Mercury in Florida's Medical Facilities: Issues and Alternatives

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FLORIDA CENTER FOR SOLID AND HAZARDOUS WASTE MANAGEMENT
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LIST OF ACRONYMS

AAMI	Association for the Advancement of Medical Instrumentation
AHA	American Heart Association
BMP	Best Management Practices
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CESQG	Conditionally Exempt Small Quantity Generator
CH^3	Methyl Carbanion
CH^3Hg^+	Methylmercury ion
CVM	Center for Veterinary Medicine
EPA	Environmental Protection Agency
FAMS	Florida Atmospheric Mercury Study
FDA	Florida Dental Association
Hg^0	Elemental Mercury
$HgCl^2$	Mercuric Chloride
HgO	Mercuric Oxide
MCL	Maximum Contaminant Level
MSW	Municipal Solid Waste
MWI	Medical Waste Incinerator
RCRA	Resource Conservation and Recovery Act
TCLP	Toxicity Characteristic Leaching Procedure

Executive Summary

Mercury is found in many manufactured products because of its unique characteristics. Mercury is commonly found in medical facilities in thermometers, blood pressure units, and a wide variety of medical devices and chemical substances. One unfortunate characteristic of mercury is that it is a neurotoxin that, when accumulated in the environment in the form of methylmercury, can cause serious damage to animals and humans through ingestion.

Concern about the dangers of atmospheric mercury has been growing since the 1980s when many states, including Florida, issued health advisories warning of the effects of consuming fish that contained toxic levels of mercury. In Florida, attention was especially focused on the Everglades where largemouth bass were found to have high concentrations of mercury.

Researchers have estimated that as much as 75% of atmospheric mercury emissions are the result of human activity. When atmospheric mercury is deposited on land or water, it is methylated and can readily enter aquatic plants, microscopic aquatic animals, sediment, and soil burrowing organisms. Methylmercury moves up the food chain and is absorbed by fish through ingestion of contaminated plants and animals or directly through the gills. Methylmercury compounds are not readily excreted from fish tissues. The result is "bioaccumulation," in which mercury concentrations increase with each step in the food chain, so that the consumers highest on the food chain - humans - are dosed with mercury levels several orders of magnitude above the original concentration. Low levels of methylmercury can cause neurological damage in fetuses and small children. Mercury toxicity has been cited as a probable or possible cause in the deaths of at least three Florida panthers since 1989.

Incinerators that burn waste have been identified as a source of mercury emissions. Mercury emissions from municipal solid waste incinerators have decreased as the amount of mercury in one major source, household batteries, has decreased. However, many mercury-containing items, devices, and chemicals are still widely used in medical facilities. When those items and devices are improperly disposed of as biomedical ("infectious") or even solid waste and are incinerated, mercury is emitted into the atmosphere.

In response to concerns about mercury emissions from incinerators that burn waste from medical facilities, the Florida Department of Environmental Protection asked the Florida Center for Solid and Hazardous Waste Management to conduct a comprehensive review of the use of mercury in Florida's medical facilities. The study sought to identify and quantify the sources of mercury, with particular emphasis on mercury-containing items and devices that can potentially reach the biomedical waste stream. The study included a literature review of previous research,

a review of state and federal laws governing the management and disposal of waste from medical facilities, contacts with vendors and manufacturers of mercury-containing items and devices, and a statewide survey of waste management practices in Florida hospitals. Best management practices were developed to assist Florida hospitals in reducing mercury in their facilities and in properly managing the mercury containing items and devices that remain in use. The Center also developed best management practices for dentists to assist them in the proper handling and disposal of dental amalgam. Finally, the Center conducted a pilot project on proper collection and disposal of spilled mercury and conducted several case studies in medical facilities seeking to reduce their use of and improper disposal of mercury-containing items and devices

1. INTRODUCTION

Mercury is unique among the earth's naturally occurring elements. While its unusual characteristics have made it one of the most widely used metals, mercury's neurotoxicity and its persistence in the environment have led to efforts in recent years to eliminate it from many industrial applications.

Beginning in the early 1970s, studies of remote lakes with no point source mercury discharges led many researchers to conclude that mercury contamination of water bodies was the result of atmospheric deposition (Minnesota, 1994). This conclusion generated a number of other studies investigating the anthropogenic sources of mercury in the atmosphere. At the time this report was written, the U.S. Environmental Protection Agency (EPA) was conducting studies to obtain more information on the environmental impacts of a variety of mercury uses.

Concern about the dangers of mercury became widespread in the 1980s after many states, including Florida, issued health advisories warning of the effects of consuming fish that contained toxic levels of mercury. In Florida, attention was especially focused on the Everglades after largemouth bass in an area about a million acres in size were found to contain mercury in concentrations greater than 2 ppm, an amount that exceeds all health-based standards.

While some mercury emissions in the atmosphere are naturally occurring, researchers have estimated that as much as 75% of the emissions are a consequence of human activity. A study in Minnesota attributed 35% of the state's anthropogenic mercury emissions to energy production and 65% to a number of other sources including municipal and medical waste combustion (Minnesota, 1994). The Minnesota study attributed 5% of total anthropogenic mercury emissions to medical waste combustion, and a study in Michigan found that medical waste combustion resulted in 9.5% of total mercury emissions (Minnesota, 1994; Michigan, 1996). A study prepared for the Florida Department of Environmental Regulation estimated that mercury emissions from medical waste incinerators (MWIs) comprised 5.9% of the total mercury emissions in Florida in 1990 (KBN, 1994).

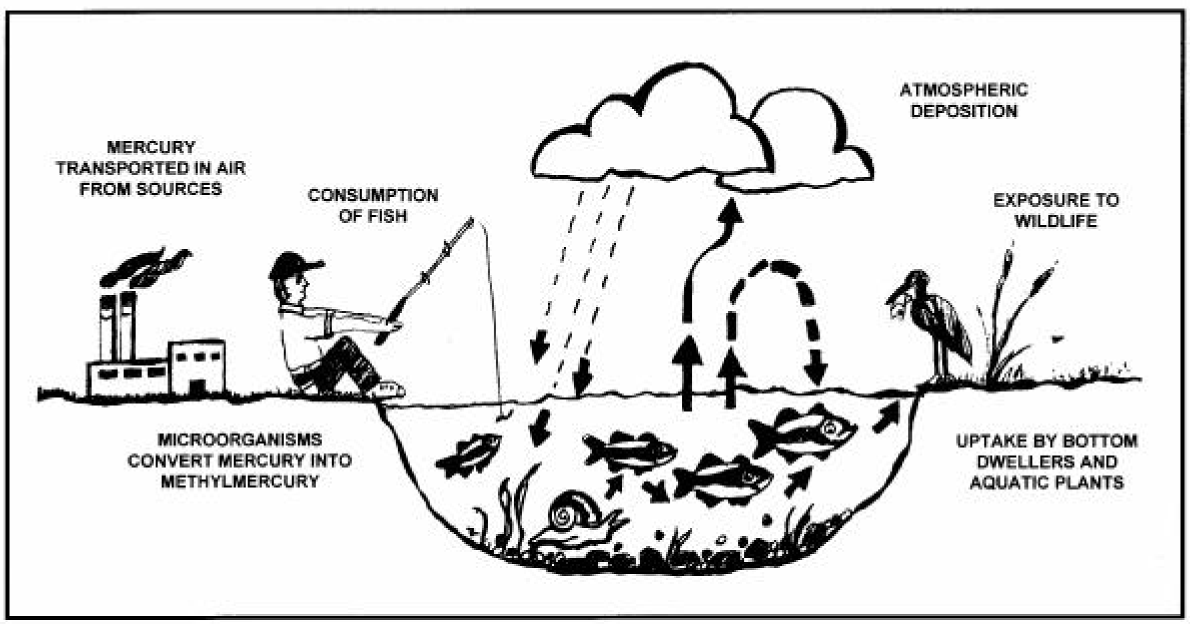
In response to concerns about mercury emissions from incinerators burning waste from medical facilities, the Florida Department of Environmental Protection asked the Florida Center for Solid and Hazardous Waste Management to conduct a comprehensive review of the use of mercury in Florida's medical environment. Previous research determined that medical facilities in Florida generate 50,000 tons of waste each year (DEP, 1995).

The present study sought to identify and quantify the sources of mercury in waste from Florida's medical facilities, with particular emphasis on mercury in the biomedical, or "infectious," waste stream. One goal of the study was to develop best management practices that medical facilities could implement to reduce their use of mercury-containing items and devices and to properly manage the mercury-containing items and devices that remained in use. The study included a statewide survey of waste management practices in Florida hospitals, a literature review on mercury in the medical environment, and contacts with manufacturers of mercury-containing items and devices.

New federal regulations regarding MWIs, issued by the EPA in August 1997, are expected to result in an eventual reduction of toxic emissions, including mercury emissions, over the next few years. In the interim, the development and distribution of best management practices on mercury use and disposal for medical waste generators can potentially have a more immediate impact. The implementation of such practices in facilities that rely on incineration as a waste disposal method should result in a reduction of mercury emissions from MWIs in Florida.

Figure 1.1 Mercury Transport and Deposition

Mercury can evaporate quickly and can be released into the air when mercury-containing products are either broken or incinerated, as well as when coal or oil which contain mercury are burned for fuel. Mercury can also be discharged



through municipal and industrial wastewater. Once mercury is released into the environment, it circulates and can be converted by microorganisms into methylmercury, the most toxic form. Methylmercury bioaccumulates in the flesh of fish (not the fat) and can build up, or biomagnifies up the food chain and can pose a health risk to humans and wildlife that consume large quantities of mercury-contaminated fish.

Source: Merc Concern: Mercury Awareness for Michigan Citizens, a brochure published by the Michigan Department of Natural Resources and endorsed by the Michigan Mercury Pollution Prevention Task Force. Used with permission.

2. CHARACTERISTICS AND EFFECTS OF MERCURY

2.1 Introduction

Mercury has attracted much attention throughout history. The ancient Chinese believed the element was an elixir of immortality. The Hindus used mercury as an aphrodisiac. Even today, mercury is used by some spiritualists in Latin American and Caribbean countries in their religious rituals (Reeder, 1995). The EPA is currently researching such uses in the United States.

Mercury has several unique properties which have made it useful to modern civilization. The quality most often exploited is that mercury is the only metal which exists as a liquid at room temperature. Environmentally, the attention mercury currently receives is also a result of its properties; it is a neurotoxin which bioaccumulates in the environment.

2.2 Human Health Effects

Evidence of mercury's neurotoxicity has been available for some time, although early on it was anecdotal. The term "mad hatter" is thought to have come from the designation given to hat makers during the 19th century. The name describes the neurological effects of elemental mercury poisoning in hat makers who used mercury to construct felt hats. Another anecdotal incident refers to a dark year (1693) in Sir Isaac Newton's life when he withdrew from family and friends because he thought they were plotting against him. He was purported to be using elemental mercury in laboratory experiments during this time (Considine, 1989).

The neurological damage caused by bioavailable mercury (methylmercury) has been well documented in the twentieth century. Methylmercury is easily absorbed by living organisms because it is water soluble (Minnesota, 1994). Once ingested by humans, about 90 to 95% of methylmercury is bound to red blood cells and the gastrointestinal tract is the most important route of absorption (D'Itri, 1972). At high concentrations, there is evidence that approximately 10% of the methylmercury body burden accumulates in the brain (D'Itri, 1972). The blood retains about 5% and the remaining balance is distributed throughout body tissues (Nordberg and Skerfving, 1972).

Even low levels of methylmercury ingestion can be a danger to small children and fetuses because their nervous systems are still developing. Since methylmercury compounds will easily pass through the blood-brain barrier, blood-testes barrier, and the placenta, they can cause neurological damage both prenatally and postnatally (D'Itri, 1972). Possible complications include spasticity, blindness, deafness, irritability, and myoclonic tremors or jerks that can lead to coma or early death (Skerfving and Vostal, 1972). Nursing mothers also can pass methylmercury to children via breast milk (Skerfving, 1972).

Research on the origin and fate of methylmercury was stimulated by the first reported large-scale incident of methylmercury poisoning in 1956. (Krishnamurty, 1992). Minamata disease" was discovered in Minamata, Japan, where a chemical manufacturing plant made acetaldehyde using an inorganic mercury catalyst. The plant generated methylmercury as a waste product and discharged its waste effluent and sludge into Minamata Bay. Local people consuming fish caught in the Bay began showing a variety of symptoms indicating neurological damage. Also, children with birth defects and severe retardation were born to women who consumed fish from the Bay. The health effects exhibited by the Minamata victims were later conclusively tied to methylmercury poisoning.

Environmental cleanup of the site did not begin until 1982, 14 years after the chemical company ceased polluting the Bay with its discharges. As of March 1993, mercury levels in 10 species of fish had dropped but were still two or three times higher than what the Japanese government deems acceptable (Cunningham et al., 1994).

Methylmercury poisoning has also been documented in a number of incidents involving the consumption of grains treated with methylmercury seed dressings. Seed dressings were developed around the end of the 19th century to prevent diseases caused by a wide variety of seed-borne plant fungi, thereby improving crop yields. The dressings were originally a formula of non-mercurial chemicals and heavy metals. However, in 1914 German scientists introduced aryl organomercurial seed dressings which were more effective than the non-mercurial formulations. These organomercurials, particularly methylmercury and ethylmercury, were used in some parts of the world until the mid-1980s, although the United States and many other countries banned their use in 1970. During the time period that organomercurials were used, many accidental poisoning incidents occurred in which hundreds of people died. The first documented poisoning occurred in Iraq in 1956. Other incidents occurred during the 1960s in West Pakistan, Guatemala, Ghana, Mexico, and the United States (Cunningham et al., 1994).

Mercury poisoning can occur not only through ingestion but also through skin absorption (Krishnamurty, 1992). In 1997, a research chemist at Dartmouth College in Massachusetts died as a result of skin exposure to the compound. In August 1996, Dr. Karen Wetterhahn, a widely known cancer researcher, was studying how mercury prevents cells from repairing themselves, much like cancer does. A tiny drop of dimethylmercury spilled on her latex glove, seeped through the gloved, and was absorbed into her skin in a matter of seconds. Within a few months, she began losing her balance and having trouble hearing and speaking, and she died less than a year after exposure. (Associated Press, 1997; Zacks, 1997).

The increase of fish consumption advisories in recent years indicates methylmercury bioaccumulation is rapidly becoming a national crisis. In August 1995, the EPA issued an update of its national listing of these advisories. This list inventories water bodies, by state, for which fish consumption advisories are in affect. Florida had 89 water bodies so designated. Within some parts of the Florida Everglades, three fish species including largemouth bass should not be consumed at all. Ranked by the number of water bodies with fish advisories, Florida is third in the nation behind Minnesota and Wisconsin (with 565 and 260 respectively).

2.3 Mercury and Wildlife

Human beings are not the only species affected by the accumulation of methylmercury in the environment. While fish advisories can persuade people to adjust their diets accordingly, many species, including alligators, eagles, herons, ospreys, otters, and raccoons, are consuming fish which is hazardous to them. It is likely that reproductive damage from mercury toxicosis is contributing to the decline of breeding wading bird populations in southern Florida (Spalding et al., 1994). According to one study, methylmercury concentrations in Florida's bald eagles are below levels that cause mortality, but they remain in the range of concentrations that can cause behavioral changes and reproductive failure (Wood et al., 1996).

Mercury toxicosis may have also been responsible for at least one Florida panther death in the Everglades National Park and is strongly implicated in two other panther deaths since 1989 (Roelke et al., 1991). This is particularly significant in Florida because the endangered panther population is dwindling and it is feared they might not be saved from extinction.

2.4 Mercury In the Environment

The most significant forms of mercury in the environment include elemental mercury; inorganic divalent mercury compounds such as mercuric chloride, mercuric hydroxide, and mercuric sulfide; and organomercury compounds such as the methylmercury ion, monomethylmercury compounds, and dimethylmercury.

All substances undergo cycling and transformations in the environment, but this is particularly so for mercury. Mercury's ability to exist in several physical states and chemical forms at commonly encountered conditions of temperature and pressure, and its propensity to undergo biological transformations, means that it is subject to complex and difficult-to-predict changes in concentration and form. When released into the environment it can either stay close to its source for long periods or it can be widely dispersed regionally or even globally.

A study conducted in Florida from 1992 to1996 investigated the atmospheric delivery of mercury to Florida ecosystems throughout Florida, especially aquatic ecosystems. The primary goal of the Florida Atmospheric Mercury Study (FAMS) was to determine seasonal and geographical variability in the atmospheric deposition of mercury. The study provided evidence that at least some of the atmospheric deposition of mercury in Florida came from regional or global sources. A study by Guentzel (1997) based on FAMS data reported that deposition was greater at monitoring sites in southern Florida than at sites in northern Florida. Guenztel's study suggested seasonal trade-wind transport and the frequency and intensity of rainfall may contribute to the higher levels of atmospheric deposition in South Florida during the summer months.

2.4.1 Background Concentrations and Regulatory Limits

On average, uncontaminated sediments contain about 0.01 to 0.2 μg/g of total mercury (Henke et al., 1993). The mercury concentration in pristine, fresh water is about 0.02 μg/L (Henke et al., 1993). Elemental mercury is about 80-99% of the mercury found in the atmosphere where average concentrations range from 0.001 $\mu g/m^3$ in open ocean areas to 0.002 to 0.02 $\mu g/m^3$ for urban environments (Henke et al., 1993).

While the EPA maximum contaminant level (MCL) for mercury in drinking water is 2.0 μg/L, and EPA's ambient water quality criterion for mercury is 12 ηg/L, the analytical method approved by EPA for mercury analysis has a method detection limit of 200 ηg/L. It has been suggested that EPA approve measurement methods for water with lower detection limits, on the order of 1.0 ηg/L (Minnesota, 1994).

2.4.2 Solubility of Mercury Compounds in Water

Elemental mercury tends to be relatively insoluble compared to other mercury compounds such as mercuric chloride and mercuric oxide occurring in the environment. Elemental mercury does not readily wash out of the atmosphere during rainfall, while divalent compounds do (Minnesota, 1994). Most mercury forms easily bind onto natural organic matter, especially humic substances.

While elemental mercury is relatively insoluble in water, it may be converted into more soluble divalent mercury forms under certain conditions favoring reduction and oxidation, and under certain pH conditions. Once in the divalent state, mercury may be further converted to highly toxic organic divalent mercury compounds by bacterial assimilation or by abiotic means.

Little quantitative information is available regarding the solubility of organic divalent mercury compounds, although some studies have suggested that dimethylmercury is sparsely soluble in water, and monomethylmercury compounds with more highly electronegative inorganic ions tend to be more soluble in water (Henke et al., 1993).

2.4.3 Methylation/Demethylation of Mercury

Methylation of mercury occurs through natural biological processes. The life processes of microorganisms, wildlife, and plants are all capable of transforming different forms of mercury although this varies from species to species. Microorganisms cannot transform elemental mercury directly into methylmercury; however, once elemental mercury is oxidized to an ionic species, certain methylating bacteria such as *Pseudomonal fluroescens* can methylate mercury ions (Henke et al., 1993). The biosynthesis of methylmercury by bacteria isolated from sediments is well established and occurs by methyl carbanion transfer (Krishnamurthy, 1992).

Abiotic processes can also result in the formation of methylmercury. Methylmercury can be produced without bacteria or light from fulvic and humic materials in sediments (Henke et al., 1993). Another important abiotic mercury methylation process is photomethylation (Henke et al., 1993).

Decomposition of methylmercury in surface waters can occur by means of photodegradation. This process is abiotic and the rate of decomposition is related to the intensity of solar radiation (Sellers et al., 1996). Tests have indicated that photodegradation rates do not vary with changes in water chemistry, although water stained by dissolved organic matter reduces light penetration and the beneficial aspect of photodegradation. Bacteria also demethylate methylmercury. The rate of biological demethylation is about 350 times slower than the rate for photodegradation (Sellers et al., 1996).

2.4.4 Bioaccumulation

Atmospheric mercury released from medical waste combustion sources is often present as a combined vapor of elemental mercury and, due to the preponderance of chlorinated plastics in the waste, mercuric chloride. When these forms of mercury are removed from the air by dry deposition or rain events, they are methylated by natural processes and can readily enter aquatic plants, microscopic aquatic animals, and sediment and soil burrowing organisms (Krishnamurthy, 1992).

Methylmercury moves up the food chain and is absorbed by fish by either ingestion of contaminated plants and animals or directly through the gills. Since methylmercury compounds are not readily excreted from the tissues of fish or other aquatic organisms, bioaccumulation results. (Henke et al., 1993). Contaminated fish are then consumed by species higher on the food chain, including humans. With each step in the chain, mercury concentrations increase so that the consumers who are highest on the food chain are dosed with mercury levels several orders of magnitude above the original concentration.

Bioaccumulation of mercury within the aquatic food chain has been well documented. Because of the inability of aquatic organisms to excrete methylmercury, it may bioaccumulate to levels that are much higher than surrounding water and sediments (Henke et al., 1993). A Minnesota study found that the average concentration of mercury in a northeastern Minnesota lake is about 2 ηg/L, and the average concentration in a 22-inch northern pike residing there is about 450 ηg/g (Minnesota, 1994). Researchers have reported that mercury biomagnification ranges from 1,000 to 10,000,000 (Cunningham et al., 1994; Henke et al., 1993).

2.4.5 Noted Trends

Mercury concentrations tend to be higher in fish that live in lakes that have been acidified by acid rain as compared to fish in more alkaline waters. Henke et al. (1993) reported that the deposition of sulfate in lake water from acid rain may stimulate methylmercury production in lake sediments. Another study also stated that acid deposition is thought to increase methylation of mercury in lakes because the sulfate ion of sulfuric acid stimulates the activity of the same bacteria that methylate mercury (Minnesota, 1994).

For reasons currently unknown but subject to considerable research, some lakes produce fish with higher mercury concentrations than other lakes that receive similar rates of atmospheric deposition. In Minnesota, the concentration of mercury in fish is positively correlated with water color (dissolved organic compounds) and sulfate, and negatively correlated with alkalinity, pH, and phosphorus (Minnesota, 1994).

One study estimated that 10% of all mercury emitted from an emission source is deposited within 10 kilometers of that source (Lindqvist and Rodhe, 1985). However, it is likely that this percentage varies depending on the chemical forms of mercury present in the stack. Generally, elemental mercury has an average residence time in the atmosphere of about one year, while the inorganic forms have residence times of a few hours to months (Porcella, 1995). If a given source emits a higher proportion of divalent mercury compounds such as mercuric chloride, rather than elemental mercury, then the source should have a greater local impact than a source that primarily emits elemental mercury. Medical waste has a relatively high percentage of plastics (including PVC) compared to other types of incinerated waste. Consequently, it would be expected that mercuric chloride comprises a greater percentage of the total mercury emissions from MWIs, resulting in more local deposition of mercury.

3. REGULATION AND TREATMENT OF WASTE FROM MEDICAL FACILITIES

3.1 Introduction

Waste generated by medical facilities can be categorized into four waste streams: biomedical waste (commonly known as infectious waste or red bag waste); hazardous waste; solid waste; and low-level radioactive waste. Regulation at the federal, state and local level may all have an impact on the management and treatment of waste from medical facilities. Historically, control of biomedical waste has been the responsibility of state health or environmental departments. The term "biomedical" waste will be used throughout this report as this is the term used in Florida laws governing the management and disposal of infectious waste.

Types and quantities of waste vary depending on the type of facility. For example, waste from a blood bank would consist largely of biomedical waste (e.g., syringes and disposable needles), whereas a hospital's waste would include all four tyupes of waste, including a heterogeneous mixture of solid waste (e.g., paper goods, corrugated cardboard, plastics, food scraps, glassware, metals) (Hasselriis and Constantine, 1992). Each of the four types of waste is subject to different regulations in Florida. Figure 3.1 shows the four types of waste, examples of each type, and the regulations that govern the management and disposal of each type. It is important for medical facility personnel to have a clear understanding of the types and quantities of waste generated.

Sometimes types of waste may be mixed; for example, a broken thermometer (hazardous waste) may be mixed with infectious waste. The handling and disposal of mixed wastes can be confusing. Medical personnel can call the Florida Department of Health (DOH), the Florida Department of Environmental Protection (DEP), or their county or municipal solid waste department for information and clarification on the proper handling of mixed wastes. Figure 3.2 summarizes the provisions of the Florida regulations that govern the management and disposal of mixed wastes.

Regulations at both the federal level and at the state level in Florida call for mercury-containing wastes to be treated as hazardous wastes. When mercury or mercury-containing items improperly enter the biomedical waste stream, or the solid waste stream, they may be unnecessarily incinerated, thus contributing to the problem of mercury emissions.

Figure 3.1 Waste Streams from Medical Facilities

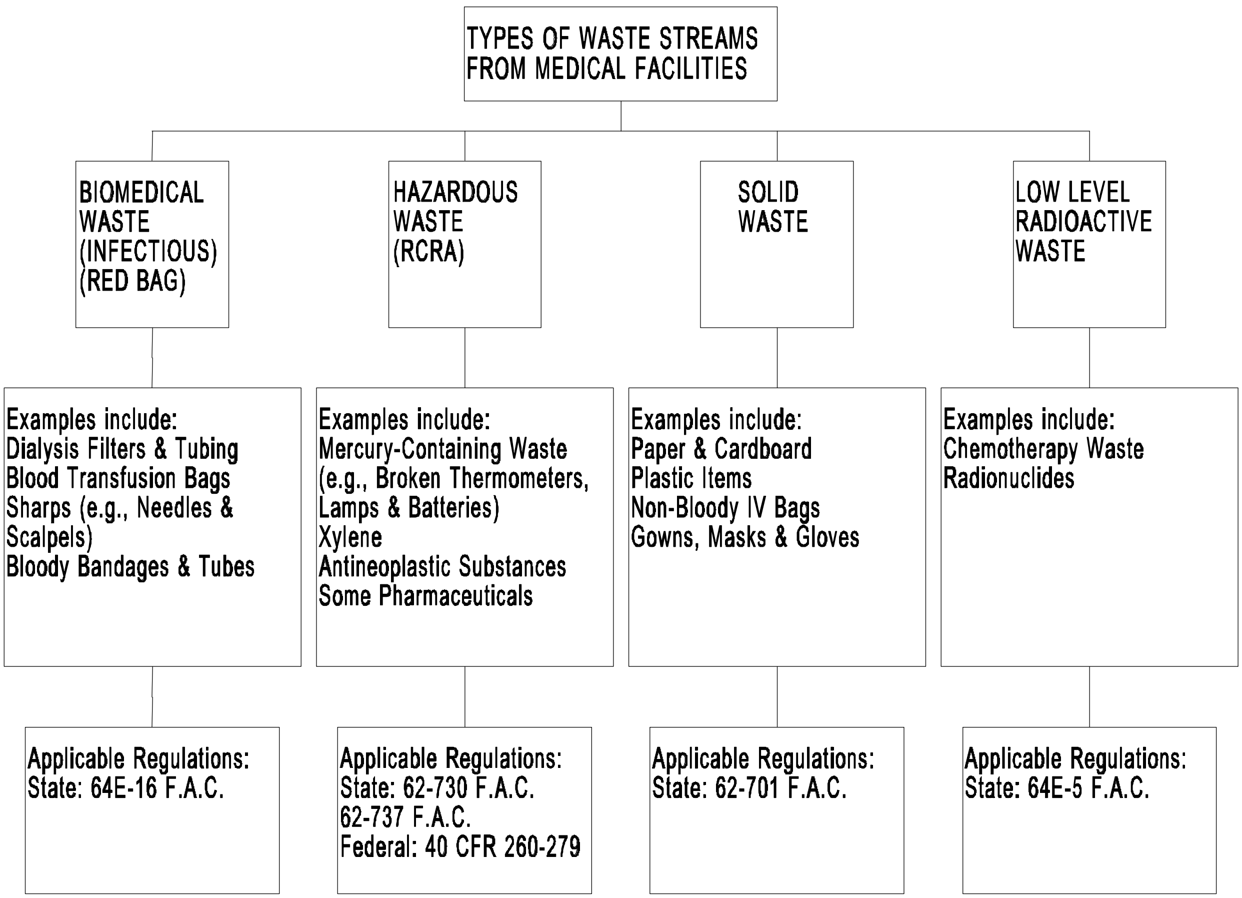


Figure 3.2 Management of Mixed Wastes Generated by Medical Facilities

WASTE MIXTURE	TREAT AS:
Solid Waste + Hazardous Waste	Hazardous Waste
Solid Waste + Biomedical Waste	Biomedical Waste
Solid Waste + Low-Level Radioactive Waste	Low-Level Radioactive Waste
Hazardous Waste + Biomedical Waste	Biomedical Waste and Hazardous Waste
Hazardous Waste + Low-Level Radioactive Waste	Low-Level Radioactive Waste and Hazardous Waste
Biomedical Waste + Low-Level Radioactive Waste	Biomedical Waste and Low-Level Radioactive Waste

3.2 Florida Regulations

In Florida, the management of biomedical waste, including segregation, handling, labeling, storage, transport, and treatment, is governed by Chapter 64E-16, Florida Administrative Code (F.A.C.). Section 64E-16.001(3) ascribes responsibility for the regulation of packaging, transport, storage, and treatment of biomedical waste to the DOH; the DEP regulates biomedical waste disposal.

Section 64E-16.002(2) defines "biomedical waste" as

> "Any solid or liquid waste which may present a threat of infection to humans, including nonliquid tissue, body parts, blood, blood products, and body fluids from humans and other primates; laboratory and veterinary wastes which contain human disease-causing agents; and discarded sharps. The following are also included:
>
> (a) Used, absorbent materials saturated with blood, blood products, body fluids, or excretions or secretions contaminated with visible blood; and absorbent materials saturated with blood or blood products that have dried.
>
> (b) Non-absorbent, disposable devices that have been contaminated with blood, body fluids or, secretions or excretions visibly contaminated with blood, but have not been treated by an approved method.

Section 64E-16.002(3) defines "biomedical waste generator" as

"A facility or person that produces biomedical waste. The term includes hospitals, skilled nursing or convalescent hospitals, intermediate care facilities, clinics, dialysis clinics, dental offices, health maintenance organizations, surgical clinics, medical buildings, physicians' offices, laboratories, veterinary clinics and funeral homes.

(a) Mobile health care units, such as bloodmobiles, that are part of a stationary biomedical waste generator, are not considered individual biomedical waste generators.

(b) Funeral homes that do not practice embalming are not considered biomedical waste generators.

In defining "biomedical waste facility," Section 64E-16.002(9) includes biomedical waste generators described in Section 64E-16.002(3), as well as treatment and storage facilities.

Section 64E-16.003(1) outlines specific waste-handling policies and procedures for the mixing of wastes, requiring that: (a) biomedical waste mixed with hazardous waste shall be managed as hazardous waste; (b) biomedical waste mixed with radioactive waste shall be managed in accordance with the radioactive waste provisions of Chapter 10D-91, F.A.C.; and (c) any other solid waste or liquid, which is neither hazardous nor radioactive in character, combined with untreated biomedical waste, shall be managed as untreated biomedical waste. The treatment of mixed wastes can sometimes be confusing. Medical personnel can call the DOH, DEP, or their county or municipal solid waste department for information and clarification on the treatment of mixed wastes.

Section 64E-16.007 states that acceptable treatment options for biomedical waste include steam, incineration, or one of the alternative processes approved jointly by the DOH and the DEP.

Florida's Hazardous Waste Rule is specified in Chapter 62-730, F.A.C. The rule adopts by reference the RCRA definition of "hazardous waste" as described in 40 CFR Part 261.3. The rule also adopts by reference the federal Universal Waste Rules outlined in 40 CFR Part 273. Hazardous wastes are wastes which are either:

- listed by the EPA in 40 CFR Part 261 Subpart D; or

- ignitable (i.e., flash point less than 140^{o} or an oxidizer), corrosive (e.g., pH of 2 or less or 12.5 or more), reactive, or toxic, as defined in 40 CFR Part 261, Subpart C. (FDEP, 1991).

The management of spent mercury-containing lamps and devices is described in Chapter 62-737, F.A.C. This purpose of this rule is to encourage the reclamation of mercury from mercury-containing lamps and devices. Chapter 62-737 also establishes criteria and procedures for obtaining permits and criteria for generators, transporters, and storage facilities. Mercury-containing lamps and devices recycled in accordance with the rule do not have to be counted toward a medical facility's hazardous waste generation status, similar to the federal Universal Waste Rule provision. The federal Universal Waste Rule allows states to add other hazardous waste groups at the state level as a state universal waste. At the time this report was written, the DEP was in the process of designating mercury-containing lamps and devices as universal wastes in Florida. Mercury-containing batteries and other items managed in accordance with the Universal Waste Rule do not have to be counted toward a facility's hazardous waste generation status.

Section 403.7186, Florida Statutes (F.S.) and Chapter 62-737, F.A.C., contain certain prohibitions on the management of mercury-containing devices and lamps. Mercury-containing devices may not knowingly be incinerated or disposed of in a landfill. Spent mercury-containing lamps may not knowingly be incinerated. Any person who unlawfully disposes of these items will be held liable to the state for any damage caused and for civil penalties.

Section 403.7192, F.S, defines the disposal requirements for consumers, manufacturers, and sellers of batteries. Consumer button dry cell battery containing a mercuric oxide electrode or a product containing such a battery not be distributed, sold or offered for sale in Florida. Larger sizes of mercuric oxide batteries may not be distributed, sold or offered for sale in Florida unless the manufacturer has implemented a unit management program for take-back or recycling. Also, batteries containing a mercuric oxide electrode or a product containing such a battery may not knowingly be placed in a mixed solid waste stream. Any person who violates any provision of this section commits a second-degree misdemeanor and may be subject to a minimum fine of $100 per violation.

3.3 Federal Regulations

In the summer of 1988, several beaches on the east coast of the United States were closed after waste from medical facilities was washed ashore. Subsequent public outrage, coupled with fear resulting from the unknown potential for transmission of communicable diseases such as hepatitis B and AIDS, prompted Congress to pass the Medical Waste Tracking Act (MWTA) in late 1988. The MWTA amended the Resource Conservation and Recovery Act (RCRA) by adding Subtitle J, and initiated a two-year demonstration program which ran from June 1989 to June 1991. It established a regional program for tracking waste generated by medical facilities as a first step in minimizing irresponsible disposal; waste would be tracked from generation to disposal. Additionally, the demonstration program was implemented so that the need for a national tracking program for wastes from medical facilities could be assessed. The MWTA expired in 1991, and the management of wastes from medical facilities continued to be the responsibility of each state.

The 1970 Clean Air Act (CAA) and the Clean Air Act Amendments of 1990 (CAAA) affect the biomedical waste disposal industry because incineration is the most utilized method for treating biomedical waste. The 1990 Act required the enactment of air emission standards for medical waste incinerators, as well as municipal solid waste (MSW) combustors. The regulations are expected to reduce mercury emissions nationwide from new medical waste incinerators by 94%.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) can also have an impact on medical facilities. Under CERCLA, a medical facility that fails to properly dispose of its wastes, including biomedical wastes, may be deemed a potentially responsible party at a Superfund site and be held responsible for some or even all of the cleanup since liability under Superfund is joint and several.

RCRA controls the disposal of any waste from a medical facility that is determined to be a hazardous waste (e.g., for mercury) as listed in section 3.2 above. This test identifies toxic materials as characteristically hazardous. In addition, the Universal Waste Rule, adopted under RCRA, applies to the management of hazardous waste batteries (including mercuric oxide batteries) and mercury thermostats.

On August 17, 1997, the EPA issued new emission guidelines for MWIs. The new rule, which amends 40 CFR Part 60, requires that medical facilities that operate incinerators develop and implement a waste management plan. The EPA recommends that the plan identify ways in which the facility can separate certain components of solid and hazardous waste from the biomedical waste stream to achieve emission reductions for mercury and other hazardous pollutants.

3.4 Incineration of Wastes from Medical Facilities

3.4.1 Incinerator Emissions

In 1995, the EPA estimated that there are approximately 3,700 existing MWIs burning an estimated 3.4 million tons of medical waste per year. EPA also estimated that the 1997 MWI emissions regulations will reduce nationwide mercury emissions from biomedical waste generated by medical facilities by 94%, and that the cost of disposing of biomedical waste will increase from $168 to $222 per ton (from $0.084 to $0.111 per pound).

A number of limited emission studies that have been performed on MWIs suggest that mercury emissions from these incinerators are highly variable. No comprehensive, statistically-based, quality-controlled study of mercury emissions from MWIs could be found during the present study. Most of the mercury emission data available is estimated (weight Hg/time period) and is based on emission factors (weight Hg/weight waste). These emission factors have been computed from a small sample of the total population of MWIs. There is no indication in the studies as to whether or not the emission measurements were made in accordance with a quality-controlled sampling protocol. The possible absence of such a sampling protocol calls into question the emission factors and the emission estimates calculated from them. The authors of one emissions estimate study commented on the wide variations in emission factors, stating that presumably the variations are the result of differences in the chemical nature of the waste feed stream. However, they acknowledged that the variability in reported metal emissions may be the result of differences in sampling techniques or sampling errors (Walker and Cooper, 1992).

A study of mercury emissions in Florida for 1990 found that 57.3% of the estimated average total mercury emissions came from anthropogenic sources; 42.7% came from natural sources. The study estimated that 12% of the anthropogenic mercury emissions came from MWIs. (KBN, 1994). Incineration of wastes from medical facilities was the fifth largest anthropogenic source, behind municipal solid waste (MSW) combustion (27.7%), paint application (21.2%), electric utility powerplants (20.3%), and electrical apparatuses such as lighting, batteries, wiring, switches, and control and measurement instruments (11.2%).

With the limitations of the overall emissions estimates in mind, studies at a number of individual MWIs have demonstrated the presence not only of mercury, but of other heavy metals, dioxins/furans, and hydrogen chloride in emissions from MWIs (Volland, 1992; Torkelson, 1992; Glasser and Chang, 1990). These studies provide ample evidence for considering the incineration of medical waste to be a health concern that is comparable to, if not greater than, the incineration of hazardous waste or MSW (Glasser and Chang, 1990).

It is accepted that all mercury burned in MSW incinerators is evaporated during the combustion process, mostly in the soluble divalent form, presumably as mercuric chloride (Volland, 1992). This is also likely to be the form in which mercury exits MWIs, considering the higher percentage of plastics in waste from medical facilities as compared to MSW. The plastics content of waste from medical facilities has been estimated to be significantly more than the amounts of plastic found in MSW. Estimates range from 15-40%, with 30% being the most quoted figure, half of which is PVC plastic (DEP, 1993).

Volland (1992) estimates that the mercury content of waste from medical facilities is 15 ppm. Using a 1995 EPA estimate of 3.4 million tons of medical facility waste incinerated in the United States per year, assuming that the population of Florida is 5.2% of the U.S. population, the amount of mercury emitted by MWIs in Florida would be 5,300 lbs/year. Glasser (1990) reported that 3.2 million tons of hospital waste are generated each year, of which 85% is incinerated. Performing the same calculation with this waste incineration quantity, the amount of mercury emitted by MWIs in Florida would be 4,250 lb/year. A study of 1990 emissions in Florida reported that 3,400 lbs/year of mercury are emitted by MWIs, based on its calculated mercury emission factors (KBN, 1994). All of these calculations rely on a certain amount of guesswork. MWI emission studies in progress at the time this report was written are expected to provide additional data on the amounts of mercury being emitted from Florida incinerators.

3.4.2 Emission Controls

Much of the information in the literature on emission controls concerns the details of various types of air pollution control equipment and their associated efficiencies in controlling the different components of emissions from MWIs, such as particulate matter, carbon monoxide, hydrogen chloride, dioxin/furans, and heavy metals. Although this information is outside the scope of this study, activated carbon injection ahead of fabric filtration has been reported to provide promising results for removing flue gas mercury from newer incinerators.

One study reported that emission factors from a particular hospital MWI were much lower as compared to those of two other hospital MWIs. It was postulated that the recycling program implemented by the hospital may have been responsible for its lower MWI emissions (Cross et al., 1993).

Smaller MWIs are often operated by a batch process which tends to decrease combustion efficiency. On the other hand, most large regional MWIs tend to operate more continuously which tends to increase combustion efficiency. It has also been noted that most older MWIs do not have air pollution controls (Borowsky and Dennis, 1992).

Given the expense and difficulty of controlling mercury emissions from incineration stack gases, many sources in the literature recommend source reduction or elimination of mercury as a control measure. One paper concerning incineration discusses reducing the total metals content of medical waste. The authors state that complete elimination of metals is not considered feasible; nevertheless, they suggest that hospital administrators take actions to proscribe the use of products containing certain metals, such as mercury, and improve waste segregation practices in order to reduce the major problem metals requiring additional air pollution equipment on MWIs (Glasser and Chang, 1990). If this is accomplished, it may be especially advantageous to hospitals which incinerate their medical waste on-site, as these facilities will be subject to stricter air pollution regulations under the EPA medical waste incinerator regulations promulgated in 1997.

4. MERCURY-CONTAINING ITEMS IN MEDICAL FACILITIES

4.1 Introduction

A review was conducted of mercury-containing items commonly found in medical facilities. Individual contributions of mercury from many of these items were obtained from both the literature and manufacturer contacts.

When discarded, mercury-containing items will be regulated as hazardous wastes under the federal and Florida's hazardous waste regulations. However, state regulations (Chapter 62-737, F.A.C.) and the federal Universal Waste Rule provide that when mercury-containing devices, lamps and batteries are managed as universal wastes, they do not have to be included in the determination of a medical facility's hazardous waste generation status. Other discarded mercury-containing items have to be managed as hazardous wastes in Florida and do not qualify for reduced regulation under either Chapter 62-737, F.A.C., or the federal Universal Waste Rule.

4.2 Mercury-Containing Devices

4.2.1 Thermometers

Mercury-containing thermometers are a concern in the medical environment because broken thermometers are sometimes incorrectly placed into red bags or sharps containers, which in turn may be sent to incinerators where the mercury is released into the atmosphere. They may also be improperly placed in containers intended for nonhazardous solid waste. In 1995 it was estimated that approximately 17 tons of discarded mercury came from thermometers nationwide. A typical fever thermometer contains approximately 0.5 grams of mercury. However, some larger thermometers used in laboratories can contain up to 3 grams per unit (Minnesota, 1994; Wisconsin, 1997).

The production of mercury thermometers is decreasing, but they are still in demand. EPA has estimated that mercury thermometers are losing 1-2% of the thermometer market share each year. However, recent information received by the DEP from the only U.S. manufacturer of mercury thermometers suggests that the market share loss may be as much as 6% per year (Kelley, 1997).

Several types of glass mercury thermometers are produced, including ASTM, laboratory, cup case (for tank sample temperature testing), tapered bulb (armored), oven, minimum/maximum (home, commercial, scientific), fever (commercial, veterinary), blood banks, incubators/water baths, dairy, and the Clerget sugar test (Gilkeson, 1995).

Available alternatives to mercury thermometers include alcohol, tympanic, digital, spirit-filled, expansion, and aneroid thermometers. Blood banks may still require the use of mercury thermometers due to the need for a very high degree of accuracy. While non-mercury-containing thermometers are gaining acceptance, some medical professionals contend they are not as accurate as mercury-containing thermometers, especially with small children. In interviews conducted by Center staff, biomedical engineers at a large Florida hospital that uses both tympanic and mercury thermometers suggested that some medical personnel do not know how to use the tympanic thermometers properly.

When using a tympanic thermometer, one must accurately insert the instrument in the ear so it is pointing at the ear drum and not at the side or top of the patient's ear canal. If it is not aimed at the ear drum, it will read the temperature of the skin in the ear, and not the membrane it is designed to measure. In the case of small children who have very small ear canals, it may be especially difficult to aim the instrument at the correct position.

Mercury thermometers coated with Teflon or mylar are available; the coating prevents spills in the case of an accident. This may be especially helpful in veterinary practices where there is a higher likelihood of thermometer breakage. Encouraging the use of non-mercury thermometers in veterinary practices would probably be the most effective strategy for reducing mercury in the veterinary environment (WLSSD, 1997).

Mercury recyclers in Florida who were contacted during this study indicated that they accept thermometers for recycling. Charges may be based either on weight or on units (e.g., $4-5/pound; about $1 per unit).

Some hospitals in Florida have significantly reduced the number of mercury thermometers in their facilities and replaced them with non-mercury types. While the costs of some non-mercury types may be quite high (more than $400), other types of non-mercury thermometers may be very cost effective. One major manufacturer of non-mercury thermometers for laboratory uses has a one-for-one take-back program for customers who are replacing mercury thermometers. The alternative thermometer is filled with natural citrus oils, the glass is lead free, and the cost is $17. The same manufacturer also sells thermometers filled with mineral spirits for $9.

4.2.2 Sphygmomanometers (Blood Pressure Units)

Sphygmomanometers are as common in medical facilities as thermometers. These blood pressure units may be wall-mounted, hand-held, or mounted on a portable cart. Two major U.S. companies have been producing mercury sphygmomanometers since the turn of the century. One of those companies currently produces mercury-free units.

One manufacturer reported that its units contain less than 10 ml of elemental mercury; the amount of mercury varies depending on the type of unit. The company's stand-up model contains the most mercury, 9.2 ml, which converts to 4.35 oz. of mercury, whereas smaller units contain about 3-4 oz. The units have a glass cartridge tube 5 mm in diameter which is 25% greater than required by federal specifications; this prevents separation of mercury which, in small tubes, causes erroneous readings. The units carry a label which states that mercury should not be disposed of in the trash or by incineration, but should be recycled. A free take-back program allows hospitals to ship their instruments back to the company.

In 1995 the company began to triple-wrap a mylar sheath around their glass tubes which contain the mercury. The sheath will contain all mercury in the event of breakage. Units purchased before the mylar system was developed can be retrofitted easily and inexpensively by the company or by a hospital's biomedical engineering department. The retrofit only takes about a minute and costs $6. To further prevent spills, the company also will install lever locks onto their units, at no cost to the customer, which prevents tampering and spills.

The second company produces both non-mercury and mercury type instruments and actively promotes its non-mercury units. The company's mercury units contain about the same amount of mercury as the other company's and the tube is plastic instead of glass. The second company had a take-back program until June 30, 1997 for customers that wanted to replace their old mercury type units with aneroid models, in which they took back the old units and properly disposed of them free of charge.

The second company has been producing aneroid units for 90 years and reports that the accuracy of its units has been steadily improving. Aneroid units include hand-held, pocket, silver-ring, pro-check, wall, and mobile sphygmomanometers. Only one model requires a battery, which is a 6V lead-acid battery.

In promoting their aneroid units, the second company cites not only the environmental, health, and economic benefits but also the recognition of the units by two organizations that set the standards for manufacturers of medical instruments. The Association for the Advancement of Medical Instrumentation (AAMI) and the American Heart Association (AHA) both recognize aneroid and mercury instruments as acceptable blood pressure devices. The second company contends that the aneroid wall unit is simply easier to read accurately and easier to maintain than a mercury wall unit. The first company contends the accuracy of its products is based on gravity and the density of mercury which are constants, and that their instruments are far more legible due to the ceramic graduation marks which are fused to the glass for permanence.

The Center interviewed biomedical engineers at a large Florida hospital regarding the accuracy of the two types of units. The engineers stated that both models are accurate and both can be used without any problems, and that the accuracy of the readings depends on the skill of the medical practitioner.

Cost is frequently cited as an obstacle in the replacement of mercury-containing blood pressure units with non-mercury units. Information from manufacturers contacted by the Center indicates that while non-mercury units generally cost more to acquire, the difference may be minimal compared to the cost of maintaining and ultimately disposing of mercury-containing units. For example, one manufacturer sells its mercury-containing wall unit for $108 and comparable non-mercury wall units for $130-140. The cost of a mercury-containing mobile unit is $208, and non-mercury alternatives cost $215-230. A company representative stated that it is more expensive to maintain mercury units because of the need to change filters and gaskets, and the mercury itself may need to be replaced at some point. In contrast, the company's aneroid units require no ongoing maintenance. The aneroid units are calibrated at the time of sale and come with a lifetime warranty for calibration.

Sphygmomanometers can be recycled in Florida for an average of $4-6 per pound.

4.2.3 Medical Tubes

Maloney or Hurst Bougies are esophageal devices frequently used in medical procedures. They are manufactured in various diameters and weighted with mercury to facilitate use. Maloney bougies have a tapered end and hold slightly less mercury than standard Hurst bougies. Manufacturers sell these tubes containing individual quantities of mercury ranging from 45 grams to over a kilogram per tube.

Miller-Abbot and Cantor tubes are specialized tubes used to relieve pressure in the small intestine. Mercury is used to weight a rubber bulb on one end which facilitates passage through the gastrointestinal tract. These tubes are sold without mercury already present, so mercury is added to the tubes when they are used. After a procedure is completed, the mercury is evacuated and the tube is removed.

Miller-Abbot and Cantor tubes observed in hospitals during this research project appeared to be fairly durable rubber tubes that can withstand a good deal of use before showing signs of wear and tear. The tubes are considered too old to use when the rubber shows signs of cracking." These tubes are primarily used in the surgical units, ICU, and CCU. These units are very busy and things happen at a fast pace, and there is a tendency to throw items into red bags unnecessarily, according to a waste management director at one Florida hospital; therefore, these units create more waste than other departments. The tubes are designed to be sterilized and reused, and the mercury that was poured inside of them gets poured out and recycled. These tubes can be a potentially significant source of mercury in the biomedical waste stream, but the occurrence of this may be infrequent. When filled with mercury, discarded tubes are considered hazardous waste under federal and Florida law (Chapter 62-737, F.A.C.), and they need to be managed properly.

One company manufactures mercury-free Maloney and Hurst Bougies that use a non-toxic tungsten gel filling instead of mercury. Some of the hospitals that were surveyed during this research project had already replaced the mercury bougies and they were found to be just as good as the mercury-containing items. The literature reviewed for this project mentioned another mercury-free substitute called an Anderson tube, but a manufacturer could not be located.

In conversations with one manufacturer of the mercury-containing Miller-Abbot and Cantor tubes, the head of the company's engineering department said that mercury has to be used because of its density in a liquid state. He said tungsten is not a suitable replacement because it would have to be in a liquid form to be poured down the tube, and tungsten is not dense enough in a liquid state to give doctors the force needed to relieve pressure or obstructions in the intestine. Tungsten can be used in the bougies because it is in a slurry or gel state already inside the tube which is dense enough, but for the Miller-Abbot application it has to be in liquid form so the doctors can pour it into the tube. The company stated that they are looking for alternatives and if they can find one, they will use it.

4.2.4 Switches

Mercury's high conductivity, surface tension, and liquid state at room temperature make it useful as a component of electrical switches such as thermostats. In a mercury thermostat, a unit of mercury floats between metal contacts in a sealed glass bulb. The mercury acts to connect or break the electrical circuit controlling the air heating and cooling equipment. The EPA estimates that 90% of the 70 million residential thermostats in the United States contain mercury (EPA, 1994). Each thermostat contains approximately 4 grams of mercury, according to a major thermostat manufacturer. Most of the 2 to 3 million mercury thermostats brought out of service each year are replaced by contractors or homeowners (EPA, 1994).

The typical thermostat used for temperature control in commercial buildings, such as hospitals, contains mercury that could potentially enter the biomedical waste stream if the thermostat is carelessly discarded as biomedical waste. Thermostats have a long useful life, estimated at more than 20 years, so the lag time before they are disposed of is quite long. They can be found in laboratory ovens, nursing incubators, room temperature control systems, and refrigerators (Wisconsin, 1997).

Although mercury thermostats are gradually being replaced by digital versions and bi-metal strips, thermostats are projected to continue to be a source of mercury through the year 2000 (Minnesota, 1994; Wisconsin, 1997). As for hospital uses, switches are usually handled properly by the biomedical or engineering departments and should be kept out of the biomedical waste stream. Possible applications for mercury tilt switches include airflow limit control, building security systems, chest freezer lid switches, fire alarm box switch, fluid level control, pressure control, silent light switches, washing machine lids, and laptop computers (Wisconsin, 1997).

Alternatives for mercury switches including hard contact, digital, and bi-metal switches are readily available. Some manufacturers may take back old switches that contain mercury. In Minnesota, Honeywell, Inc., a major thermostat manufacturer, implemented a take-back and recycling program for thermostats (Minnesota, 1994). Other manufacturers have joined with Honeywell to expand the program to Florida and other states. Thermostats can be recycled in Florida for a cost of approximately $1 per unit or for about $4.50 per pound.

4.2.5 Medical Equipment (Barometers, Manometers, and Gauges)

Some barometers, manometers and gauges found in medical instruments also contain mercury. Mercury in these gauges respond to changes in air pressure to give precise readings on calibrated scales. Barometers contain mercury and are used to measure weather conditions. Some infrared heaters and furnaces use a flame sensor/safety valve that may contain mercury (Wisconsin, 1997).

No data was found in the literature as to the quantities in which these items are found in medical facilities. Of the 92 hospitals that responded to the Center's mercury waste management survey, only two indicated that they recycle manometers, and one indicated that barometers are recycled. Because of the low number of responses, it is impossible to draw conclusions at this time about the quantities of these items in the medical waste stream in Florida, or the methods used to dispose of them. Additional research is needed to determine the extent to which these items may be contributing to mercury emissions from medical waste incinerators.

These devices can be recycled in Florida at a cost of approximately $4.50/lb. On a per unit basis, barometers can cost $4-20 each.

4.3 Mercury-Containing Lamps

Fluorescent lamps are the most ubiquitous type of mercury-containing light, and generally come in 4-foot and 8-foot lengths. Smaller quantities of other types, including metal halide, mercury vapor, and high pressure sodium, are also used. At the time this report was written, there were six qualified light recycling companies in Florida: Envirolights in Riviera Beach, MTI in West Melbourne, P-3 in Tampa, Quicksilver in Tampa, and Recyclights in Tallahassee and Lakeland. Hospitals, veterinary clinics, nursing homes, dental clinics, and labs use mercury-containing lamps which can be easily collected and recycled.

It is illegal in Florida to dispose of any of these lamps by incineration, under Section 403.7186, F.S. Any facility that disposes of more than 10 spent lamps per month must arrange for disposal of the lamps in a permitted lined landfill or at an appropriately permitted reclamation facility. If sent to a recycler, fluorescent lamps do not have to be handled as a hazardous waste or considered when making hazardous waste generation status quantity determinations per Chapter 62-737, F.A.C.

4.4 Batteries

Sources of alkaline batteries in medical facilities could be flashlights, portable cassette players, radios, remote controls, toys, smoke alarms, Doppler ultrasound blood flow devices, and most digital thermometers (DEHNR, 1996). One manufacturer stated that its tympanic, rectal, and oral digital thermometers operate on three AA alkaline batteries. In the past, mercury has been used in consumer batteries as an electrode and to protect other battery components. In alkaline batteries, mercury was used to protect the zinc cathode from oxidation and prevented the generation of hydrogen gas.

In the early 1990s, the four major U.S. alkaline battery manufacturers began reducing mercury content to no greater than 250 ppm. By 1993, U.S. batteries contained only 1-5 ppm of naturally occurring mercury, and no mercury was being added (Massachusetts, 1996). Some alkaline batteries manufactured before mercury content was reduced are still being used, and other types of batteries, such as mercuric oxide, silver oxide, and zinc-air, still contain mercury (EPA, 1994). Thus, the potential still exists for mercury in batteries that may wind up in the biomedical waste stream to contribute to mercury emissions.

In Florida, Section 403.7192, F.S, prevents battery manufacturers from selling alkaline-manganese or zinc-carbon batteries in the state which contain any intentionally introduced mercury and more than 0.0004% mercury by weight. Alkaline-manganese button batteries may not contain more than 25 mg of mercury (Section 403.7192(b), F.S.).

Mercuric oxide batteries come in two types: button cell and larger sizes. The small mercuric oxide button cell batteries typically used in hearing aides were banned from sale in Florida after October 1, 1993 under Section 403.7192, F.S. The larger mercuric oxide batteries are often used in hospitals and contain 33-50% mercury by weight (Wisconsin, 1996). Manufacturers and distributors of the non-button cell mercuric oxide batteries, and products containing these batteries, must implement a unit management program to collect, recycle, or dispose of discarded items according to Section 403.7192(6), F.S.

Sources of mercuric-oxide batteries in hospitals include hearing aids, body aides, cameras, tape recorders, oxygen monitors, pagers, fetal monitors, digital thermometers, and portable EKG monitors (DEHNR, 1996). It is possible to substitute other batteries, such as zinc-air, for mercuric oxide batteries in this equipment, and this possibility should be investigated. Although manufacturers in the U.S. have almost stopped production of mercuric oxide batteries, they still can be bought from other countries (Massachusetts, 1996).

Silver-oxide and zinc-air button cells also still contain added mercury of up to 1-2% total weight per cell (Massachusetts, 1996). Manufacturers still have not been able to completely eliminate mercury from button cells; the added mercury is necessary to control gas formation and prevent the rupturing or exploding of the cells (Massachusetts, 1996). These batteries can be found in medical electronics, hearing aids, pagers, and medical equipment (DEHNR, 1996).

Even though mercuric oxide batteries are being used less frequently than in the past and alkaline batteries contain only contain a small amount of naturally occuring mercury, there is still a possibility that mercury can enter the biomedical waste stream when they are disposed of improperly. Batteries have been the primary source of mercury emissions from municipal solid waste incinerators (Massachusetts, 1996). This is probably due to the disposal of older alkaline and zinc-carbon batteries. Research suggests that many hospitals have some type of battery recycling program, but sometimes there is confusion about recycling the various types of batteries in use in hospitals.

4.5 Other Items

4.5.1 Plastics

Mercury has a long history of use as a component in plastic pigments. The estimated amount of cadmium-mercury plastic pigments produced in the United States decreased by more than 50% from 1987 to 1988. The amount of mercury used in those pigments decreased from 45,600 pounds to 21,800 pounds, and this trend is expected to continue through the year 2000 (EPA, 1992). But even at reduced levels, the presence of mercury is a concern because plastics comprise 10-40% of medical waste by weight; in some departments, plastic wastes may account for as much as 60% of waste from medical facilities by volume (ASHES, 1996; DEP, 1995; Hasselriis, 1992).

Plastic items in medical facilities that may ultimately make their way into the biomedical waste stream include gloves, IV and blood bags, plastic eating utensils, trays, excessive plastic packaging of medical supplies, containers, syringes, caps of test tubes, and many other items. Polyvinyl chloride (PVC) has been the most commonly used polymer in medical care products, accounting for as much as half of all plastic wastes found in the waste stream of medical facilities (Wagener et al., 1992; DEP, 1993). Other plastics that are widely found in medical facilities include low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), and polystyrene (PS).

The major problem associated with PVC is its high chlorine content, estimated to be at least 45% by weight (Bulley, 1992; Wagener, 1992). PVC products may contain mercury not only in pigments, but also in one of the stabilizers (alkalytin mercaptoacid ester salts) commonly used in PVC production (Wagner et al., 1991). In addition, the PVC plastics can combine with mercury during the incineration process and form reactive divalent mercury species, such as mercuric chloride. The reactive mercury species have a shorter residence time in the atmosphere before deposition occurs.

The plastics found in the waste from medical facilities comes not only from medical devices, such as tubing or IV bags, for example, but also from packaging. Section 403.7191(3), F.S, limits the amount of toxic metals in packaging. The legislation mandated a 3-step reduction in the total combined concentration (by weight) of lead, cadmium, mercury, and hexavalent chromium in a package or packaging material sold in Florida. After July 1, 1994, the combined limit was 600 ppm; after July 1, 1995, the limit was 250 ppm; and since July 1, 1996, the limit has been 100 ppm.

The red bags used to collect biomedical waste are considered by some people in the medical field to be a significant source of mercury emissions. Several manufacturers contacted during this studied reported that red bags meet the certification requirements of Section

403.7191(3), F.S., and that the concentration of mercury and other metals has been greatly reduced in recent years. While the concentration of mercury in each bag may be quite small, the bags may be contributing to mercury because of the number of bags that are incinerated on a daily basis. The mercury in red bags may come not only from the red pigment, but also from the carbon black print that is applied to make the international biological hazard symbol (Tamaddon and Hogland, 1992; Gilkeson, 1995).

4.5.2 Laboratory Products

Mercury can be found as an ingredient in discarded laboratory reagents and catalysts for certain applications. Mercury compounds are used as staining solutions, fixatives, and preservatives. Some of the most common items used are mercurochrome, mercuric oxide (hematoxalyn stain), and B-5 solution. Improperly discarded containers with residuals can potentially introduce mercury into the biomedical waste stream. There has been a steady decline in nationwide laboratory consumption of free mercury from 35 tons in 1990 to 11 tons in 1991.

B-5 is a fixative that contains 37 g/L of mercury (Wisconsin, 1997). It is most commonly used in making bone marrow slides, which requires a great deal of cellular detail. With bone marrow slides, a histologist is looking for a variety of blood disorders, all of which attack similar cell structure groups with only minor differences in cell effects. This makes it very crucial for the histologist to get a clear image in order to properly diagnose the disorder. Mercury is needed for clarification due to its bonding properties and how it makes an image more visible. Mercury bonds readily to the tissue, giving a clear view of the nuclear detail in the cells, and gives a three-dimensional fixed image. When a non-mercury substitute is used, such as like formalin or zinc, the image is more two-dimensional and the nuclear detail it not as clear. Using mercury-free alternatives may increase the likelihood of misdiagnosis.

Hematoxalyn stains contain a unique chemical called Hematin which is extracted from the longwood tree to be refined and oxidized. Mercury is a naturally occurring element in Hematin, and is chemically changed into mercuric oxide after the product is refined and oxidized.

Slides that require the use of mercury containing chemicals are kept on file for a very long time, so they are not discarded in the red bags. Histologists have been aware of the potential health and environmental effects of mercury for many years and have been working to reduce its use. However, until a substitute that is not costly is developed, some mercury chemicals will continue to be used.

B-5 and other mercury-containing wastes should be collected and sent to a hazardous waste contractor.

A report produced in Canada identified commonly used laboratory chemicals and available substitutes (Pollution Probe, 1996).

4.5.3 Veterinary Products

Mercury use in veterinary products is regulated by the U.S. Food and Drug Administration Center for Veterinary Medicine (CVM) for non-vaccines, and by the U.S. Department of Agriculture (USDA) for vaccines. USDA has approved the use of thimerosol (1:10,000) in leptospirosis bacterins vaccines for cattle, swine, and dogs. Veterinary products containing mercury in measurable amounts include Dip-A-Way and Wound Control, which both contain merbromin; RX ICK Control, which also contains merbromin; and Aqueous Red Mercury Blister, which contains mercuric iodide. It is possible that other veterinary products contain mercury but in such low amounts that they are considered a low regulatory priority and not listed by the regulators. Veterinarians use mercury thermometers and may also use certain fixatives or dyes that may contain mercury.

4.5.4 Vaccines and Pharmaceuticals

Vaccines and pharmaceuticals were not investigated thoroughly for this report, but were reported to possibly contain mercury in the form of thimerosol, a preservative. However, it appears that, for pharmaceuticals at least, the use of thimerosol has become less common.

4.6 Dental Amalgam

Dental amalgam has been used for more than a century. Its popularity can be attributed to its bonding ability, durability, and simple preparation. Amalgam is a mix of mercury (50%) with silver, tin, and alloys. The toxicity of this material, and the merits of placing mercury in patients' mouths, has been a subject of controversy for many years. Fillings made from non-toxic composite materials have been an available alternative for a number of years. The American Dental Association has stated that amalgam fillings are not toxic or harmful when placed in the mouth and that they do not react with the environment when released into a sewer system or transported to a landfill.

Some states regulate amalgam as a hazardous waste because Toxicity Characteristic Leaching Procedure (TCLP) tests have shown that amalgam can exhibit characteristic toxicity for mercury. The argument against considering amalgam as a hazardous waste is that the mercury is amalgamated or "bonded" to the mixture of silver and zinc, and does not evaporate or leach out of the material. During 1997, DEP analyzed amalgam samples from two Florida dental facilities and found that the samples exhibited the toxic characteristic for mercury.

The Center conducted an extensive literature search on mercury handling and disposal in the dental environment. Many articles have reported on the use of amalgam and mercury's toxicity to humans and the environment, focusing primarily on the risks of occupational exposure. Very little research has addressed the issues of proper management, waste stream analysis, and mercury emissions.

In the past, the components of amalgam were mixed in dental offices. Today most dentists order boxes of capsules that contain pre-measured amounts of mercury, silver, zinc, and other alloys. The capsules can be ordered in three sizes: single (400 mg of material), double (600 mg), or triple (800 mg). The capsules are unmixed upon delivery, and a membrane inside the capsule keeps the mercury separated from the silver, zinc, and other alloys. With one type of capsule, the dentist squeezes the ends of the capsule together to rupture the membrane and facilitate mixing. Some capsules are self-activating and do not require squeezing.

To prepare the amalgam, the dentist places a capsule in an amalgamator, a small machine that shakes the capsule rapidly to achieve a uniform mixture. Once the mercury is in contact with the other materials, it bonds to them rapidly and the mixture begins to harden quickly. The dentist removes the capsule from the machine, opens it up, and uses the amount of amalgam that is needed, which varies depending on the size of the tooth and the size of the decayed area. As much as 50% of the amalgam may remain unused after the decayed area is filled.

The disposal of amalgam depends on how it was used. The excess amalgam that is unused after a tooth is filled is called "non-contact" amalgam: it was never placed into a tooth and was never in contact with any human tissue. "Contact" amalgam is amalgam that has been in contact with human teeth or tissue. This material is generated when dentists remove old fillings, when they extract teeth that contain amalgam, and when they polish a new filling to remove the excess amalgam. It is very important to keep these two types of amalgam waste segregated due to differences in recycling and disposal requirements.

Non-contact amalgam can easily be collected, stored, and recycled. A standard practice for collecting excess material not used for a new filling is to place it in a durable container with a tightly fitting lid. A general practice dentist may generate as little as 3 ounces a year of non-contact amalgam. Dentists typically accumulate non-contact amalgam in a container for some time before they properly package it and send it to a permitted mercury recycling facility. The non-contact amalgam should not be contaminated with contact amalgam, as recyclers may not accept the extraneous material found in contact amalgam.

Contact amalgam is treated as infectious waste in other states. Chapter 64E-16, F.A.C., does not specifically list contact amalgam in its definition of biomedical waste. Dental clinics are listed as generators of biomedical waste based on their generation of such materials as blood, body fluids, non-liquid tissue, etc. Chapter 64E-16 also states that any material which comes into contact with biomedical waste also must be handled as biomedical waste. The rule also states that any other solid waste, which is neither hazardous nor radioactive in character, when mixed with biomedical waste, must be managed as biomedical waste. (See Figure 3.2.)

Standard practice calls for contact amalgam to be sterilized and stored under a weak concentration of bleach and water and stored until enough is collected for shipment. Collection, sterilization, recycling, packaging, and labeling for contact amalgam are discussed in detail in Appendix C, Best Management Practices for Mercury-Containing Items in Dental Facilities.

It should be noted that not all recycling facilities will accept contact amalgam, but some do, so it is possible to ensure that amalgam waste does not go into red bags.

Literature on the contribution of dental amalgam to total anthropogenic mercury emissions suggests that it is a relatively insignificant source. A Florida study determined that amalgam accounted for 50 pounds out of a total of 29,348 pounds attributed to anthropogenic mercury emissions, or 0.17% (KBN, 1994). This calculation of air emissions was derived from the national estimate of the amount of mercury used in dental supplies. To the extent that amalgam may be improperly disposed of in red bags and incinerated, the contribution of amalgam would be higher.

A waste stream characterization survey of 145 Seattle dentists in 1991 found that the mean number of amalgams removed per week per dentist was 14, and the mean number of amalgams placed per week was 15. Eighty-two percent of the respondents said they used amalgam, with 57% reporting that they recycle amalgam. The Seattle report used the number of dentists in the county (1,500) and estimated that each dentist works 48 weeks of the year. Based on survey recycling information and a weight of 200 mg of mercury per amalgam filling, the researchers were able to quantify the amount of mercury going to the waste water stream, to the landfills, and the amount being reclaimed (Municipality of Metropolitan Seattle, 1991).

One of the goals of this project was to quantify the amount of mercury emissions generated by dental amalgam in medical waste incinerators in Florida. Site visits were conducted with two Florida dentists whose average number of patients per week was 63, lower than for the dentists in the Seattle study, where the mean number of patients was 79. These Florida dentists place an average of eight new amalgams per week, with an average of 15% excess material that is usually left over after placement.

The following calculation for the quantity of non-contact amalgam generated is based on the following: (1) dentists will work 48 weeks per year, as assumed in the Seattle study; (2) using the smallest size capsule (400 mg total, 200 mg of mercury) will yield the most conservative estimate; (3) the Florida Dental Association has approximately 6,400 members; and (4) the dentists visited reported an average of 15% excess amalgam per filling.

A Calculation of the Amount of Non-Contact Amalgam Generated by Florida General Practice Dentists in a Year

$$\frac{200 \text{ mg Hg}}{\text{capsule}} \times \frac{8 \text{ capsules}}{\text{week}} \times \frac{48 \text{ weeks}}{\text{year}} \times .15 \text{ (excess)} \times \frac{1 \text{ g}}{1000 \text{ mg}} = 11.52 \text{ g Hg/dentist/year}$$

11.52 g Hg/dentist/year x 6,400 Florida dentists* = 73,728 g = 2633.14 oz.

= 164.57 lbs. Hg/year of non-contact amalgam

* The Florida Dental Association membership includes about 80% of approximately 8,000 dentists in Florida. Based on the Seattle study, it can be assumed that about 80% of dentists (FDA and non-FDA) practice general dentistry. Thus, there would be approximately 6,400 general practice dentists in Florida.

Previous research suggests that the amount of excess amalgam remaining after a filling is completed may be as much as 50%. Also, the Seattle study found that general dentists placed an average of 16 new fillings per week. Assuming the above calculation to represent the minimum amount of non-contact amalgam generated each year in Florida, the maximum amount can be calculated to be 1096.04 lbs/year:

Percentage of amalgam not used in filling	Avg. number of placements per week	lbs. of Hg waste/year from non-contact amalgam in FL
15%	8	164.57
50%	16	1096.04

Contact amalgam waste is generated when old fillings are replaced, teeth with amalgam are removed, or when new fillings are polished. When old amalgams are drilled out of a patient's tooth, the amalgam tends to come out of the tooth in many sizes from fine dust particles to small chips. These particles and chips are sucked up by a vacuum device. The larger particles are caught in the chair side traps and the finer particles move down the lines and either settle out in another amalgam trap made for particles or they pass into the sewer system.

The particle trap that allows amalgam dust to settle out is generally located next to a wastewater vacuum pump. This is a simple filter which allows the dense amalgam particles to settle out of the waste water before it is sent to the sewer, creating an amalgam sludge. For the main chair side trap, there is a plastic or metal mesh filter which comes in different mesh sizes.

The amount of amalgam caught in the traps depends on how fine the mesh is. The material which is caught in the traps is mixed with many other different kinds of biomedical waste such as root canal material and parts of teeth.

It would be difficult to determine how much material is being lost to the sewer and how much is going into red bags because dentists use a variety of different size mesh traps, different types of collection systems, and different methods to remove old fillings. A rough estimate can be made to at least get a range of the amount of amalgam that may be going to the incinerators.

The Seattle study states that 25% of the removed amalgam material goes to the sewage system passing through the traps. The remaining 75% is caught in the traps (Municipality of Metropolitan Seattle, 1991). From their survey it was found that general practice dentists remove an average of 17 amalgams per week, with each amalgam filling having 200 mg mercury each (400 mg material). Applying these numbers to Florida, based on 6,400 dentists, as much as 1748.46 lbs. of contact amalgam waste may be generated in the state each year:

A Calculation of the Amount of Contact Amalgam Generated by Florida General Practice Dentists in a Year

$$\frac{200 \text{ mg Hg}}{\text{capsule}} \times \frac{17 \text{ capsules}}{\text{week}} \times \frac{48 \text{ weeks}}{\text{year}} \times .75 \text{ (amount caught in traps)} \times \frac{1 \text{ g}}{1000 \text{ mg}}$$

= 122.4 g Hg/dentist/year x 6,400 Florida dentists* = 783,360 g = 27,977.14 oz.

= 1748.57 lbs. Hg/year of contact amalgam

* The Florida Dental Association membership includes about 80% of approximately 8,000 dentists in Florida. Based on the Seattle study, it can be assumed that about 80% of dentists (FDA and non-FDA) practice general dentistry. Thus, there would be approximately 6,400 general practice dentists in Florida.

The dentists visited during this project suggested that anywhere from 0-50% of the removed amalgam is lost to the sewer, and anywhere from 50-100% of the amalgam may be disposed of as biomedical waste in red bags. Based on these assumptions, it could be estimated that the amount of contact amalgram going into red bags in Florida each year may range from 875 lbs. (50% of contact amalgam generated) to 1749 lbs. (100% of contact amalgam generated).

These calculations would suggest that there is a great opportunity for training and education in the dental community to reduce the amount of contact amalgam being disposed of in red bags by increasing the amount that is disinfected and recycled. It should be noted that no definitive conclusions can be drawn from these calculations before additional research is conducted in Florida to determine the extent to which dentists may be disposing of contact amalgam in red bags.

The above calculations do not include whole extracted teeth with amalgam fillings that are removed. Dental school facilities are also not included. To accurately estimate the total amount of mercury waste from dental offices in Florida, it would be necessary to conduct a comprehensive study similar to the one conducted in Seattle.

The generation of mercury-bearing wastes from dental offices could be substantially reduced if fillings made from composite materials were to become more popular, although it is unlikely that this will happen on a large scale in the near future. Composites, which can be made to match the color of teeth, are most often used in the front teeth for aesthetic reasons. But they tend to break down under the pressure of chewing when used in back teeth and are more likely to allow a new cavity to form underneath (Landry, 1996).

The composite material also is more expensive and takes longer to install (Times, 1996). One Florida dentist that was visited stated that an amalgam filling costs around $50 per filling, compared to $70 for a composite filling. Other mercury-free cavity fillers are being developed due to the concerns with mercury. The American Dental Association's Pafenbarger Research Center is currently looking into a material that is made of a silver powder that melds with itself under pressure (Landry, 1996). Researchers also are developing new composites which are more durable and less expensive. In the future, such materials may provide a more popular alternative to amalgam.

Recycling both contact and non-contact amalgam waste from dental facilities is the best option for reducing mercury emissions from dental sources. There are a number of refiners, recyclers, and collectors in the nation who accept both contact and non-contact amalgam, although some will accept only non-contact amalgam. Costs vary widely; in some cases, the company will pay dentists for the material; in other cases, dentists may be paying as much as $200 per year for these services. One of the dentists visited sent 6.2 oz. of non-contact amalgam to a recycler and received a check for $1.32. The recycling companies in Florida charge a small amount for their services, depending on the amount of material.

It should not be difficult for dentists in Florida to locate a facility that will accept amalgam for free or for a nominal cost. Some companies try to encourage dentists to buy amalgam recovery kits that they are selling. These kits contain a disinfectant, containers, personal protective equipment (gloves, masks), shipping documents, and instructional information. Kits from these companies are expensive. They cost about $100 and last for less than six months. Dentists need to be aware that these kits are not necessary and that they can make their own. Most dentists already send silver and gold to refiners. Dentists should check with their refining companies to see if they accept amalgam waste, and if so, dentists should be sure that the mercury is ultimately recycled or disposed of in a proper manner.

5. MANAGEMENT OF MERCURY WASTES AND MERCURY-CONTAINING ITEMS IN FLORIDA HOSPITALS: A SURVEY

One of the goals of this study was to identify current practices for managing mercury-containing items and mercury-containing wastes in Florida's hospitals. The Center developed and conducted a survey that was faxed to 232 hospitals throughout the state. Responses were received from 92 hospitals. This section presents a brief summary of the survey results. Appendix A contains tabulations of the responses to each of the survey questions, as well as a copy of the survey instrument form.

The Center obtained a list of Florida hospitals from the Department of Health and called every facility on the list to identify the person in each facility who would be most likely to be able to provide accurate answers to the survey questions. The calls revealed that some hospitals on the list were no longer operating and that some had merged with other facilities, reducing the total number of facilities the Center was able to contact to 232.

Hospitals were promised that their responses would remain confidential. This was done to encourage respondents to be truthful and accurate. With initial phone calls to each facility, researchers attempted to identify the most knowledge person within the facility with regard to the survey questions, and to solicit that person's participation in the survey. Facilities were asked to respond within five days. After the surveys were faxed, numerous followup phone calls were needed to obtain responses. Center staff made a maximum of eight calls to each facility that received the survey to obtain a response. The 92 responses that were received were representive of the hospitals in Florida in terms of size, type of facility, occupancy rate and geographic location.

Job titles varied widely for the contact person and included titles as diverse as Plant Operations Supervisor, Safety Officer, Environmental Health Specialist, Environmental Services Manager, and Director of Nursing. These titles provided one of the Center's first indications that different hospitals may have very different forms of organization with regard to who is responsible for the proper handling and disposal of medical waste and hazardous waste.

The survey and its results are presented in detail in Appendix A. Some of the results are summarized below:

- 86% of respondents burn at least some of their medical waste.

- 83% of respondents have a policy on mercury handling and disposal. Of those, 84% have a written policy.

- 67% of the respondents use new-employee orientations to inform staff about the facility's mercury policy. 43% use periodic health and safety training, 26% use special training workshops or sessions, and 15% use in-service training. Other methods include bulletin boards (11%), publications (8%), and manuals and MSDS sheets (7%).

- 71% of the respondents reported that containers for non-infectious wastes are available near containers (red-bags) for infectious wastes.

- In response to a question about the facility's mercury recycling program, 11% of respondents said they did not know whether their facility had such a program. The remaining 89% were evenly divided between those who said they did have a recycling program and those who said they did not have one.

- 35% of respondents reported that they recycle fluorescent lamps. Other items recycled include thermostats/switches (9%), esophageal devices (9%), free mercury (9%), thermometers (7%), batteries (7%). Smaller percentages of respondents reported recycling numerous other items used in the medical environment.

- 61% of respondents said that their employee health and safety training program includes procedures on mercury handling and disposal. 28% said the program did not include mercury handling and disposal procedures, and about 10% said they did not know if mercury handling and disposal was included.

- 53% of respondents reported that mercury spill clean-up materials are disposed of in special containers. 15% said they are disposed of in red bags. Other disposal methods include hazardous waste contractors (11%), and recycling (5%).

- The most frequently used mercury-containing items are fluorescent lamps (87%), sphygmomanometers (75%), high pressure sodium lamps (56%), thermomenters (53%), mercury vapor lamps (46%), metal halide lamps (44%). (For a complete list of items, see Appendix A.)

- 29% of responding facilities maintain a centralized inventory of mercury-containing products.

-43% of respondents require mercury disclosures for products and materials purchased that contain mercury.

- 38% of respondents have replaced mercury-containing items with substitutes containing less or no mercury.

Purchasing practices and policies can play a major role in reducing the amount of mercury-containing items and ultimately, mercury-containing wastes, in hospitals. Prior to sending out the survey, the Center's research had suggested that hospital purchasing was rarely centralized. However, the responses that were received contradict that conclusion, as 94% of the responding facilities said that their purchasing departments are centralized.

The results suggest that while the majority of hospitals in Florida are following the rules and recommended practices with regard to mercury spills and mercury-containing devices, compliance is far from unanimous. It is clear that a substantial amount of education is needed to accomplish a significant reduction of mercury in the medical environment.

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Appendix A

Management of Mercury Wastes and Mercury-Containing Items in Florida Hospitals: A Survey

MANAGEMENT OF MERCURY WASTES AND MERCURY-CONTAINING ITEMS IN FLORIDA HOSPITALS: A SURVEY

1. Introduction

A survey was developed to collect quantitative data on the management of mercury-containing wastes in Florida hospitals. The survey included questions on general medical waste handling and disposal practices as well as specific questions about the use of mercury-containing devices. A blank copy of the six-page survey form is included at the end of this Appendix.

2. Methodology

In developing the survey, the Center used information from the literature review that had been conducted during the early months of the study. Meetings with environmental and safety staff at Shands Hospital at Gainesville provided researchers with useful information on the waste management practices commonly followed in hospitals. Center staff toured the facility to become familiar with the waste generation, management, and disposal procedures for solid waste in general and mercury-containing wastes in particular. A draft of the survey was reviewed by Florida Department of Environmental Protection staff, who provided suggestions that were incorporated into the final draft.

The Center obtained a list of Florida hospitals from the Florida Department of Health and called every facility on the list to identify the person in each facility who would be most likely to be able to provide accurate answers to the survey questions. The calls revealed that some hospitals on the list were no longer operating and that some had merged with other facilities, reducing the total number of facilities the Center was able to contact to 232.

Job titles varied widely for the contact person and included titles as diverse as Plant Operations Supervisor, Safety Officer, Environmental Health Specialist, Environmental Services Manager, and Director of Nursing. These titles provided one of the Center's first indications that different hospitals may have very different forms of organization with regard to who is responsible for the proper handling and disposal of medical waste and hazardous waste.

The survey was sent out via fax with a cover memo addressed to the person who had been previously identified. The transmission also included a one-page memo describing the Center's study and asking for cooperation. The memo asked the recipient to respond within five days.

Follow-up phone calls were necessary to obtain a reasonable response rate and were an integral part of the survey process. The people receiving the fax were generally people who have complex responsibilities and are extremely busy. Despite the request to return the survey within five days, very few responses were received within that time period.

The purpose of the first follow-up call was to determine whether the survey had been received by the intended recipient. This call was made within a day or two of the initial fax. In many cases two or more attempts were necessary to find out whether the survey was received. If it was not, it was re-faxed, and another follow-up call was made to ensure receipt.

After confirming receipt of the survey, Center staff waited a minimum of five days, but generally at least seven days, and if a response was not received, reminder calls were made. Again, numerous calls were often necessary to reach the intended recipient or an assistant. A minimum of four follow-up calls, and a maximum of eight, were made to any one facility in an attempt to get a completed survey returned. Eventually, 92 responses were received, for a 40% response rate, which is generally considered to be acceptable for this type of survey.

This section presents the results for each question on the survey. A copy of the survey instrument is included, along with a sample of the follow-up call sheets. Some questions were not answered, so the total number of respondents is different for each question. The percentages for the responses to each question were calculated from the number of responses to that question, which in some cases was a lower number than the 92 surveys received.

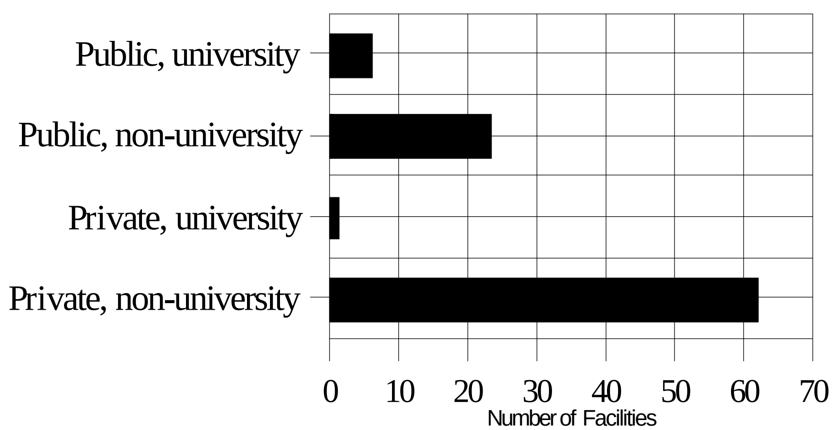
3. **Survey Results**

SECTION I: FACILITY INFORMATION

QUESTION #1: <u>Type of Facility</u>

Two-thirds of the facilities that responded to the survey were private, non-university-affiliated hospitals. One-fourth were public non-university-affiliated hospitals.

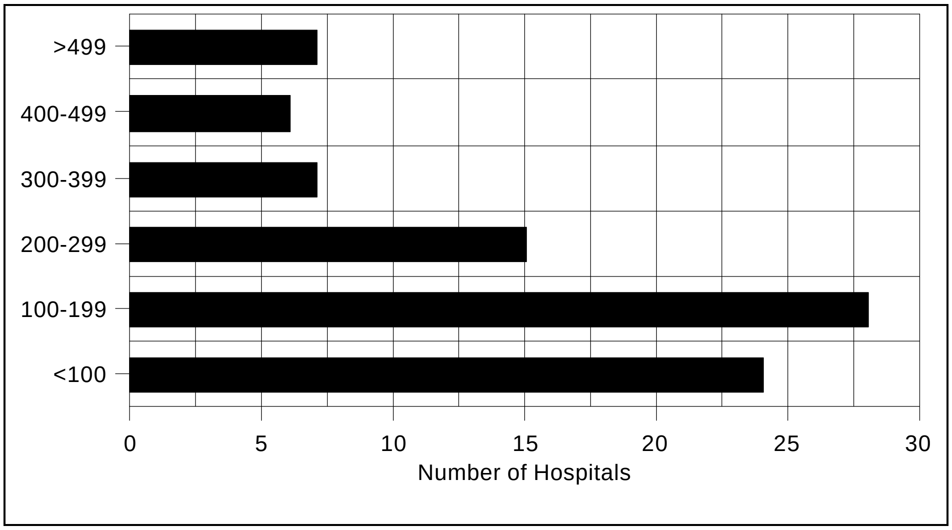
Facility Type	Number	Percentage
Private, non-university	62	67%
Private, university	1	1%
Public, non-university	23	25%
Public, university	6	7%
Total:	**92**	**100%**



QUESTION #2. <u>Number of Beds</u>

Respondents represented small, medium-sized and large Florida facilities. The majority of the facilities had fewer than 200 beds; of those, almost half had fewer than 100 beds. About 25% of the responding facilities had 200-400 beds, and 15% had 400 beds or more.

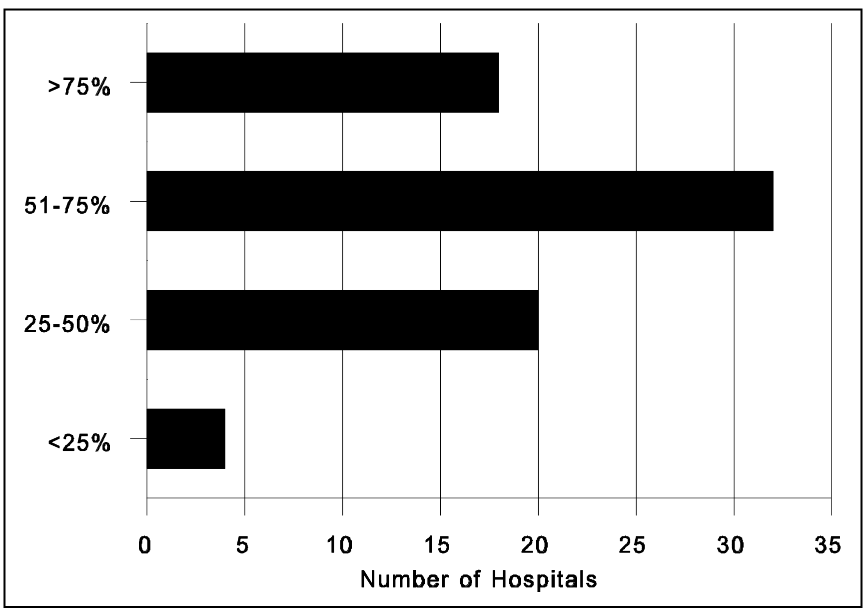
Beds	Number	Percentage
<100	24	28%
100-199	28	32%
200-299	15	17%
300-399	7	8%
400-499	6	7%
>499	7	8%
Total:	**87**	**100%**



QUESTION #3. Average Occupancy

One-third of the responding facilities had an average occupancy rate of 50% or less. Two-thirds of the facilities had an average occupancy rate of 51% or more.

Occupancy Rate	Number	Percentage
<25%	4	5%
25-50%	20	27%
51-75%	32	43%
>75%	18	24%
Total:	**74**	**100%**



QUESTION #4. <u>Special Service Units</u>

The next question asked hospitals to list any special service units, such as psychiatric, pediatrics, cardiac, oncology, etc. Some facilities did not list any specialties; most of those who responded listed several. The table below presents the responses received. The first column lists responses in alphabetical order. The second column shows the number of hospitals that listed each special service unit. The third column shows the percentage of respondents that listed each special service unit.

Special Service Units	Number	Percentage
Behavioral Health	1	1%
Brain Injury Rehab	5	5%
Cancer	3	3%
Cardiac	16	17%
Catheterization	3	3%
Children's Services	1	1%
Critical Care	2	2%
Dental	2	2%
Dialysis	2	2%
Forensic	2	2%
Geriatric	2	2%
Hyperbaric Medicine	2	2%
ICU	8	9%
Labor/Delivery	5	5%
Obstetrics/Gynecology	15	16%
Oncology	24	26%
Pain Management	2	2%
Pediatric	28	30%
Preferred Care	1	1%
Psychiatric	37	40%
Rehabilitation	7	8%
Skilled Nursing	4	4%
Substance Abuse	2	2%
Surgical	5	5%
Trauma	4	4%
Women's Services	3	3%

SECTION II: MEDICAL WASTE HANDLING AND DISPOSAL PRACTICES

In Section II, the survey sought current data on hospital waste handling, disposal, policies, and training. Questions on the handling and disposal of mercury-containing items were included in this section.

QUESTION #5a: What percentage of the facility's regulated medical waste is incinerated?

A total of 73 responding facilities reported that they incinerate at least some of their regulated medical waste. Of those, 66 facilities incinerate 100% of their medical waste. Seven of the respondents incinerate between 10% and 90% of their medical waste.

Percentage of Medical Waste Incinerated	Number of Hospitals Responding
100%	66
90%	1
80%	1
30%	2
25%	1
10%	2
Total:	**73**

QUESTION #5b.   What is the approximate percent of waste incinerated on-site?

Of the 73 facilities that reported that they incinerate their regulated medical waste, three facilities reported that 100% of their medical waste is incinerated on-site, and five facilities reported that their medical waste is incinerated both on-site and off-site.

Percentage of Medical Waste Incinerated On-Site	Number of Hospitals Responding
100%	3
90%	3
80%	1
50%	1
Total:	**8**

QUESTION #5c. **What is the approximate percent of waste incinerated off-site?**

A total of 70 hospitals reported that they incinerate their regulated medical waste off-site. Of those, 63 facilities incinerate 100% of their waste off-site.

Percentage of Medical Waste Incinerated Off-Site	Number of Hospitals Responding
100%	63
90%	1
80%	1
30%	2
25%	1
10%	2
Total:	**70**

Question #5d. Off-site incinerator contractor.

Of the 68 facilities that responded to this question, 86% listed BFI as their contractor. Five other companies were also listed. Two facilities that reported in Question 5c. that they incinerate waste off-site did not provide the contractor's name.

Contractor	Number of Hospitals Responding
American 3CI	1
BFI	57
Bio Med Waste Ind. Inc.	1
Med-X	3
Medico	4
Safety Disposal Systems	2
Total:	**68**

QUESTION #5e. Location of contractor.

The table below presents the responses to this question in alphabetical order. Some of the locations are the sites of actual medical waste incinerators, while some of the cities listed are the locations of offices of the contractors named above.

Location	Number
Apopka, FL	2
Bartow, FL	4
Birmingham, AL	1
Clearwater, FL	2
Davie, FL	2
Eaton Park, FL	2
Ft. Lauderdale, FL	1
Ft. Myers, FL	3
Gainesville, FL	3
Hialeah, FL	2
Lakeland, FL	2
Medley, FL	1
Miami, FL	7
Mobile, AL	1
Opalocka, FL	1
Orlando, FL	3
Pensacola, FL	5
Pinellas, FL	2
Reserve, LA	1
Sarasota, FL	1
St. Petersburg, FL	1
Tallahassee, FL	1

QUESTION 6a. **<u>Does the facility have a policy on mercury handling and disposal?</u>**

Of the 92 facilities that answered this question, 76 said they did have a mercury policy, and 14 said they did not.

Mercury Policy	Number	Percentage
YES	76	83%
NO	14	15%
DON'T KNOW	2	2%
Total:	**92**	**100%**

QUESTION #6b. Is the mercury handling and disposal policy written?

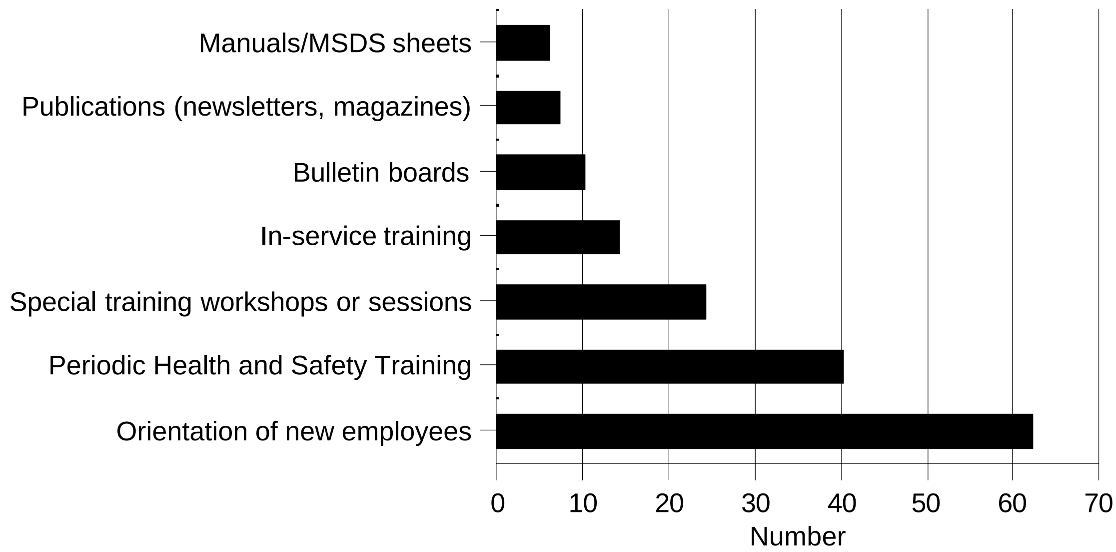
Of the 76 responding facilities that have a mercury policy, 64 have a written policy, while 10 do not.

Written Policy	Number	Percentage
YES	64	84%
NO	10	13%
DON'T KNOW	2	3%
Total:	**76**	**100%**

QUESTION #6c. In what ways does the facility inform staff about the policy?

The responses to this question indicate that most hospitals rely primarily on new-employee orientation sessions and various types of employee training sessions and workshops to educate their staff about mercury handling and disposal. Bulletin boards and hospital publications are not widely used for this purpose. Only 7% of facilities consider manuals or Material Safety Data Sheets (MSDS) as tools to educate staff about mercury handling and disposal.

Information Method	Number	Percentage
Orientation of new employees	62	67%
Periodic Health and Safety Training	40	43%
Special training workshops or sessions	24	26%
In-service training	14	15%
Bulletin boards	10	11%
Publications (newsletters, magazines)	7	8%
Manuals/MSDS sheets	6	7%



QUESTION #7. **<u>In what locations are red bags available for disposing of regulated medical wastes?</u>**

To ensure that regulated medical wastes are placed in red bags, the bags need to be conveniently located in or near areas where regulated medical wastes are generated. The table below presents the responses to this question.

Location	**Number**	**Percentage**
Clinics	19	21%
Nursing stations	30	33%
Operating Rooms	37	40%
Other	6	7%
Total:	**92**	**100%**

QUESTION #8. <u>How many red-bag holding rooms are located in the facility?</u>

The table below presents the responses to this question.

Holding Rooms	**Number**	**Percentage**
<10	53	69%
10-20	16	21%
21-30	4	5%
>30	4	5%
Total:	**77**	**100%**

QUESTION #9a. <u>Are separate containers for non-red-bag medical wastes available near red bags?</u>

When containers for non-red-bag wastes are conveniently located near red bags, the potential for other types of wastes to be thrown in red bags is reduced. The table below presents the responses to this question.

Separate Containers	**Number**	**Percentage**
YES	65	71%
NO	24	26%
DON'T KNOW	2	2%
Total:	**91**	**100%**

QUESTION #9b. <u>What types of non-red-bag medical wastes are collected separately?</u>

The responses to this question indicate that chemotherapy waste containers and non-infectious solid waste containers are the types of containers most frequently located near red bags.

Other Containers	Number
Batteries	1
Chemotherapy	39
Dialysis	1
Diapers	1
Dietary wastes	1
Formalin	1
IV Bags	1
Paper products	7
Radioactive wastes	4
Solid Waste (non-infectious)	34
Xylene	2
Total:	**92**

QUESTION #10a. <u>Does the facility have a mercury recycling program</u>?

Of the 92 responses received for this question, 10 respondents said they did not know whether their facilities had a mercury recycling program. The rest of the responses were evenly divided: half the facilities have a mercury recycling program in place and half do not.

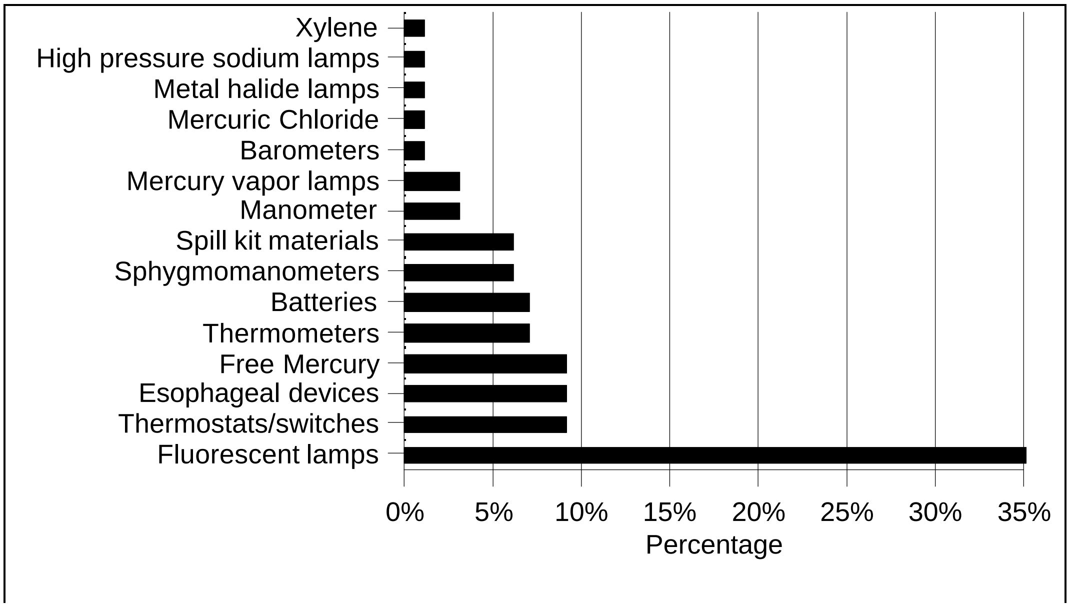
Recycling Program	Number	Percentage
YES	41	45%
NO	41	45%
DON'T KNOW	10	10%
Total:	**92**	**100%**

QUESTION #10b. **Please list the products that are recycled.**

Responses to this question indicate that fluorescent lamps are the most frequently recycled mercury-containing item among the facilities that responded to the survey. Of the 68 responses received, 24 facilities reported that they recycled fluorescent lamps. It is likely that the number of hospitals that recycle fluorescent lamps is substantially higher than these responses would suggest. It should be noted that the individuals who provided the answers for this survey were those who were most knowledgeable about the handling and disposal of medical wastes, whereas the disposal of fluorescent lamps is generally the responsibility of the hospital's plant maintenance department.

While a wide variety of other mercury-containing items are recycled, fewer than 10% of the facilities reported recycling any one single item.

Products Recycled	**Number**	**Percentage**
Fluorescent lamps	24	35%
Thermostats/switches	6	9%
Esophageal devices	6	9%
Free Mercury	6	9%
Thermometers	5	7%
Batteries	5	7%
Sphygmomanometers	4	6%
Spill kit materials	4	6%
Manometer	2	3%
Mercury vapor lamps	2	3%
Barometers	1	1%
Mercuric Chloride	1	1%
Metal halide lamps	1	1%
High pressure sodium lamps	1	1%
Xylene	1	1%
Total:	**68**	**100%**



QUESTION #10c. **<u>Please provide the name(s) and address(es) of mercury recycling contractors.</u>**

The responding facilities listed a total of 21 contractors in response to this question. The table below presents the responses.

Contractor	Number
Envirolights (FL)	6
Recyclights (FL)	5
AERC (FL)	3
Return to Manufacturer(s)	2
American Compliance Tech (FL)	1
Bethlehem Apparatus Co. (PA)	1
Chemical Conservation	1
COMR Biomed	1
Doolan Recovery	1
Florida Scrap Recycling (FL)	1
Full Circle, Inc.	1
Intersol, Inc. (FL)	1
Intervent, Inc. (FL)	1
Luminaire Recyclers (MN)	1
P3 Inc. (FL)	1
Perma-Fix (FL)	1
Rusch, Inc. (GA)	1
Quicksilver (FL)	1
Universal Waste (FL)	1
WA Baum Company	1
Wellington Environmental (FL)	1
Total:	**33**

QUESTION #10d. **<u>If mercury is recycled on-site (for example, removed from out-of-date or broken equipment and used in newer equipment), please list these items and the location(s) where this recycling takes place.</u>**

Five respondents indicated that mercury is recycled on-site. Three respondents said that recycling takes place in the biomedical engineering department, one respondent said mercury is recycled in the clinical engineering department, and one respondent said mercury is saved in the event it is needed in the future. Only one of the five facilities listed an item (thermostats) from which mercury is removed on-site.

QUESTION #11a. <u>Does the facility have an employee health and safety training program?</u>

Of the 92 facilities that answered this question, 91 said that they have an employee health and training program.

Health and Safety Training	**Number**	**Percentage**
YES	91	99%
NO	1	1%
DON'T KNOW	0	0%
Total:	**92**	**100%**

QUESTION #11b. <u>Does the training program include procedures on mercury handling and disposal?</u>

Of the facilities that answered this question, 61% said that mercury handling and disposal is included in employee safety programs, and 28% said that mercury handling is not included. The other 10% did not know whether it was included.

Mercury Handling & Disposal	**Number**	**Percentage**
YES	54	61%
NO	25	28%
DON'T KNOW	9	10%
Total:	**88**	**100%**

QUESTION #12a. **Does the facility use specialized materials/equipment to clean up mercury spills?**

The responses to this question indicate that 84% of the responding facilities use special materials and/or equipment to clean up mercury spills.

Special Materials/Equipment	**Number**	**Percentage**
YES	76	84%
NO	12	13%
DON'T KNOW	2	2%
Total:	**90**	**100%**

QUESTION #12b. **What kind of mercury spill equipment is used?**

Some of the responding facilities provided more than one answer to this question, as expected. About 82% of facilities said they use spill kits. Some of those facilities use specialized vacuum devices as well. It is likely that more than 2% of facilities use amalgam sponge/powder, as this material may be included in a spill kit and some respondents may not have listed this material separately.

Type of Equipment	**Number**
Spill kits	75
Specialized vacuum devices	15
And/or other:	
Amalgam sponge/powder	2
Syringe	1
None	1

QUESTION #12c. Where are spill kits and clean-up equipment located in the facility?

Spill kits and spill clean-up equipment are most commonly located in environmental services departments, engineering or operations departments, and nursing areas. Laboratories and other units sometimes have their own spill kits. Only 10% of the responding facilities reported keeping spill kits in emergency rooms, and only 3% keep them in operating rooms.

Location	Number	Percentage
Environmental services	32	52%
Engineering/operations	18	30%
Nursing areas	16	26%
Laboratories	12	20%
Security/safety office	9	15%
Central services	8	13%
Emergency room	6	10%
Endoscopy unit	3	5%
Pharmacy	3	5%
Spill control closets	3	5%
HazMat spill cart	2	3%
Operating room	2	3%
Pediatric care unit	2	3%

QUESTION # 13a. Are different materials/equipment used to clean up mercury spills on different floor surfaces?

Materials/equipment	Number	Percentage
YES	20	24%
NO	56	67%
DON'T KNOW	8	9%
Total:	**84**	**100%**

QUESTION #13b. What materials/equipment are used on carpeted floors vs. hard-surface floors?

Materials/equipment	**Number**
Carpeted Floors:	
Absorbent	8
Vacuum with absorbent	6
Vacuum	3
Remove the carpet	3
Spill kits	2
Talcum powder	1
Total:	**23**

Materials/equipment	**Number**
Hard-surface floors:	
Absorbent/spill sponge	8
Absorbent/broom	1
Vacuum/broom	2
Vacuum	2
Vacuum/adsorbent	2
Syringe	2
Total:	**17**

QUESTION #14. How are mercury spill clean-up materials disposed of?

Of the 92 responses received for this question, 53% of the facilities said spill clean-up materials are disposed of in special containers.

Disposal Method	**Number**	**Percentage**
Stored onsite and reused	2	2%
Picked up by recycler contractor	5	5%
Stored onsite until further disposal	9	10%
Picked up by Hazmat Contractor	10	11%
Red bag	14	15%
Special container	52	53%
Total:	**92**	**100%**

The next group of questions asked about laboratory waste disposal practices.

QUESTION #15a. **Are there medical laboratories within the facility?**

Medical laboratory	**Number**	**Percentage**
YES	74	82%
NO	16	18%
Total:	**90**	**100%**

QUESTION #15b. Are mercury-containing reagents used in the labs?

Mercury Reagents	Number	Percentage
YES	14	19%
NO	36	48%
DON'T KNOW	25	33%
Total:	**75**	**100%**

QUESTION #15c. How are used or out-of-date reagents disposed of?

Disposal Method	Number	Percentage
Red bag	1	5%
Drain	3	16%
Special containers	7	37%
Disposed as hazardous waste	8	42%
Total:	**19**	**100%**

SECTION III. Use of Mercury-Containing Devices

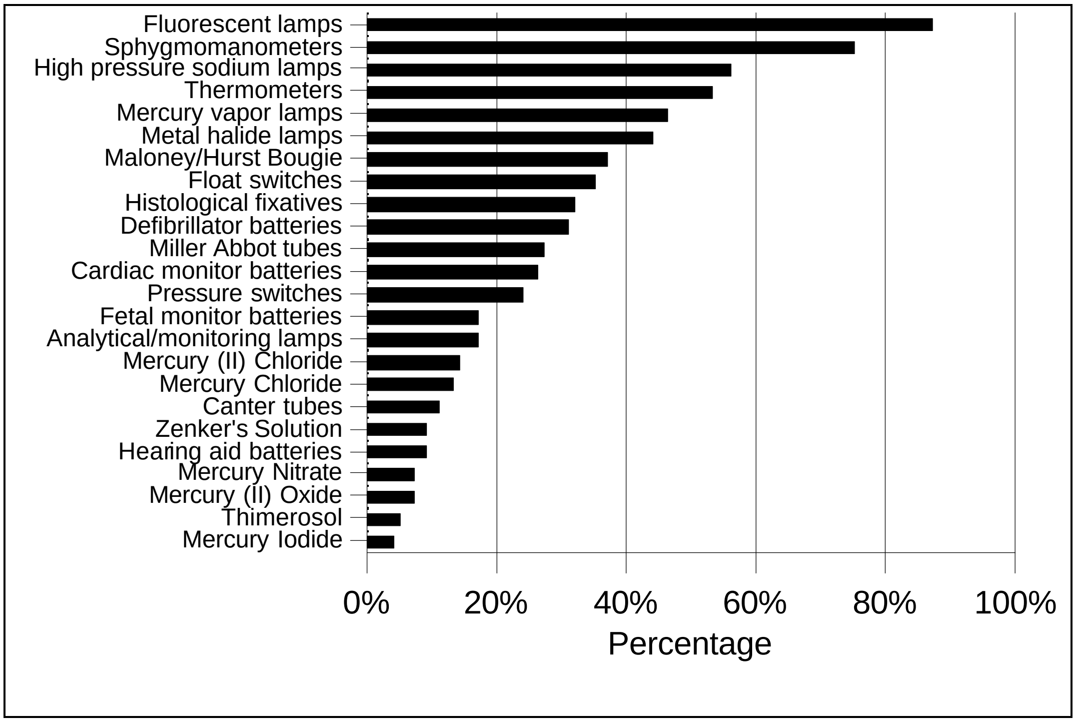
This section of the survey was designed to obtain data on the types and quantities of mercury-containing devices and other items used in Florida's hospitals. While most of the respondents placed a check in either the "yes" box or the "no" box for each listed item, few respondents provided information on quantities collected for disposal each year.

QUESTION #16. **For each of the mercury-containing items listed below, please indicate whether the item is used by your facility, the approximate quantity collected for disposal on a yearly basis, and the disposal method, such as recycling, red bag, or hazardous waste disposal.**

The responses to this question are presented in the table below. The "total sample" column represents the total number of facilities that checked either the "yes" box or the "no box. Some respondents did not check either box for some of the listed items, and where the boxes were left blank, the facility was not included in the "total sample" for that item. The "yes" and "no" percentages below were derived only from the "yes" and "no" answers for each individual item.

The table below lists the items alphabetically. The bar chart that follows the table lists the items in descending order by use.

Item Used?	**Total Sample**	**YES**	**NO**
Analytical/monitoring lamps	53	17%	83%
Canter tubes	55	11%	89%
Cardiac monitor batteries	61	26%	74%
Defibrillator batteries	67	31%	69%
Fetal monitor batteries	60	17%	83%
Float switches	65	35%	65%
Fluorescent lamps	75	87%	13%
Hearing aid batteries	58	9%	91%
High pressure sodium lamps	61	56%	44%
Histological fixactives	57	32%	68%
Maloney/Hurst Bougie	60	37%	63%
Mercury Chloride	56	13%	88%
Mercury (II) Chloride	58	14%	86%
Mercury Iodide	54	4%	96%
Mercury Nitrate	55	7%	93%
Mercury (II) Oxide	55	7%	93%
Mercury vapor lamps	61	46%	54%
Metal halide lamps	57	44%	56%
Miller Abbot tubes	56	27%	73%
Pressure switches	62	24%	76%
Thermometers	77	53%	47%
Thimerosol	55	5%	95%
Sphygmomanometers	76	75%	25%
Zenker's Solution	57	9%	91%


Fluorescent lamps
Sphygmomanometers
High pressure sodium lamps
Thermometers
Mercury vapor lamps
Metal halide lamps
Maloney/Hurst Bougie
Float switches
Histological fixatives
Defibrillator batteries
Miller Abbot tubes
Cardiac monitor batteries
Pressure switches
Fetal monitor batteries
Analytical/monitoring lamps
Mercury (II) Chloride
Mercury Chloride
Canter tubes
Zenker's Solution
Hearing aid batteries
Mercury Nitrate
Mercury (II) Oxide
Thimerosol
Mercury Iodide
0%
20%
40%
60%
80%
100%
Percentage

SECTION IV. Purchasing Practices

Purchasing practices and policies can play a major role in reducing the amount of mercury-containing items and ultimately, mercury-containing wastes, in hospitals. Prior to sending out the survey, the Center's research had suggested that hospital purchasing was rarely centralized. However, the responses received contradict that conclusion, as 94% of the responding facilities said that their purchasing departments are centralized. The responses to the purchasing questions are presented in the tables below.

QUESTION # 17. <u>Does a centralized Purchasing Department handle medical supply orders for all units?</u>

Centralized Purchasing	Number	Percentage
YES	83	94%
NO	4	5%
DON'T KNOW	1	1%
Total:	**88**	**100%**

QUESTION #18. <u>Does the facility maintain a centralized inventory of mercury-bearing products purchased?</u>

Centralized Inventory	Number	Percentage
YES	25	29%
NO	36	41%
DON'T KNOW	26	30%
Total:	**87**	**100%**

QUESTION #19. Do purchasing agents require mercury disclosures for products and materials containing mercury?

Mercury Disclosure Disclosures	**Number**	**Percentage**
YES	37	43%
NO	24	28%
DON'T KNOW	26	30%
Total:	**87**	**100%**

QUESTION #20a. Have any mercury-bearing products been replaced with substitutes containing less or no mercury?

Substitutes	**Number**	**Percentage**
YES	33	38%
NO	21	24%
DON'T KNOW	33	38%
Total:	**87**	**100%**

QUESTION #20b. **List the products for which the substitutes have been identified and placed into use.**

Item	Substitute
Batteries	Reduced Mercury/ Mercury Free Zinc Air Batteries Ni-Cad Batteries
Maloney/Hurst	Gel-filled Tubes Tungsten-filled Tubes
PVA Preservative	Sodium Acetate Formalin
Sphygmomanometer	Aneroid Dial Type Electronic Pulse Oxygen Machine
Thermometers	Electronic Thermoscan Tympanic
Thermostats	Epenematic Thermostats

Florida Center for Solid and Hazardous Waste Management

MEDICAL WASTE MANAGEMENT

FOR HOSPITALS AND CLINICS

I. Facility Information

Facility Name:	Address:
Contact Name:	Title:
Department:	Phone/ext.: ( ) x
Email address:	Fax Number: ( )

1. Type of Facility:

- ☐ Private, non-university affiliated
- ☐ Private, university affiliated
- ☐ Public, non-university affiliated
- ☐ Public, university affiliated
- ☐ Other (please specify):____________________

2. Number of Beds: ☐

3. Average Occupancy: ☐ %

4. Please list any special service units (e.g., psychiatric, pediatrics, cardiac, oncology, etc.)

II. Medical Waste Handling and Disposal Practices

5.a. What percentage of the facility's regulated medical waste is incinerated? ☐ %

5.b. Approximate percent incinerated on-site: ☐ %
5.c. Approximate percent incinerated off-site: ☐ %
5.d. Off-site incinerator contractor:____________________
5.e. Location of contractor:____________________

6.a. Does the facility have a policy on mercury handling and disposal?

☐ Yes ☐ No ☐ Don't Know

6.b. IF YES to 6.a.: Is the mercury handling and disposal policy written?

☐ Yes ☐ No ☐ Don't Know

6.c. IF YES to 6.a.: In what ways does the facility inform staff about the policy?

- [ ] Orientation for new employees
- [ ] Periodic health and safety training
- [ ] Special training workshops or sessions
- [ ] Publications (facility newsletters, magazines,etc.)
- [ ] Information on bulletin boards
- [ ] Other: Describe:

7. In what locations are red bags available for disposing of regulated medical wastes?
(List all locations: for example, nursing stations, operating rooms, etc.)

8. How many red-bag holding rooms are located in the facility?

9.a. Are separate containers for non-red bag medical wastes available near red bags?

[ ] Yes [ ] No [ ] Don't Know

9.b. IF YES, what types of non-red bag medical wastes are collected separately?

[ ] Chemotherapy waste [ ] Other: Describe

10.a. Does the facility have a mercury recycling program?

[ ] Yes [ ] No [ ] Don't Know

10.b. IF YES : Please list the products that are recycled:

10.c. IF YES : Please provide the name(s) and address(es) of mercury recycling contractors:

10.d. If mercury is recycled on site (for example, removed from out-of-date or broken equipment and used in newer equipment), please list these these items and the location(s) where this recycling takes place.

11.a. Does the facility have an employee health and safety training program?

☐ Yes ☐ No ☐ Don't Know

11.b. IF YES : Does the training program include procedures on mercury handling and disposal?

☐ Yes ☐ No ☐ Don't Know

12.a. Does the facility use specialized materials/equipment to clean up mercury spills?

☐ Yes ☐ No ☐ Don't Know

12.b. IF YES : What kind of mercury spill equipment is used?

☐ Spill kits
☐ Specialized vacuum devices
☐ Other: Describe

12.c. IF YES : Where are spill kits and clean-up equipment located in the facility?

13.a. Are different materials/equipment used to clean up mercury spills on different floor surfaces?

☐ Yes ☐ No ☐ Don't Know

13.b. IF YES : What materials/equipment are used on:

Carpeted floors:	
Hard-surface floors:	

14. How are mercury spill clean-up materials disposed of?

☐ Red Bag ☐ Special containers
☐ Other: Describe:

15.a. Are there medical laboratories within the facility?

☐ Yes ☐ No ☐ Don't Know

15.b. IF YES : Are mercury-containing reagents used in the labs?
☐ Yes ☐ No ☐ Don't Know

15.c. IF YES to 15.b.: How are used or out-of-date reagents disposed of?
☐ Red Bag
☐ Poured down drains
☐ Special containers for mercury-containing waste
☐ Other: Describe

III. Use of Mercury-Containing Devices

16. For each of the mercury-containing items listed below, please indicate whether the item is used and disposed of within your facility, the approximate quantity collected for disposal on a yearly basis, and the disposal method, such as recycling, red bag, or hazardous waste disposal.

	Yes	No	Quantity/year	Disposal Method
Mercury Thermometers				
Sphygmomanometers				
Mercury Batteries for:				
Defibrillators				
Hearing Aids				
Cardiac Monitors				
Fetal Monitors				
Esophageal Devices:				
Maloney or Hurst Bougie				
Gastrointestinal Devices:				
Canter Tubes				
Miller Abbot Tubes				
Mercury-containing Lamps:				
Fluorescent				
Metal Halide				
Sodium-Vapor				
Mercury Vapor				
Analytical or Monitoring				

	Yes	No	Quantity/year	Disposal Method
Switches:				
Float				
Pressure				
Chemicals:				
Mercury(II) chloride				
Zenker's Solution				
Thimerosol				
Histological Fixatives				
Mercury chloride				
Mercury(II) oxide				
Mercury iodide				
Mercury nitrate				
Other items:				
(e.g., mercury for lab				
calibration equipment)				

IV. Purchasing Practices

17. Does a centralized Purchasing Department handle medical supply orders for all units?

☐ Yes ☐ No ☐ Don't Know

18. Does the facility maintain a centralized inventory of mercury-bearing products purchased?

☐ Yes ☐ No ☐ Don't Know

19. Do purchasing agents require mercury disclosures for products and materials containing mercury?

☐ Yes ☐ No ☐ Don't Know

20.a. Have any mercury-bearing products been replaced with substitutes containing less or no mercury?

☐ Yes ☐ No ☐ Don't Know

20.b. IF YES : List the products for which the substitutes have been identified and placed into use:

Product	Substitute

21. How were past problems(if any) with mercury handling or disposal resolved?

22. Do you have any plans to reduce the use of mercury-bearing materials within your facility?

23. Do you have any suggestions for other facilities on the handling, disposal or reduction of mercury?

We welcome any additional comments you might have:

Thank you for completing this survey. Your assistance is greatly appreciated.

Florida Center for Solid and Hazardous Waste Management
2207-D NW 13th Street
Gainesville, FL 32609

Fax (352) 846-0183
Phone (352) 392-4595 or (352) 392-6264

Appendix B

Best Management Practices for Reducing and Properly Managing Mercury-Containing Items in Hospitals

BEST MANAGEMENT PRACTICES FOR REDUCING AND PROPERLY MANAGING MERCURY-CONTAINING ITEMS IN HOSPITALS

Introduction

Any plan designed to change equipment or procedures in a hospital setting can be expected to face difficult challenges. The hospital environment is complex, fast-paced, and constrained by economic pressures, and rapid changes may not be possible. Despite these obstacles, the concept of waste reduction has gained wide acceptance in recent years, as the benefits of reduced risk and reduced potential for liability have become more apparent. Many medical facilities have taken steps to reduce the use of hazardous materials and to increase recycling where possible.

Two documents produced under the auspices of the American Society for Healthcare and Environmental Services (ASHES) of the American Hospital Association provide comprehensive guidance on implementing waste reduction and recycling strategies throughout a health care facility. An Ounce of Prevention: Waste Reduction Strategies for Health Care Facilities, presents the rationale for reducing waste and guides readers through the process of conducting waste assessments, implementing waste reduction and recycling strategies, and designing effective education and communication programs. Its companion publication, Guidebook for Hospital Waste Reduction Planning and Program Implementation, provides specific planning and decision-making tools. These documents can provide helpful assistance for any facility that seeks to reduce solid waste and improve waste management procedures. The U.S. EPA's new rule on medical waste incinerator emissions, promulgated in August 1997, requires that any facility with a medical waste incinerator have a waste reduction plan that is based on the information presented in these publications.

The Best Management Practices presented here are not nearly as far-reaching in scope as the ASHES publications. Rather, they focus on the management of a specific substance - mercury. They were designed with the specific goal of reducing the amount of mercury that ultimately reaches Florida's environment as a result of the combustion of waste from medical facilities or the disposal of solid waste destined for landfilling. These practices can be used alone or as a supplement to the broader strategies outlined in the ASHES publications.

On the following pages, five steps for reducing mercury in waste from medical facilities are outlined: communication and education efforts, identification of the sources of mercury in the hospital environment, proper handling of mercury to minimize spills, keeping mercury out of the biomedical waste stream, and identification of substitutes and alternatives for mercury-containing products. These BMP’s can be tailored to specific facilities and even departments within a medical facility, e.g., ICU/ER/Surgery, laboratory, nursing station, patient rooms or storage/maintenance.

1. COMMUNICATION AND EDUCATION

Communication and education are the first steps in any plan to increase awareness about the importance of handling and disposing of mercury properly, and ultimately, reducing its presence in the hospital environment. The broad steps outlined below can be adapted to meet any hospital's specific requirements.

Develop a broad-based communications program to increase the awareness of the human health and environmental dangers of mercury (e.g., memos, meetings, newsletters or a combination of these).

Include articles devoted to mercury reduction, handling, and proper disposal in staff newsletters.

Include specific information about the proper handling of mercury in new-employee orientation and "Right-to-Know" Training.

Ensure that all personnel - including temporary workers - are familiar with the facility's mercury-handling procedures and protocols to prevent mercury from being disposed of in sharps containers, red bags or solid waste containers.

Include information about waste reduction and pollution prevention in in-service training sessions.

Encourage personnel to be label readers.

Place placards or labels on or above red bags, sharps containers and solid waste containers that state NO MERCURY'.

Make sure you have mercury spill kits available in all labs, nursing stations, ICU/ER/Surgery rooms, patient rooms and storage/maintenance facilities.

Monitor your program to define all strengths and weaknesses and create changes to reduce the weaknesses.

2. IDENTIFICATION OF SOURCES OF MERCURY

Mercury can be found in many locations throughout the hospital environment. Thermometers and sphygmomanometers are the most widely used items, but mercury is also contained in many other products and devices. It is important to ensure that all personnel are knowledgeable about the mercury-containing devices and substances that are used in their work area.

The following pages list the products and devices generally found in some specific areas within a hospital. Using these lists as a guide, lists for different departments within a specific medical facility can be made and posted. These facility-specific lists would include only the mercury-containing items which are used in each particular department. This would avoid cluttering the lists with items which department staff would never see or handle. The list could then be posted near any biomedical or solid waste container which should <u>not</u> receive any mercury-containing wastes. The list should also include instructions on how to properly manage mercury-containing waste, e.g., Put these items into the hazardous waste container.

DEPARTMENT	SOURCES OF MERCURY
ICU/ ER/ SURGERY	Cantor Tubes Feeding Tubes Lamps High Pressure Sodium Lamps Fluorescent Lamps Metal Halide Lamps Ultraviolet Lamps Mercuric Oxide Batteries Used in Defibrillators ECG Monitors Fetal Monitors Hearing Aids Hofler Monitor Oxygen Monitors Pacemakers Miller Abbot Tubes Sphygmomanometers Thermometers Treatments Antifungal/Anti-Infectious/Bacteriostatic Enzyme/Ammonia Thimerosal Mercury Iodide Mercury Nitrate Merthiolate

DEPARTMENT	SOURCES OF MERCURY

LABORATORIES	Electron Microscope
	Fixatives
	    Mercuric Chloride
	        B5 Fixative
	        Carnoy-Lebrun
	        Helly
	        Ohlamacher
	        Shardin
	        Zenker's Solution
	Manometers
	Mercuric Batteries
	Reagents
	    Camco
	    Hitergent
	    Immu-sal
	    Mercuric Chloride
	        Used in Sequential Multiple Analyzer (SMAC) AU 2000
	    Mercuric Oxide
	        Stabilur Tablets
	    Mercury Sulfate
	    Mercurochrome
	    Mercurophyline
	    Million's Reagent
	    Nessler's Solution
	    Phenol Mercuric Acetate
	    Takata's Reagent
	    Thimerosal
	        Buffer
	        Mercury Iodide
	        Mercury Nitrate
	        Merthiolate
	        Mucolex
	Sink Sewage Traps
	Stains
	    Alum Hematoxylin (Solution A)
	    Cajal's
	    Carbol Gentian Violet
	    Gomori's
	    Golgi's
	    Gram Iodine
	    Mercury Chloride
	Thermometers

DEPARTMENT	SOURCES OF MERCURY

NURSING STATION	Barometers
	Cantor Tubes
	Electrical Equipment
	    Laboratory ovens
	    Nursing Incubator
	    Refrigerators
	    Relays
	    Switches
	Feeding Tubes
	Lamps
	    Fluorescent Lamps
	    High Pressure Sodium Lamps
	    Metal Halide Lamps
	    Ultraviolet Lamps
	Mercuric Oxide Batteries
	  Used in
	    Blood Analyzer
	    Defibrillators
	    Fetal Monitors
	    Hearing Aids
	    Hofler Monitor
	    Pacemakers
	    Pagers
	    Picker Caliber
	    Spirometer Alarm
	    Telemetry Transmitter
	    Temperature Alarm
	Sink Sewage Traps
	Sphygmomanometers
	Thermometers

DEPARTMENT	SOURCES OF MERCURY
PATIENT ROOMS	Electrical Instruments Nursing Incubators Thermostats Mercuric Oxide Batteries Used in Defibrillators ECG Monitors Hearing Aids Oxygen Monitors Pacemakers Temperature Alarm Sphygmomanometers Switches Thermometers

DEPARTMENT	**SOURCES OF MERCURY**
STORAGE AND MAINTENANCE	Antifouling Agents Cleaning Chemicals Degreasers Outdated Mercury-Containing Equipment Paints Preservatives Sink Sewage Traps Solvents Spent Batteries Spent Mercury-Containing Lamps Spent Mercury-Containing Thermostats

3. PROPER HANDLING OF MERCURY-CONTAINING ITEMS

The following list includes some of the common practices and procedures that can effectively reduce the amount of mercury improperly disposed of in red bags, sharps containers or solid waste containers. These practices can be adapted for your specific facility and for specific departments.

Included in this section is an example of an easy-to-read Do's and Don'ts list that can be posted in any area where any mercury items are used. Posting of Do's and Don'ts lists, like the example shown here, is a very effective educational tool and is strongly recommended.

Never place any mercury-containing item into a red bag, a sharps container or a solid waste container.

Handle all mercury containing lamps, batteries and devices as outlined in the Universal Waste Rule (40 CFR 273) and as in Management of Spent Mercury-Containing Lamps and Mercury-Containing Devices Destined for Recycling (62-737 F.A.C.). Handle all other mercury containing items as hazardous waste under the Hazardous Waste Rule (62-730 F.A.C.).

Prevent spills. Even small spills can result in cleanup and disposal costs. Avoiding spills of large quantities of mercury can save thousands of dollars in labor, cleanup, and disposal costs.

Transport mercury-containing substances and devices in a secondary container that can be easily cleaned if a spill occurs. Transfer mercury within the secondary container.

When spill cleanup equipment is located in a central location, such as the safety manager's office, ensure that all personnel know who to call when a spill occurs.

When spill kits are located in various areas in the hospital, ensure that all personnel are familiar with the location and proper use of the nearest spill kit.

Ensure that the proper equipment is available to clean up spills. Equipment must be appropriate for the size of the facility and types of spills that can be anticipated. If your facility does not have a mercury vacuum aspirator, purchase one.

Collect spill clean up materials and send them to a mercury recycler or a hazardous waste contractor. They should not be disposed of in red bags or solid waste containers.

Keep spilled mercury or broken mercury-containing items in a sealed container (e.g., a sealable plastic bag) and then place in a secondary container (e.g., a plastic container with a tight-fitting lid).

Consider placing mercury spill kits in areas where spills are likely to occur.

Train employees to monitor changes in the volume of mercury on hand--any reductions in use, spill incidents, or mercury recovered.

Maintain an up-to-date inventory of mercury containing materials, their arrival, history of use, and final destination.

Maintain an accurate log of mercury spills. Review the log frequently to identify areas where spills occur frequently.

Keep a quantitative record of the amount of mercury in use or stored on the premises, and how much has been spilled, recovered, or discarded.

Contract with a hazardous waste disposal contractor for all mercury-containing wastes that cannot be recycled.

For sphygmomanometers with glass tubes, contact the manufacturer to obtain some inexpensive mylar sheaths that can be easily placed around the tube to prevent spills.

For information on recycling and disposal for mercury-containing lamps and other mercury-containing devices, call the Florida Department of Environmental Protection toll-free hotline:

1-800-741-4DEP
(1-800-741-4337)

DO'S AND DON'TS
FOR MERCURY-CONTAINING ITEMS

Post This List in Areas Where Mercury-Containing Items Are Used

PROPER HANDLING OF MERCURY

DO'S

Do prevent mercury spills.

Do transport mercury-containing substances and devices in a secondary container that can be easily cleaned if a spill occurs.

Do know who to call when a spill occurs.

Do know where the nearest spill kit is and how to use it.

Do keep containers of spilled mercury closed.

Do log all mercury spills.

Do record the amount of mercury in use, stored, recovered and discarded**.**

Do place discarded, damaged, or broken mercury-containing devices and lamps and used mercury absorbent in special mercury collection containers.

DON'TS

Don't place used mercury absorbent material in red bags or solid waste containers.

Don't place discarded, damaged, or broken mercury-containing devices and lamps in red bags or solid waste containers.

Don't pour spilled mercury down the sink.

4. RECYCLING

There are several mercury recyclers in Florida who are permitted to accept a wide variety of mercury-containing lamps, devices, chemicals, spill kits, and pourable mercury. The costs associated with recycling vary with the type, amount, and containment of the mercury. If the lamps, batteries and devices are recycled in accordance with Florida's Universal Waste Rule (40 CFR 273), they do not have to be counted toward a facility's hazardous waste generation.

Section 403.7186, F.S., states that any mercury-containing device shall not be disposed of in landfills. It also states that mercury-containing lights from businesses, including medical facilities, may not be knowingly incinerated. By recycling, the facility can reduce its hazardous waste disposal costs and decrease future liability associated with improper disposal.

Provide separate collection systems for recyclables, reusables, etc.

Mercury in spill kits can be reclaimed and recycled at some facilities but it still must be treated as a hazardous waste.

Contact your facility's mercury recycler about recycling spilled mercury

All metallic mercury should be recycled.

Mercury from many mercury-containing devices and items - including thermometers, sphygmomanometers, switches, gauges, batteries, Maloney and Hurst bougies, Miller Abbot and Cantor tubes and dental amalgam can be reclaimed.

If mercury-containing batteries are used, ensure that they are being properly collected for disposal. Recycle batteries when possible, or contract with a hazardous waste contractor. In Florida, manufacturers and marketers of mercuric oxide batteries must have a program for proper disposal or recycling of the batteries they sell.

Lamp Recycling

Handle and store fluorescent lamps and HID lamps properly for recycling:

Store lamps in an area and in a way that will keep them from breaking, such as in boxes they are shipped in.

Mark the lamp storage area with the words Mercury-containing lamps for recycling.

Do not crush or intentionally break lamps because mercury may be released.

If lamps are accidentally broken, store them in a sealed container, and pick up any spilled powder with a cleanup kit and dispose in the same container.

Take lamps to a consolidation site or recycling facility, if available, or arrange with a transporter to take them to a recycling facility.

To protect the facility from future liability, save the invoices that track your lamps and include the date, number of lamps, your facility address, shipping destination with permit number, and transporter name with identification number (if applicable) on the invoice.

For information on recycling and disposal for mercury-containing lamps and other mercury-containing devices, call the Florida Department of Environmental Protection toll-free hotline:

1-800-741-4DEP
(1-800-741-4337)

5. MERCURY REDUCTION: SUBSTITUTES AND ALTERNATIVES

Identifying substitutes and alternatives for mercury-containing products may be time-consuming but the health and economic benefits make the effort worthwhile.

It may be best to phase out mercury-bearing items gradually. Mercury-free items are available to replace some existing items without loss of quality. Replacing these items decreases the need to recycle these items, thus saving money and reducing liability. Listed below are some suggestions for starting a mercury reduction program. The following pages list some existing substitutes for mercury-containing products.

Seek and evaluate alternatives to mercury-containing products currently used.

Require mercury disclosures on all products purchased by the facility, and request the use of recovered mercury in all products purchased that do not yet have alternatives available.

Encourage purchasing personnel to leverage their buying power with other hospitals to make mercury-free alternatives more readily available at reasonable prices.

Replace mercury-containing batteries:

A number of alternatives to mercuric oxide batteries exist. Alkaline, zinc-air, rechargeable nickel-cadmium, and lithium make good replacements for these items.

Replace mercury-containing button batteries with zinc-air, lithium, or alkaline batteries.

Zinc-air batteries can often be used for telemetry cardiac monitors. It has been reported that these batteries perform better and last longer than mercury-containing batteries. <u>Always verify the suitability of zinc-air batteries for cardiac monitors before making a change</u> since these items are used for emergency care. Zinc-air batteries may be especially appropriate for monitors that are in constant use, as these batteries continue to discharge while in storage.

Replace mercury-containing thermometers:

Electronic digital thermometers and thermometers filled with alcohol or mineral spirits meet the calibration standards of the National Institute of Standards & Technology. If you must purchase a mercury thermometer, ensure it is one with a Teflon coating to help prevent breakage and spillage.

Include non-mercury thermometers in new baby kits. Alternatives include tympanic thermometers and Temp-A-Dot.

Replace manometers and other pressure gauges, dials and switches with digital electronic models. Pressure transducers can substitute for manometers. Manometers can be filled with a variety of high-density liquids other than mercury.

Replace sphygmomanometers with non-mercury units. If replacement of all mercury sphygmomanometers has to be done on a unit in/unit out basis, then the glass tubes of existing mercury units should be wrapped with an inexpensive mylar coating, available from the manufacturer, to prevent a mercury spill in the case of breakage. The mylar coating can be installed quickly and easily by the hospital's biomedical engineering personnel.

Mercury's use in chemical analysis can be phased out in some cases, such as the use of Zenker's solution and certain histological fixatives. Obtain information from vendors and review Material Safety Data Sheets for alternative products. Some substitutes, such as copper-, tin-, and chromium-based chemicals, are less of an environment risk than mercury-based products.

Effective substitutions for some mercury-containing stains exist. Disposal costs can be reduced by switching to non-mercury containing items. Examples include:

Mercury-containing chemical	Alternative
Mercury (II) chloride	Zinc Formalin
Zenker's solution	Zinc Formalin
Histological fixatives	Freeze drying
Mercury (II) oxide	Copper catalyst
Mercury (II) chloride	Magnesium chloride/ sulfuric acid
Mercury (II) sulfate	Potassium/ chromium-(III) sulfate
Mercury iodide	Phenate Method
Mercury nitrate	Ammonia/copper sulfate

Substitute esophageal dilator tubes with tubes containing water-based or Tungsten compounds.

Replace conventional fluorescent tubes. T-8 fluorescent lamps use electronic ballasts and contain 20% less mercury that previous lamps.

When possible, replace Canter tubes with Anderson tubes which contain no mercury and can be an acceptable substitute.

There are many alternatives to mercury-containing thermostat switches. They are electronic, snap action, reed switch, bi-metal, and vapor-filled diaphragm thermostats. These items are accurate, reliable, and inexpensive.

For other mercury switches used in equipment, solid-state or hard-contact switches can be used in some applications. When replacing or installing new switches, contact the manufacturer about mercury-free alternatives.

MERCURY-CONTAINING ITEMS	ALTERNATIVES
B5 Solution	Zinc Formalin Freeze Drying
Cantor Tubes Feeding Tubes Miller Abbot Tubes	Tungsten-weighted tubes.
Hematoxylin	Sodium Iodate Gill's Hematoxylin Mercury-free Hematoxylin
Lamps	Ordinary Glow Lights Low Sodium Vapor Tubes (Yellow) Opticals High Energy Long-Lasting Lights
Mercuric Chloride	Magnesium Chloride/Sulfuric Acid Proclain Zinc Formalin Freeze Drying
Mercuric Oxide	Copper Catalyst
Mercuric Oxide Batteries	Lithium Zinc Air Alkaline Batteries
Mercurochrome	Neosporin Mycin
Mercury Iodide	Phenate Method
Mercury Nitrate	Ammonia/Copper Sulfate Neosporin Mycin
Mercury Sulfate	Silver Nitrate/Potassium/Chromium-(III) Sulfate
Mercury Switches	Bi-metallic Strips Electronic Strips
Nursing Incubator Thermostat	Thermostats that contain alcohol instead of mercury
Sphygmomanometers	Electronic Vacuum Gauge Expansion Aneroid Models

Thermometers	Electronic (Digital) Expansion Temperature Strips Tympanic Gallistan Red Bulb (Alcohol) Aneroid Models
Thermostats	Electronic Models Snap Switches
Thimerosal	Proclain Thimerosal-Free Bactericides
Zenker's Solution	Zinc Formalin Freeze Drying

Appendix C

Best Management Practices for Mercury-Containing Items in Dental Facilities

BEST MANAGEMENT PRACTICES
FOR MERCURY-CONTAINING ITEMS
IN DENTAL FACILITIES

Sources of mercury in dental offices include amalgam waste (contact and non-contact), fluorescent lamps and FM lamps. Below are recommended practices for the proper management of amalgam, amalgam spills and training and education of dental office personnel.

SOURCES OF MERCURY

- Extracted amalgams
- Excess contact and excess non-contact amalgam
- Capsules with mercury or amalgam residue left in them
- Leaking amalgam capsules
- Faulty amalgamators Fluorescent light bulbs Monitoring/Analytical lights

AMALGAM MANAGEMENT

DO's

- **Do** limit the amount of amalgam generated to the smallest appropriate size for each restoration.
- **Do** use precapsulated dental amalgam only.
- **Do** use disposable amalgam traps instead of reusable traps.
- **Do** sterilize reusable amalgam traps if disposable traps are not appropriate in your facility. **Do** install several filtration devices on the amalgam traps.
- **Do** change the vacuum pump filters at least once a month.
- **Do** maintain a log of your generation and disposal of waste amalgam.
- **Do** recycle all elemental mercury and amalgam.
- **Do** separate contact and non-contact amalgam at all times to facilitate recycling.
- **Do** store amalgam in a container with a sulfide solution and an airtight fitting lid.
- **Do** react small amounts of unused elemental mercury with silver alloy to recycle as waste amalgam.
- **Do** label waste amalgam containers with your name, phone number, address and date.
- **Do** disassemble and clean the amalgamator on a regular basis.
- **Do** properly seal all amalgam capsules before amalgamation.
- **Do** reassemble capsules immediately after dispensing the amalgam.
- **Do** consider, when appropriate, mercury-free alternatives to amalgam (e.g., gold, ceramic, porcelain, composites, polymers or glass ionomers).

- **Do** encourage insurance companies to develop plans to include competitive coverage for mercury-free alternatives.
- **Do** determine if you are a conditionally exempt small quantity generator.
- **Do** research your amalgam recycler to assure that the mercury is being properly managed after it is separated from the silver.

DON'Ts

- **Don't** rinse amalgam traps over drains.
- **Don't** discard amalgam, extracted teeth containing amalgam or amalgam traps into the garbage, red bags or sharps container.
- **Don't** handle mercury or mix the amalgam in a carpeted area.

AMALGAM SPHL MANAGEMENT

DO's

- **Do** place mercury spill kits in appropriate and easy to access locations.
- **Do** immediately clean up any mercury spill with appropriately trained personnel.
- **Do** recycle the elemental mercury from spills and absorbent from all clean-ups.
- **Do** use a vacuum cleaner specifically designed to clean up mercury spills.

DON'Ts

- **Don't** use a regular vacuum cleaner to clean up mercury spills.

TRAINING AND EDUCATION

DO's

- **Do** train all employees the proper usage of **all** procedures for proper handling of mercury.
- **Do** increase education among dental personnel about proper dental amalgam waste collection and disposition.
- **Do** develop and implement an amalgam waste tracking system to track captured waste amalgam to reclamation facilities per Chapter 62-730 F. A. C.
- **Do** create a written statement of policies and goals tailored to your practice.
- **Do** continuously monitor your polices and goals and make any necessary changes.
- **Do** provide an annual refresher course on proper amalgam management for all employees.
- **Do** develop a spill response plan.

Appendix D

Proper Collection and Disposal of Spilled Mercury in Hospitals: A Pilot Project

PROPER COLLECTION AND DISPOSAL OF SPILLED MERCURY IN HOSPITALS: A PILOT PROJECT

Introduction

The Florida Center for Solid and Hazardous Waste Management conducted a study for the Florida Department of Environmental Protection on the use, handling, and disposal of mercury-containing items and devices in medical facilities. The study included a survey of waste management practices, and specifically, of mercury management practices, in Florida hospitals. Of the 232 hospitals contacted, the Center received 92 responses. The responses are summarized in Appendix A.

The survey responses suggested that while many hospital employees are aware of proper procedures for handling mercury wastes and spills, others are unaware that broken thermometers and other mercury-containing items must be disposed of as hazardous wastes and not as biomedical wastes. Some hospital staff mistakenly believe that because broken thermometers are sharp, they should be disposed of in a sharps container. Some believe that because a thermometer was in contact with a patient, it should be disposed of as biomedical waste in a red bag. However, it is important for all hospital staff to know that red bags and sharps are incinerated, and the combustion process causes mercury to be released into the environment.

Hospitals typically have one or more mercury spill kits that include small containers for storing spilled mercury. During site visits to hospitals in connection with this project, Center staff noticed that occasionally, some mercury was observed rolling around in the bottom of the spill kit outside the mercury storage containers. This may be because the containers provided in many spill kits are fairly small and it may be difficult to place the broken item inside the container without some of the mercury spilling into the kit.

The accumulation and storage of free mercury in a plastic or metal spill kit box is hazardous. Workers in the area where the spill kit is stored may be exposed to hazardous mercury vapors because (1) the box may not be airtight when closed, (2) it may not always be kept completely closed, and (3) each time the kit is opened, vapors are released into the ambient air of the work area. In general, if a container of mercury is stored in the workplace environment without a lid on it, the mercury vapors that accumulate in the ambient air of the workplace will exceed limits set by the National Institute for Occupational Safety and Health (NIOSH).

An extensive body of research on recycling and other environmental behaviors suggests that ease and convenience play a significant role in achieving a desired result. This widely accepted notion was applied to the proper handling and disposal of broken thermometers and mercury spills from other mercury-containing items and devices commonly found in the hospital environment. The Center designed a pilot project based on the premise that if proper storage containers were more conveniently located, hospital staff would be more likely to use those containers and less likely to improperly dispose of mercury-containing wastes in red bags or in sharps containers.

Methodology

The Center purchased Nalgene plastic containers that were 10 inches high with tight-fitting screw-on lids. This size was chosen because it was large enough to hold the types of thermometers commonly encountered in hospitals and hospital laboratories, as well as mercury ampules from thermostats and mercury from esophageal or intestinal tubes. The container was also small enough to be placed on a shelf in a convenient location. Nalgene containers were selected because they are made from sturdy, durable plastic and when the lids are screwed on properly, mercury vapors will not escape into the workplace or into the environment.

In June 1997, the Center faxed a letter to each of the 232 hospitals that had received the waste management survey. The letter was directed, with a cover sheet, to the person previously identified as the one responsible for, or most knowledgeable about, the facility's waste management procedures. In the letter, the Center offered to send the facility up to three storage containers, at no charge to the hospital, along with "spill logs" to record the source of any mercury wastes deposited in the containers during a three-month period. A one-page "order form" was faxed with the letter. A copy of the Center's letter to the hospitals, with the order form, is included in this appendix as Attachment D-1.

Before the containers were shipped to hospitals, two self-adhesive labels were affixed. One label was entitled "Facts About Mercury" and contained educational information about the characteristics of mercury, means of exposure, and potential health effects. The other label provided specific instructions on:

- using the container ("for spilled mercury and broken thermometers only");
- recording breaks or spills on the spill log;
- keeping the container lid tightly closed;
- not disposing of mercury in red (biomedical waste) bags or white (general solid waste) bags; and
- reading the other label which contained educational information about mercury.

At the bottom of the label, the Center was identified as the provider of the container, and the Center's full name and telephone number were given. A copy of the two labels is included in this appendix as Attachment D-2.

A small plastic pocket was also affixed to each bottle. A spill log was folded and placed in the plastic pocket so that whenever any material was deposited in the container, it would be easy to record the necessary information on the log.

The Center received "orders" from 34 hospitals and shipped a total of 97 storage containers. Hospital staff were asked to log all materials deposited in the containers for the three-month period from July 1 through October 1 and to mail or fax the spill logs to the Center on October 1. The transmittal letter explained that the Center was to receive the logs only, and that the mercury collected in the containers needed to be sent to a mercury recycler or a hazardous waste disposal contractor. Attached to the letter were an extra copy of the spill log form and a list of mercury recycling companies and hazardous waste disposal companies. A copy of the transmittal letter and attachments are included in this appendix as Attachment D-3.

The Center made followup calls during the month of August to try to determine whether the bottles had been placed in the intended locations. Most of the people the Center was successful in contacting reported that they liked the containers and that no spills had occurred since the containers were received. However, one facility reported that by August 8, the container was 1/4 full.

On October 2, the Center began calling the hospital contacts again to get the spill logs mailed or faxed back. On average, three or four calls needed to be made to get the logs sent back, but as many as five or six calls were made to a number of hospitals before the logs were received. A total of 81 spill logs were received, which represented 83.5% of the 97 logs that the Center had sent out.

Results

Of the 81 spill logs received, 73 reported no spills during the three-month pilot project period. On 8 of the logs, a total of 19 incidents were reported. Table D-1 presents the number of spills for description/source of mercury.

Table D-1. Mercury Spills Report, July 1-October 1, 1997: By Spill Type

Number of Spills	Description/Source
12	Thermometers
4	Sphygmomanometers
1	Esophageal Dilator
1	Mercury Switch
1	Mercury found in cabinet from a previous cleanup

Table D-2 presents the number of spills reported by location within the hospital. It should be noted that from the data received, no conclusions should be drawn as to the locations that are most likely to experience mercury spill incidents, as not all of the 81 logs that were returned indicated where the bottles had been placed. The location of one spill was not recorded on the log, so the total number of spills listed in Table D-2 is 17.

Table D-2. Mercury Spills Reported, July 1-October 1, 1997: By Location

Number of Spills	Location
4	Bone Marrow Transfusion Unit
2	Neonatal ICU
2	Non-Emergency
2	Plant Operations
1	Endoscopy
1	Nursing
1	ICU
1	Patient Room
1	Newborn Nursery
1	Labor Delivery Recovery
1	Lab

Each of the eight spill logs was received from a different facility. Table D-3 presents the spills that were recorded on each of the eight logs. Three of the facilities recorded one incident on the log during the three-month period. Two facilities reported two spills, one facility reported four spills, and one facility recorded six spills.

Table D-3. Mercury Spills Reported, July 1 - October 1, 1997: By Hospital

Log	Location	Source of Mercury
1	Intensive Care Unit	Blood Pressure Cuff
2	Non-Emergency	Rectal Thermometer
	Non-Emergency	Rectal Thermometer
3	Lab	Found mercury in cabinet from previous cleanup
	Patient Room	Blood Pressure Equipment
	Nursing	Spill: Sphygmomanometer
	Endoscopy	Esophageal Dilator Tube

Table D-3. Mercury Spills Reported: By Spill Log (continued)

Log	Location	Source of Mercury
4	(not recorded)	Wall-mounted Sphygmomanometer
5	Newborn Nursery	Thermometer
	Labor Delivery Recovery	Thermometer
6	Bone Marrow Transfusion	Thermometer
	Bone Marrow Transfusion	Thermometer
	Neonatal ICU	Thermometer
	Bone Marrow Transfusion	Thermometer
	Bone Marrow Transfusion	Thermometer
	Neonatal ICU	Thermometer
7	(not recorded)	Thermometer
8	Plant Operations	Thermometer
	Plant Operations	Mercury Switch

Conclusions

The data collected during the pilot project is consistent with the Center's review of previous research that indicates that thermometers are the most common source of mercury spills. Thermometers accounted for 12 of the 19 incidents, or 63% of the incidents reported. Additionally, it is evident from the data collected that mercury spills can occur in any location where mercury or mercury-containing items and devices are handled.

Although the total number of reported incidents is relatively small, they suggest that the provision of mercury storage containers was helpful. Furthermore, the data suggest that mercury handling and disposal in Florida hospitals can be substantially improved by:

* Reducing the use of mercury-containing thermometers and sphygmomanometers.

* Increasing the training of hospital staff in all locations where mercury-containing items and devices are handled.

Future projects designed to implement and measure the effectiveness of these suggested practices could have a significant impact on reducing the amount of mercury in incinerators that burn biomedical waste.

THE FLORIDA CENTER FOR SOLID AND HAZARDOUS WASTE MANAGEMENT

University of Florida
2207 NW 13 Street, Suite D
Gainesville, FL 32609

Tel: (352) 392-6264
Fax: (352) 846-0183
E-mail: fcshwm@eng.ufl.edu

June 2, 1997

We recently sent you a survey on hospital waste management and disposal practices.

Information from hospitals that responded to the survey suggests that some hospital staff aren't sure how to properly dispose of broken items that contain mercury, such as thermometers.

The proper disposal of mercury-containing wastes is important because much of the medical waste from Florida hospitals is burned in incinerators that do not have mercury pollution control equipment. When airborne mercury emitted from incinerators is deposited on land or in surface waters, it is converted to methyl mercury, an extremely toxic form of mercury. Mercury concentrations are relatively high **in** many aquatic ecosystems, and fish caught in some areas of Florida should not be eaten due to high concentrations of mercury.

Some hospitals have eliminated mercury thermometers, but others continue to use them, especially in pediatric units and in blood banks. Broken thermometers should be disposed of as hazardous wastes.

However, our research indicates that sometimes the mercury wastes are improperly placed in red bags or sharps containers for disposal.

We **believe that if special mercury waste disposal/storage containers were placed in convenient *locations, hospital staff would use them*** to properly dispose of broken thermometers and the **mercury that was contained in the thermometers and other devices, such as sphygmomanometers and mercury switches.**

We **have purchased special mercury waste storage containers that we can send you A T** *NO COST* They are wide-mouth nalgene bottles, about 10" high, with a tight-fitting screw-type lid. They are labeled, "For Storage of Mercury and Broken Mercury Thermometers." When mercury is stored in this type of container, the mercury vapors will not escape into the work place or the environment.

We will send you up to three of these containers, along with a log your staff can use to record broken thermometers and other types of mercury spills. After three months, we would like you to fax your completed log to us. This will assist us in the development of recommendations on how Florida hospitals can improve their management of mercury-containing wastes.

A form for ordering the FREE storage bottles is attached. For more information about this study, or if you have any questions, please call Brian Timmins or Anita Kugler at (352) 392-6264.

Request for
Storage Bottles

for Mercury and
Broken Mercury Thermometers

FAX TO: (352) 846-0183 **(if you experience difficulty with faxing, please call (352) 392-6264.)**

Please send____________bottles to:

(PLEASE PRINT)

Name: ____

Title: ____

Hospital Name: ____

Shipping Address: ____

____

____

Phone Number: ______________________ **Ext.** ______________________

FACTS ABOUT MERCURY

Potential Health Effects

- Can accumulate in brain, nervous system, internal organs and may be "stored" in fatty tissue
- Can damage liver and kidneys
- Can affect personality, leading to mood and personality changes
- Although slowly excreted from the body, effects are cumulative and irreversible.

Means of Exposure

- Inhalation of vapor
- Absorption-through skin
- Ingestion

Characteristics

- Gives off poisonous vapors at room temperature
- Vaporization increases with temperature and surface area

Use this Bottle for

SPILLED MERCURY And BROKEN THERMOMETERS ONLY.

Record each break or spill on the attached log.

Keep lid tightly closed.

DO NOT DISPOSE OF MERCURY IN RED BAGS OR WHITE BAGS.

See the label on the back of this bottle for important information about mercury.

This bottle was provided by the Florida Center
for Solid and Hazardous Waste Management
at the University of Florida, Gainesville.
Phone (352) 392-6264

Attachment D-2

THE FLORIDA CENTER FOR SOLID AND HAZARDOUS WASTE MANAGEMENT

University of Florida
2207 NW 13 Street, Suite D
Gainesville, FL 32609

Tel: (352) 392-6264
Fax: (352) 846-0183
E-mail: fcshwm@eng.ufl.edu

July 1, 1997

To: ____

____

Thank you for requesting the enclosed containers for mercury waste storage and disposal. As you can see, each container has a pocket on it with a log for conveniently recording the date, time, location and source of spills. An extra-log form is attached and you may make additional copies as needed. These storage containers should be used in conjunction with your mercury spill kits.

On **October 1, 1997,** by fax or by mail, please send us the log sheet(s) for each container you received.

Please note that at the bottom of the log form, there is a place to insert your name and extension so that your staff will know who to contact for recycling or disposal. A list of hazardous waste disposal contractors and mercury recyclers is attached for your convenience. **Please do not send the containers to us.** We are not permitted to accept them and we would have to send them back to you.

We will contact you sometime during the next three months to see how things are going and whether the containers are helpful to you in ensuring that mercury wastes are handled properly. Our intent is to help you ensure that mercury wastes are not going into red bags and ultimately, to incinerators.

As we mentioned in our previous letter, the proper disposal of mercury-containing wastes is very important. When airborne mercury emitted from medical waste incinerators is deposited on land or in surface waters, it is converted to methyl mercury, an extremely toxic form of mercury. Mercury concentrations are relatively high in many aquatic ecosystems, and fish caught in some areas of Florida should not be eaten due to high concentrations of mercury.

Your assistance in this research project is greatly appreciated. We will send you a copy of our final report which we expect to publish by the end of the year.

If you have any questions in the meantime, please do not hesitate to call us at (3 52) 3 92-6264.

Anita Kugler
Project Manager

MERCURY SPILL LOG

July 1 - Sept. 30, 1997

Please record the information below each time a thermometer or spilled mercury is placed in the plastic container.

Container #

Date	Time	Location	Description/ Source of Mercury	Recorded by

Please fax or mail this log on October 1, 1997 to:

Florida Center for Solid and Hazardous Waste Management
2207-D N.W. 13th Street
Gainesville, FL 32609
Phone (352) 392-6264
FAX (352) 846-0183

Do NOT send containers with mercury to the above address. Only mercury recycling companies and licensed hazardous waste disposal companies can receive mercury wastes.
Contact ______________________ to arrange for proper disposal.

VENDOR LISTING

This information was voluntarily supplied by the companies listed below and is not necessarily a complete fist of available services. A company's absence from this list does not imply prejudice or impropriety. The Florida Center for Solid and Hazardous Waste Management does not endorse any specific waste Management Company or recycler. Users of this fist are responsible for ensuring that products, equipment or services comply with the requirements of local state, and federal law. The Center cautions generators to personally evaluate the services and compliance status of any company they use.

Mercury Recycling Companies

MTI (800) 808-4MTI
4317-J Fortune Place, West Melbourne, FL 3290 (407) 952-1516

Quicksilver Environmental, Inc. (800) 376-7888
8503 Sunstate St., Tampa, FL 33634 (813) 249-0608

Recyclights
4972 Woodville Hwy, Tallahassee, FL 323 11 (904) 878-2259

Hazardous Waste Disposal Companies

Ashland Chemical Company
3930 Glenwood Drive, Charlotte, NC 28208 (800) 637-7922

Environmental Management
4303 Vineland Road, Suite F-6, Orlando, FL 32811 (407) 649-1459

Heritage Environmental
4132 Pompano Road. Charlotte, NC 28216 (704) 392-6276

Intervent Recycling Service, Inc.
20713 N. Highway 301, Dade City, FL 33525 (800) 621-6102

Laidlaw Environmental
5303 126th Ave N., Clearwater, FL 3462 (813) 573-1405

Perma-Fix of Florida
1940 NW 67th Place, Gainesville, FL 32653 (904) 373-6066

Safety-Kleen Corp.
161 Industrial Loop South, Jacksonville, FL 32073 (904) 264-2607

TankTek, Inc.
2522 Hunt Road, Land O'Lakes, FL 34639 (813) 909-004

Appendix E

Case Studies

CASE STUDIES

CASE STUDY #1

Hospital A is a large hospital in central Florida. Waste managers have been proactive in seeking ways to reduce and properly handle mercury-containing items and devices. Three areas were studied: the Histology Lab, the Biomedical Engineering Department, and staff training issues.

Histology Lab

The histology lab uses Mercurochrome, B-5, and mercuric oxide in stains. The lab manager explained that slide processing is a very complex procedure which generally requires the use of these mercury-containing products to obtain the quality of results that are needed by the histologist. B-5 is used primarily for bone marrow slides which require a great deal of cellular detail. Bone marrow slides are kept in the hospital indefinitely. With these slides, the histologist is looking for a variety of blood disorders, all of which attack similar cell structure groups with only minor differences in cellular effects. This makes it very crucial for the histologist to get a "clear" reading in order to properly identify the disorder. Mercury is needed for a good diagnosis of which disorder it is: lymphoma vs. Hodgkins vs. leukemia, for example. Mercury bonds readily to the tissue giving a clear view of the nuclear detail in the cells, and maintains a clear 3-D fixed image. When Formalin is used instead, the image is not as clear: the nuclear detail is more of a 2-D image, and there is an increased chance of misdiagnosis by the histologist.

B-5 waste is picked up by a biowaste contractor. For this lab, it takes two to three years to fill up a 5-gallon drum. The lab manager reported that labs generally are using a lot less B-5 than in the past. The lab processes about four bone marrow slides per day using a total of about 100 cc of B-5 for each slide, which results in four empty plastic containers that go in red bags. He said the containers would have 1/100th or less of a gram of mercury in them. If B-5 is dumped down the drain, 1/4 gram could enter the environment.

Another process that requires mercuric oxide is Hematoxylin staining. Until recently, non-mercuric substitutes were not available. Hematoxylin is a unique stain that is derived from a chemical in the pulp of the longwood tree.

The lab still uses mercuric chloride as a fixative because it allows the tissue to achieve a certain density, and mercury makes things brittle and hard. Alternatives to mercury products are expensive, up to five times as much and they do not give good results.

Biomedical Engineering Department

The majority of mercury spills come from thermometers or sphygmomanometers. One of the engineers pointed out that the amalgam powder used to clean up mercury spills creates mercuric oxide, which is potentially more dangerous than elemental mercury.

The Biomedical Engineering group has retrofitted all of facility's Baum sphygmomanometers with mylar sheaths. They collect all alkaline, ni-cad, and lead acid batteries. Batteries come mainly from digital thermometers, dopplers, and defibrillators.

A discussion was held with several of the engineers about the accuracy of electronic thermometers, and of aneroid sphygmomanometers vs. the mercury-containing units. The consensus was that the accuracy of any of these items is dependent upon the methodology and the technique of the user, rather than on the equipment.

Staff Training Issues

Frequent training is necessary to ensure that staff is properly segregating wastes and that they are clear about what is infectious (biomedical) waste and what is not. Because employees would "rather be safe than sorry," there is a tendency to throw things in red bags when there is doubt.

The lack of financial accountability is probably the major obstacle hospitals face with regard to the proper handling and disposal of mercury-containing wastes, as well as with regard to waste reduction and prevention in general. Disposal costs typically are not included in departmental budgets; therefore, there is no incentive to reduce or prevent waste.

Surgical units tend to produce the most waste. Instruments, equipment, tubes, weights, and other items sometimes wind up in red bags even if they are reusable or if they are not biomedical waste. Again, it is a case of employees who would rather be safe than sorry. This hospital estimates that it may be losing as much as $40,000 a year as a result of reusable items and devices being discarded in red bags.

Signs and notices on bulletin boards are considered to have limited effectiveness. People don't feel personal responsibility because waste disposal is not in anyone's budget. Managers at this hospital strongly believe that financial incentives are the best way to achieve behavior modification. They suggest that charging the departments directly for waste disposal would go a long way toward getting people to pay attention to how much waste they are producing. This hospital has instituted one type of financial incentive to get departmental groups to reduce their red bag waste: if a group doesn't meet measurable reduction goals, they don't get their full bonus.

CASE STUDY #2

Hospital B is a medium-sized hospital in central Florida. The hospital has replaced many of its mercury-containing sphygmomanometers and thermometers and has taken a proactive approach to staff training and purchasing issues.

Sphygmomanometers

This hospital identified sphygmomanometers as the most serious source of mercury spills because they can easily be knocked off their holders and onto the floor. Because of the quantity of mercury these units contain, the spills are expensive to clean up. The mercury-containing units are gradually being replaced with non-mercury units. This hospital found that it could purchase non-mercury sphygmomanometers for about $60 per unit, compared to $80 for the mercury-containing units. Some resistance has been encountered from doctors and nurses who prefer the mercury-containing units, but the majority of the staff have been satisfied with the non-mercury units.

Before this change could take place, the Product Standards Committee had to review and approve the change. The Product Standards Committee is made up of people from each of the departments in the hospital. A majority of the departments have to agree on a product change before it can be implemented.

Thermometers

Mercury thermometers have been replaced with two types of thermometers. The hospital now purchases disposable, paper thermometers which cost 6 cents each. They also use spirit-filled thermometers which are similar in cost to mercury-containing thermometers. Both types have been widely accepted and are considered to be very accurate by the medical staff. The blood bank and the pediatric unit still use mercury-containing thermometers due to a need for greater accuracy.

Mercury-Containing Substances and Devices

The lab has replaced Zenker's solution/B-5 with a non-mercury containing product that is formalin-based. The manager of the lab is very happy with the substitute product's performance.

Mercury-containing esophageal and intestinal dilators are used in this hospital, but there have been no reported spills from these devices during the past five years. The tubes are sterilized and reused for as long as the rubber remains in good condition, and then they are sent back to the manufacturer for disposal.

Staff Training Issues

Staff training is a key element in the proper prevention and management of mercury spills. Each department manager is trained in spill response procedures, and each has received a copy of a written spill response plan developed by the hospital. The manual describes the proper procedures for immediate action. The manual is updated annually and department managers attend training sessions annually. It has been found that most employees will retain the information for a few months but are likely to forget the proper procedures as time goes on.

One problem with staff training is that the time provided for the orientation of new employees is very limited. There is a lot of material to cover in the orientation, and as little as five minutes may be devoted to the management, handling, and proper disposal of hazardous wastes. The people who are responsible for waste management are well aware that this is not enough time, but it has been difficult to convince hospital administrators to change this practice.

Another problem is that there is not a financial incentive for departments to reduce the amount of waste they produce or to try to find less hazardous materials as substitutes. Waste management costs are not charged to individual departments. Waste is considered a product of the hospital as a whole, and there are no requirements for departments to keep track of how much they are producing. Administrators strongly believe that if waste management and disposal costs were distributed on a departmental basis, people would become interested in trying to reduce the types and quantities of waste produced.

<u>Purchasing</u>

The lack of a truly central purchasing program was identified as an obstacle in the reduction and proper management of mercury-containing items and devices. All purchases are supposed to go through a central purchasing department where Material Safety Data Sheets (MSDS) are reviewed by a committee before the purchase is approved. It is not uncommon, however, for some departments make purchases directly, especially the labs. People in the various departments are very busy and they tend to view the central purchasing process as taking too long. The result is that items come into the hospital which purchasing, safety, and security personnel were not aware off, which complicates their job of managing hazardous substances "from cradle to grave."

Waste managers expect this situation to get worse, rather than better, because of cost-cutting and downsizing. As downsizing happens, the remaining individuals in a department are given increased responsibilities that take up more time, which contributes to the perception that following proper purchasing procedures takes too long. One administrator who was interviewed said, "It is easier to buy a truck than to hire a new employee. The truck is considered capital, while the employee is seen as a cost."

<u>CASE STUDY #3</u>

Hospital C is a small hospital in north Florida. The hospital has replaced its mercury thermometers and reports that mercury spills or problems with mercury-containing devices are quite rare.

The hospital replaced its mercury-containing thermometers with digital thermometers. The medical staff are happy with the digital thermometers. The hospital has not replaced its sphygmomanometers and still uses mercury-containing wall units and rolling units. Hospital staff report that spills from the units are rare, and they consider the rolling units to be quite sturdy and not likely to tip over.

The quantity of biomedical waste generated in this hospital is considerably less than in larger hospitals which typically have one or more large red dumpster-type containers picked up by a disposal contractor on a daily basis. This hospital has the equivalent of about one of the larger containers picked up once a week.

A smaller hospital, where the number of staff is relatively small and stable, seems less likely to encounter many of the staff training difficulties that larger hospitals experience. Center staff observed that the level of activity seems somewhat slower in a small hospital. The fact that people may be less likely to be in a hurry may contribute to this hospital's experience that mercury spills are quite rare.