites; and
- labels affixed to the DTC (see Figure A-1).

Provide Services for the Life of the DTC: Many DTC manufacturers not only sell DTCs, they also offer services to the DTC user. These services might include initial and follow-up training for operators, management of crushed lamps, routine inspection and maintenance, and routine mercury monitoring to ensure OSHA compliance. By providing these services, manufacturers can support proper lamp management and optimal DTC performance. Additionally, manufacturers would have the opportunity to interact with customers who are currently using DTCs. This would allow for regular communication about safe practices and feedback from the customer about the effectiveness and ease of use of the DTC.

Figure B-1: Example Checklist Label that Can Be Affixed to DTC for Operator Reference
***Note that this is an example and different durations or specific recommendations might be appropriate for different devices, depending on the device and the intended use patterns.**

For optimal operation Follow these routine steps:		Crushing log	
		Date	# Lamps Crushed
Before You First Operate the DTC:	1. Read and understand the user manual		
	2. Practice operation of DTC - filter and drum changes - feeding spent lamps		
	3. Learn how to use personal protective equipment (PPE)		
	4. Learn how to clean up broken lamps		
Before Each Use:	1. Inspect DTC for proper assembly		
	2. Inspect for damage or wear		
	3. Put on appropriate PPE		
	4. Inspect for proper vacuum and air flow		
After Each Use:	1. Write the number of lamps that were crushed and the date on the Crushing Log		
When Drum is Full (approximately 650 lamps have been crushed):	1. Never try to crush more than 650 lamps into one drum		
	2. Have two trained operators change the drum		
	3. Never remove crushed lamps from the drum		
	4. Cover a full drum as quickly as possible and seal it tightly		
At least once per every two drums:	1. Monitor mercury emissions and operator exposure to mercury during operation		

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http://www.epa.gov/epawaste/hazard/wastetypes/universal/lamps/links.htm