Mercury Switches in Appliances
Final Report
Presented to MA DEP
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I. INTRODUCTION

The Franklin County Solid Waste Management District received a technical assistance grant from the Massachusetts Department of Environmental Protection (DEP) for the 2000-2001 fiscal year. The intent of this grant was to study and assess the volume and frequency of mercury (Hg) switches and other mercury-bearing devices found in residential and commercial appliances. The goal was to remove the mercury switches prior to end disposal and avoid mercury contamination in the recycling and disposal wastestream. This study was one component of a statewide effort to reduce mercury in the municipal wastestream.

National studies have shown that municipal waste incinerators produce mercury pollution as a by-product of the incineration process. The release of mercury into the atmosphere is of particular concern due to its eventual precipitation into lakes and streams. In New England, there are a large number of water bodies that are affected by this toxic pollutant. Many Northeastern states have issued public warnings about consuming fish from lakes and streams due to the methylmercury contained in the fish. The mercury moves up through the food-chain after aquatic organisms consume mercury-coated plankton and algae from the stream or lakebed. Mercury concentrations increase as the toxin is stored in larger and larger fish. Once humans consume these game fish, the mercury levels may be severe enough to poison them. When mercury is in the methylmercury form, it creates the largest hazard to human health due to the human body's inability to process and detoxify it quicker than it accumulates. Methylmercury poisoning primarily affects the central nervous system. According to a report by the U.S Geological Service[1], 33 states have issued fish consumption advisories due to high levels of mercury contamination. In Massachusetts, public health officials recently expanded a statewide fish consumption advisory to include women who may become pregnant, nursing mothers and children under 12.[2] Mercury also affects salt-water species of game fish such as tuna.

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[1] "Mercury Contamination of Aquatic Ecosystems", U.S. Geological Survey, Fact Sheet FS-216-95, D.P. Krabbenhoft and D.A. Rickert.

[2] Internet Source: www.statehousenews.com, Michael Levinson, 7/24/01

Mercury switches in appliances account for only a small percentage of this pollution, approximately 0.77 percent of the total mercury in the solid wastestream[3], yet mercury switches and sensors are relatively easy to manage with the proper training and management plan. It is important to note that only a gram of mercury can pollute an entire body of water. Many of the switches found in appliances may contain up to 3 grams of mercury.

The scope of this report includes general information on mercury, existing mercury switch removal programs in other states, an overview of two educational workshops on mercury switches conducted for Massachusetts municipal employees, the design of a pilot collection system for the mercury devices at District transfer stations, specific data relating to mercury switch removals, and conclusions.

II. MERCURY SWITCH APPLICATIONS

Mercury has been used in appliances for many decades now. Mercury switches have provided superior means of making electrical contact switches, safety sensors and measurement devices. The unique properties of mercury in its elemental form have proven to be very valuable in appliance applications. Due to its liquid state, high density and conductivity, mercury is often used as a tilt switch, turning on or off a lamp, electrical motor, or pump. The mercury makes or breaks an electrical connection inside a sealed ampoule that typically has two wires attached to it. The switch makes contact when the orientation of the device is changed, for example when a washing machine lid is raised, or when a space heater tips over. These switches are very durable and very reliable. The mercury also makes for a smooth, quick switch with little or no contact chatter. This is important when the switch is used to start an electric motor.

Another characteristic of mercury is its sensitivity to temperature. As we all know, mercury has been used for many years in thermometers. The elemental mercury expands when heated, and contracts when chilled, thus creating an accurate gauge to record temperatures. This same principle is used in flame sensor applications on some gas stoves. The mercury is contained in a probe and capillary that is connected to a valve body which regulates a gas valve. The probe is commonly located at the pilot light, where it heats up and expands the mercury inside the capillary. This expansion causes a diaphragm to push open, allowing the gas valve to feed a constant supply of gas to the pilot light. If the pilot goes out, the mercury cools, contracts, and closes the diaphragm, shutting off the gas supply to the pilot. This safety feature keeps gas from escaping into the home and causing an explosion. Newer types of ignition sources have been in use for some years now that do not require the use of a pilot light. Electronic ignition and Hot Surface ignition are two commonly used controls now. There is no mercury contained in these ignition devices. Gas stoves are still being manufactured with mercury flame sensors, however, they are only used in stoves that have no electrical supply and use a standing pilot for ignition.

Mercury switches have proven to be a reliable component of many lighting and safety features in our modern-day appliances. Often they outlast the life of the appliance itself. Appliance manufacturers have been phasing out the use of mercury over the past

[3] U.S. Environmental Protection Agency. "EPA Municipal Solid Waste Factbook," Ver.1.2. EPA-530-C-93-001a. May 1994.

few years. According to a spokesperson for the National Association of Home Appliance Manufacturers, all household appliances manufactured after January 1, 2001 have not contained any mercury. This effort by the manufacturers has been voluntary. Mechanical switches are being used as alternatives to the mercury switches. The one exception to this is the gas stove with a standing pilot that has no electrical connection. During a quick Internet search, the District found one mercury switch manufacturer promoting tilt switches for industrial machine applications, but no switches for appliances. Many of the older mercury switches encountered were manufactured for Honeywell and Mercoid controls, which were used in a wide array of applications.

Due to the many possible applications of mercury it can be found in a variety of household and commercial appliances. During this study mercury switches or sensors were identified in washing machines, gas stoves, gas-fired pool heaters, chest freezers, space heaters, steam pressure controls, gas heaters, sump pumps, and thermostats. The District learned of other applications such as gas-fired refrigerators, some larger commercial gas-fired water heaters, and r/v gas-fired equipment but did not happen upon any of these items during the study.

Mercury switches pose no threat to human health or the environment while they are intact. The mercury is typically encapsulated in a hard plastic casing, stainless steel, or in a glass ampoule. Most of these devices are very well protected in the inside of the appliance. Normal handling of these appliances during their lifetime will not disturb the mercury switch. Even during rough handling at a solid waste facility the majority of mercury switches appear to stay intact. The critical time when these switches can become capsules of poison is when the appliances are shredded by a scrap metal recycler or crushed in a landfill. Both of these processes are likely to compromise the integrity of the switch casing. There is only a small window of opportunity for mercury switches to be removed after the consumer throws them away and before the appliance reaches its final destination. Herein lies the problem of mercury switch removal, it is often that the opportunity to remove the switches only occurs when a) the appliance is at a municipal or commercial waste facility waiting to be recycled, or b) at the end-disposal facility. This places the burden of extra labor, disposal costs, training and safety concerns onto individual cities and towns or scrap metal companies.

III. EXISTING MERCURY SWITCH REMOVAL PROGRAMS

Although many states are focusing on eliminating mercury from our environment, the primary focus seems to have been on mercury thermometers, thermostats, fluorescent lamps, and batteries. This makes sense to concentrate on the mercury devices that are most common, contribute the greatest amount of mercury to the wastestream, and are simple to manage. Mercury switches in appliances are not typically visible to the consumer, constitute only a small portion of mercury in the wastestream, and involve greater amounts of labor and resources to extract. Due to these factors, few states have taken action yet to manage mercury switches in appliances although most states are aware of their existence.

The mid-western states of Minnesota, Wisconsin and Illinois in EPA Region 5 (Great Lakes Region) have identified mercury devices in appliances as a potential pollutant and seem to have a grasp of the situation. They have worked with the appliance

repair industry and end-facilities to eliminate the mercury components of appliances prior to disposal. Mercury in repaired or replaced items must be reused or recycled. According to John Gilkeson from the Minnesota Office of Environmental Assistance, the appliances that are destined for the scrap metal yard go to an appliance recycler first, who refurbishes and repairs the appliances that are worthy. The appliance recyclers then process the appliances that are non-repairable and remove the mercury devices from these appliances before scrapping. Illinois, Indiana, and Wisconsin have also targeted the removal of mercury devices in appliances. A report from the Virtual Elimination Pilot Project supports these findings stating that the disposal of mercury from appliances is regulated by law in the states of Minnesota and Illinois.[4] (See Appendix A.) California has a legislative mandated requirement to remove mercury switches from appliances and is developing a program at this time.

In the Northeast, Maine, Vermont, and New Hampshire have identified the problem of mercury in appliances. In New Hampshire, the District found at least one town that voluntarily removes switches from appliances at their transfer station. Further contact and information has been difficult to establish.

Vermont currently has two Solid Waste Districts, Addison and Chittenden, that remove the mercury devices at their transfer stations prior to scrapping. The Vermont program was the best replicable model of a mercury switch removal program that the District could find. The Vermont Agency of Natural Resources is also developing a training manual that will outline step-by-step procedures for removing the various mercury devices. A rough draft of that manual was available for review by the District Program Director. The manual will be a valuable tool for individuals to refer to when they are removing mercury switches. This manual will provide guidance in the field for appliance dismantlers until they become familiar with the removal of mercury switches. It is well written and has photographs of the various stages of mercury switch removal. The final copy should be available by the fall of 2001 according to the Vermont Agency of Natural Resources.

The issue of mercury pollution is so dynamic at this time that information on state and federal regulatory initiatives is changing from day-to-day. The District concentrated on the Vermont mercury in appliances program due to its close proximity to our county and to the fact that it has been established for a considerable amount of time.

IV. TRAINING WORKSHOPS

The District held two workshops to train municipal personnel and scrap metal recyclers on the proper identification and removal of mercury devices from appliances. Both workshops were identical in format and presentation content. The first workshop was held in Northampton, MA on February 19, 2001 at the Smith-Vocational Agricultural and Technical School. Approximately 50 people attended. Please refer to Appendix B for copies of the announcement flyer, agenda, evaluation forms and a summary of the evaluations. Evaluations from the first seminar were positive despite the cramped quarters of the lecture room.

[4] Virtual Elimination Pilot Project. Appendix C: "Regulations on Products that Contain Mercury," Ross & Associates Environmental Consulting, Ltd.

The second workshop was held on March 28, 2001 in Natick, MA. It was at the Natick Department of Public Works. A mailing list from the MA DEP was provided to the District for invitations. Approximately 25 solid waste professionals and transfer station attendants attended the second workshop. Evaluations from this workshop were also very positive.

Both workshops included a lecture type presentation on the health and environmental effects of mercury presented by Sami Izzo, formerly of the Upper Valley Solid Waste Management District in VT, now employed by Dartmouth-Hitchcock Medical Center in Dartmouth, NH. Ms. Izzo discussed how mercury gets into the food chain through a variety of natural and anthropogenic means; the effects it has on human health; the applications of mercury in appliances; the amounts of mercury in the switches; and other uses of mercury in novelty items. This presentation is attached in Appendix C.

The second portion of the workshops involved a demonstration by Gary Winnie, of the Chittenden County (VT) Solid Waste Management District. Mr. Winnie's presentation covered the actual practice of removing the mercury devices. Two handouts were used as guides to his presentation. The first was a report by John Gilkeson of the Minnesota Office of Environmental Assistance, and the second was a fact sheet from the Appliance Recycling information Center. Both handouts were very valuable resources, showing exactly were switches were located and explaining the methods of removal. Both handouts are attached in Appendix C. Mr. Winnie also used numerous props to demonstrate where the switches/devices could be found, what they looked like, and how to safely remove them. A brief time was spent discussing the personal protective equipment (PPE) needed to protect workers engaged in removing mercury devices. Mr. Winnie also explained how to use a mercury spill kit. A brief presentation on Massachusetts (MA) regulations concerning the proper handling and storage of mercury, and the federal and state Universal Waste Rule was made by MA Department of Environmental Protection staff member, Lori Segall.

The final component of the training was a hands-on practice session with appliances that contained mercury devices. These appliances were selected and transported to the seminar locations by the District with the help of a local appliance dealer and a scrap metal facility. This hands-on participation encouraged participants to utilize the information that had just been presented and to put it to use in a real-life application. This part of the training was the most valuable, and we had many comments that suggested we might increase the time allotted for this portion of the presentation in the future.

Effective training on how to identify and remove mercury switches from appliances can be accomplished in 3-4 hours. The workshops we held were three hours in duration but could have easily extended another hour for more hands-on practice. Approximately half of the participants felt comfortable enough to remove a mercury switch on their own after the training.

Many participants felt there was a need for more training on this issue throughout the state. The evaluation also asked participants what barriers might exist for municipalities to implement a mercury removal program. The top three reasons given were worker safety, labor costs, and lack of funding for mercury spill kits and disposal.

The District Program Director attended both of these workshops and in turn was able to make a presentation on this subject at the Northeast Resource Recovery

Association (NRRA) conference that was held in June 2001 at Hyannis, MA. The conference had attendees from other New England states besides Massachusetts. The presentation included a demonstration of mercury switches that had been removed from appliances during the grant study. The same handouts were used that had been offered at the District-sponsored training seminars. Feedback was generally positive from the 35 or so participants.

V. MERCURY STUDY AT FCSWMD TRANSFER STATIONS

The District undertook the task of studying mercury in appliances at its transfer stations. First, a list of appliances that may contain mercury was developed (Appendix D). Secondly, the District determined that it had 12 transfer stations in its jurisdiction that accepted appliances for disposal. The District conducted its study at five (5) of these facilities. These were in Bernardston, Conway, Montague, Northfield, and Orange. These towns are all very rural and operate drop-off facilities for residents to bring their appliances to. The typical facility had between ten (10) and thirty (30) total appliances on site during visits for this study. The combined volume of appliances that are received at these locations in one year is but a fraction of the number received at a metropolitan facility in one month. But volume alone doesn't determine the likelihood of finding appliances that contain mercury. Even at a small transfer station with only a dozen appliances on site, mercury switches were present. In some cases, up to thirty percent of the appliances contained mercury. In every case, at least one appliance was discovered to contain mercury.

This study involved three components: identification and separation of appliances that contain mercury, recording the make and model (whenever possible) of the appliances, and removal of the mercury switches from the appliances. The location of the switch and the amount of time taken to remove was recorded. Please refer to Appendix D for a complete listing of mercury-bearing appliances found and processed.

The proper identification of mercury-bearing appliances was based on the materials and training presented in the earlier two workshops. This process of identification was time-consuming but relatively easy. Each appliance that was suspected to contain a mercury device was marked with spray paint.

A. PREPARATION

After organizing and attending the two training workshops, the District Program Director was confident of his ability to remove mercury switches. The Program Director prepared for the study by purchasing the various tools necessary to perform the switch removals such as a pair of wire cutters, screwdrivers, assorted open-end wrenches, a pry bar and sledge hammer. Data sheets were created to record the information collected. The data includes the manufacturer, the model (when available), the location of the mercury switch, and the amount of time taken to remove.

A travel plan and a schedule was plotted to visit the five transfer stations. A late winter snow cover did effect that schedule but not to any degree that compromised the study. A spill kit and PPE were combined with the tools to

make one large kit that was brought to each site. A large piece of cardboard was also brought to serve as a flat-surfaced work area in case of a mercury spill.

B. FIELD WORK

Appliances most often were in the scrap metal pile or had been sorted adjacent to the pile. Instead of performing another separation, or sort, the appliances to be studied were marked with paint. Next, each appliance that had been marked was scrutinized further to determine whether it contained a mercury switch. This entire identification process typically took a maximum of five to ten minutes, depending mainly on the number of appliances. These are small, rural transfer stations; on average there were between two and four appliances that might contain mercury out of twenty total appliances. A greater number of gas stoves and gas heaters containing mercury flame sensors were found in Montague, which has a natural gas pipeline throughout the town.

The District also received aid in this task from Daniel Schell, the Recycling Coordinator for the City of Holyoke, MA. Mr. Schell began removing mercury switches from appliances at the City of Holyoke Transfer Station after attending the training workshop in Northampton. He successfully removed gas flame sensors and other mercury devices from appliances at his facility and recorded the information for the District (included in Appendix D).

C. REMOVAL OF MERCURY DEVICES

All mercury switches that were found were removed. The identification and removal of these mercury devices from the appliances became easier with experience. Removal of a chest freezer mercury switch, for instance, only takes about 30-50 seconds now, compared to removal times of well over a minute when first attempted. Of course some appliances, such as gas stoves may still take longer than average to facilitate the removal of the mercury. Rusty screws, stripped heads, grease, rodents' nests, and fragile mercury-containing capillaries can make for longer, tedious removals. In some cases, the appliance had to be partially dismantled, often using a sledge-hammer and pry bar. Persons removing mercury devices must be conscious of safety concerns due to sharp edges of metal and other hazards that are associated with any type of mechanical labor.

The Program Director performed approximately eighteen (18) extractions of mercury devices and none of these devices were broken in the process. Most of the devices are contained in hard plastic, rubber, and steel capsules. The mercury flame sensors found in gas ovens were the only devices that posed any threat of breakage and mercury exposure to the dismantler. Glass ampoules containing mercury also posed a threat but are not very common in appliances (only two were found during the study). It was also reported that there were no breakages in Holyoke while Mr. Schell was removing mercury switches from appliances.

After removal, the mercury switches were bagged and labeled for identification purposes. These bags were stored in an approved five-gallon pail

with a tight lid, and later consolidated at one of the District's permanent Universal Waste collection sites.

D. SUMMARY OF FIELD STUDY

In one month's time, the District and the Holyoke Transfer Station successfully collected a combined total of thirty-five mercury switches from appliances; eighteen from the five rural transfer stations the District visited, and seventeen from the City of Holyoke. Refer to the individual data sheets for details, located in Appendix D. A compilation of findings is listed below by type of appliance:

Chest Freezers

Six chest freezers were discovered to contain mercury, representing seventeen percent (17%) of the total number of mercury switches found. The brands of these freezers were: Sears, GE, Montgomery Ward, and one unidentifiable brand. All of these freezers had convenience lights located in the top of the freezer that were designed to turn on when the lid was lifted. The mercury switches in these lights were typically contained inside the actual light socket. The sockets were constructed of a hard, black plastic casing, or of a black or white rubber boot-type casing. In either case, the mercury could be felt and heard inside the device when shaken by hand.

Removal of the devices was simple: unscrew the light dome and fixture, cut the electrical wires connected to the light socket, and remove the light socket from the freezer lid. The average time for removal of these two types of switches was 1.7 minutes. One other type of switch was found in a GE chest freezer. A glass ampoule switch was found to be located in-line of the wiring of the freezer's light. It was located inside the cover, buried in the insulation. It was necessary to cut away some of the metal on the underside of the lid to obtain the switch safely. This type of switch took four (4) minutes to remove.

The weights of these chest freezer switches ranged between 0.6 ounces and 3.0 ounces including the casings. Some of the light sockets can be further dismantled after removal from the freezer. The hard cased plastic switches can be taken apart to remove the small metal disk of mercury. The amount of mercury contained in these switches could not be determined but according to data presented in the training workshops the average switch contains 1 to 1.5 grams of mercury. (There are approximately 28 grams to one ounce.) Nearly all of the chest freezers found during this study contained mercury switches. Newer and older models were both discovered.

Gas Stoves

Nineteen gas stoves, ranges, and ovens were discovered to contain mercury flame sensors at the burner under the broiler section. These stoves represent fifty-four percent (54%) of the appliances studied. The brands of these stoves and

ovens were Colson, Coloric, GE, Gibson, Glenwood, Magee, Magic Chef, Preway, Sears, and Whirlpool. The mercury is contained in a probe and thin steel capillary that is connected to the gas control valve. These are not to be confused with the probes and capillaries found in the ovens themselves. The probes in the ovens are thermostatic devices that regulate the oven temperature. These oven thermostats do not contain mercury. The use of a magnet is encouraged to determine if the device contains mercury. The oven thermostat capillaries are often copper and will not be attracted to a magnet. The steel mercury flame sensors will be attracted to the magnet.

Average removal time of this device was 4.7 minutes. Difficult conditions such as grease or debris will increase the removal time. Remove all three components (probe, capillary, and gas valve) in one piece. The probe is normally protruding into the pilot light area and can be loosened by a setscrew that holds it in place. Next, trace the capillary back to the gas valve. There are typically four large screws that hold the gas valve body in place. Remove these screws and the valve should be free of the stove frame. Carefully remove the valve body, capillary, and probe taking caution not to break the capillary in the process. Once removed from the broiler compartment, further disassembly may be performed. The capillary is screwed onto the valve with four smaller remaining screws. Remove these and carefully pry apart the valve at the seam. This last step is not necessary for recycling but it does reduce the weight of the device, thus reducing the disposal costs. Sometimes the gas valves are corroded and will not come apart at the seam. In this case it is better to not risk breaking the fragile capillary and to leave the device intact.

These mercury flame sensors come in different sizes and weights depending on the manufacturer but they are all basically identical in components. The average weight of the mercury flame sensors (stripped down to their minimum size) found in this study was one (1) ounce. Units with the gas valve still intact weighed an average of 4.9 ounces. According to the Association of Home Appliance Manufacturers these devices contain two (2) grams of mercury each.

Three gas stoves were found to contain another pilot flame sensor in stoves that had gas-fired space heaters side by side with the oven. These stoves were two Calorics and a Magee that were obviously very old. The removal of these mercury flame sensors was a very difficult process, taking an average of 8.5 minutes each. The cast iron burners used in these space heaters must be removed with the probe, capillary, and gas valve and then undergo further disassembly outside of the stove. The weights of these devices were not available. The assumption can be made that these flame sensors contain approximately 2 grams of mercury each since they are similar to the flame sensors found in gas ovens.

Washing Machines

One washing machine was found that contained a mercury shut-off switch when the lid was opened. This washer accounted for three percent (3%) of the total appliances studied. According to the Appliance Recycling Information

Center Info Bulletin #8, published by the Association of Home Appliance Manufacturers' Association, this application was only used in washing machines prior to 1972 era. Washing machines manufactured after that date utilized a mechanical switch to turn on and shut off the washer. Other sources claim that these switches may have been used in the early 1980s as well.

This washing machine is simple to identify. Many newer washers have a small tab that pokes through a hole in the washer that will open an electrical switch that shuts off the machine when the lid is opened. This Whirlpool washer has no tab or hole. Remove the top section of the washer by unscrewing a few sheet metal screws or simply bang it loose with a sledgehammer. Lift the top section of the washer up, cut away the wires, and completely remove from the main body of the machine. Turn the washer top over and look to the right side off the lid. The mercury tilt switch is mounted to the hinge pin. It is cylindrical, with a hard plastic casing, normally blue or black, and has two wire leads coming from it. Remove the switch from its bracket and cut the two wire leads. Complete removal time was three (3) minutes.

The switch weighs 0.6 ounces with its wire leads. The mercury content is estimated at two (2) grams. Mercury switches in Maytag washing machines are glass ampoules, and the mercury can be seen.

Space Heaters

Often electric space heaters have safety switches that shut off the heater if it is tipped over. Quartz heaters were quite common during the past two decades. The District found one of these heaters during the study, a Presto brand Quartz heater. These electric heaters are tall and round, have a vertical orientation, and sit on a plastic base. They don't have a fan, so they are considered a radiant space heater. The Presto Quartz heater has a mercury tip switch mounted inside the heater. To remove the switch, unscrew the plastic base of heater, locate the two power supply wires, and trace these wires to the mercury tip switch mounted in the thermostat area. The metallic disk-shaped mercury switch can be unscrewed and the wires removed. There is a small piece of plastic used as a mounting insulator attached to the switch. Remove the disk and black plastic piece as one.

This switch represents two percent of all the mercury switches found in the study wastestream. Removal time for this switch was three and a half (3.5) minutes. The switch weighs 0.7 ounces. The amount of mercury in this switch could not be determined at this time. The best estimate would be 1 _ - 2 grams.

On a commercial scale, a Thermo Pride, gas-fired space heater was discovered to have a flame sensor located on its burner. This mercury flame sensor took twenty-five (25) minutes to remove by the technician in Holyoke. Data on weights is incomplete.

Pool Heaters

Pool heaters circulate water through heat exchangers that are heated by a burner. Some of these burners are gas-fired. One pool heater was found to

contain a mercury flame sensor in this study. This represented 3% of the total appliances studied. A Telydyne Lars, Telstar model, gas-fired heater contained a mercury flame sensor located at the burner. The mercury sensor took six and a half (6.5) minutes to remove. The capillary and probe device weigh 0.8 ounces. The amount of mercury contained is estimated to be 2 to 2 _ grams.

Commercial Water Heaters

For purposes of this study, a commercial water heater is typically one that is 100 gallons or larger. Residential gas-fired water heaters do not contain mercury. These water heaters are often used in wide variety of commercial applications such as car washes or large restaurants. The Holyoke facility identified four commercial water heaters that contained mercury. These four were manufactured by GE and Rheem, and accounted for 11% of the total appliances studied. The average time to remove the safety flame sensors from these water heaters was seven and a half (7.5) minutes. The mercury devices were located on the burners and contained approximately two (2) grams of mercury each.

Electric Stoves

Many electric stoves use a fluorescent lamp to light the back panel. These fluorescents contain mercury. Although they are not considered a switch, the District felt that it was important to include them in the study. The removal of fluorescent lights is very simple and often overlooked. Many of these bulbs were discovered during the study but only two were recorded. A GE and a Gibson electric range were recorded. The fluorescents can be removed easily by unscrewing the guard over the light, if necessary, and by gently twisting the bulb out of the socket ends. The removal of these fluorescent bulbs took one minute each. In Massachusetts, these bulbs are managed as Universal Waste.

Other Appliances

There are numerous other appliances that may contain mercury that were not encountered during this study. The District has learned of mercury in gas-fired refrigerators, camper appliances that are gas-fired, HVAC equipment and controls, float devices used in sump pumps, pressure controls for steam systems, and also in some household irons. Commercial appliances that are gas-fired should be looked at closely to determine if there are mercury-flame sensors at the burner or point of combustion. This study did not even scratch the surface of the industrial and commercial uses of mercury such as in gas meters, sewage treatment plant flow meters, machinery controls, car alarms, and flight simulators. The probability of discovering these items in municipal solid waste is low.

E. BRIEF ANALYSIS OF FINDINGS

The total amount of mercury collected during the month-long study is estimated at eighty (80) grams. If multiplied by twelve for each month, the total would be 960 grams or just over two (2) pounds per year. Holyoke, a city with a population of approximately 50,000 collected roughly half of that amount (40 grams/month).

There are many factors that will affect annual generation of mercury switches, such as seasonal fluctuations, availability of scrap recyclers to residents, convenience of transfer stations, etc. This study is only a snapshot in time. It is not really known how much mercury could be captured with a comprehensive switch removal program at transfer stations, end-disposal facilities or scrap recyclers. One thing the District was able to establish from this study is that communities that have a natural gas utility infrastructure are more likely to produce a higher number of gas-related mercury devices at their solid waste facilities.

VI. COSTS

The estimated costs associated with this study were as follows:

ITEM		COST
Two Training Workshops (Speaker fees, postage, copies, expenses, etc.)		$3,130
Tools (Newly acquired)		$ 55
Mercury Spill Kit	(estimated)	$ 100
Personal Protective Equipment	(estimated)	$ 50
Labor @ $35/ hr.		
Workshop organization	167 hours	$5,845
Switch removal	40 hours	$1,400
Holyoke Switch removal		$ 450
	Estimated Total	**$11,030**

NOTES: A) Mercury Disposal/Recycling costs were not included because the switches collected in this study have not been disposed of yet. Money was budgeted for the District to dispose of these switches through a MA state contract at the rate of $3.75 per pound. This price reflects the cost per pound of the entire device, not just the mercury contained inside. B) The District owned some tools at the onset of this project and only had to purchase what was lacking. C) The District already had a Mercury Spill Kit and PPE.

VII. CONCLUSIONS

This study shows that mercury in household appliances is a real and present danger to our environment and to humans, old and broken appliances with mercury switches enter the wastestream every day. In approximately forty (40) hours of study time, thirty-five mercury devices were found. Mercury was found not only at the larger city transfer station but also at each of the five rural transfer stations. A very conservative estimate would be that 3% of all the appliances looked at contained mercury devices. At one facility the percentage was as high as 30%. Although one study suggests that mercury in appliances only accounts for 0.77 % of the mercury in solid waste, this figure is dynamic and may be changing every day. With the advent of thermometer exchanges and thermostat collection programs, the total amount of mercury in the wastestream is being reduced but there is still a percentage that is left unmanaged.

Mercury in appliances is one of the more difficult components to manage because it is unseen, there is not a comprehensive list of appliances that contain it, mechanical skills are needed to remove it, and there is no motivation for transfer station employees to put themselves at risk of exposure. The evaluations from our training seminars cite costs, worker fear, time, labor, and safety issues as the major barriers to implementing a mercury switch removal program. Those are the real hurdles to overcome and solutions must be sought. The life of a new appliance is approximately twenty years, therefore mercury removal from appliances will be an issue for an entire generation.

Some municipal transfer station attendants already handle mercury in other forms such as fluorescent lamps, batteries, and other devices. Worker fear of mercury and safety issues can be addressed through proper training and technical support. However, not every transfer station attendant will be able to perform this task. Finding the right person to perform this task is the most difficult barrier. It might be necessary to train an individual from another department to perform mercury extractions.

Only one or two persons per facility need to be trained. In Vermont, one technician handles mercury in appliances at a regional facility for an entire county. The City of Holyoke was also able to remove switches for a population of approximately 50,000 with only one technician. The Franklin County Solid Waste District covers 500 square miles of very rural area, thus it would not be cost-effective to have only one person removing mercury switches due to the travel expenses and time involved, but in centralized collection locations and areas with high population densities one person will suffice.

Time and labor issues are concerns that accompany any new solid waste program that requires more work. Municipal solid waste facilities have encountered growing labor demands for sorting of recyclables, hazardous materials, and other items that need to be managed separately from the mainstream of solid waste. For interested facilities, removing mercury switches from appliances may increase the workload for transfer station operators significantly in the beginning but should decline after the workers have had some practice and are comfortable performing mercury switch removals. Identification of appliances that contain mercury should become second nature after a short time. Removal of the devices normally takes no longer than ten minutes per unit at most. Each facility can develop its own system that will be the most efficient. Obviously, not every facility will need or want to implement a mercury switch removal program.

According to the seminar evaluations, the training conducted by the District during this study was effective in providing a majority of the participants with the knowledge and confidence to remove mercury switches from appliances after only one session. The set-up costs to conduct the initial training were higher than expected but decreased for the second training session. These trainings are now replicable across the state.

The key elements to a successful municipal program are as follows: hands-on training, reference materials, a field manual, the proper tools and safety equipment to facilitate removal of the switches, a permitted Universal Waste storage shed, and a disposal plan. State environmental agencies looking to establish such programs at municipal facilities should help by providing free training sessions, and perhaps mini-grants to cover start-up expenses such as spill kits, personal protective equipment, tools, and storage sheds. State agencies could also provide a technical hotline for dismantlers to call if they had questions or concerns while removing a device. This practice is common in the HVAC trades with companies such as Honeywell and White-Rodgers.

Once a state agency commits to providing the infrastructure and support for such a program, municipalities may be more likely to participate. State mandates that leave municipalities scrambling to maintain regulatory compliance without financial and educational support may prove unrealistic, unfair, and counter-productive.

Disposal costs under the available state contract are not exorbitant for most mercury switches. For example, a device weighing one ounce would cost approximately twenty-four cents to dispose of at the current contract price. Naturally, these costs do add up as devices are accumulated for disposal but it may be possible to defer them by charging a fee to residents who bring these appliances to the facility. The same issue has been encountered with CFCs. It is the discretion of the town to determine the most appropriate way to fund the disposal costs. Offering state grants to communities for mercury disposal costs is also an alternative.

Removal of mercury switches may be performed by appliance repair shops, scrap metal dealers, and at end disposal facilities. The District encouraged people from the scrap metal sector to attend our training sessions. The District is looking at ways to involve our local scrap metal dealer in this project since it is there that the appliances from our transfer stations become centralized. This would greatly economize our program by reducing the time and energy spent traveling throughout the county. We expect the scrap metal dealer would include a processing fee for these appliances, similar to the fee charged for freon removal.

We recommend continuation of pilot projects that compare the costs of a program at transfer stations and end-disposals facilities to one at scrap metal dealers. The District's study only provides the foundation for training and the first analysis of the relative proportion of appliances with mercury switches and the volume of mercury in each switch. It does not test or assess the on-going labor requirements or costs associated with a permanent mercury switch removal program.

Mercury Collection Data Sheet
District Transfer Stations

Appliance Type	Manufacturer	Model	Switch Location	Removal Time
Washing Machine	RCA Whirlpool	LRA7800W2	Under top section/ rt.side	2.5
Chest Freezer	Unknown		Light socket in lid	2
Chest Freezer	Sears Coldspot	198.710440	Light socket in lid	2.5
Chest Freezer	GE		In-line ampoule in lid	4
Chest Freezer	Sears Coldspot	198.571500	Light socket in lid	2.5
Elect. Range	Gibson	R3070A-80	Fluorescent lamp	1.5
Gas range	Caloric		Rear of broiler burner	4
Gas range	Caloric		Rear of broiler burner	4
Gas range w/space heater	Caloric		Rear of Broiler / Heater burner	4 / 7.5
Gas range w/space heater	Magee		Rear of Broiler/ Heater burner	3.5/ 8
Gas range w/ space heater	Magee		Rear of broiler/ Heater burner	4 / 10
Gas range	Magic Chef		Broiler burner	4.5
Gas Oven	Preway	3710W	Burner	5
Quartz Space Heater	Presto		Inside Bottom/ tip switch	3.5
Pool Heater	Telydyne Lars	Telstar	Burner	6.5
Chest Freezer	Montgomery Ward	575	Light socket in lid	2

Mercury Collection Data Sheet
City of Holyoke Transfer Station

Appliance Type	Manufacturer	Model	Switch Location	Removal Time (min)
Range	Colson (very old)	?	Front of broiler	15
Range	GE		Rear of broiler	3.5
Range	GE		Rear of broiler	3.5
Range	GE		Rear of broiler	3.5
Range	Glenwood		Rear of broiler	3.5
Range	Glenwood		Rear of broiler	3.5
Range	Magee		Rear of broiler	7
Range	Magee		Rear of broiler	5
Range	Sears		Rear of broiler	3.5
Range	Sears		Rear of broiler	3.5
Range	Sears		Rear of broiler	3.5
Range	Whirlpool		Rear of broiler	5
Commercial Water Heater	GE		On Burner	10
Commercial Water Heater	GE		On Burner	10
Commercial Water Heater	Rheem		On Burner	5
Commercial Water Heater	Rheem		On Burner	5
Commercial Space Heater	Thermo Pride		On Burner	25